Green Jobs:

Towards decent work in a sustainable, low-carbon world

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Solar panels being installed at a former mining site in Germany.

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E-recycling of old mobile phones: employee is repairing mobile phone for re-usage.

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Construction of a wind engine by workers.

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Towards decent work in a sustainable, low-carbon world

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Explanatory Notes

This report is written in American English. All units are metric unless otherwise indicated.

Currency values are reported in U.S. Dollars throughout the report. Original currency values other than Dollars are reported in parentheses and are translated into U.S. Dollars using the following 2007 average exchange rates: 1 € (Euro) = $1.37; 1 £ (British Pound) = $2.00 (Federal Reserve Bank of New York ("Foreign Exchange Rates Historical Search," at www.ny.frb.org/markets/fxrates/historical/home.cfm).

Foreword by UNEP, ILO, IOE, ITUC

Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World is the first comprehensive report on the emergence of a "green economy" and its impact on the world of work in the 21st Century.

Until now, there has been much anecdotal evidence indicating that the pattern of employment is indeed changing—and that new jobs are beginning to emerge in favor of greener, cleaner and more sustainable occupations. This report shows for the first time at global level that green jobs are being generated in some sectors and economies.

This is in large part as a result of climate change and the need to meet emission reduction targets under the UN climate convention. This has led to changing patterns of investment flows--flows into areas from renewable energy generation up to energy efficiency projects at the household and industrial level.

The bulk of documented growth in Green Jobs has so far occurred mostly in developed countries, and some rapidly developing countries like Brazil and China. Green Jobs are also beginning to be seen in other developing economies. A project in Bangladesh, training local youth and women as certified solar technicians and as repair and maintenance specialists, aims to create some 100,000 jobs. In India, an initiative to replace inefficient biomass cooking stoves in nine million households with more advanced ones could create 150,000 jobs. It now appears that a green economy can generate more and better jobs everywhere and that these can be decent jobs.

Despite such optimism, it is clear that urgent action is needed. In some areas, especially in the developing world, new jobs being created in the food, agriculture and recycling sectors as a result of climate change and environment leave much to be desired and can hardly be considered as decent. Climate change is also having a negative impact on jobs in some areas. Sectors consuming large amounts of energy and natural resources are likely to see a decline in jobs. Climate change is already damaging the livelihoods of millions, mostly poor people in developing countries. Thus, just transitions to new opportunities and sustainable jobs and incomes are needed for those affected.

So what of the future? Clearly much depends on a deep and decisive response to climate change at the UN climate convention meeting in Copenhagen in late 2009. Equity is going to be a key condition for a new agreement, between countries as well as between social groups within countries. This report provides important pointers for how this can be achieved.

A climate deal is also likely to support payments to countries for managing forests for their carbon absorption potential opening up new opportunities for Green Jobs in the forestry sector of the Tropics.

An agreement by 2010 under the Convention on Biological Diversity on Access and Benefit Sharing of Genetic Resources could trigger similar North-South funding flows with job implications in conservation and natural resource management.

The future trajectory of the Green Jobs Initiative will therefore depend on a wide range of factors and actors. Governments, as well as the private sector will play a key role. Changes in the decisions, practices and behaviors of millions of managers, workers and consumers will be needed. This report attempts to contribute the necessary awareness about Green Jobs and a green economics to help make those changes happen.

The report also comes amidst a visible period of transition: trade unions, employers' organizations, the private sector and the UN are natural allies in this quest. Each has a critical role to play, not least in the areas of boosting efficiency in the use of energy and raw materials through better work organization and of retraining and retooling the global workforce to seize the new opportunities and to master the transition to green production and consumption.

Certainly there will be winners and losers, so support for workers and enterprise adaptation will be key. But if the international community can get it right there is the real prospect of generating and fostering Green Jobs and Decent Work for ever more people. Green Jobs and Decent Work are a new and powerful force for achieving a more resource efficient and equitable global economy that mirrors all our aspirations for true sustainable development.

This report was commissioned and funded by the United Nations Environment Programme (UNEP) as part of the Green Jobs Initiative of UNEP, the International Labour Organization (ILO), the International Organization of Employers (IOE) and the International Trade Union Confederation (ITUC). It has been compiled by the Worldwatch Institute with technical assistance from the Cornell University Global Labor Institute.

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List of Acronyms

ABVAKABO	Civil servant union (Netherlands)
ACEA	Association des Constructeurs Européens d'Automobiles (European Automobile Manufacturers Association)
ACEEE	American Council for an Energy-Efficient Economy
ADB	Asian Development Bank
ADM	Archer Daniels Midland
ALMP	Active Labour Market Policies
APP	Asia Pacific Partnership
ASES	American Solar Energy Society
AWEA	American Wind Energy Association
BASF	Largest chemical company in the world (German)
BAU	Business as usual
BEA	Berlin Energy Agency
BEE	Bundesverband Erneuerbare Energien (Federal Association for Renewable Energy, Germany)
BIR	Bureau of International Recycling
BMRA	British Metals Recycling Association
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Federal Ministry for Environment, Nature Protection and Reactor Safety, Germany)
BOI	Board of Investment (Thailand)
BREEAM	Building Research Establishment Environmental Assessment Method (UK Green Building Standard)
BRT	Bus Rapid Transit
BTU	British Thermal Unit (heat value of fuels; 1 BTU is equivalent to about 1,054–1,060 joules)
BWI	Building and Woodworkers International Union
C&DW	Construction and demolition wastes
CAFE	Corporate Average Fuel Economy (U.S. fuel-efficiency standard)
CALPIRG	California Public Interest Research Group
CASBEE	Comprehensive Assessment System for Building Environmental Efficiency (Japan Green Building Standard)
CBI	Confederation of British Industry
CCI	Clinton Climate Initiative
CCOO	Confederación Sindical de Comisiones Obreras (Trade Union Federation, Spain)
CCS	Carbon capture and sequestration/storage
CDM	Clean Development Mechanism (Kyoto Protocol)
CEMPRE	Entrepreneurial Commitment for Recycling (Brazil)
CFLs	Compact f uorescent lamps
CGIAR	Consultative Group on International Agricultural Research
CGT	Confédération Générale du Travail (General Confederation of Labor, France)
CIS	Commonwealth of Independent States (an alliance consisting of eleven former Soviet Republics: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Ukraine, and Uzbekistan.
CNG	Compressed natural gas
CNMIA	China Nonferrous Metals Industry Association

CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COG	Coke oven gas
COSATU	Congress of South African Trade Unions
CREIA	Chinese Renewable Energy Industries Association
CSC	China Steel Corporation
DEFRA	Department of Environment, Food and Rural Af airs (United Kingdom)
DOE	Department of Energy (United States)
DRI	Direct reduced iron (steel-production process)
EAA	European Aluminium Association
EAF	Electric Arc Furnace (steel-production)
EBI	Environmental Business International
EC	European Commission
ECOTEC	British-based consulting firm
EE	Energy efficiency
EEN	Energy Efficiency Network
EFTE	European Federation for Transport and Environment
EJ	Exajoule (exa denotes 10^{18}, or 1,000,000,000,000,000,000)
EPA	Environmental Protection Agency (United States)
EPIA	European Photovoltaic Industry Association
EPR	Extended producer responsibility
EREC	European Renewable Energy Council
ERI	Energy Research Institute (China; part of the National Development and Reform Commission, see NDRC)
ESCOs	Energy Service Companies
ETUC	European Trade Union Confederation
EU	European Union
EU ETS	European Union Emission Trading Scheme
EU-15	European Union prior to eastward expansion, with 15 members
EU-25	European Union after expansion, with 25 members
EWEA	European Wind Energy Association
FAO	Food and Agricultural Organization of the United Nations
FNV	Federatie Nationale Vakbonden (trade union confederation, Netherlands)
FSC	Forest Stewardship Council
FTE	Full-time equivalent
GAO	Government Accountability Office (United States)
gCO_2/km	Grams of carbon dioxide per kilometer
GDP	Gross domestic product
GEF	Global Environment Facility
GFRA	Global Forest Resource Assessment
GHG	Greenhouse gas

List of Acronyms (continued)

GJ	Gigajoule (giga denotes 109, or 1,000,000,000)
GJ/t	Gigajoules per ton
GS	Grameen Shakti (microcredit bank, Bangladesh)
GW	Gigawatt
GWEC	Global Wind Energy Council
GWth	Gigawatts-thermal
HGV	Heavy Goods Vehicle
HVAC	Heating, ventilation and air conditioning
IATA	International Air Transport Association
ICCT	International Council on Clean Transportation
ICFPA	International Council of Forest and Paper Associations
IEA	International Energy Agency
IFAD	International Fund for Agricultural Development
IISI	International Iron and Steel Institute
ILC	International Labour Congress
ILO	International Labour Organization
ILUMEX	Illumination of Mexico
IOE	International Organization of Employers
IPCC	Intergovernmental Panel on Climate Change
IPRs	Intellectual property rights
ISRI	Institute of Scrap Recycling Industries (United States)
ISTAS	Instituto Sindical de Trabajo, Ambiente y Salud (Spain)
ITDP	Institute for Transportation and Development Policy
ITUC	International Trade Union Confederation
IUF	International Union of Food, Agricultural, Hotel, Restaurant, Catering, Tobacco and Allied Workers' Associations
JAA	Japan Aluminium Association
JAMA	Japan Auto Manufacturers Association
JI	Joint Implementation (Kyoto Protocol mechanism)
Joule (J)	The Joule replaces an older unit, the calorie (one calorie equals 4.2 joules)
JPA	Japan Paper Association
KAMA	Korea Automobile Manufacturers Association
KCYP	Kibera Community Youth Program (Nairobi, Kenya)
kgce	Kilograms of coal equivalent
km/l	Kilometers per liter (vehicle fuel consumption measure)
kW	Kilowatt
kWh	Kilowatt-hour
l/100 km	Liters per 100 kilometers (vehicle fuel-consumption measure)
LBNL	Lawrence Berkeley National Laboratory (United States)
LED	Light-emitting diode

LEED	Leadership in Energy and Environmental Design (building efficiency standard, United States)
LFGTE	Landfill gas-to-energy
light trucks	U.S. vehicle category (encompassing passenger cars as well as heavier vehicles, such as SUVs, pick-up trucks, and minivans)
LLL	Reliable and responsive lifelong learning
LPG	Liquid petroleum gas
MDGs	Millennium Development Goals
MIT	Massachusetts Institute of Technology
mpg	Miles per gallon (vehicle fuel-consumption measure)
MSN	The Microsoft Network
Mt	Million tons
MTCC	Malaysian Timber Certification Council
MW	Megawatt
NAFTA	North American Free Trade Agreement
NAPEE	National Action Plan for Energy Efficiency (United States)
NDRC	National Development and Reform Commission (China)
NGO	Non-governmental organization
NOx	Nitrogen oxides
NTFP	Non-timber forest products
OCAW	Oil, Chemical and Atomic Workers
ODA	Official development assistance
OEA	European Aluminium Refiners and Remelters
OECD	Organization for Economic Co-operation and Development
OFARM	Organic Farmers' Agency for Relationship Marketing
PBB	Polybrominated biphenyls, also called brominated biphenyls or polybromobiphenyls
PBDE	Polybrominated diphenyl ethers
PCB	Polychlorinated biphenyl
PEFC	Programme for Endorsement of Forest Certification
PES	Payment for environmental services
PFCs	Perf uorocarbons
PTC	Production Tax Credit (United States)
PV	Photovoltaics
R&D	Research and development
RATP	Régie Autonome des Transports Parisiens de France (public transit agency, Paris, France)
RE	Renewable energy
RE&EE	Renewable Energy & Energy Efficiency
REDD	Reducing Emissions from Deforestation and Degradation
REN21	Renewable Energy Policy Network for the 21st Century
REPP	Renewable Energy Policy Project (United States)
RFP	Request for proposal
RITE	Research Institute of Innovative Technology on Earth (Japan)

List of Acronyms (continued)

RoHS	Restrictions on Hazardous Substances (EU directive)
ROI	Return on investment
RPS	Renewable Portfolio Standard
SAI	Sustainable Agriculture Initiative
SEBRAE	Small Business Support Services (Brazil)
SEIA	Solar Energy Industry Association (United States)
SEIU	Service Employees International Union (United States)
SFM	Sustainable Forest Management
SMFEs	Small and medium sized forest enterprises
SOx	Sulfur oxides
sqm	Square meter
STIB	Société Transport Intercommunaux de Bruxelles (public transit agency, Brussels, Belgium)
SUV	Sport utility vehicle
SWEEP	Southwest Energy Efficiency Project (United States)
TCO	Confederation of Professional Employees (trade union, Sweden)
TRIPs	Agreement on Trade-Related Aspects of Intellectual Property Rights
TRT	Top-pressure turbines
TUAC	Trade Union Advisory Committee to the OECD
TUC	Trades Union Congress (United Kingdom)
TWh	Terawatt-hours
UCS	Union of Concerned Scientists (non-governmental organization, United States)
UITP	International Association of Public Transport
ULCOS	Ultra-Low CO_2 Steelmaking (European Union initiative)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USGS	U.S. Geological Survey
VAT	Value-added tax
VC	Venture capital
WBCSD	World Business Council for Sustainable Development
WEEE	Waste Electronic and Electrical Equipment Directive (European Union)
WRAP	Waste and Resources Acton Programme (United Kingdom)
WRAP	Waste and Resources Action Programme (UK)
WTO	World Trade Organization
WWEA	World Wind Energy Association
ZEDP	Zabaleen Environmental Development Programme (Cairo, Egypt)

Executive
Summary

© Wolfgang Maria Weber / Argus / Still Pictures
E-recycling of old mobile phones: employee is repairing mobile phone for re-usage.

Defining Green Jobs

The latest assessment report by the Intergovernmental Panel on Climate Change (IPCC) and the widely-noted Stern Review on the Economics of Climate Change have lent new urgency to countering the challenge of global warming—a calamitous development in its own right and a phenomenon that further aggravates existing environmental challenges. There is now a virtual avalanche of reports by international agencies, governments, business, labor unions, environmental groups, and consultancies on the technical and economic implications of climate change as well as the consequences of mitigation and adaptation strategies. Many declaim a future of green jobs—but few present specifics. This is no accident. There are still huge gaps in our knowledge and available data, especially as they pertain to the developing world.

Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World assembles evidence—quantitative, anecdotal, and conceptual—for currently existing green jobs in key economic sectors (renewable energy, buildings and construction, transportation, basic industry, agriculture, and forestry) and presents estimates for future green employment. The pace of green job creation is likely to accelerate in the years ahead. A global transition to a low-carbon and sustainable economy can create large numbers of green jobs across many sectors of the economy, and indeed can become an engine of development. Current green job creation is taking place in both the rich countries and in some of the major developing economies.

We define green jobs as work in agricultural, manufacturing, research and development (R&D), administrative, and service activities that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high-efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution.

From a broad conceptual perspective, employment will be affected in at least four ways as the economy is oriented toward greater sustainability:

- First, in some cases, additional jobs will be created—as in the manufacturing of pollution-control devices added to existing production equipment.
- Second, some employment will be substituted—as in shifting from fossil fuels to renewables, or from truck manufacturing to rail car manufacturing, or from landfilling and waste incineration to recycling.
- Third, certain jobs may be eliminated without direct replacement—as when packaging materials are discouraged or banned and their production is discontinued.
- Fourth, it would appear that many existing jobs (especially such as plumbers, electricians, metal workers, and construction workers) will simply be transformed and redefined as day-to-day skill sets, work methods, and profiles are greened.

Green jobs span a wide array of skills, educational backgrounds, and occupational profiles. This is especially true with regard to so-called indirect jobs—those in supplier industries. Even for new industries like wind and solar power, supply chains consist largely of very traditional industries. For instance, large amounts of steel are incorporated into a wind turbine tower.

Technological and systemic choices offer varying degrees of environmental benefit and different types of green employment. Pollution prevention has different implications than pollution control, as does climate mitigation compared with adaptation, efficient buildings vis-à-vis retrofits, or public transit versus fuel-efficient automobiles. These choices suggest that there are "shades of green" in employment: some are more far-reaching and transformational than others.

Greater efficiency in the use of energy, water, and materials is a core objective. The critical question is where to draw the line between efficient and inefficient practices. A low threshold will define a greater number of jobs as green, but may yield an illusion of progress. In light of the need to dramatically reduce humanity's environmental footprint, the bar needs to be set high: best available technology and best practices internationally will need to be replicated and adopted as much as possible. And, given technological progress and the urgent need for improvement, the dividing line between efficient and inefficient must rise over time. Seen in this context, "green jobs" is a relative and highly dynamic concept.

A successful strategy to green the economy involves environmental and social full-cost pricing of energy and materials inputs, in order to discourage unsustainable patterns of production and consumption. In general, such a strategy is diametrically opposite to one where companies compete on price, not quality; externalize social and environmental costs; and seek out the cheapest inputs of materials and labor. A green economy is an economy that values nature and people and creates decent, well-paying jobs.

Green jobs need to be decent work, i.e. good jobs which offer adequate wages, safe working conditions, job security, reasonable career prospects, and worker rights. People's livelihoods and sense of dignity are bound up tightly with their jobs. A job that is exploitative, harmful, fails to pay a living wage, and thus condemns workers to a life of poverty can hardly be hailed as green. There are today millions of jobs in sectors that are nominally in support of environmental goals—such as the electronics recycling industry in Asia, or biofuel feedstock plantations in Latin America, for instance—but whose day-to-day reality is characterized by extremely poor practices, exposing workers to hazardous substances or denying them the freedom of association.

As the move toward a low-carbon and more sustainable economy gathers momentum, growing numbers of green jobs will be created. Although winners are likely to far outnumber losers, some workers may be hurt in the economic restructuring toward sustainability. Companies and regions that become leaders in green innovation, design, and technology development are more likely to retain and create new green jobs. But workers and communities dependent on mining, fossil fuels, and smokestack industries—or on companies that are slow to rise to the environmental challenge—will confront a substantial challenge to diversify their economies. Public policy can and should seek to minimize disparities among putative winners and losers that arise in the transition to a green economy, and avoid these distinctions becoming permanent features.

Drivers

What are the key drivers of green employment? Green innovation helps businesses stay at the cutting edge, retaining existing jobs and creating new ones. While some companies have barely progressed past green sloganeering—or worse, "greenwashing"—a growing number have announced ambitious goals to reduce their carbon footprint or make their operations "carbon neutral." The global market volume for environmental products and services currently runs to about $1,370 billion (€1,000 billion), according to German-based Roland Berger Strategy Consultants, with a projected $2,740 billion (€2,200 billion) by 2020.

Forward-thinking government policies remain indispensable. They are important for providing funding of green projects; overall goal- and standard-setting beyond the time horizons typical in the business world; providing infrastructure that private enterprises cannot or will not create; and creating and maintaining a level playing field for all actors. Key policies include:

- Subsidies. Phase out subsidies for environmentally harmful industries, and shift a portion or all of those funds to renewable energy, efficiency technologies, clean production methods, and public transit.
- Carbon Markets. Fix the current shortcomings inherent in carbon trading and Kyoto Protocol-related innovations like the Clean Development Mechanism so that they can become reliable and adequate funding sources for green projects and employment.
- Tax Reform. Scale up eco-taxes, such as those adopted by a number of European countries, and replicate them as widely as possible. Eco-tax revenues can be used to lighten the tax burden falling on labor while discouraging polluting and carbon-intensive economic activities.
- Targets and Mandates. Ensure that regulatory tools are used to the fullest extent in the drive to develop greener technologies, products, and services—and thus green employment. This includes land-use policies, building codes, energy-efficiency standards (for appliances, vehicles, etc.), and targets for renewable energy production.
- Energy Alternatives. Adopt innovative policies to overcome barriers to renewable energy development, including feed-in laws that secure access to the electrical grid at guaranteed prices.
- Product Takeback. Adopt "extended producer responsibility" laws (requiring companies to take back products at the end of their useful life) for all types of products.
- Eco-Labeling. Adopt eco-labels for all consumer products to ensure that consumers have access to information needed for responsible purchasing decisions (and hence encouraging manufacturers to design and market more eco-friendly products).
- R&D Budgets. Reduce support for nuclear power and fossil fuels and provide greater funding for renewable energy and efficiency technologies.
- International Aid. Reorient the priorities of national and multilateral development assistance agencies as well as export credit agencies away from fossil fuels and large-scale hydropower projects toward greener alternatives.

Modern economies mobilize enormous quantities of fuels, metals, minerals, lumber, and agricultural raw materials. Although some changes have been made in past decades to reduce the world economy's environmental impact, these gains are insufficient and may simply be overwhelmed by continued economic growth.

In view of the gathering environmental crisis, and especially the specter of climate change, there is an urgent need to make economies far more sustainable and thus to re-examine the prevailing production and consumption model. Concepts such as dematerialization, remanufacturing, "zero-waste" closed-loop systems, durability, and replacing product purchases with efficient services (such as "performance contracting") have been discussed for some time and tested in some instances, but by and large have yet to be translated into reality.

Economic systems that are able to churn out huge volumes of products but require less and less labor to do so pose the dual challenge of environmental impact and unemployment. In the future, not only do jobs need to be more green, their very essence may need to be redefined. A number of countries and companies have wrestled with proposals to reduce individuals' work time in order to share available work better among all those who desire work.

Green Jobs: Now, and In The Future

This report presents a series of quantifications, estimates, and projections of green jobs around the world. Inevitably, there are substantial remaining data gaps. Governments must establish statistical reporting categories that recognize and help capture relevant employment in both newly emerging industries and green employment in established sectors. As the German government has done, governments should also commission in-depth modeling and econometric efforts to analyze not just direct green jobs, but also those that are related in a more indirect manner. Business associations and trade unions can play a useful part as well. They have begun to do job surveys and profiles, but far more of these kinds of efforts are needed. Attention also needs to be given to disaggregating data on the basis of gender in order to ensure that there is equality of opportunity for women and men for green jobs. Below, we summarize key findings.

Energy Supply Alternatives

Along with expanding investment flows and growing production capacities, employment in renewable energy is growing at a rapid pace, and this growth seems likely to accelerate in the years ahead. Compared to fossil-fuel power plants, renewable energy generates more jobs per unit of installed capacity, per unit of power generated and per dollar invested.

Globally, some 300,000 workers are employed in wind power and perhaps 170,000 in solar photovoltaics (PV). More than 600,000 people are employed in the solar thermal sector—by far most of them in China. Almost 1.2 million workers are estimated to be employed in generating biomass-derived energy (mostly biofuels) in just four leading countries: Brazil, the United States, Germany, and China. Overall, the number of people presently employed in the renewable energy sector runs to about 2.3 million. (See Table ES-1.) Given the gaps in employment information, this is no doubt a conservative figure.

Table ES-1. Estimated Employment in the Renewable Energy Sector, Selected Countries and World, 2006

Renewable Energy Source	World*	Selected Countries	
Wind	300,000	Germany	82,100
		United States	36,800
		Spain	35,000
		China	22,200
		Denmark	21,000
		India	10,000
Solar PV	170,000**	China	55,000
		Germany	35,000
		Spain	26,449
		United States	15,700
Solar Thermal	624,000-plus	China	600,000
		Germany	13,300
		Spain	9,142
		United States	1,900
Biomass	1,174,000	Brazil	500,000
		United States	312,200
		China	266,000
		Germany	95,400
		Spain	10,349
Hydropower	39,000-plus	Europe	20,000
		United States	19,000
Geothermal	25,000	United States	21,000
		Germany	4,200
Renewables, Combined	2,332,000-plus		

**Countries for which information is available. **Under the assumption that Japan's PV industry employs roughly as many people as Germany's PV industry.*

Half of these jobs are in biofuels—mostly in growing and collecting feedstock, but also in (better paying) processing industries. There is contentious debate over biofuels' economic and environmental merits, their energy content and energy net balance, and the question whether biofuels compete with food production. Much of the employment on sugarcane and palm oil plantations in countries like Brazil, Colombia, Malaysia, and Indonesia is marked by poor pay and dangerous working conditions. There is also concern that large-scale biofuels production might drive large numbers of people off their land in future years. For all these reasons, close scrutiny is needed to determine what portion of biofuels jobs can legitimately be counted as decent green jobs.

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Wind farm construction - Danish / Indian joint venture Vestas RBB. Tamil Nadu, Cape Comorin, India.

So far, a small group of countries accounts for the bulk of renewables investments, R&D, and production. Germany, Japan, China, Brazil, and the United States play particularly prominent roles in renewable technology development, and they have so far garnered the bulk of renewables jobs worldwide. European manufacturers account for more than three-quarters of global wind turbine sales, but India's Suzlon also is a major force in the industry. China's employment numbers are particularly high because the country continues to rely on large numbers of relatively low paid workers in contrast with the fewer higher paid workers found in Western industrialized countries.

Jobs in installing, operating, and maintaining renewable energy systems tend to be more local in nature and can thus benefit other countries as well. Kenya, for example, has one of the largest and most dynamic solar markets in the developing world. In Nairobi, the Kibera Community Youth Program initiated a simple solar PV assembly project, providing young people with employment and engendering considerable interest in emulating the success story in neighboring countries. In Bangladesh, Grameen Shakti microloans have helped to install more than 100,000 solar home systems in rural communities in a few years, with a goal of 1 million by 2015. Grameen is training local youth and women as certified solar technicians and as repair and maintenance specialists, hoping to create some 100,000 jobs.

Given rapidly rising interest in energy alternatives, future years may well see worldwide employment soar—possibly as high as 2.1 million in wind energy and 6.3 million in solar PVs by 2030, and on the order of 12 million jobs in biofuels-related agriculture and industry. Projections for individual countries all indicate strong potential for large job creation in coming years and decades. Installations and maintenance of solar PV and solar thermal systems in particular offer tremendous job growth.

For countries or regions that have suffered from manufacturing job loss and de-industrialization (such as the so-called U.S. "rust belt" or the former East Germany), wind and solar technology development offers a welcome alternative. For countries like China, India, and others, renewables technologies are an important opportunity for continued economic and technological development.

But there is also a potential contradiction between renewables as a global source of jobs and renewables as part of national competitive economic strategies. Although this does not have to be a zero-sum game, a stellar export performance by a handful of countries does imply more limited opportunities elsewhere on the planet. As renewables industries mature, they will increasingly be marked by difficult issues of competitiveness, trade rules, and wage differentials that are already familiar topics in other industries.

In addition to renewables, considerable attention has been directed toward the mitigation potential of carbon capture and storage (CCS). From a climate stabilization point-of-view, phasing out coal-fired power plants in particular is preferable; yet current policy in a number of countries—China, India, and the United States in particular—is headed in the opposite direction. Whether CCS is workable is open to question, and the technology is unlikely to come on-stream at a large scale for many years. The employment implications have received scant consideration. CCS jobs are not clearly distinct from those in conventional coal-fired base-load power stations. Many of the subsurface operations are likely to be conducted by workers who are already in the oil and gas industry, although some are technically more complex and will involve workers with a very different skill set to those found at conventional power stations. CCS can also be expected to generate employment through the construction of carbon dioxide pipeline networks. But overall, it is capital intensive, and therefore the jobs created per million dollars of investment can be expected to be low. Meanwhile, there is a danger that money spent on CCS may simply crowd out investments in renewables and other energy alternatives.

Buildings

In the building sector and elsewhere in the economy, defining the energy-efficiency sector is a vexing problem, since most of the relevant forms of employment are embedded in a broad range of existing industries such as vehicle manufacturing, construction, lighting, heating and cooling equipment, electronics, appliances, and so on. A major study commissioned by the American Solar Energy Society (ASES) concludes that in 2006, there were 3.5 million direct jobs in energy efficiency-related activities in the United States, plus another 4.5 million indirect jobs, for a total of just over 8 million. (These numbers include various sectors beyond the building sector, such as the recycling industry, vehicle manufacturing, and construction.) They are based on the assumption that existing U.S. government standards and efficiency ratings are sufficiently indicative of (currently) achievable energy efficiency. At least in some respects, however, this is a somewhat questionable assumption, and it follows that the ASES findings overstate the extent of existing green jobs.

Efficiency measures in the building sector include green buildings and retrofitting as well as improving the efficiency of individual building components including: water heaters, cooking equipment, domestic appliances, office equipment, electronic appliances, heating, ventilation and air conditioning systems, and lighting. Macroeconomic studies, most of which have occurred in the United States and European Union, show that these energy-efficiency measures lead to an overall net increase in jobs. This positive result of both environmental gains and employment generation is known as the "double dividend."

Some data on green employment specific to the building sector already exists, but they tend to be small snapshots of a particular project or country, rather than a more comprehensive picture of the sector. The most impressive building project to date is the German Alliance for Work and the Environment, a retrofitting program serving 342,000 apartments as of March 2006. From 2001–2004, this project was responsible for creating 25,000 jobs and saving an existing 116,000. In 2006, an estimated 145,000 additional FTE (full-time equivalent) jobs were attributed to this building retrofit program as a result of increased levels of public-private spending. Additionally, many studies have begun to assess the number of potential jobs that would be created through energy-efficiency measures including investment, standards, and mandates. Table ES-2 highlights some of these job predictions.

Table ES-2. Job Projections from Energy-Ef ciency Measures in the Building Sector

Country	Study or Project Description	Projected Jobs
Canada	Retrofit municipal buildings on a national scale	5,600–7,840 full-time equivalent
European Union	European Commission Study: 20 percent reduction in EU energy consumption	1 million
	European Trade Union Confederation Study: 75 percent reduction of CO_2 emissions in the residential building sector	1.377 million by 2050 or 2.585 million by 2030
India	Replacing traditional cook stoves with recently developed biomass cooking technologies for 9 million households	150,000
United States	Apollo Alliance Study: $89.9 billion investment in financing for green buildings, providing tax incentives, investing in research and development, and promoting new building codes and standards.	827,260
	U.S. Department of Energy: Standards on clothes washers, water heaters, and f uorescent lamp ballasts	120,000 through 2020

Types of jobs that are created in green building and the retrofitting process include green designers, architects, auditors, engineers, estimators, project managers, and various jobs in the construction trades, such as pipe fitters, sheet metal workers, and general construction workers, among others. These jobs are created during the initial construction or investment periods and are likely to be local jobs, which is especially beneficial for developing regions and areas of high unemployment.

The increase in demand for green building components and energy-efficient equipment will stimulate green manufacturing jobs. Energy-efficient equipment often requires more skilled labor than their inefficient counterparts, thus leading to not only a larger number of jobs, but also higher-skilled, higher-paying employment.

Induced jobs are also created as money that would have been spent on energy services is re-spent back into the community. This effect can be larger than the direct and indirect generation of green jobs themselves, particularly where energy is imported. Sectors such as manufacturing, construction, education, services, finance, and agriculture, which are more labor intensive than traditional energy services, stand to benefit from the re-spending effects associated with energy efficiency. Workers in coal, oil, gas extraction, and fuel refining could see a reduction of jobs in the traditional energy sector.

The IPCC's ***Fourth Assessment Report***, published in 2007, identifies buildings as having the capacity to reduce projected emissions 29 percent by 2020, the single largest potential of any sector, but for the most part the green building sector is limited to a small fraction of workers in a handful of countries. (The 2007 ASES study concluded that only 3 percent of buildings in the United States qualified for LEED (Leadership in Energy and Environmental Design) certification. Similarly, Canada reported only 150 LEED projects in 2005.) Fortunately, much of what is needed for greening the building sector can be done on the basis of existing technology with little or no net cost. Governments must play a key role in creating mandates and standards, increasing research and development funds, and providing financing incentives.

Arrays of photovoltaic cells on the roof of a government of ce building. In background, Swiss federal parliament buildings. Berne, Switzerland.

Greening the building industry in the European Union and the United States would create at least 2 million jobs (3.5 million jobs using the European Trade Union Confederation (ETUC) goal of a 75 percent reduction of carbon emissions by 2030). Although exact figures are unknown, it is easy to imagine that a worldwide transition to energy-efficient buildings could create millions or even tens of millions of jobs and would green existing employment for many of the estimated 111 million people already working in the sector. Furthermore, greening municipal, commercial, industrial, and residential buildings will radiate out to people who work in these energy-efficient buildings.

Transportation

Characterized by a heavy reliance on cars and trucks—and increasingly airplanes—for both passenger and freight movement, transportation is a major consumer of fossil fuels and a big contributor to climate change. It is responsible for an estimated 23 percent of energy-related greenhouse gas emissions, with the fastest-rising carbon emissions of any economic sector.

Air traffic is growing by leaps and bounds, but is by far the most fuel-intensive mode—and thus extremely difficult to make more green at present or projected levels of activity. New aircraft are 70 percent more fuel-efficient than those designed 40 years ago. A further 20 percent gain by 2015 over 1997 levels seems attainable, and perhaps a 40–50 percent gain by 2050. However, such improvements are insufficient in view of aviation's rapid expansion. Soaring fuel prices may alter the trajectory of global air travel in future years, and are becoming a major incentive for airline companies to pursue fuel efficiency more vigorously.

Road transport is heavily tilted toward cars and trucks. Producing more fuel-efficient vehicles is the most immediate way in which environmental impacts can be reduced. An assessment of the most efficient passenger cars available today suggests that relatively green auto-industry jobs may number about a quarter million. (See Table ES-3.) This estimate is based on carbon emission thresholds of 120 grams of CO_2 per kilometer for passenger vehicles made in Europe, Japan, South Korea, and the United States, which together account for more than 4 million car-manufacturing jobs, or half the global total. Under a more lenient threshold of 140 grams, the number rises to about 800,000.

Comparable calculations are not possible for other car-producing countries, but the number of green jobs elsewhere can be assumed to be very limited at present. The situation is likely to change significantly in China in the next few years, as it implements rules to produce more efficient and cleaner cars. Thailand has launched a promising initiative to produce more fuel-efficient cars and looks to be on track to green a good portion of its 182,000-strong vehicle-manufacturing workforce.

Hybrid vehicles can be an important part of the solution, provided the added electric motor is used to reduce gasoline consumption instead of adding to a vehicle's power and acceleration. The pursuit of plug-in electric and hydrogen/fuel cell-powered vehicles promises greener jobs in future years (however, the environmental acceptability of plug-ins depends critically on changing the mix of fuels used to generate electricity, relying less on coal).

Table ES-3. Fuel-Efﬁciency, Carbon Limits, and Green Jobs Estimates in Vehicle Manufacturing

	European Union	Japan	South Korea	United States
Passenger Car Manufacturing Workforce	2,000,000	952,000	247,000	1,095,000
Share of vehicles emitting ≤ 120 grams of CO_2 per kilometer (percent)	7.5	6.3	4.3	n.a.
Share of vehicles achieving 40 miles per gallon or more (percent)	n.a.	n.a.	n.a	1.2
Jobs in Manufacturing "Green" Vehicles	150,000	62,000	10,000	13,000

The onslaught of ever-growing motorized transportation threatens to overwhelm the gains derived from per-vehicle efficiency measures. A more sustainable system will have to be based on shorter distances. Reduced distances and greater density of human settlements enables a re-balancing of transportation modes—giving greater weight to public transit systems, as well as walking and biking. A modal shift away from private vehicles and toward rail and other public transport can generate considerable net employment gains, while reducing emissions and improving air quality.

Railways are more environment-friendly and labor intensive than the car industry. But the trend over the last few decades has been away from railways in many countries, and employment—both in running rail lines and in manufacturing locomotives and rolling stock—has fallen accordingly. Even in China (where the rail network grew by 24 percent in 1992–2002) railway employment was cut from 3.4 million to 1.8 million. India's railway jobs declined from 1.7 million to 1.5 million. In Europe, railway employment is down to about 900,000 jobs; the number of workers in manufacturing rail and tram locomotives and rolling stock there has declined to 140,000. A sustainable transport policy needs to reverse this trend. A strategic investment policy to build and rebuild rail networks, integrating high-speed inter-city lines with regional and local lines would offer a substantial expansion in green jobs.

Buses, trams, and railways use far less energy per passenger- or freight-kilometer than road vehicles. Jobs in manufacturing the requisite rolling stock and equipment and in operating these systems are, in principle, green jobs. Modern "Bus Rapid Transit" systems are being put in place in growing numbers of cities around the world. Still, improvements are needed especially with regard to emissions of air pollutants. Older diesel buses are notorious polluters. There are substantial green employment opportunities in retrofitting buses to reduce particulate matter and nitrogen oxides emissions, and in manufacturing new buses that run on alternative fuels including compressed natural gas (CNG) or hybrid-electric buses. China, India, and Pakistan are among the countries that have invested heavily in CNG. For instance, in India's capital New Delhi, the introduction of 6,100 CNG buses by 2009 is expected to lead to the creation of 18,000 new jobs.

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A hydrogen fuel cell-powered electric bus in service crossing Tower Bridge in London. Part of the CUTE (Clean Urban Transport Europe) demonstration project testing 27 such pollution-free buses in 9 European cities. UK.

Similar retrofits are needed for the highly polluting two-stroke engines that are ubiquitous in two- and three-wheeled vehicles in developing countries, and particularly in Asia. Pilot projects in the Philippines suggest that retrofits cut fuel consumption by 35–50 percent and emissions of air pollutants by as much as 90 percent. Jobs can be created through installing and servicing the kits.

Hundreds of millions of people in developing countries suffer from insufficient mobility. They may never be able to afford an automobile, and may not even have access to public transit. Yet, bicycles and modern bicycle rickshaws offer a sustainable alternative and create employment in manufacturing and transportation services. Nevertheless, their growing essential mobility needs must be met, and this will require the development of innovative approaches that should also generate new employment opportunities.

Basic Industry and Recycling

Industries producing basic materials—iron and steel, chemicals, cement, aluminum, and pulp and paper—are among the most energy-intensive industries. It may be difficult to regard them as "green." However, boosting energy and materials efficiency, curtailing pollution, and enhancing use of scrap for recycling (which offers substantial energy savings over virgin production) are key to bringing these industries' environmental footprints more into balance with environmental needs.

Steel

China's steel production has surged to account for 38 percent of global output in 2007, but despite improvements the country's mills are still lagging behind those of Japan, South Korea, and Western Europe in terms of energy efficiency, carbon emission reductions, and waste avoidance.

Steel recycling saves 40 to 75 percent of the energy needed to produce virgin steel. Scrap-based production keeps rising, but accounts for a stagnant share of total output (41 percent in 2006). Turkey, the United States, South Korea, the Commonwealth of Independent States (CIS) countries, Germany, Japan, and Spain rely to a significant degree on scrap for their steel production, and their steel employment can thus be regarded a shade of green. In the United States, some 30,000 people work in secondary production, and worldwide a back-of-the-envelope calculation suggests some 225,000 jobs. Ferrous slags are valuable byproducts of steelmaking. In the United States, recovery and reprocessing of slag provides employment for about 2,700 people. (Under the assumption of comparable labor productivities elsewhere, slag recycling worldwide might employ some 25,000 people.)

Making steel mills greener and more competitive is a must for job retention. The business-as-usual outlook for Europe and North America is for ongoing employment retrenchment. However, a proactive policy in favor of low-carbon, high-quality steel can help retain jobs. The European Union has kicked off an "Ultra-low CO_2 Steelmaking" (ULCOS) initiative. More than any other country, Brazil relies to a significant extent on charcoal in its iron and steel-making operations. To the extent that this is derived from sustainable-managed forests, one can speak of "green pig iron."

Aluminum

Like the steel sector, the aluminum industry is becoming more energy-efficient, but further improvements are needed and possible. Scrap-based production saves up to 95 percent of the energy required to make aluminum from scratch. So-called secondary production has grown considerably and now accounts for about 22 percent of total production worldwide. Its share is highest in Japan, Germany, and the United States. But as in the steel industry, primary production requires more workers than secondary production, so the share of green jobs is lower than this percentage would suggest.

Close to 13,000 jobs are involved in secondary production in Japan, more than 10,000 in Europe, and roughly 6,000 in the United States. There are no comparable data for other producers, including China, the world's leading aluminum producer.

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Smelters in the protection suit.

Cement

Not surprisingly, China is also the leading producer of cement with over 1 billion tons, almost half of the total global production. Comprised of mainly small and medium-sized production facilities, on average China's cement facilities generate more CO_2 emissions per ton than those in Japan, Australia, New Zealand, and the European Union.

Cement is responsible for 5 percent of greenhouse gases emitted worldwide. While there has been some progress in reducing CO_2 emissions—the industry had reduced the CO_2 intensity of cement production by 1 percent per year over the last decade—this small decrease was far outweighed by increasing production and consumption. Moreover, cement production is expected to double from 25 billion tons in 2007 to 5 billion tons by 2050. Given escalating cement production, it is imperative to green the industry through measures including the utilization of rotary cement kilns and the dry production process, alternative materials, and recycled content.

The three largest cement companies, Cemex, LaFarge, and Holcim, have pledged to reduce energy use by 20–25 percent within the next ten years. Similarly, the Chinese government has also released new energy standards for the cement industry aimed at a 15 percent reduction in energy use by 2010. This shift toward energy-efficient plants, both newly constructed and retrofitted, is likely to produce some construction jobs in the short term, but will require fewer workers in the long run. Jobs remaining in this more efficient industry will require higher levels of skills and enhanced training programs for workers, and could be considered a light shade of green, but this industry is not expected to be a major source of new green employment.

Pulp and Paper

When viewed as an entire system including waste production and resource and energy use, recycling emerges as the most sustainable practice in the pulp and paper industry. Led by strong government policies in countries like Germany, Japan, and South Korea, and widespread implementation of paper recycling programs in many other countries, the global paper collection rate increased from 24.3 percent to 45.3 percent between 1970 and 2004. Recycling is the fastest growing source of green employment and offers the greatest opportunity to create new green employment in the industry.

Although employment data for paper recycling are often lumped in with recycling employment in general, there are some data pertaining specifically to paper. In 2000, 9,765 jobs in paper reprocessing (along with an additional 5,450 in general recycling collection and 1,624 in general sorting) were reported in the United Kingdom. The World Bank estimates that Brazil had 28,347 jobs in paper recycling in 2002. Given continued rising paper collection rates, these numbers are expected to be even higher now. The U.S. Environmental Protection Agency (EPA) estimates 150,000 people are employed in the recycled paper manufacturing. A rough estimate for the number of paper collectors and processors adds another 103,500 people for a total of 253,500 in paper recycling in the United States. Similar or slightly higher employment figures would be expected for the European Union, which recycles more paper than the United States.

Non-wood pulp and paper production, still a common but shrinking proportion of paper production, is very labor intensive and remains a major source of income and employment in China, India, and other developing and emerging countries. The current shift away from non-wood pulp and paper manufacturing, especially in China, has resulted in loss of income and jobs. Upgrading non-wood pulp and paper mills could be a major source of green employment, which has the potential to maintain employment for as many as 1 million people and income levels for the 8 million farmers in China alone.

Recycling

Recycling makes an important contribution to reducing energy consumption and associated pollution of air and water. Besides scrap-based manufacturing, there are many jobs in materials collection and recovery, sorting and processing, as well as re-manufacturing of appliances and other equipment. However, there are no global figures, and communal recycling and composting efforts are especially difficult to document.

In many developing countries, much of the recycling work is performed by an informal network of "scrap collectors," who collect the recycled materials for revenue. China, which has the largest amount of waste, has a mix of formal and informal collectors. About 1.3 million people are employed in the formal waste collection system and an additional 2.5 million informal workers or scrap collectors. But beyond waste and scrap collection activities, China has a far larger number of people involved in all aspects of recycling, reuse, and remanufacturing—as many as 10 million according to one estimate. In Cairo, there are an estimated 70,000 or so Zabaleen—independent garbage pickers and recyclers—in addition to formal-sector garbage-collecting companies that are far less focused on recycling than on waste disposal.

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The garbage people of Muqattam. In Cairo you have several garbage cities. The garbage collectors go from house to house to collect all garbage. In the garbage area it get sorted and recycled. Pigs are eating the organic garbage. Cairo, Egypt.

Different methodologies in tallying employment, plus different approaches and diverging labor intensities in materials collection and recovery, make it almost impossible to compare countries across the world or to compute a reliable global total. Recent reports estimate the total number of recycling jobs in the United States at more than 1 million. In Brazil, half a million people are involved in materials collection activities (170,000 in aluminum can recycling alone). (See Table ES-4.) In countries like Brazil and India, recycling is driven largely by poverty.

In many developing countries, recycling jobs are often dirty and hazardous, involving crude forms of breaking apart discarded products and equipment. Such operations are oriented more toward earning money from salvaged materials than toward waste reduction per se. Indeed, there may be substantial environmental penalties involved. This is the case in ship dismantling, the bulk of which is carried out by many thousands of people, often migrant workers, in South Asia. It is also true with regard to the growing mountain of electronics waste, most of which is disassembled in China in small workshops where safety and environmental rules are mostly non-existent.

Table ES-4. Selected Employment Estimates in the Recycling Sector

	Country	Number of Jobs (millions)
All Recycling	China United States Brazil	10 1.1–1.3 0.5
Aluminum Can Recycling	Brazil	0.17
Electronics Recycling	China	0.7

Food and Agriculture

The future of green jobs in food and agriculture is uncertain. In key parts of the economy such as renewables, energy conservation, and transportation, win-win and double-dividend employment scenarios are encouragingly evident. In the case of agriculture, however, a green jobs scenario will require policy interventions to overcome a series of formidable obstacles. It will also unfold at a time when the proportion of the world's population making their main living from agriculture is in sharp decline. In 2006, 36.1 percent of the Earth's population, or around 1.3 billion people, made their living from growing food and raising livestock, compared with 44.4 percent in 1995. Moreover, serious decent work deficits exist both for smallholders and for a large portion of the waged agricultural workforce. But the numbers of people making part or all of their living from agriculture is still enormous and will remain so for some decades, so any successful attempts to spread green and decent work in this sector will have a massive quantitative impact on the global green jobs picture.

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Deforestation - Slash and burn migrant farmer clearing land. The whole valley once forested have been cleared and only the steep slopes remain. Few settlers have the experience or knowledge to farm the poor soil on slopes recently under forest cover. Few bother with terracing. The land rarely remains productive for more than a couple of years and they are forced to move on. Slash and burn agriculture is now the biggest cause of forest destruction. Vicinity of Satipo, Amazon, Peru.

Today, however, the employment trend in food and agriculture is actually moving away from sustainability and decent work. At the base of the supply chain, low-input and relatively sustainable forms of smallholder agriculture are being squeezed on all sides, a process that is accelerating urbanization, informality, and social and environmental stress across the developing world in particular. Smallholders are also being displaced by the spread of plantation crops like soy and palm oil, which creates fewer jobs per hectare of cultivated land than small farms and often has serious effects on biodiversity. In some countries, the rise of the higher-value "New Agriculture" (export-oriented production of tropical fruits, vegetables, wine, and cut flowers) is creating much-needed employment, but the energy and chemical inputs are such that these jobs are generally not green. The working conditions in these industries are often extremely poor and disproportionately affect women. The growth of intensive livestock systems as a result of rising meat consumption is similarly creating work that is neither green nor decent.

The prospects for green jobs in food and agriculture are also not being helped by the horizontal and vertical integration of the global food industry, which has seen the emergence of a group of large retailers and producers. The market power of the large companies allows them to dictate "take it or leave it" terms on those who actually grow the food. The growing distances from plough to plate have helped drive a sharp increase in food-related trucking and a significant increase in food traded across borders. This has created many jobs, but they cannot be described as green. Finally, modern retail establishments often consume much more energy per square meter than factories, which means that among the growing global army of Tesco and Wal-Mart workers (to name just two large retailers), green jobs are few and far between

This decidedly ungreen picture can be turned around. However, it will first and foremost require a long-term commitment to the preservation of the green, or relatively green, livelihoods that already exist by ensuring the long-term viability of small farming systems. A high proportion of the food that is consumed in the larger developing countries is grown locally, and with the right incentives and efforts to help farmers raise their ecological literacy still further, yields can rise within a sustainable framework. Policymakers often recognize the social, environmental, and economic potential of high-yield small farming systems using sustainable methods, but they have struggled to have any major influence over the dominant trends and powerful interests that shape today's system. However, the need for sustainability requires preserving and repairing the world's natural resources and reducing the enormous amount of greenhouse gases generated by agriculture (roughly 15 percent). Thus, the markets and the interests that control them must be brought into line with a program to restore sustainability and thus grow green employment.

Farmers and agricultural workers' unions, along with many in the non-governmental organization (NGO) community, have articulated a broad agenda for sustainable food and agriculture. This agenda includes the phasing out of subsidies to rich-country agribusiness, as well as the need for action to secure land tenure and property rights to farmers. Farmers' organizations are also concerned to stop the encroachment of plantations on forests and land used for food, including most present-generation biofuels. As part of this broad vision for sustainability, urban agriculture may have an increasing role to play (especially as urbanization itself is likely to forge ahead).

Already 800 million people are engaged in growing food in urban areas. The employment benefits of sustainable urban agriculture are potentially enormous. While this work seldom accrues wages, this expansion promises to generate much-needed urban employment that can produce cash income or spread existing incomes further, particularly in areas with high levels of underemployment and informality.

Meanwhile, the jobs dividend associated with local food systems in the developed world is also becoming clear. These systems help sustain local economies while returning a larger share of the proceeds to the producers—reducing emissions from "food miles" at the same time. Studies in the United Kingdom and Republic of Ireland, as well as India and Turkey, show that organic farming normally requires additional manpower than high-input conventional systems. Reduced reliance on machinery and chemicals in weeding, cultivating, and plant and animal maintenance activities requires more labor for planting cover crops, spreading manure, and producing compost. The knowledge and skills required for organic farming cannot be easily replaced by mechanization.

Policies that are aimed at rebuilding rural communities in the developed world and restricting the expansion of superstores will also preserve jobs in smaller food retail establishments, which are somewhat greener than those found in larger retail establishments. The UK-based National Retail Planning Forum reports that many of the new superstore jobs are also part-time, lower paying, and tend to be of poorer quality than those found in retail generally.

Payment for environmental services (PES) could create a lot of green jobs in the future, or at least supplement the income of rural dwellers, smallholders, and agricultural workers. The English Countryside Stewardship Scheme has created jobs for farmers, contractors, and other small rural businesses. In Central and South America, silvopastoral practices have developed in Columbia, Costa Rica, and Nicaragua to conserve forests that raised farmer income by 10–15 percent. These examples suggest that a global shift toward PES could generate very large numbers of jobs, especially when administered as public works projects. An impressive example of job creation is South Africa's "Working for Water" program, which has provided work for 25,000 previously unemployed people.

Proposed improvements in natural resource management appear to have green employment potential. Terracing or contouring of land, building irrigation structures, etc., are labor intensive and are urgently needed to prevent further depletion and degradation. Investments in means to store and save water can create employment in producing, installing, and maintaining the necessary equipment. Integrated water management, which involves canal lining and microirrigation, also involves labor inputs. Other sources of work include rehabilitating dams, barrages, and embankments that improve the flow of rivers. Raising water productivity will require substantial job-creating public investments in off-farm infrastructure.

Climate change adaptation and mitigation can also create green employment, although the numbers involved are again difficult to estimate. Soil conservation efforts such as conservation tillage and the rehabilitation of degraded crop and pasture land promise to create employment and sustain rural livelihoods.

The potential for green employment in agriculture and related activities is therefore very considerable. Whether this potential is ever fully realized will depend on how decisive and effective policymakers are in their efforts to make fundamental changes in the way the present unsustainable system operates. The environmental and social problems of today's agriculture are severe enough to warrant immediate action. With the steep rise in the price of food on global markets already leading to riots and starvation, the need for fundamental change is tragically underscored.

Forestry

Jobs in the forestry sector should be broadly defined to include all work that provides income and helps alleviate poverty. These jobs include the formal sector, informal sector, and subsistence workers. It is currently unknown how many people are employed in the forestry sector, but a rough estimate of people dependent on forests for income and subsistence is likely to be between 1 and 1.75 billion people.

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Establishing a contour hedge to prevent erosion. The A-frame is used to plot a level contour across the slope. Initially, Tephrosia, a leguminous shrub is sown followed by Calliandra, an exotic tree species. Contour hedges help prevent soil loss from steep slopes, thus reducing the need to destroy more of the forest. Mount Oku, Bamenda Highlands, Cameroon.

Formal employment estimates in forestry range from 12.9 million to 20 million. Estimates of informal employment, which is not captured by national statistics of employment and relies mainly on micro-level studies, vary widely between 30 and 120 million. The World Bank estimates that 1.6 billion people depend on the forest for their livelihoods, including 60 million indigenous people who are fully dependent upon the forests and an additional 350 million who depend on them to a high extent for income and subsistence. Additionally, there are more than a billion people, most of whom are counted as agriculture workers or forest-dependent people, who engage in agroforestry practices.

The IPCC has identified several key land-use changes for carbon mitigation in the forestry sector, including: reduced deforestation and forest degradation, conservation, afforestation/reforestation, and sustainable forest management. These land use changes will result in economic and employment changes.

There is general agreement that developing countries with forest area require financial assistance from the developed nations in order to reduce deforestation. The Stern Review estimates that the amount of money needed for deforestation avoidance or prevention would equal roughly \$5–10 billion annually. Advocates of Reducing Emissions from Deforestation and Degradation (REDD) schemes believe that this money will directly benefit rural populations by generating increased employment and incomes. If this scenario unfolds, then the programs would be a source of much-needed green jobs for rural and forest economies; however, concerns of land ownership and corruption may prevent the economic benefits from actually reaching the intended recipients. At this time, there are very few examples of REDD schemes and little empirical data on whether these programs actually provide additional sources of employment and income for indigenous people in these forest communities.

Afforestation and reforestation projects will create new employment. While it may seem obvious that these new jobs would be considered green employment, it is important to consider what type of work is generated from these projects. Currently, the industry standard is dominated by seasonal, contract work. Tree planting is also generally low paid with few to no benefits. Payment is commonly determined by piece wages, which often leads to rushed work and long hours on the job. To create "green" jobs may necessitate more vigorous project requirements to ensure that decent work is created with above-poverty level incomes.

Agroforestry also has a great potential for employment and income generation, especially for rural areas. Comprehensive agroforestry programs—which include some combination of fruit trees, medicinal trees, timber, fertilizer trees, and fodder for animals on traditional farms—have been shown to alleviate poverty, contribute to food security, help alleviate fuelwood shortages, and improve health. The increased production and diversification of farm products can also lead to supplementary sources of income. Agroforestry projects are limited by their reliance on external funding, and unless there are large, ongoing, sustainable sources of funds, agroforestry is unlikely to be scaled up in a way that makes a significant impact on deforestation, emissions, income, and employment.

Sustainable Forestry Management and Certification standards have been growing rapidly in the last few years and could become a source of long-term employment for rural economies. Certification provides additional tax revenue, increased wages, improved working conditions, compliance with contracts, and leads to a decrease in illegal logging. From an employment and income perspective, illegal logging relies on cheap labor and would not be considered decent work. In addition, local communities and governments are further hurt by the loss of large sums of tax revenue that could be used to improve basic infrastructural needs (schools, hospitals, roads, water, energy, etc).

Certain certification schemes have specific standards for employment. For example, the Programme for Endorsement of Forest Certification (PEFC), Forest Stewardship Council (FSC), and Malaysian Timber Certification Council (MTCC) require some employment standards including compliance with national labor laws and international agreements, minimum health and safety rules, and the guaranteed right to join a union, among others. While the economic and employment consequences of certification standards are generally positive and provide long term benefits, at least in one case, there was evidence to suggest that certification decreased the amount of land that could be harvested and in turn reduced the number of jobs.

Due to the lack of information about employment in this sector, it is impossible to give a global quantification of green jobs that might be created through agroforestry, afforestation and reforestation, sustainable forest management, and avoided deforestation projects. These sustainable land-use changes are likely to have positive long-term impacts on employment measured both in the quality and quantity of employment. These sustainable land-use changes may, however, have some immediate negative consequences, but sustaining this sector is likely to have a long-term positive effect on employment as jobs are extended over a much longer period of time.

Policies For a Green Jobs Future

The growth of green jobs is encouraging. However, this trend needs to be seen against the backdrop of broad challenges as humanity grapples with ways to achieve a sustainable and equitable economy:

- Green jobs are not yet growing rapidly enough. In 2006, the International Labour Organization reported that the number of unemployed people is at record levels: 195.2 million. Together the unemployed and underemployed (those working hard without earning sufficient incomes) amount to 1 in 3 of the world's workers. Unemployment has hit young people (aged 15 to 24) the hardest, with 86.3 million young people representing 44 percent of the world's total unemployed in 2006.

- Green employment has gained an important foothold in the developed world, but with the major exception of China and Brazil, it is still quite exceptional in most developing countries. Yet these are the countries that account for some 80 percent of the world's workforce.

- The rising level of informality in the global economy constitutes a major challenge to green job growth. Moreover, the chronic and worsening levels of inequality both within and between countries are a major impediment. The effort to advance decent work and pro-poor sustainable development is critical to building green jobs across the developing world in particular.

- Unsustainable business practices are still prevalent—and often remain more profitable. Short-term pressures of shareholders and financial markets are not easily overcome. The early adopters of green business practices have to contend with companies—manufacturers and retailers—that command consumer loyalty through low prices achieved on the back of "externalized" costs.

The right approach—striking the right balance between government and private sector action, financing a green jobs agenda, developing worker skills, and ensuring a just transition—can move the transition to sustainability forward at a much faster pace.

Business and Government Action

Green innovation helps businesses stay at the cutting edge and hold down costs by reducing wasteful practices. This is essential for retaining existing jobs and creating new ones. However, the risk and profit appraisals typical of business, the seemingly ever-rising expectations of shareholders, as well as concerns about protecting intellectual property, may together impede the flow of capital into the green economy. On the basis of current experience in various areas—from vehicle fuel economy to carbon trading—it appears that a purely market-driven process will not be able to deliver the changes needed at the scale and speed demanded by the climate crisis.

Forward-thinking public policies remain indispensable in facilitating and guiding the process of greening business. Governments at the global, national, and local levels must establish an ambitious and clear policy framework to support and reward sustainable economic activity and be prepared to confront those whose business practices continue to pose a serious threat to a sustainable future. Timely action on the scale needed will occur only with a clear set of targets and mandates, business incentives, public investment, carbon or other ecological taxes, subsidy reform, sharing of green technologies, and scaling up and replicating best practices through genuine public-private partnerships. With progress on these fronts, millions of new green jobs can indeed be generated in coming years.

The business world rightly expects that governments and international bodies provide clear, reliable signals and create a solid framework within which business can green its operations. However, many activities that are essential for climate protection or preserving natural resources may never become profit-making ventures. These are the responsibility of government.

Expedited development and diffusion of green technologies worldwide is critical to a global green jobs future. But the competitive calculus of private companies may be at odds with the need to share cutting-edge green technologies as rapidly as possible. Likewise, nations leading in green technologies are understandably averse to freewheeling technology sharing, preferring to press their advantage and capture lucrative export markets. New mechanisms need to be developed that overcome obstacles to expedited technology diffusion. Cooperative R&D centers that anchor green technology development in the public realm are another. And an adequately endowed global fund to expedite the spread of green technologies and climate adaptation measures, as proposed by China and others, also deserves urgent consideration.

Financing a Green Jobs Agenda

While the renewable energy sector has fared well, in other regards present levels of investment are not commensurate to the task at hand. The Stern Review notes that investment levels in energy-saving technology in power generation have actually declined by as much as 50 percent over the last two decades in real terms. Energy conservation investments stood at a paltry $1.1 billion in 2006.

From what sources might investments for green job creation materialize? There is a range of options, among them the phasing out of fossil fuel subsidies, taxing "windfall" oil profits, adopting carbon taxes, and auctioning pollution allowances. In the United States, the latter could generate anywhere between $30 billion and $250 billion annually; the European Union's Emission Trading Scheme (EU ETS) is expected to generate $68.5 billion (€50 billion) per year in the next implementation period. The precise parameters that will rule carbon markets are critical for ensuring that resulting revenues do indeed become available for green business purposes.

The development of green employment across the developing world is compromised by the abysmally low levels of financial assistance made available. Donor countries have largely failed to make good on their commitments. The 2007/2008 ***Human Development Report*** laments "chronic under-financing...and a failure to look beyond project-based responses." The lack of adequate adaptation funds not only impedes the development of green jobs, it can lead to many existing jobs being lost and livelihoods, particularly in agriculture, wrecked as a result of climate disaster events.

An effective global adaptation financing strategy is clearly needed. The United Nations Development Programme (UNDP) has estimated that to adequately finance "climate-proofing" development investments and infrastructure will require $44 billion per annum by 2015. A further $40 billion per year will be needed to adapt poverty-reduction programs to climate change, and thus strengthen human resilience. Climate-related disaster response could add another $2 billion, for a combined $86 billion.

Worker Training

A transition to a green economy will create demand for workers, many of them in skilled trades or professions, and filling these positions will require adequate training programs. At the cutting edge of technology development for wind turbine or solar PV design, for instance, specialization has progressed to the point where universities need to consider offering entirely new study fields and majors. Several countries have reported that a "skills gap" already exists between available workers and the needs of green industries:

- A 2007 survey of Germany's renewables industry concludes that companies in this field are suffering from a shortage of qualified employees, and especially those needed in knowledge-intensive positions.
- The Confederation of British Industry has expressed concern that sectors going green are struggling to find technical specialists, designers, engineers, and electricians.
- In the United States, the National Renewable Energy Laboratory has identified a shortage of skills and training as a leading barrier to renewable energy and energy-efficiency growth.

In addition, Australia, Brazil, and China also report shortages of skilled workers. To remedy such shortages requires not only adaptations in training new workers, but also retraining efforts for those workers who transition from older, polluting industries to new ones.

Along with the skills gap can be placed the "management challenge," which will consist in the development of new perspectives, awareness, and managerial capacities. Managers must be willing and able to learn new skills, and to make use of the skills their subordinates have obtained.

There are important equity issues with regard to minorities as well as gender. In the United States, community organizations have promoted the idea that green collar employment offers a "pathway out of poverty" for individuals in economically depressed or marginalized areas. Racial and ethnic minorities often have difficulty in gaining access to apprenticeship programs for skilled trades—at a time when skilled workers are aging and shortages of skilled workers are becoming a major concern for employers. The doors to the new green economy need to be fully opened to those who had difficulty finding their place in the "old" economy for reasons related to discrimination or lack of skills, resources, or opportunities. Proposed U.S. legislation would provide funding of up to $125 million to establish job training programs, curricula, and job standards on the federal and state levels, and the "Green for All" campaign is working to secure $1 billion by 2012 to "create green pathways out of poverty" for 250,000 people in the United States.

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Training of trainers on Climate change, and Sound and sustainable management of chemicals for workers and trade unions, May 2008, UNEP / Sustainlabour.
Environment at work: trade unionists from four regions reflect on how to design coherent strategies and participate eff ectively in international environmental processes on Climate change, and Sound and sustainable management of chemicals. This fi rst group of trade union trainees is key to disseminate knowledge and mobilize workers and trade unions' networks on these two crucial environmental issues.

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Training of trainers on Climate change, and Sound and sustainable management of chemicals for workers and trade unions, May 2008, UNEP / Sustainlabour.
First day of an intense training and brainstorming session on Climate change, and Sound and sustainable management of chemicals, and related risks and opportunities for the world of labour. Trade unionists from all over the world gather for one week to gain better expertise, share regional experiences and reach coordinated action at the regional and global level on these two issues.

Promoting such job training is equally important in developing countries. A variety of U.N. and other international agencies such as UNEP, ILO, the United Nations Industrial Development Organization (UNIDO), and the Consultative Group on International Agricultural Research (CGIAR), working in conjunction with business, trade unions, and community organizations, could play a critical role in setting up green training and expertise centers in developing countries. In all countries, it is important to link green subsidies, tax breaks, and other incentives provided to companies with job quality and training standards, to ensure the creation of what the Apollo Alliance and Urban Habitat have called "high-road jobs"—decent pay and benefits and safe working conditions.

Just Transition

The shift to a low carbon and sustainable society must be as equitable as possible. It must, in a phrase, be a "Just Transition." A Just Transition framework is being assembled as a result of the work of the trade unions, the ILO, national and local governments, sustainability-conscious business and community-based organizations. The framework is built around the idea that the coming transition will have a huge effect on workers and communities. Many will benefit but others may face hardships as certain industries and occupations decline.

From the point of view of social solidarity, and in order to mobilize the political and workplace-based support for the changes that are needed, it is imperative that policies be put in place to ensure that those likely to be negatively affected are protected through income support, retraining opportunities, relocation assistance, and the like. Social dialogue is a critically important component of a Just Transition, especially in the workplace where the worker/union voice is needed to help determine the design of new sustainable production systems and work practices. Here there is an important role for joint labor-management committees and similar bodies. These committees could work to identify ways to improve energy efficiency, more efficient use of water and other natural resources and raw materials, and low-carbon work schedules. In some instances, employers and unions are beginning to work together in greening the workplace, building on a long tradition of collaborating on occupational safety and health and other issues.

But just as there are risks and opportunities for workers, the same is true of many employers. Government support and assistance for business should be provided where needed. There are, however, differences of philosophy and approach between businesses and civil society actors (especially trade unions) around who should shoulder what responsibilities. Businesses frequently have a broad range of obligations to consider. They have obligations to governments as taxpayers, to consumers, suppliers, and investors, as well as to employees and communities. They usually operate in a competitive marketplace and can often ill afford to make commitments to workers who are no longer required. As discussed elsewhere in this report, many investors today routinely expect returns that would have been regarded as exceptional just two or three decades ago, and within shorter time frames.

Examples of Just Transition are still few and far between. However, some governments, employer's organizations, and trade unions are in a number of social dialogue arrangements presently set up to help achieve Just Transition at the national level:

- In Spain, industry-based roundtables have been established in order to identify and reduce adverse effects on Spain's competitiveness and workforce as the country seeks to comply with the Kyoto Protocol.

- In Germany, a broad coalition of government, industry, unions, and environmental NGOs have collaborated around initiatives to renovate buildings for climate protection purposes, while at the same time creating green jobs.

- In the Netherlands, social dialogue across civil society has brought forth a comprehensive energy plan to reduce the Netherlands' greenhouse gas emissions by half before 2030, based on 1990 levels.

- In the United States, the idea of a Just Transition is embedded in proposed Congressional legislation on climate protection. The provisions include quality job training to any workers displaced, temporary wage assistance, health care benefits to workers in training programs, and other measures.

- In Argentina, the government expounds the incorporation of environmental clauses in collective agreements and the participation of workers in policy processes to achieve sustainable development. Plans have been proposed to offer training for trade union "environmental delegates" and to promote good-quality green jobs in different economic sectors.

A broader interpretation of Just Transition will seek to address equity issues at the global level. Just as vulnerable workers should not be asked to incur the costs of solving a problem they did not cause, the same principle should apply to resource-starved countries that today face major problems due to climate change caused by the emissions of the richer countries. The commitment by the wealthy countries under the Kyoto Protocol to assist poor countries with funds for adaptation to climate change, and to find ways to transfer green technology, will need to be met and extended into the second phase of the treaty.

The real-world challenges to implementing Just Transition policies are formidable. At the global-societal level, workers' rights and decent work are a long way from being installed. These decent-work and rights deficits often transmit down to the local level. Establishing a moral economy based on social solidarity in an environment of intense competition is therefore a major challenge.

Economic prosperity and employment depend in fundamental ways on a stable climate and healthy ecosystems. Without timely action, many jobs could be lost due to resource depletion, biodiversity loss, increasing natural disaster impacts, and other disruptions. Meanwhile, employment that actually contributes to reducing our collective carbon footprint offers businesses and workers a tangible stake in a green economy. The pursuit of green jobs will likely be a key driver as the world sets out into the uncharted territory of building a low-carbon economy. Climate-proofing the economy will involve large-scale investment in new technologies, equipment, buildings, and infrastructure, representing a major stimulus for much-needed new employment as well as an opportunity for retaining and transforming existing jobs

Part I
Definitions and Policies

© *Jenny star*
Demonstration of workers in front of the capitol. USA.

1. Definitions, Scope, and Concepts

In October 2007, the online global career and recruitment service MonsterTRAK launched "[1] GreenCareers," a service allowing both entry-level and experienced job seekers to identify green jobs and green companies. In making the announcement, the company noted that in a recent survey of its users, "80 percent of young professionals are interested in securing a job that impacts the environment in a positive way, and 92 percent give preference to working for a company that is environmentally friendly."[a] GreenCareers, like GreenBiz.com, Greenjobs.com, Treehugger.com, and others, is an indication that environmental issues are becoming increasingly important and more routine aspects of job-search and hiring decisions.

The surging interest in the intersection of environment and employment comes against the backdrop of profound crisis in both of these areas. There is growing recognition that humanity faces a severe environmental emergency. Modern economies have been built on an unsustainable foundation. Activities ranging from agriculture and mining to manufacturing, services, and transportation rely on fossil fuels, generate copious amounts of pollution and waste, and undermine critical ecosystems, eco-services, and life-support. Air and water pollution, hazardous wastes, deforestation, desertification, and overfishing are among the key challenges.

But these longstanding environmental problems are now increasingly compounded and aggravated by the specter of climate change. The latest assessment report by the Intergovernmental Panel on Climate Change (IPCC) and the widely noted Stern Report on The Economics of Climate Change—which warns of the catastrophic economic consequences of inaction—have lent new urgency to countering what may be humanity's greatest challenge ever. A virtual avalanche of reports by international agencies, governments, businesses, labor unions, environmental groups, and consultancies weighs in on the technical, economic, and security implications of climate change as well as mitigation and adaptation strategies.

Many studies that lay out pathways toward a sustainable economy declaim a future of green jobs—but few present specifics. This is no accident. There are still huge gaps in our knowledge and available data, especially as they pertain to the developing world. And green jobs rhetoric is not always backed up by serious programs and planning to advance the needs and interests of workers in a warming world.

Addressing the climate challenge will require a range of far-reaching policies: the development of more benign technologies, a boost in the efficiency with which energy and raw materials are being used, a critical reassessment of lifestyle and consumption choices, as well as economic structures, environmental restoration and mitigation efforts. It will also require adaptation to those changes that now seem inevitable and perhaps irreversible. These changes amount to a fundamental ecological transformation of the economy.

But these changes will not happen automatically. Without initiative and impulse from both government action and private investment, needed change will not happen sufficiently fast.

Subsidies, tax structures, and accounting methods that permit the continued "externalization" of severe environmental costs—and that therefore make unsustainable practices appear to be sustainable and profitable—remain fundamental barriers to more rapid change.

Meanwhile, the world faces equally challenging employment problems. Outright unemployment stands at roughly 6 percent, affecting some 190 million people.[2] But even among the world's 3 billion jobholders aged 15 or older, many confront vulnerable employment situations. And about 487 million workers do not earn enough to rise above the $1-a-day line of extreme poverty; some 1.3 billion earn less than $2 a day. Particularly in developing countries, many people work informally, in situations typically marked by very low pay, dangerous work conditions, and a lack of health insurance.[3] (See Table I.1-1.)

Table I.1-1. Working Poor and Workers in Vulnerable Employment Situations, 2007

	US$1 a Day Working Poor	US$2 a Day Working Poor	Vulnerable Employment
World			
Total (million)	487	1,295	—
Share (percent)	16.4	43.5	49.9
	As Share of Total Employment		
Developed Economies & EU	—	—	9.2
Central/Southeastern Europe & CIS	1.9	21.0	19.3
East Asia	8.7	35.6	55.7
South East Asia & Pacific	13.4	50.3	59.4
South Asia	33.0	80.3	77.2
Latin America & Caribbean	8.0	25.4	33.2
Middle East	4.2	19.3	32.2
North Africa	1.6	42.0	30.7
Sub-Saharan Africa	53.0	85.4	72.9

Source: See Endnote 3 for this section.

Tens of millions of young people newly enter the world's labor market each year, but not all of them secure gainful employment. For 2008, even as 40 million new jobs are being created, the International Labour Organization (ILO) expects world unemployment to grow by 5 million.[4] Particularly in countries with large populations of young people, the need for jobs in coming years and decades will be intense; already, youth unemployment represents a major challenge for all societies. And existing workers hope to hold on to their jobs in the face of growing outsourcing, a steady pace of automation, and other worries about job and income safety.

The urgent need to move toward a more sustainable economy further complicates these issues. It at once poses a profound challenge for governments, companies, communities, and individuals, but also offers vast business and employment opportunities. Indeed, the pursuit of green jobs will be a key economic driver in the 21st century, as the world sets out into the largely uncharted territory of achieving a low-carbon global economy. Greening the economy will involve large-scale investment in new technologies, equipment, buildings, and infrastructure, and could thus be a major stimulus for much-needed employment.

In part, this requires a greening of education, skill building, and on-the-job training. But making the economy more sustainable will also require a just transition for those who now hold jobs in carbon-intensive and polluting industries. For labor unions, already buffeted by the forces of globalization that bear an uncertain future in terms of wages, job security, and organizing rights, this transition is a major challenge. Traditionally, workers in dirty industries have succeeded in securing higher degrees of organizing and better wages than those in other sectors of the economy, and so it is not surprising that unions would want to defend jobs in those industries. But greening the economy is also a key union issue from a positive vantage point because workplaces are at the forefront of the existential struggle to counter climate change and other environmental ills and because green jobs can, in principle, be a driver for a more secure future for workers.

Defining and Counting Green Jobs

Will future jobs increasingly be "green"? And if so, what renders them so?

Given the broad scope of the needed technological change and economic transformation and restructuring, there are many aspects and dimensions to greening the economy. According to the Organisation for Economic Co-operation and Development (OECD), "environmental protection consists of activities to measure, prevent, limit, minimize, or correct environmental damage to water, air, and soil, as well as problems related to waste, noise, and ecosystems. This includes activities, cleaner technologies, products, and services that reduce environmental risk and minimize pollution and resource use."[5]

There are many technologies, work processes, and products and services that reduce humanity's environmental footprint, making the economy become more sustainable. Given the urgent nature of the environmental crisis, however, these improvements must be very substantial. Marginal changes are inadequate to the task ahead—and may simply be overwhelmed by a combination of growing per-capita consumption and rising human numbers.

In an ideal state of affairs, a green economy is one that does not generate pollution or waste and is hyper-efficient in its use of energy, water, and materials. Using this green utopia as a yardstick would mean that currently there are few, if any, green jobs. A more realistic, pragmatic approach is process-oriented rather than fixated on an ideal yet elusive end-state. In other words, green jobs are those that contribute appreciably to maintaining or restoring environmental quality and avoiding future damage to the Earth's ecosystems.

We define green jobs as positions in agriculture, manufacturing, construction, installation, and maintenance, as well as scientific and technical, administrative, and service-related activities, that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect and restore ecosystems and biodiversity; reduce energy, materials, and water consumption through high-efficiency and avoidance strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution. But green jobs, as we argue below, also need to be good jobs that meet longstanding demands and goals of the labor movement, i.e., adequate wages, safe working conditions, and worker rights, including the right to organize labor unions.

Conventional industries tend to be well captured in government and other statistics. By contrast, of the totality of what can be characterized as green economic activities, employment data are available only for certain segments (industries or countries). Even where such data are available, they tend to be snapshots rather than time series, and to be estimates and projections more than firm figures. New industries—such as the renewable energy sector or energy auditing—can be identified relatively easily. But other changes that help green the economy are much harder to define and capture: for instance, new technologies, business practices, and shifts in professions and occupations that yield improved energy, materials, and water efficiency; methods and techniques that help avoid or minimize the generation of waste; or new structures and infrastructures that generally make an economy less reliant on material inputs. Many of these changes will occur in existing companies and industries, but are difficult to separate out.

Greater efficiency is a core requirement of an economy that is less environmentally damaging—achieving the same economic output (and level of wellbeing) with far less material input. But efficiency is a relative and highly dynamic concept. There is no easily agreed threshold or cutoff point that separates efficient and inefficient. How much more efficient is sufficient? And, given technological progress and the ever-present need to minimize environmental impacts associated with energy and materials consumption, can yesterday's level of efficiency still be regarded as adequate tomorrow? Thus, while the basic definition of a green job may stay the same, its essence keeps changing over time.

For newly emerging "green" sectors of the economy, such as renewables, employment estimates may alternatively be derived from industry surveys, from analyses that generate employment coefficient estimates (such as jobs per unit of production or production capacity installed, or jobs per unit of investment spending), or from macroeconomic models (such as input-output models that seek to capture direct and indirect employment and estimate net employment impacts). The modeling exercises are usually based on a key underlying assumption, such as meeting a specific policy goal (for instance, generating a portion of energy supplies from clean sources by a given target year), spending a given amount of money, or implementing a policy tool (such as a carbon tax). These different approaches result in findings that cannot simply be aggregated or extrapolated.

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Solar panels being installed at a former mining site in Germany. Goettelborn, Germany.

Other studies, based on macro-economic calculations, do not focus on green industries but seek to determine the likely overall effect on the economy arising from policies aiming to reduce greenhouse gas emissions or other environmental impacts. They focus on the ways in which production costs may change, how demand for products and technologies may be altered by new regulations and standards, etc.

The results of such analyses are heavily influenced by the basic assumptions that go into them. For instance, how will the costs of energy and material inputs evolve? A basic assumption among environmentalists and ecological economists is that prices for energy and materials will have to rise in order to stimulate greater conservation and efficiency measures. But how fast will prices rise, and will this change occur as part of a deliberate, far-sighted policy or as a consequence of unforeseen and unwanted shocks? How well do companies adapt, and to what extent do they attempt to green their operations in a proactive fashion or resist such change?

The nature of these and other assumptions inevitably colors the general nature of the findings. Thus, skeptical assumptions about reducing greenhouse gas emissions or other environmental measures will likely produce studies that predict job losses, just as more positive assumptions will yield upbeat results. Most studies agree, however, that the likely impact is a small positive change in total employment.[6]

Green Jobs 'Radiating Out'

According to the United Nations Framework Convention on Climate Change (UNFCCC), just three sectors of the world economy—electricity generation, fuel supply, and transportation—together directly account for close to 40 percent of all carbon emissions. (This does not obviate the need for greening other sectors of the economy in their own right, of course, but energy and transportation clearly have strategic character.) The jobs in these sectors do not amount to a very large number relative to the overall size of the world labor market. However, a point that is not always recognized is that greening jobs in core areas of the economy has the potential to "radiate" across large sections of the economy and to contribute to the greening of other jobs that make up large sections of the total workforce.

For instance, even with strong growth in renewables, the energy industry itself will always remain a relatively small employer (as is the case now, with fossil fuels dominant). But clean energy radiates out far beyond the confines of the energy sector itself. It means that any business activity will have far less environmental impact than today, when fuels and electricity are still largely produced from dirty sources. Likewise, greening vehicles (that is, producing cars, trucks, and buses that run on cleaner fuels and are more efficient) means that the many millions of jobs in transportation services are by implication also greener. The number of jobs in transportation services surpasses vehicle-manufacturing jobs several-fold.

The present study is focused on the transformation toward a low-carbon economy and hence does not include an analysis of sectors that, for different reasons, have tremendous impacts on sustainability. Reducing the environmental and health impacts of the chemical sector, for instance, is also critical. Like energy, synthetic chemicals are ubiquitous in all walks of life, and developing safe alternatives to toxic substances almost automatically makes many other jobs outside this industry proper—from agriculture to medicine—more sustainable.

Green and Decent Jobs

In addition to quantities of jobs, there is a range of qualitative questions, relating to occupational profiles and work skills, wage levels, and the degree to which worker representation (unionization) and workplace involvement (empowerment) are advanced or not. To fully identify, adopt, and implement green opportunities in the workplace, the active involvement of workers and unions is essential.

Green jobs span a wide array of skills, educational backgrounds, and occupational profiles.[7] (See Box I.I-1.) They occur in research and development; professional fields such as engineering and architecture; project planning and management; auditing; administration, marketing, retail, and customer services; and in many traditional blue-collar areas such as plumbing or electrical wiring. Also, green jobs exist not just in private business, but also in government offices (standard setting, rule-making, permitting, monitoring and enforcement, support programs, etc.), science and academia, professional associations, and civil society organizations (advocacy and watchdog groups, community organizations, etc.).

Box I.1-1. Occupational Profiles in the Wind Power Industry

Wind power development opens up employment opportunities in a variety of fields. It requires meteorologists and surveyors to rate appropriate sites with the greatest wind potential; people trained in anemometry (measuring the force, speed, and direction of the wind); structural, electrical, and mechanical engineers to design turbines, generators, and other equipment and to supervise their assembly; workers to form advanced composite and metal parts; quality-control personnel to monitor machining, casting, and forging processes; computer operators and software specialists to monitor the system; and mechanics and technicians to keep it in good working order. Many of these are highly skilled positions with good pay. An analysis of an Ohio-based wind turbine manufacturing company found that the average annual earnings per employee were about $46,000, with a range of about $30,000 for the lowest-paid to $120,000 for the highest-paid. This average figure is slightly above the U.S. national average wage level of about $43,000 for 2006.

Source: See Endnote 7 for this section.

Environmental awareness and applied green literacy will become increasingly important in many professions. But not all green jobs will be new ones, and in fact, it is likely that in most workplaces low-key changes in day-to-day work practices and methods will predominate. Blue-collar workers may fairly quietly be transformed into green-collar workers. Indeed, a November 2007 report published by the American Solar Energy Society (ASES) finds that, "the vast majority of the jobs created by RE&EE [renewable energy and energy efficiency] are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, truck drivers, mechanics, etc. In fact, most of the workers employed in these jobs may not even realize that they owe their livelihood to RE&EE." The ASES study emphasizes that renewables and efficiency-related parts of the economy employ workers at all educational and skill levels.[8]

A narrow definition of green jobs may focus solely on the green credentials of a job. However, worker advocates and the ILO rightly emphasize that green jobs also need to be decent jobs—pairing concerns like efficiency and low emissions with traditional labor concerns including wages, career prospects, job security, occupational health and safety as well as other working conditions, and worker rights. Of course, the precise nature and quality of jobs across the planet varies enormously. While desirable, there will be no single global standard for the foreseeable future. But even accepting the inevitability of differentials in pay and other characteristics, certain standards need to be upheld. People's livelihoods, rights, and sense of dignity are bound up tightly with their jobs; jobs need to provide equal hope for the environment and the jobholder. A job that is exploitative, harmful, or fails to pay a living wage (or worse, condemns workers to a life of poverty) can hardly be called green. (See Figure I.1-1.)

Figure I.1-1. Green and Decent Jobs? A Schematic Overview

Environment

Green, but not decent *Examples:* ❑ Electronics recycling without adequate occupational safety ❑ Low-wage installers of solar panels ❑ Exploited biofuels plantation days laborers	**Green and decent** *Examples:* ❑ Unionized wind and solar power jobs ❑ Green architects ❑ Well-paid public transit employees
Neither green nor decent *Examples:* ❑ coal mining with adequate safety ❑ Women workers in the cut f ower industry in Africa and in Latin America ❑ Hog slaughterhouse workers	**Decent, but not green** *Examples:* ❑ Unionized car manufacturing workers ❑ Chemical engineers ❑ Airline pilots

Decent Work

Ideally, the future of employment will increasingly be marked by jobs that are respectful and protective not only of the natural environment, but also of workers' health, human needs, and rights. As this report will show, however, there are today millions of jobs in sectors that are nominally in support of environmental goals—such as the electronics recycling industry in Asia, for instance—but whose day-to-day reality is characterized by extremely poor practices, exposing workers to hazardous substances that endanger their health and lives. In agriculture as well, there are enormous deficits with regard to decent work—including such fundamental problems as lack of freedom of association, forced labor, child labor, and other shortcomings. A green jobs strategy needs to be fully attentive to these problems and to seek to overcome them. Decent work conditions need to be as important to advocates for the environment as environmental concerns to advocates for labor.

Shades of Green

Environment-related technologies and activities are often lumped together under terms such as "environmental industry" or "clean tech." While these are convenient catchall references, they are also somewhat problematic.

"Clean tech" spans a broad spectrum of products and services, including, among others, alternative energy (generation, batteries and storage, infrastructure); more resource-efficient industrial processes; advanced materials and nanotechnology; remanufacturing; chemicals recovery and biological and chemical processes for water and waste purification; and testing, monitoring, and compliance services. The common thread is the use of new, innovative technology to create products and services with less detrimental impact on the environment.[9]

However, the term clean tech does not necessarily make a basic, yet crucial, distinction: whether the generation of pollutants and wastes is to be managed or to be minimized and avoided, and thus what types of green jobs will result. The first category encompasses industrial and service-oriented branches of the economy that specialize in air and water pollution-control equipment, waste management, and remediation efforts. As the world moves to confront climate change, adaptation measures such as carbon sequestration, flood protection, and climate-resistant crops could be included under this category as well.

Like clean tech, "environmental industry" is unfortunately also often used as a broad aggregation that may group together pollution control and waste management strategies with approaches that avoid the generation of pollutants and waste in the first place. A study by Environmental Business International put the environmental goods and services sector worldwide at $548 billion in 2004, though most of that turnover was related to pollution control measures. The sector was expected to grow to close to $800 billion by 2015.[10]

Pollution control responses were central to the initial response to signs of environmental degradation from the 1960s and 70s on. Environmental regulations led to the creation of a sizable industry that, by the turn of the 21st century, employed a conservatively estimated 11 million people worldwide, many of them in traditional manufacturing and construction jobs.[11]

But the pollution control approach remains wedded to the resource- and waste-intensive economy, addressing environmental consequences as an afterthought. The depth of the environmental crisis compels a more fundamental, ecologically inspired, transformation of the economy—in agriculture, mining, manufacturing, services, and infrastructure. This restructuring will need to bring about a reduction in resource consumption and associated emissions (air and water pollutants, carbon emissions) and the minimization or avoidance of waste streams. Therefore, the promotion of alternative sources of energy; advancement of energy, water, and materials efficiency; greening of new building construction and retrofitting and weatherizing of existing structures; diversification of transportation modes; and development of non-polluting methods are key measures. We are seeing the beginnings of this transformation today.

There are different degrees to which technologies, products, businesses, and business practices can be said to be green, ranging from reactive and remedial measures on the one hand to proactive measures on the other. Table I.1-2 gives an indication of this graduation from more limited to more transformative approaches for major parts of the human economy and society.

Table I.1-2. Shades of Green: Pro-Environmental Measures in Major Segments of the Economy

Energy Supply	
	Integrated gasification/ carbon sequestration
	Co-generation (combined heat and power)
	Renewables (wind, solar, biofuels, geothermal, small-scale hydro); fuel cells
Transport	
	More fuel-efficient vehicles
	Hybrid-electric, electric, and fuel-cell vehicles
	Car sharing
	Public transit
	Non-motorized transport (biking, walking), and changes in land-use policies and settlement patterns (reducing distance and dependence on motorized transport)
Manufacturing	
	Pollution control (scrubbers and other tailpipe technologies)
	Energy and materials efficiency
	Clean production techniques (toxics avoidance)
	Cradle-to-cradle (closed-loop systems)
Buildings	
	Lighting, energy-efficient appliances and office equipment
	Solar heating/cooling, solar panels
	Retrofitting
	Green buildings (energy-efficient windows, insulation, building materials, HVAC)
	Passive-solar houses, zero-emissions buildings
Materials Management	
	Recycling
	Extended producer responsibility/ product take-back and remanufacturing
	De-materialization
	Durability and repairability of products
Retail	
	Promotion of efficient products/ eco-labels
	Store locations closer to residential areas
	Minimization of shipping distances (from origin of products to store location)
	New service economy (selling services, not products)
Agriculture	
	Soil conservation
	Water efficiency
	Organic growing methods
	Reducing farm-to-market distance
Forestry	
	Reforestation and af orestation projects
	Agroforestry
	Sustainable forestry management and certification schemes
	Halting deforestation

Developing renewable energy and raw materials, as well as efficient and waste-avoiding technologies, production processes, products, and services is crucially important to greening the economy. For example, producing aluminum from recycled scrap is environmentally preferable to virgin production because it is far less energy-intensive. But equally important are the structures and spatial arrangements that characterize an economy. To the extent that great distances—between industries and their suppliers, between stores and homes, between homes and workplaces—are a feature of an economy, there is a built-in need for large-scale motorized transportation services. That need can be met by more fuel-efficient vehicles, but it is a less optimal solution than one that allows for public transit or one that minimizes the need for such transportation.

Especially in OECD countries, there is a rapidly growing literature on the subject of environment and employment. However, the proliferation of studies and reports does not necessarily permit a straightforward aggregation of results. One key reason is the lack of a commonly accepted, consistent definition of "green"—the boundaries of renewable energy, energy efficiency, clean technology, sustainable transport, organic agriculture, and so on.

The scope of available studies varies considerably. Individual analyses are based on widely diverging assumptions and scenarios, methodologies, variables, base years, and future time horizons for estimates and forecasts. While available studies allow certain conclusions to be drawn, their findings cannot be aggregated or extrapolated. The result is more of an impressionistic picture than a precise set of job figures.

Employment Shifts

From a broad conceptual perspective, employment will be affected in at least four ways as the economy is oriented toward greater sustainability:

- First, in some cases, additional jobs will be created—as in the manufacturing of pollution control devices added to existing production equipment.
- Second, some employment will be substituted—as in shifting from fossil fuels to renewables, or from truck manufacturing to rail-car manufacturing, or from landfilling and waste incineration to recycling.
- Third, certain jobs may be eliminated without direct replacement—as when packaging materials are discouraged or banned and their production is discontinued.
- Fourth, it would appear that many existing jobs (especially such as plumbers, electricians, metal workers, and construction workers) will simply be redefined as day-to-day skillsets, work methods, and profiles are greened. It goes without saying that this last aspect is by far the hardest to document and analyze, and the hardest for which to foresee the full implications.

Highly aggregated findings of employment impacts of green policies and business ventures are of somewhat limited utility: the job effects will necessarily vary for different firms, industries, regions, and countries. Table I.1-3 offers a number of distinctions and observations.[12]

Table I.1-3. Greening the Economy: Types of Employment Ef ects

Type of Effect	Observation
Positive and negative employment effects	• Green policies and business practices can create new jobs or preserve existing ones. • On the other hand, environmental regulations can, in theory, have negative job consequences (by raising costs, reducing demand, or rendering a factory or company uncompetitive). This, however, has proven to be an exceedingly rare outcome.
New job creation and job preservation	• To some extent, green jobs will be created through the development of new technologies and the emergence of new industries (wind turbines, solar photovoltaics, fuel cells, biofuels, etc.). • As established firms and industries green their operations, existing jobs may be transformed, and thus preserved against possible loss (implying changes in work methods, retraining).
Direct and indirect employment effects	• Jobs are created directly through increased demand and output induced by environment-related expenditures. • Indirect employment ef ects arise in supplier industries. • Induced job ef ects occur as wage incomes are spent generating demand in additional industries.
Temporary and long-term jobs	• Construction and installation jobs (for instance, of a wind turbine) are usually of a temporary nature (as are jobs that are supported by a specific policy measure or program). • Manufacturing and maintenance jobs, on the other hand, are in principle of a longer-lasting nature.
Part-time and full-time employment	• Part-time jobs may be expressed in terms of full-time equivalents (ref ecting the aggregate amount of employment generated).

Source: See Endnote 12 for this section.

There is also the question of to what extent specific communities, regions, or countries benefit from green employment. In part, this is linked to the questions of to what extent energy and materials need to be imported, what share of revenues is captured by local producers as opposed to middlemen and globally-operating companies, and whether the necessary industrial and knowledge base, as well as infrastructure, exist in a particular country, region, or other locality.

Countries that become leaders in green products, services, and technology development will want to press their advantage and capture export markets in addition to serving their own domestic markets. Indeed, countries like Germany and Japan see the environment as a key dimension of their future economic strategy. This implies that the bulk of green business revenues and jobs in R&D and manufacturing operations accrues to a relatively small group of countries, at least until other countries catch up. By contrast, jobs in operations and maintenance tend to be created in or near the location where wind turbines, solar panels, efficient windows, etc. are installed and used; they cannot be easily outsourced.

Direct, Indirect, and Induced Jobs

Like any other economic activity, investment in environment-friendly economic activities—whether it be renewable energy, efficiency improvements, railroads and public transit, clean production methods, or others—generates a certain number of direct jobs (design, construction, operations, maintenance) and indirect jobs (in supplier industries). Aggregate employment figures, however, can hide important dimensions such as the spatial distribution of jobs—where will jobs be created, and which regions will benefit most? To a large extent, this depends on the technology, skill, and manufacturing base of a given country or region. Particularly in the energy, extractive, and agricultural sectors of the economy, a key question is where processing of raw materials takes place, and thus where the "value-added" from such operations is accrued.

Economists also speak of "induced jobs." Those are jobs that are supported by the everyday consumer spending of those in direct and indirect jobs. Of course, any sector in the economy entails such induced employment, and one might question whether induced jobs should even be considered here. However, there are two important distinctions. One concerns wage levels: better-paid jobs translate into greater purchasing power and thus more induced employment. The second distinction relates to the composition of purchases of food, clothing, etc., and where these goods and services were produced; in other words, to what extent money spent circulates in the local or regional economy or "leaks" out into the broader world economy.

Some green jobs are easily identifiable—such as people employed in installing a solar panel or operating a wind turbine. Others, particularly in supplier industries, may be far less so. For instance, a particular piece of specialty steel may be used to manufacture a wind turbine tower without the steel company employees even being aware of that fact. Thus, some jobs come with a clear "green badge," whereas others—in traditional sectors of the economy—may not have an obvious green look and feel.

A crucial question is whether investments in environment-friendly economic activities support more, or fewer, jobs per unit of spending than expenditures in more polluting and waste-generating industries. In other words, are they more or less labor-intensive?

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Chimneys billowing out industrial pollution into the air. Many industrial processes have led to the pollution of virtually every aspect of the biosphere: land, rivers, seas and the atmosphere. Romania.

Re-Spending and the Rebound Effect

Greater efficiency in resource inputs (energy, materials, water) and greater reliance on recycling and reuse open the door to potential employment gains through what economists refer to as "re-spending." For example, if energy inputs needed in the manufacturing and use of products and production equipment can be reduced through higher levels of efficiency (more-efficient motors, appliances, and equipment; reduced transmission losses; or recycling steel and aluminum instead of producing these materials from virgin ores), then the money saved—the avoided fuel and materials costs—can in principle be re-spent elsewhere in the economy. To the extent that this re-spending benefits segments of the economy that are more labor-intensive than the conventional energy sector, it generates additional employment.

It must be noted, however, that a "rebound effect" could limit money available for re-spending: lower per-unit energy or materials requirements through higher efficiency translate into lower consumer costs, which in turn encourage increased usage. For instance, greater automobile fuel efficiency means that motorists can drive longer distances at the same cost. An in-depth literature review prepared by the U.S. Department of Energy on behalf of the International Energy Agency (IEA) in 1998 found that the effect is less than 10 percent for residential appliances, residential lighting, and commercial lighting; less than 20 percent for industrial process uses; small-to-moderate (less than 10–40 percent) for residential space heating, water heating, and automotive transport; and anywhere from 0 to 50 percent for residential space cooling.[13] Based on a review of studies from 2000 and 2007, a RAND Corporation report concludes that the rebound effect for automobile fuel consumption is in the range of 10–20 percent.[14] The rebound effect thus somewhat lowers the reductions in fuel use, and associated emissions of air pollutants and carbon, made possible by greater fuel efficiency.

When energy, materials, and water efficiency gains cross a threshold of magnitude, they make possible savings in capital costs (those that would have been necessary to construct and open additional refineries, power stations, coal or bauxite mines, metals-processing plants, dams, and so on). Because many of these types of investments require huge amounts of capital but offer relatively few jobs, avoiding a portion of them would save large amounts of money; the savings, in turn, could be invested in more labor-intensive sectors. The authors of a 1999 book, Natural Capitalism, noted that building "superwindow and efficient-lamp factories instead of power stations and transmission lines requires about a thousand-fold less capital per unit of extra comfort or light, yet these businesses are considerably more labor-intensive."[15]

Shifting from fossil fuels to domestic solar energy, wind power, and biofuels, or reducing fossil fuel use through greater energy efficiency, can improve a country's trade balance and ensure that more money stays in the domestic economy, with attendant job benefits—assuming that these energy alternatives can be provided domestically. By the same token, however, fossil fuel exporting countries suffer from this development and need to undertake efforts toward diversifying their economies.

Although the shift toward sustainability offers economic benefits, at first it may entail higher costs. With regard to alternative sources of energy, for example, it took a number of years for wind-generated electricity to become cost-competitive with gas and coal-fired power plants. Solar photovoltaics (PV) remain more expensive for the foreseeable future. To the extent that governments mandate that such alternatives be given equal access to the grid, higher costs will be passed on to consumers. Higher energy spending means that less money is available for other consumer purchases, and this in turn has negative consequences for employment in affected sectors of the economy, until the cost of alternatives is brought down. However, as renewables mature technologically and reach greater economies of scale, such cost disadvantages disappear and may turn into a cost advantage.

For energy efficiency projects, in turn, the upfront cost is usually higher, and the big question concerns the payback period: how long does it take before the higher purchase costs of an efficient appliance, light bulb, car, or building are offset by lower operating expenses? A big factor in this context is the price development for conventional sources of energy—determined not only by world market trends, but also by applicable subsidies (and subsidy shifts) and efforts to internalize the social and environmental costs of fossil fuels.

Labor, Energy, and Materials Productivity

For a long time, it was an article of faith among economists that energy and materials consumption moved in lockstep with the gross national product, meaning that reduced resource use (or, for that matter, undue market intervention in the form of environmental regulations and mandates) equaled lower growth and less employment. But this direct link has been broken as far as energy use is concerned, and it is no longer as strong as it once was for materials use.

Harking back to the early days of the Industrial Revolution, businesses have sought to economize on their use of labor. Labor—and especially skilled labor—was scarce, but land and natural resources seemed inexhaustible. In today's globalizing economy, slashing labor costs is still seen as a key means to stay competitive. While companies have emphasized raising labor productivity, far less attention has been given to energy and materials productivity. Indeed, when economists refer to productivity, it is often implied that they mean labor productivity.

U.S. data show that labor productivity in manufacturing more than tripled between 1950 and 2000. Energy productivity, however, was only marginally higher than in 1950, having declined until the early 1970s when rising oil prices helped bring about more efficient production methods. U.S. materials productivity, too, is barely higher now than it was in 1950.[16]

European and Japanese economies have been more attentive to efficiency goals (and consume far less in per-capita terms). For example, driving one mile (1.6 kilometers) in the United States requires an estimated 37 percent more fuel than it does in Europe, according to the McKinsey Global Institute—a difference explained by larger U.S. vehicles and less-efficient engine technologies. Under current policies, the gap will increase further.[17]

Nonetheless, similar trends are observable in Europe as in the United States. In Germany, for example, labor productivity rose 3.5-fold between 1960 and 2000, while materials productivity only doubled. This is curious, as raw materials account for about 40 percent of the production costs of German industry, surpassing labor costs which weigh in at less than 25 percent.[18] German industry could save about 20 percent of its current raw materials use by 2016 through higher materials efficiency—avoiding annual inputs worth about $37 billion (€27 billion).[19] In a joint statement in August 2006, the environment ministry and the IG Metall trade union reaffirmed the government's goal of doubling energy and raw materials productivity by 2020.[20]

Directly comparable statistics are not available for most countries. Although countries like China and India consume far less per capita than the established industrial economies, their resource productivity remains very low.[21] (See Table I.1-4.) In light of the rapid economic growth in both countries, translating the potential for much higher productivities into reality is one of the key challenges in the struggle for sustainability.

Table I.1-4. Energy Consumption and Energy Intensity, Selected Countries and World, 2003

Country	Energy Consumption	Energy Intensity
	(Million BTUs per capita)	(BTUs per Dollar of Real GDP)
United States	316	8,900
Northwestern Europe*	175	7,200
Japan	163	4,400
South Korea	129	15,100
China	45	31,400
World Average	67	12,600

Source: See Endnote 21 for this section.

The past preference for wringing more out of each hour of human work has indeed brought rapid economic progress. But today, given evidence of increasing resource scarcity and environmental degradation on one hand, and the growing abundance of human labor, particularly in developing countries, on the other, it is time to base competitiveness and economic progress far more on improvements in energy and materials productivity.

Worldwide, the McKinsey Global Institute notes, energy productivity improved by about 1.3 percent per year between 1980 and 2003. Under existing policies, McKinsey projects only a 1 percent per year improvement from today until 2020—not enough in the face of expected economic growth and the specter of climate change.[22]

Higher energy and materials productivities are particularly critical in those industries that are the biggest resource consumers, polluters, and contributors to climate change. Mining, electric utilities and oil refining, transportation, chemicals, primary metals processing (such as steel and aluminum), and pulp and paper production are among them. These sectors account for a much more prominent share of energy use and toxic waste generation than they contribute to employment.[23]

There are many opportunities for business innovations, including better design, new materials, improved fabrication technologies, and use of innovative software.[24] An ethic of "eco-efficiency" is an increasingly accepted business perspective. A resource productivity perspective views discharges of waste as evidence of the inefficient use of raw materials. Minimizing the environmental impact of production is likely to reduce costs and improve product quality, and hence can create an advantage for businesses rather than an unwanted burden. Yet many profit-driven organizations are still blind to obvious opportunities for savings derived from efficiency and waste reduction. The potential is enormous, but the political will and business determination to pursue opportunities is still highly uneven from country to country.

Winners and Losers

As the move toward a low-carbon and more sustainable economy gathers momentum, growing numbers of green jobs will be created. Overly aggregated job numbers, however, may hide important distinctions, exceptions, and disparities. For instance, local communities and regions will want to ensure that green jobs are created within their jurisdictions; governments and unions will watch closely whether green development will benefit the domestic economy or companies and communities in other countries.

Not everyone will be a winner. There will also be losers—at least temporarily. These include employees of companies that are slow to rise to the environmental challenge, heavily polluting industries, and regions where many livelihoods depend on them. The policy challenge is not to let these distinctions become permanent features. The transition to sustainability and greener employment needs to be well planned.

Environmental regulations can have "technology-forcing" effects—stimulating safer and more benign products and production processes—that give companies a competitive edge rather than putting them at a disadvantage. Smart innovations and modifications to the production process offer substantial savings in outlays for energy and raw materials, in operating costs, and in avoided waste, disposal expenses, and associated liabilities. Such advantages will loom larger as governments move more aggressively to counter climate change and to direct economies toward greater sustainability through full-cost accounting and other measures.

Unlike the conventional energy industries of coal, oil, and natural gas, the winners in the development of renewable energy sources are determined less by natural endowment (i.e., where extractable resources are located) than by policies in support of technological development and training the required skilled labor. However, in contrast to manufacturing activities, the installation of solar panels and wind turbines, or the weatherization of buildings and retrofitting of industrial equipment, are activities that are by definition far more local.

Companies, countries, and regions that become leaders in green innovation, design, and technology development are more likely to retain and create new green jobs. This will translate into tremendous market and export opportunities for the early actors. The laggards, however, may well incur substantial business and job penalties. In the automotive industry, for example, Toyota has been a leader in hybrid technology. U.S. automakers have long been reluctant to pursue this technology (and fuel efficiency more generally). Now losing market share, they have announced heavy layoffs in recent years.

Public policy can and should seek to minimize disparities among putative winners and losers that arise in the transition to a green economy. Although the losers, with regard to employment, are likely to be far outnumbered by the winners, some workers will undoubtedly be hurt in the economic restructuring toward sustainability—primarily those in mining, fossil fuels, and smokestack industries. At least some, perhaps many, of the displaced individuals will not have the requisite skills for the new jobs without retraining. A laid-off coal miner cannot easily switch to a job installing solar panels. Also, new green jobs may arise primarily in locations other than those shedding jobs in polluting industries. Regions and countries that depend heavily on extractive and polluting industries will confront a substantial challenge to diversify their economies.

There are examples of cities and regions that have begun to successfully reinvent themselves. Toledo, Ohio, a typical "rust-belt" city in the United States that was once dominated by automobile-related firms, has become a desirable location for solar companies. Glass manufacturers there have reoriented themselves from making car windshields to making solar panels.[25]

Resource extraction and heavily polluting industries are likely to feel the greatest impact of moving toward sustainability. But blocking environmental action would not save jobs in these industries. The rapid pace of automation and resource depletion means that employment in many of these industries is still shrinking even as output grows. In fact, in many industries jobs are more likely to be at risk where environmental standards are low and where innovation in favor of cleaner technologies is lagging. And as the urgency of more sustainable practices rises over time, so do the costs of a do-nothing strategy that misses opportunities for early action that can be phased in and are thus less disruptive in impact.

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A labourer works at an electronic waste disposal in Yingtan. China.

2. Green Policies and Business Practices

Opportunity and Innovation

With growing awareness of the global environmental crisis, growing confirmation that climate change is a real and imminent challenge, rising oil prices, as well as concerns over energy supply security in many countries, more and more opportunities are emerging for expanding green business. The World Business Council for Sustainable Development (WBCSD) offers the following pragmatic reasons why business should consider investing in sustainable ecosystems:[26]

- Create new revenue streams by introducing innovative products and services.
- Reduce dependence on increasingly scarce raw materials or fragile services through the introduction of substitutes or the use of alternative abundant or renewable resources.
- Mitigate rising costs caused by scarcity of raw materials.
- Create new markets for certified, fair trade, organically grown or environmentally friendly products.
- Develop new businesses such as water-quality trading, wetland banking, mitigation credit trading, threatened species banking, or pollution prevention, capture, treatment, and reuse.
- Strengthen businesses' license to operate.

Corporate executives increasingly understand that they need to scrutinize their way of doing business. Beyond the factors listed above, forward-looking business leaders understand that public legitimacy, consumer trust, and the ability to comply with present and likely future regulations are critical.

While some companies have barely progressed past green sloganeering—or worse, "greenwashing"—a growing number have announced ambitious goals to reduce their carbon footprint or make their operations "carbon-neutral." Traditionally, many businesses have been loath to see new environmental requirements imposed, and indeed many continue to prefer voluntary measures over mandates. The auto industry continues to take this line. But there are also more encouraging examples. For instance, in 2007 European light-bulb makers, including Philips and Osram, decided to lobby governments to promote low-energy light bulbs over traditional incandescent bulbs.[27] The same year, Siemens, one of Germany's corporate giants, decided to devote half its research budget of $7.8 billion (€5.7 billion) to climate-protection programs.[28] Xerox and Canon have been pioneers in so-called "remanufacturing"—reconditioning and refurbishing equipment and other goods. In the industrial carpet business, Interface has for many years championed more durable carpets based on materials that can be recycled and reused rather than thrown away.

The Growth in Green Markets

At present, the global market volume for environmental technologies—products and services—runs to about $1,370 billion (€1,000 billion), according to German-based Roland Berger Strategy Consultants, with a projected $2,740 billion (€2,200 billion) by 2020. The firm offers the following estimates for individual market segments:[29]

- Energy efficiency technologies (appliances, industrial processes, electrical motors, insulation, etc.): $617 billion (€450 billion) at present; $1,233 billion (€900 billion) by 2020
- Waste management/recycling: $41 billion (€30 billion); $63 billion (€46 billion) by 2020
- Water supply/sanitation/water efficiency: $253 billion (€185 billion); $658 billion (€480 billion) by 2020
- Sustainable transport (more-efficient engines, hybrids, fuel cells, alternative fuels, etc.): $247 billion (€180 billion); $493 billion (€360 billion) by 2020.

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Recycling oil drums. Yogyakarta, Indonesia.

Constructing a green, post-carbon world will undoubtedly entail a massive undertaking in areas like the electricity network and off-grid applications; mass transit and less-polluting cars, the building sector; and organic and sustainable agriculture. Currently, much of the world's infrastructure, industrial machinery, buildings, and transportation system is still highly inefficient and overly reliant on fossil fuels. Hence, there are unparalleled investment and employment opportunities in reorienting the world economy's products and services, and jobs, toward a greener future.

For instance, each year, an estimated $200–250 billion is invested in energy-related infrastructure to replace existing capital stock and meet ever-rising demand (and another $1.5 trillion is spent on energy consumption).[30] The choices made today—whether to invest predominantly in conventional energy or in alternatives—will be a major determinant of how the world fares in its efforts to address environmental degradation and climate change.[31] Each new coal-fired plant, each poorly insulated new home or office building, each car factory that churns out gas-guzzlers commits the world to an unsustainable path and represents a missed opportunity.

Green employment is clearly on the rise. Roland Berger projects that employment in the environmental technology industry will surpass the number of jobs in the machine tool or automobile industries in Germany by 2020. The firm predicts that environmental technology will make up 16 percent of German industrial production by 2030, a fourfold increase over 2005. Green business is becoming an engine of German economic development.[32] In the United Kingdom, a 2004 government assessment estimated that around 400,000 people were working in environmental technology industries, up from 170,000 two years earlier. A study for the Regional Development Agencies, meanwhile, put the total at 690,000 jobs.[33]

Financial Flows in the Energy Sector

The United Nations Framework Convention on Climate Change (UNFCCC) notes that, "the additional estimated amount of investment and financial flows needed in 2030 to address climate change is large compared with the funding currently available under the Convention and its Kyoto Protocol, but small in relation to estimated global gross domestic product (GDP) (0.3–0.5 per cent) and global investment (1.1–1.7 per cent) in 2030."[34] At about 86 percent, the private sector controls the bulk of all international financial flows. Greening these flows—ensuring that a steadily growing portion supports, rather than undermines, sustainable development and green job creation—is critical.

In recent years, venture capital (VC) investment in the clean-tech sector has boomed—jumping 78 percent in North America in 2006, so that clean tech now accounts for 11 percent of all VC investments, trailing only the software and biotech sectors. In China, clean tech VC investments soared 147 percent just between 2005 and 2006, representing 19 percent of all VC investment in that country.[35] A 2004 report found that, as a general rule of thumb, every $100 million in venture capital investments can generate 2,700 direct jobs in North America.[36] By a rough calculation, clean-tech start-ups there might receive between $14 billion and $19 billion in venture financing between 2007 and 2010, and these investments could lead to the creation of between 400,000 and 500,000 jobs.[37] These trends are encouraging, but the importance of venture capital is not as pronounced in many other countries, where more conventional channels of financing predominate.

Assessing all global financial flows, it is clear that current investment priorities continue to point in the wrong direction. According to International Energy Agency estimates, in 2005, $138.5 billion was invested in fossil fuel supplies and petroleum refining, $107 billion went in support of fossil fuel power generation, and another $44 billion underwrote large hydropower projects and nuclear energy. In comparison, renewable sources of energy received $35.5 billion. (Also, $225.7 billion was invested in electricity transmission and distribution networks.) Energy-efficiency investments, at about $1.5 billion, were tiny. A worrisome aspect is that more than 90 percent of renewables and efficiency investments went to developed countries, although a handful of developing countries, China, India, and Brazil among them, are attracting rapidly rising funding flows.[38] Clearly, these priorities need to undergo a major shift if sustainable development and green job creation are to be central features of coming decades around the world.

Market Forces and Regulation

Market forces and voluntary means alone will not be enough to translate green potential into reality as rapidly as is needed in light of climate change and other environmental urgencies. Regarding European developments, a March 2007 Reuters news article notes that, "While in some cases there is still a yawning gap between rhetoric and reality, European businesses are rapidly going green—albeit driven more by profits and regulations than a desire to do good."[39] Recent reports by prominent business consultants, governments, and the United Nations alike underline this point:

- McKinsey & Company does not mince words in stating that, "Without a forceful and coordinated set of actions, it is unlikely that even the most economically beneficial options would materialize at the magnitudes and costs estimated here."[40] Though made in a U.S. policy context, this observation is equally valid elsewhere. And in a report assessing global energy productivity developments, the McKinsey Global Institute cautions about market distortions, disincentives, and failures.[41]

- The Stern Report on the Economics of Climate Change finds that, "clean energy technologies face particularly strong barriers—which, combined with the urgency of the challenge, supports the case for governments to set a strong technology policy framework that drives action by the private sector." It goes on to say that, "without [government] support the market may never select those technologies that are further from the market but may nevertheless eventually prove cheapest."[42]

- The United Nations Development Programme's (UNDP) *Human Development Report 2007/2008* concludes: "Putting a price on carbon either through taxation or cap-and-trade schemes is a necessary condition for avoiding dangerous climate change. But carbon pricing alone will not be sufficient to drive investments and change behavior at the scale or speed required. There are other barriers to a breakthrough in climate change mitigation—barriers that can only be removed through government action. Public policies on regulation, energy subsidies, and information have a central role to play."[43]

Government policy is essential in a number of regards. It is important for overall goal- and standard-setting; especially ensuring movement toward long-term development goals beyond the time horizons typical of business; providing infrastructure that private enterprises cannot or will not create; and creating and maintaining a level playing field for all actors.

The Policy Toolbox: Financial and Fiscal Shifts

Governments can take a number of steps to drive the development of green technologies, products, and services, and thus drive forward a strong framework within which green employment can be promoted far better than is possible today. This section will first discuss a variety of financial and fiscal shifts (pursuing pro-environment procurement and public investment strategies, recalibrating tax and subsidy policies, providing more appropriate levels of international development assistance) before moving on to several regulatory measures (establishing appropriate standards, mandates, regulations, and market incentives).

Public investment and procurement programs can be important tools for governments to push the economy in a greener direction. From the national to the local level, government authorities spend trillions of dollars on public purchases every year. By buying environmentally preferable products, they can exert a powerful influence on how products are designed, how efficiently they function, how long they last, and whether they are handled responsibly at the end of their useful lives. Well-designed purchasing rules can drive technological innovation and help establish green markets.[44]

There are many examples of small- and large-scale efforts. In China's drive to accelerate the development of its renewable energy sector, for instance, Chen Deming, vice chairman of the National Development and Reform Commission (NDRC), announced in September 2007 that the country was planning to invest 2 trillion yuan ($265 billion) in renewables.[45] An effective effort on a much smaller scale is the four-year, $7.6 million Indian Solar Loan Program that was launched by the United Nations Environment Programme (UNEP) and two Indian banks in 2003 to help accelerate the market for domestic solar systems in the country's south.[46]

Subsidy Shifts

A key ingredient in shifting the economy to a more sustainable footing is phasing out subsidies for industries that pollute or use natural and financial resources inefficiently. Numerous subsidies allow the prices of fuels, timber, metals, and minerals (and products incorporating these commodities) to be far lower than they otherwise would be, encouraging greater consumption. Limits in data availability prevent a complete accounting of subsidies for environmentally harmful activities, and underlying methodologies and definitions may differ from study to study. But a 2002 report by the Organisation for Economic Co-operation and Development (OECD) estimated global subsidies at about $1 trillion a year, with OECD member states accounting for three-quarters of the total.[47]

A 2001 study by Norman Myers and Jennifer Kent put perverse subsidies in six sectors—agriculture, energy, road transportation, water, fisheries, and forestry—at a minimum of $850 billion annually. In addition, Myers and Kent found that there are about $1.1 trillion worth of quantifiable environmental "externalities." Although these are not subsidies in a formal sense, they do represent uncompensated costs that have to be borne by society at large and that, like subsidies, have distorting and detrimental impacts. For instance, the environmental and health costs associated with automobile use are not charged to motorists, which makes individual vehicle travel cheap in comparison with rail and other modes of transportation.[48]

Worldwide subsidies for fossil fuels and nuclear power ran to about $250–300 billion annually in the mid-1990s. Many former Communist and developing countries have reduced their energy subsidies significantly in the intervening years. However, subsidies for conventional forms of energy continue to be magnitudes higher than those available for renewable energy.[49] Phasing out destructive subsidies and shifting a portion of those funds to renewable energy, efficiency technologies, clean production methods, and public transit would give the transition toward sustainability and green employment a powerful boost.

Various types of renewables subsidies have had considerable success in a number of countries. Providing favorable financing through low-interest loans for individuals and businesses can help create a market that otherwise might take a very long time to emerge and to climb to a scale where significant cost reductions become feasible. Germany's Solar Roofs programs (started as a 1,000 Roofs program in 1991 and expanded to 100,000 Roofs in 1998) is one such well-designed initiative. In China, the government supports biogas, solar energy, small hydro, and wind projects with low interest loans (at rates typically half those of a standard loan). In Nepal, the government subsidizes 75 percent of the cost of small biogas plants and solar-powered drinking water pumps used by families. Bangladesh's Grameen Bank has operated a loan program for household photovoltaic systems since 1996. Micro-lending for renewables could play a huge role in many developing countries and help create jobs.[50]

A distinction needs to be made between fossil fuel subsidies for producers and for consumers. On the consumer side, subsidies are often essential for the poor to gain access to energy and energy services. The poor often spend a much higher share of their income on heating fuels, electricity for cooling, and other forms of energy than those in the middle class, let alone the wealthiest in society. Without subsidies, they may not be able to afford commercial energy sources critical for their wellbeing and survival, or they may rely on highly polluting energy such as wood burning. A phase-out of fossil fuel-related subsidies needs to be accompanied by measures that make alternative energy affordable. This is yet another instance where environmental and social objectives need to be integrated.

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An employee of German Cell Ltd in Freiberg is stacking a machine producing solar cells in the sterile room. The company is owned by SolarWorld Corporation, Bonn, a share company listed in the TecDax. In one of the most advanced facilities worldwide, solar cells are produced using the most recent equipment with a high degree of automation under sterile and dust-free conditions. All processes are continuously improved by the firm's own research and development department. The products of SolarWorld Corp. are considered lead-free and therefore already exceed the legal limits to be expected. In addition to Germany, SolarWorld also manufactures in Sweden and in the United States.

Rethinking R&D Priorities

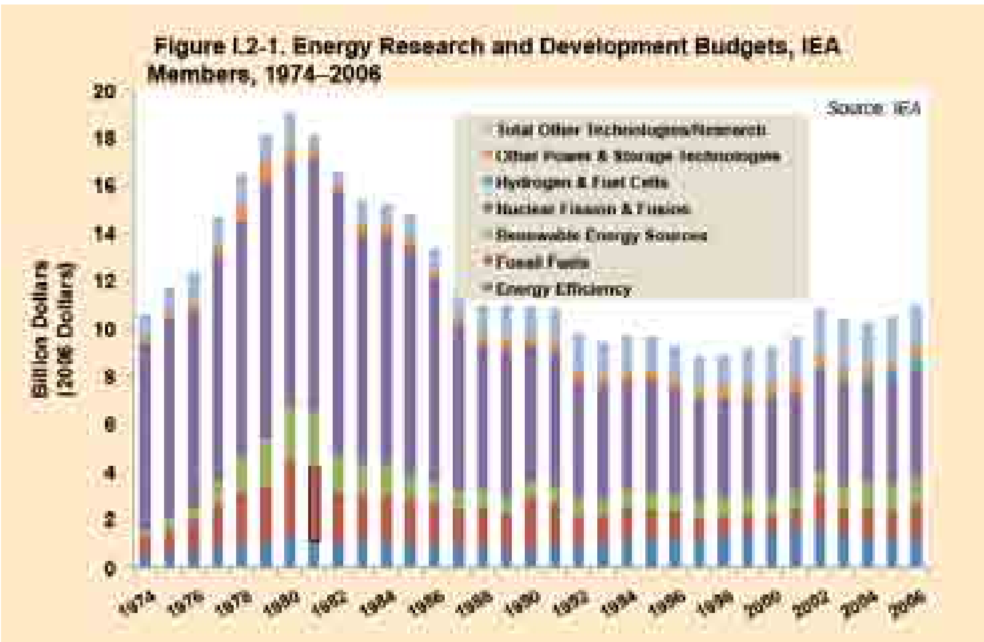
In addition to subsidies, conventional sources of energy including oil, gas, coal, and nuclear power have also long received generous R&D support from governments. Data for member states of the International Energy Agency—essentially wealthy Western industrialized countries—still indicate priorities that are highly inappropriate in the age of climate change. Although support for fossil fuels is now down from the levels of the 1980s, it is still quite generous for what, after all, is a highly mature industry. Nuclear technologies also continue to receive massive assistance.

On average, energy efficiency and renewable energy received a combined $2 billion per year in R&D support between 1974 and 2006, compared with $1.5 billion for fossil fuels and $6.7 billion for nuclear fission and fusion. Even though energy efficiency budgets increased in recent years, they peaked in 2002 and are now back to levels already reached in 1980. Support for renewables peaked in 1980 and is now at just slightly more than half that year's level.[51] (See Figure I.2-1.)

The Stern Review recommended doubling the aggregate amount of public funds devoted to energy R&D from the current level to about $20 billion per year. (According to the Renewable Energy Policy Network for the 21st Century—REN 21—public and private R&D funds devoted to renewables ran to about $16 billion in 2007.[52])

In the United States, both public and private energy R&D has declined. Corporate energy R&D spending fell by 50 percent between 1991 and 2003.[53] The federal government's energy R&D budget of $3.2 billion in 2006 was far less than the $8.5 billion spent in 1979. Renewables R&D is now one-sixth the 1980 level; energy-efficiency R&D stands at a little more than one-half of 1980 spending.[54]

Figure I.2-1. Energy Research and Development Budgets, IEA Members, 1974–2006



Dan Kammen of the University of California notes that the U.S. National Renewable Energy Laboratory budget and assistance to low-income families for home weatherization are both slated for cuts, and, "as a nation we invest less in energy research, development, and deployment than do a few large biotechnology firms in their own, private R&D budgets." This is a matter of priorities, rather than lack of resources: the decline in energy spending has occurred even as total U.S. R&D (and especially military R&D) has grown by 6 percent annually, and even though past R&D investments in solar technologies have led to strong improvements and cost reductions.[55]

In sharp contrast with the United States, Japan increased its R&D support for efficiency and renewables 2.5-fold between 1980 and 2006.[56]

International Development Assistance

The spending bias toward fossil fuels is also apparent in the budget priorities of international development institutions, export credit agencies, and bilateral development assistance programs. At $26.5 billion, World Bank funding for fossil fuel projects in the decade to 2004 exceeded that for renewable energy and efficiency (about $1.5 billion) by a factor of 18, and dwarfed the $650 million allocated by the Global Environment Facility to renewable energy projects in developing countries between 1992 and 2002.[57] By 2006, the World Bank had increased its support for energy efficiency projects ($447 million) and renewable energy ($412 million).[58]

Export credit agencies have provided massive funding for fossil fuel plants. By contrast, renewable energy projects account for a tiny share. For example, when the U.S. Export-Import Bank provided $28 billion in loans and guarantees for energy-related projects from 1990 to 2001, 93 percent went to fossil fuel projects and only 3 percent to renewable energy projects.[59]

Meanwhile, overseas development assistance (ODA) by members of the OECD has been heavily focused on hydropower, and the amounts provided have fluctuated heavily.[60] (See Table I.2-1.) Given the problematic nature of large-scale hydropower projects, these priorities need scrutiny. And the overall amounts will need to be scaled up dramatically. The Global Leadership for Climate Action—a task force of world leaders from over 20 countries—released a statement in October 2007 that estimated that about $50 billion per year will be needed for activities in developing countries in support of a comprehensive climate change agreement. Phased in from a starting level of $10 billion per year, such funding could come from increases in ODA (thus, a significant increase over current levels) and financing derived from the emerging carbon market (i.e., auctioning of emissions allowances).[61]

Table I.2-1. Overseas Development Assistance for Renewable Energy, 1999–2003

	1999	2000	2001	2002	2003
			(million dollars)		
Hydro	244	368	584	694	239
Geothermal	33	0.3	0	1.7	0.2
Solar	8	13	197	32	50
Wind	33	3	31	53	151
Ocean	0	0.003	0	0	0
Biomass	0.9	8.4	3.8	10.4	1.5
Total Non-Hydro	75	25	232	97	203

Note: Average for period for non-hydro renewables is $130 million/year, and for hydro $420 million/year.
Source: See Endnote 60 for this section.

Carbon Trading and Finance

Official development assistance accounts for a very small share of global financial flows, and analysts have pointed to alternative funding mechanisms. Carbon trading in general, and the Clean Development Mechanism (CDM) and Joint Implementation (JI) instruments included in the Kyoto Protocol in particular, have been cited as potential large-scale sources to support the development of renewable energy and energy efficiency, and thus green jobs. Companies and governments can acquire carbon credits by supporting specific emissions reduction projects, using either of these two mechanisms (with the CDM, targeting developing nations, so far playing a much larger role than the JI, targeted at former Communist countries). The European Union's Emission Trading Scheme (EU-ETS)—which currently accounts for the bulk of all carbon trading—specifically provides for such transactions.

In 2006, the value of CDM and JI projects amounted to about $4.4 billion (out of about $30 billion worth of carbon transactions).[62] According to estimates from the United Nations Framework Convention on Climate Change, international carbon finance flows to developing countries could eventually climb as high as $100 billion a year in coming decades, as carbon trading expands.[63] It is tempting to regard CDM-related flows as a way to overcome international financing strictures. But there are some major problems that need to be addressed:

- First is the highly slanted distribution of CDM projects. Analyzing the projects that are likely to take place between 2002 and 2012, China alone looks set to garner more than half—almost 53 percent—of all associated funds. Three other countries—India, Brazil, and South Korea—account for another 27 percent. Most of Latin America is largely losing out. And Sub-Saharan Africa weighs in with an abysmal 2 percent.[64]

- Second, the costs of certifying a project under CDM have so far been exorbitant, amounting on average to 14–22 percent of the projected revenue from selling project carbon credits. This is a barrier that poorer countries and smaller projects cannot overcome and limits what is ultimately available for actual green project and employment generation.[65]
- Third, the CDM approach has been narrowly project-focused and piecemeal. The process appears driven more by the needs and interests of private companies looking for cheap carbon credits than by a strategic assessment of the investment needs as developing countries move toward sustainable economies. Green employment will need to be strengthened as an objective of CDM projects.

Beyond CDM, if carbon trading is indeed to become a major funding source for climate mitigation and adaptation, then it is important that emissions rights be made available for sale. In the first phase of the EU-ETS, 95 percent of the permits were distributed for free to large emitters—effectively foregoing substantial revenue that could have been used to promote environmentally benign technologies, either within the European Union or abroad.[66] In addition, due to successful corporate lobbying, too many carbon permits had been allocated overall—more than actual emissions—causing carbon prices to fall to nearly zero before recovering somewhat. The cap set for 2008–2012 is just 2 percent below actual emissions for 2005, and at most 10 percent of permits can be distributed via auction.[67] Under these circumstances, cap-and-trade cannot become a tool for realizing lofty goals of carbon reductions. And revenue generation will remain extremely limited.

Ecological Tax Reform

Current tax systems discourage job creation even as they encourage resource consumption. Carbon taxes, levies on the use of nonrenewable energy and virgin materials, landfill fees, and other waste and pollution charges provide an incentive for manufacturers to move away from heavy fossil fuel use, to boost energy and materials productivity, and to curtail the generation of wastes and emissions. Rather than merely imposing a new tax, though, it makes sense to advance a shift in taxes. Current systems make natural resource use far too cheap and render labor too expensive. Using eco-tax revenues to lighten the tax burden now falling on labor (by deploying tax revenues to finance national health or social security funds that are now typically funded through payroll taxes) would help lower indirect labor costs and could thus boost job creation without hurting workers' interests.[68]

Discussed theoretically since the late 1970s, ecological tax shifting started to become a reality in the 1990s in a growing number of European countries. Denmark, Germany, Italy, the Netherlands, Norway, Sweden, and the United Kingdom introduced reforms linking a variety of green taxes to reductions in social security contributions. Before adjustment for inflation, environmental tax revenues in the EU more than quintupled between 1980 and 2004, to $364 billion (€266 billion).[69] (See Table I.2-2.) The bulk of these revenues are derived from taxes on gasoline and diesel, and on motor vehicles.[70]

Table I.2-2. Environmental Tax Revenue, European Union, Selected Years

Environmental Taxes	1980	1990	2000	2004
	(billion dollars)			
Revenues	74.8	178.6	332.6	365.0
	(percent)			
Revenues as Share of All Taxes and Social Contributions	5.8	6.2	6.7	6.7
Revenues as Share of Gross Domestic Product	2.2	2.5	2.8	2.7

Note: Data are for EU-15 members.
Source: See Endnote 69 for this section.

Unfortunately, eco-taxes are frequently weakened by a variety of loopholes—granting exemptions to certain industries or energy sources, applying reduced tax rates to energy-intensive firms, or making companies eligible for partial reimbursements. Often, this is done in the name of preserving the competitiveness of domestic industries on the world market. A recent study on Climate Change and Employment in the context of the European Union laments that, "the use of taxes to internalize the social costs of transport has so far run up against major forces of inertia within the Member States," and concludes that, "the use of energy taxes for European environmental ends still remains very little advanced."[71]

This is not to say that nothing has been accomplished. In Germany, for instance, an eco-tax levied on different forms of energy consumption was first introduced in 1999. By 2002, it had already helped avoid emissions of more than 7 million tons of carbon dioxide. Reductions in social security contributions made possible by these funds helped create 60,000 additional jobs by 2002 and possibly as many as 250,000 by 2005.[72]

The Policy Toolbox: Mandates

Extended Producer Responsibility

Green production—and employment—starts with the design of products that minimize resource inputs, avoid the generation of waste and emissions, and can easily be disassembled, recycled, remanufactured, or reused. To encourage companies to move in this direction and assess the full lifecycle impacts of their products, a growing number of governments are adopting "extended producer responsibility" (EPR) laws that require companies to take back products at the end of their useful life. These typically ban the landfilling and incineration of most products, establish minimum reuse and recycling requirements, specify whether producers are to be individually or collectively responsible for returned products, and stipulate whether producers may charge a fee when they take back products.

Part of the challenge is to develop materials that can easily be reused or otherwise will not linger in a landfill for centuries. For instance, German chemical giant BASF invented a new material made from an infinitely recyclable nylon-6 fiber; it can be taken back to its constituent resins and made into new products. The Swiss textile firm Rohner and the textile design company DesignTex jointly developed an upholstery fabric that, once it has been removed from a chair at the end of its useful life, will naturally decompose.[73]

The EPR philosophy had its beginnings in Germany's Packaging Ordinance of 1991, widely credited with motivating many other governments in Europe, Asia, and Latin America to embrace this concept (the United States, by contrast, is lagging behind). The EPR approach has spread far beyond packaging to encompass a growing range of products and industries, including consumer electronics and electric appliances, office machinery, cars, tires, furniture, paper goods, batteries, and construction materials.[74] (See Table I.2-3.)

Table I.2-3. Extended Producer Responsibility Laws, Selected Industries

Product Area/ Industry	Countries with EPR Laws
Packaging	More than 30 countries, including Brazil, China, the Czech Republic, Germany, Hungary, Japan, the Netherlands, Peru, Poland, South Korea, Sweden, Taiwan, and Uruguay (beverage containers only)
Electric & Electronic Equipment	Currently, more than a dozen countries, including Belgium, Brazil, China, Denmark, Germany (voluntary only), Italy, Japan, Netherlands, Norway, Portugal, South Korea, Sweden, Switzerland, and Taiwan.
Vehicles	Brazil, Denmark, France, Germany, Japan, Netherlands, Sweden, and Taiwan
Tires	Brazil, Finland, South Korea, Sweden, Taiwan, and Uruguay (considering voluntary measures)
Batteries	At least 15 countries, including Austria, Brazil, Germany, Japan, the Netherlands, Norway, Taiwan, and Uruguay (considering voluntary measures)

Note: Except for tires, EU Directives have been promulgated in all of the sectors covered in the table. In addition to national rules already adopted by a number of EU members independent of EU action, these Directives are binding on all member states.
Source: See Endnote 74 for this section.

Driven by concern over rapidly accumulating electrical and electronics waste from computers, cell phones, and similar equipment, the EU adopted an Electronic and Electrical Equipment Directive in February 2003. A companion directive on Restrictions on Hazardous Substances (RoHS) requires that manufacturers of electronic and electrical equipment no longer use lead, mercury, cadmium, hexavalent chromium, and the brominated flame retardants PBDE and PBB in products sold after July 1, 2006. There is growing concern worldwide about these hazardous materials; Japan is the leader in eliminating such substances from electrical and electronic products.[75]

Eco-Labeling

Eco-labeling programs "pull" the market by providing consumers with the requisite information to make responsible purchasing decisions, and hence encourage manufacturers to design and market more eco-friendly products. Labeling schemes have been developed for a wide range of products, including appliances, electricity, wood products, and agricultural goods such as coffee and bananas. Some focus on a single product or product class, whereas others evaluate a broad range of items.

The first, and most comprehensive, labeling program—Germany's Blue Angel—has been in existence for a quarter century. The number of products covered grew from about 100 in 1981 to 3,600 currently.[76] Another eco-label, developed in 1992 by the Swedish Confederation of Professional Employees (TCO), now extends to more than 7,000 products worldwide. More than 100 manufacturers have agreed to display the label on their products. TCO addresses aspects like energy efficiency, use of toxic chemicals, radiation exposure, health and safety, and ergonomics.[77]

Other prominent programs include the U.S. Energy Star label (initiated in 1992), and the Energy Saving Labeling Program and Top Runner Program in Japan.[78] The Energy Star appliance label is also being used in other countries like Japan, Australia, South Korea, and members of the European Union (for office equipment only). Unlike earlier criteria, which were less demanding, the new Energy Star requirements distinguish the top 25 percent of appliances in each product group.[79] Developing countries also have adopted or are developing eco-labels, including India, Indonesia, Thailand, and the Philippines. Thailand's Green Label involves some 148 brands in 39 product categories.[80] In India, the government has established criteria for 16 product groups under its 1991 Ecomark label.[81]

By 2005, 37 countries had adopted energy-efficiency labeling systems for appliances and electronic equipment. China has started labeling air conditioners and refrigerators with a goal of saving 18 billion kilowatt-hours of electricity by 2010 and 87 billion kilowatt-hours by 2020, and is planning to extend efficiency labels to television sets, irons, and electric fans.[82]

Labeling programs have mushroomed in recent years, to the point where competing labels can confuse consumers. Some programs, particularly industry-sponsored ones, may make vague or unsubstantiated claims concerning recycled content of a product, organic growing methods, biodegradability, and other issues. Others may be based on relatively low performance standards. Concerned about these problems, an OECD report argued: "To avoid a general discredit of labeling schemes, some kind of regulatory instruments may be needed to signal to consumers that certain schemes are more appropriate for certain issues than others." Qualified certification bodies may be needed to evaluate whether a product conforms to existing standards or verify the accuracy of environmental claims made by manufacturers.[83]

Another dimension that has received inadequate attention is the linkage between environmental labels and labor conditions. Many export-oriented economies, especially in Asia, rely on cheap and exploited labor, and a single-minded focus on greening the businesses involved is not enough. As this report argued earlier, there is a need to ensure that future jobs are not only green, but also decent with regard to wages, labor conditions, and workers' rights. In the future, labeling programs need to pay greater attention to integrating environmental and labor conditions.[84]

Energy Targets and Mandates

Regulatory tools play a crucial role in the drive to develop greener technologies, products, and services—and thus green employment. This includes land-use policies (for which jurisdiction tends to be on the local and regional, rather than national, level), building codes, various kinds of energy efficiency standards, and targets for renewable energy production.

A growing number of governments have mandated efficiency standards for household appliances. By 2000, for instance, 43 countries had such programs in place—seven times as many as in 1980. Most of these were in Europe and Asia.[85] The Australian Government, meanwhile, announced in February 2007 that all inefficient light bulbs will be phased out by 2009–2010 in favor of more efficient compact fluorescent lamps (CFLs). It expects that the move will reduce the country's greenhouse gas emissions by 4 million tons by 2012.[86]

The European Commission (EC) has issued directives on the energy performance of buildings and on the final uses of energy and energy services. The first, adopted in December 2005, asks member states to define national action plans that will yield annual energy savings of 1 percent during 2008–2017. The second came into effect in January 2006 and requires member states to establish minimum standards of energy performance for new buildings and large renovated buildings. The EC also issued a directive on the promotion of cogeneration in 2004.[87]

With regard to industrial energy efficiency, the Chinese government requires that the efficiency of pumps and fans be improved from a typical 75–80 percent in 2000 to 80–87 percent, and coal-fired industrial boilers from 65 percent to 70–80 percent (both by 2010). It has also mandated a reduction, between 2000 and 2020, of the energy needed per ton of steel produced from 906 kilograms of coal equivalent (kgce) to 700; for aluminum from 9.9 tons of coal equivalent to 9.2 tons; and for cement from 181 kgce to 129 kgce. These measures are ambitious, but also very difficult to implement.[88]

A number of countries have adopted either minimum vehicle fuel efficiency requirements or upper allowable limits for greenhouse gas emissions.[89] (See Table I.2-4.) Japan has mandatory passenger vehicle fuel economy standards, which were tightened further in 2006 with the goal of improving average vehicle fuel efficiency by 20 percent between 2004 and 2015.[90] Europe, focusing on greenhouse gas emissions, is poised to move from voluntary to mandatory measures.[91] In contrast with Europe and Japan, corporate average fuel economy (CAFE) standards have languished unimproved in the United States for the past quarter century. But in January 2007, California adopted a Low-Carbon Fuel Standard that requires a 10 percent decrease in the carbon intensity of California's transportation fuels by 2020.[92] China recently established standards that almost match levels prevalent in Japan and Europe, and are higher than those in the United States.[93] (See Box I.2-1.)

*Table I.2-4. Vehicle Fuel Efficiency and Greenhouse Gas Emissions Standards, Selected Countries**

Country/ Region	Target Unit	Decision Standard	Implementation
Fuel Efficiency			
Japan	Kilometers/liter	Weight-based	Mandatory
China	Liters/100 kilometers	Weight-based	Mandatory
United States	Miles per gallon	Single standard for cars; size-based for trucks	Mandatory
Australia	Liters/100 kilometers	Single standard	Voluntary
South Korea	Kilometers/liter	Engine size-based	Mandatory
Taiwan	Kilometers/liter	Engine size-based	Mandatory
Greenhouse Gas Emissions			
European Union	Grams/kilometer	Single standard	Voluntary**
Canada	5.3 ton reduction	Vehicle class-based	Voluntary
California	Grams/mile	Vehicle class-based	Mandatory

**Standards are applicable for new vehicles only, except for Canada (new and in-use).*
***EU is moving toward mandatory standards.*
Source: See Endnote 89 for this section.

Some 50 countries—including almost a dozen in the developing world—have established targets for renewable energy as part of their greenhouse gas reduction policies, either in the form of specific quantities of installed capacity or as a percentage of total consumption. The European Union has been in the forefront of goal-setting. In 1997, it adopted a goal of doubling the share of renewable energy to 12 percent by 2010. In 2001, the EU's Renewable Electricity Directive set a goal of increasing the share of renewables in electricity generation from 14 percent in 1997 to 21 percent by 2010.[94] And in March 2007, the European Council agreed on a binding target of a 20 percent share of renewable energies in overall energy consumption by 2020 (the actual share was less than 7 percent in 2005).[95]

Germany's Renewable Energy Sources Act set a target of at least 12.5 percent by 2010 for renewables' share in electricity production. But because this goal was already exceeded in 2007, the environment ministry is considering new mandatory targets of at least 27 percent in 2020 and 45 percent in 2030.[96]

Box I.2-1. China's Fuel Economy Standards: Policies and Current Status

China's oil consumption has been increasing, driven mainly by a fast expanding automobile fleet. Transportation accounted for 50 percent of oil consumption in 2005 and is expected to reach 87 percent by 2030. Oil import dependence and vehicle pollution are among the concerns behind China's recent efforts in improving vehicle fuel economy.

China is modeling its policy on the European approach, which assesses fuel consumption in conjunction with emission measurements. Initially adopting the European I emission standards (used in Europe in 1992), China began to enforce standards that correspond to the European III level in July 2007.

The Chinese government issued its first compulsory standards for controlling vehicle consumption, the Limits of Fuel Consumption for Passenger Cars, on September 2, 2004, and the policy became effective on July 1, 2005. For each of 16 vehicle weight classes, it establishes fuel consumption limits (ranging from 7.2 liters per 100 kilometers (km) for the lightest passenger cars to 15.5 liters per 100 km for the heaviest). In January 2008, a second phase tightens the allowable limits (with a range of 6.2–13.9 liters per 100 km). (China has also enacted its first compulsory limits on fuel consumption of light commercial vehicles, to take effect on February 1, 2008.)

Half of the car models currently on the market fail to meet the phase 1 standards. Most of them are based on outdated foreign technologies from the 1980s and are scheduled to be phased out soon. Fuel consumption limits for the second phase are 10 percent stricter than those of the first phase. The second phase will also see an update of the fuel consumption measurement methods based on the European III and IV emission standards.

Automakers have roughly three years to improve their technology to meet the first phase limits, and almost six years to meet the second phase limits. Cars that fail in this endeavor will be suspended from production or sales. The standards currently apply only to passenger cars manufactured in China, not to imported cars. Auxiliary policies are being formulated to assist enforcement. They include tax incentives for fuel efficient and environmentally friendly vehicles, tariff reductions for the imports of parts, punitive tax policies on oil guzzlers, and an environmental tax.

—Yingling Liu, Worldwatch Institute
Source: See Endnote 93 for this section.

Outside the European Union, a growing number of countries have established renewable energy targets. In non-EU Europe, they are Croatia, Norway, Switzerland, and Turkey; in North America, Canada, Mexico, and the United States; in South and Central America, Argentina, Brazil, and the Dominican Republic; in Asia/Oceania, Australia, China, India, Japan, Malaysia, New Zealand, Pakistan, the Philippines, Singapore, South Korea, and Thailand; in the Middle East, Egypt, Iran, Israel, Jordan, Morocco, Syria, and Tunisia; and in Sub-Saharan Africa, Mali, Nigeria, Senegal, South Africa, and Uganda.[97] The Chinese government set ambitious targets—the goal is to generate at least 15 percent of electricity from renewable energy sources by 2020.[98] (See Table I.2-5.)

Table I.2-5. Renewable Energy Production Targets in China

Energy Source	Unit	2006 actual	2010 target	2020 target
Wind Power	gigawatts	2.6	5	30
Biomass	gigawatts	2.0	5.5	30
Solar PV (grid)	gigawatts	0.08	0.3	1.8
Solar Hot Water	million square meters	100	150	300
Ethanol	million tons	1	2	10

Source: See Endnote 98 for this section.

Promotion of Energy Alternatives

The success of Germany and Japan in transforming themselves into leaders in renewable technologies in less than a decade is testament to the fact that proper policies play a more fundamental role than an ample resource base: long-term commitments, consistent policies, the use of gradually declining subsidies, and an emphasis on government R&D and market penetration.

Germany has adopted a range of successful policies that eliminated barriers to renewable energy development. Low-interest loans (some offered through the country's 100,000 Solar Roofs program) helped overcome the obstacle of high initial capital costs. Income tax credits drew investments of billions of Euros into renewable energy. But the policy with the greatest impact was an electricity feed-in law (*Strom-Einspeisungsgesetz*). Inspired by similar policies in Denmark, it was promulgated in 1990 and followed by successive measures, including the 2000 Renewable Energy Sources Act. The feed-in law requires utility companies to purchase electricity generated from renewable energy sources and established a minimum price. The law created certainty for investors and led to economies of scale as well as dramatic cost reductions.[99]

Japan's "New Sunshine" program, established in 1992, set renewable energy targets and led to a net-metering law that requires utilities to purchase excess PV power. In 1994, Japan launched a Solar Roofs program to promote PV through low-interest loans, a comprehensive education and awareness program, and rebates for grid-connected residential systems in return for data about systems operations and output.[100]

Around the world, governments have adopted a range of measures, including feed-in/pricing laws; quota systems such as renewable portfolio standards; tradable renewable energy certificates; capital subsidies, grants, or rebates; investment excise or other tax credits; sales tax, energy tax, or value-added tax (VAT) reductions; net metering; public investment, loans, or other financing; and public competitive bidding.[101] (See Table I.2-6.) About 40 countries, states, and provinces had enacted feed-in laws and renewable portfolio standards by 2006.[102]

Table I.2-6. Policies in Support of Renewable Energy Development

Policy Category	Policy Initiatives
Market Access	**Pricing Laws.** Guarantee producers of renewable energy fixed, minimum prices and obligate electric utilities to provide grid access. Fixed payments, also known as tarif s, are paid over several years, and typically decline over time to ref ect cost reductions. Costs are covered by energy taxes or an additional per-kilowatt-hour charge on electricity consumers. Germany, Spain, and Denmark have all adopted highly successful pricing laws that made them renewables leaders.
	Quota Systems. Governments set renewables targets and let the market determine prices. The most common form is the so-called Renewables Portfolio Standard (RPS). Texas' RPS led to rapid wind growth, but failed to encourage solar PV development. Under Tendering Systems, companies submit bids to a public authority for contracts to fulfill quota mandates. In the U.K., this approach facilitated financing, but led to uneven progress (f urries of activity followed by long lulls). The lack of deadlines delayed implementation of many projects.
	Net Metering. Can be used in conjunction with quota systems. It allows households and other energy consumers that install small renewable systems to sell excess electricity into the grid at wholesale market prices. Adopted in Canada, Japan, Thailand, several U.S. states, and some other countries.
Financial Incentives	**Investment subsidies, tax credits, rebates, loans, etc.** These and other mechanisms have been used to subsidize investment in technology development or to support power production from renewables in Europe, India, Japan, and the United States. California and India underwent wind energy booms with such policies. But their experience suggests that a lack of technology standards and overly generous tax breaks can lead to fraud and substandard equipment. In the United States, Congressional extension of a federal incentive program for wind energy, the Production Tax Credit (PTC), to the end of 2007 brought a much-needed window of stability. (Failure to enact timely extensions in earlier years—in 1999, 2001, and 2003—had caused a boom-and-bust cycle. The PTC's expiration in 2003, for example, led to the loss of more than 2,000 manufacturing and construction jobs and more than $2 billion in investments were put on hold.) Rebates appear preferable to tax breaks: Japan subsidized investment through rebates and saw dramatic successes in PV development. Some 24 U.S. states of er PV rebates as well. Low-interest, long-term loans and loan guarantees are essential to overcome high upfront capital costs, as experience in China, the Dominican Republic, India, Indonesia, and South Africa suggests.
Standards	**Standards.** Essential to ensure high-quality technologies, reduce associated risks, and attract investors. Denmark's 1979 wind turbine standards are credited with making the country the world's leading turbine manufacturer. Germany's 1991 turbine standards and certification requirements prevented quality control problems such as those experienced in California and India. Building codes can also be designed to require the incorporation of renewable into building designs. Spain, for instance, instituted a new building code in 2006 requiring all new large nonresidential buildings to generate a portion of their electricity with solar PV.
Vocational Training	**Training and certifying workers.** Essential to ensure that competent people are available to manufacture, install, and maintain renewable energy systems. Austria, India, and Germany are among the countries that have established successful training programs.

Sources: See Endnote 101 for this section.

Of various regulatory options, pricing laws have so far proved to be the most successful. Reviewing the experience in the European Union to date, the German environment ministry concludes that "feed-in regulations...are very effective in promoting wind energy. Quota systems with tradable certificates that have been implemented in some countries have thus far failed to produce comparable results. The costs are also higher than in countries with feed-in regulations."[103]

Several recent trends are indicative of the fact that the renewables industry is not yet self-sustaining. These include the U.S. experience with the on-again, off-again Production Tax Credit, German reports in late 2007 of weak renewables sales in the face of uncertainty about changes in government incentives, and indications of China's failure to date to develop a strong domestic market for solar cells.[104] Two U.S. industry groups, the American Wind Energy Association and the Solar Energy Industries Association, warned in early 2008 that non-renewal of renewable energy tax credits by the U.S. Congress would endanger some 116,000 jobs.[105] A stable policy framework, with regard to government incentives and rules, will continue to be critical for the speedy development of alternatives.

© Peter Duddek / VISUM / Still Pictures
Young woman trainee.

© (Freelens Pool) Tack / Still Pictures
Mobile phones have been become one of the major symbols of mass consumption in today's society.

3. Toward a New Production/ Consumption Model

Modern economies mobilize enormous quantities of fuels, metals, minerals, construction materials, and forestry and agricultural raw materials. The changes that are in place or in the works today have made the global economy more resource-efficient and have the potential to substantially reduce its reliance on fossil fuels. However, the limits of these changes are also evident. Gains in efficiency may simply be overwhelmed by continued economic growth. More far-reaching concepts—such as dematerialization, remanufacturing, "zero-waste," closed-loop systems, making products more durable and repairable, and replacing products with efficient services—have been discussed for some time, but need to be translated into reality on a more urgent basis.

A range of studies and assessments has affirmed the potential of a "dematerialization" strategy—which aims to reduce the amount of raw materials needed to create a product by, for example, making paper thinner and vehicles lighter, and to cut the amount of energy needed to operate products—from light bulbs to washing machines and automobiles. Specifically, the advocates of dematerialization have pushed for "Factor 10"—policies that aim at providing a given volume of goods and services with one-tenth as much material input.[106]

Advocates of "clean production" say that there are plenty of opportunities to reduce and perhaps eliminate the reliance on toxic materials in manufacturing, to prevent air and water pollution, and to avoid hazardous waste generation.[107]

There is also a need to question whether a system of unbridled consumption—well entrenched in Western industrialized countries, but spreading rapidly to the growing middle classes of countries like China and India—can ultimately be sustainable even with "leaner" ways of producing. This calls into question basic precepts of the economic system. It also requires more thought with regard to the future of employment and how best to share available work. Economic systems that are able to churn out huge volumes of products but require less and less labor to do so pose the dual challenge of environmental impact and unemployment. In the future, not only do jobs need to be more green, but their very essence may need to be redefined. A number of countries and companies have wrestled with proposals to reduce individuals' work time in order to share available work better among all those who desire work.

These are questions that mostly pertain to the richer countries. For countries at the other end of the spectrum, where poverty and deprivation, even food insecurity and hunger, dominate daily existence, these seem to be idle questions. In order to achieve a decent life, hundreds of millions of people will need to produce and consume more, not less. However, it is precisely because the global poor—close to 3 billion people—need to consume more that the need for the global consumer class of about 1.7 billion people to dramatically reduce theirs is so important. Stepping back from the environmental precipice and achieving greater equity in humanity's draw on Earth's resources requires nothing less. Rough calculations suggest that in order to accommodate these twin imperatives, the rich nations may need to cut their use of materials by as much as 90 percent over the next few decades. There are many ideas and proposals for accomplishing this task. Combining this quest with job creation and retention is the ultimate green jobs challenge.

The standard industrial "cradle-to-grave" approach means that raw materials are extracted and processed, and the substances not directly useful to a factory become unwanted waste. An alternative "cradle-to-cradle" system seeks to build integrated, closed-loop systems, in which the byproducts of one factory become the feedstock of another, instead of becoming environmental time bombs. [108]

Environmentalists widely regard the community of Kalundborg in Denmark as a trailblazer of industrial ecology. An increasingly dense web of symbiotic relationships among a number of local companies there has slowly been woven over the past three decades, yielding both economic and environmental gains. For instance, natural gas previously flared off by a refinery is being used as feedstock in a plasterboard factory, desulfurized fly-ash from a coal-fired power plant goes to a cement manufacturer, and nitrogen- and phosphorus-containing sludge from a pharmaceutical plant is used as fertilizer by nearby farms. This experience presents a real-life alternative to industrial orthodoxy. But replicating this model may not be all that easy. Setting up a zero-waste industrial symbiosis takes considerable time. And it may be more workable to construct such reciprocal webs piece by piece (as actually happened in Kalundborg) rather than drawing up overly ambitious plans from the outset.[109]

Finding new ways to reduce waste and pollution by closing the production loop requires close attention to production methods and workplace habits. Close inspection of existing arrangements in each factory implies a greater need for labor. The cost of adding employees for such purposes could be offset by the savings achieved from reduced waste and waste disposal costs. But in order to turn such a general observation into a more specific sense of what it might mean for added employment, it is necessary to implement and analyze specific cases.

Durability and Repairability

Resource productivity can be boosted not only through greater energy and materials efficiency, but also by moving the economy away from the idea that churning out products designed to fall apart easily is good for the economy and good for the consumer. Durability, repairability, and "upgradability" of products are essential to achieving sustainability. By working to extend and deepen useful product life, companies can squeeze vastly better performance out of the resources embodied in products—improving the productivity of these resources—rather than selling the largest possible quantity of products. Such a move will have implications for employment across the economy, in extractive industries, manufacturing, transportation, and services.

In today's industrial economies, many products, even some that are nominally durable, have become "commodified": large quantities can be manufactured with such ease and at such relatively little monetary cost that there is considerable incentive to regard them as throwaways rather than to produce them for durability. Consumer electronics such as mobile phones now have particularly short life cycles. If planned obsolescence rules, then not only is the use of energy and materials far higher than need be, but human dexterity, skill, and workmanship are also likely to be given low priority by management. Not just the product, but the labor that generates it, too, becomes a cheapened, undervalued commodity.

Many of today's consumer products are made in such a way as to discourage repair and replacement of parts, and sometimes even to render it impossible. And even when repair is possible, the cost is often too high relative to a new item. If repair and maintenance are not "worth the trouble," then most jobs in such occupations are condemned to vanish, as many have done in past decades. Although consumers have an obvious interest in cheap products, the price must be sufficiently high to justify ongoing maintenance, repair, or upgrading, and hence to make jobs in these occupations viable, satisfying, and well paying.

Over time, a durable product, such as a watch or a pair of shoes, with higher upfront cost of purchase will be economically more advantageous to consumers than cheaper, flimsier items that must be replaced frequently. Still, for certain items, the upfront cost could be steep, and this calls for the development of innovative financing plans. Where consumer credit is now geared to maintaining the hyper-throughput economy, allowing people to carry high personal debts and to rebound from insolvency in order to keep consuming, finance in a durable product economy will need to devise ways to make possible—and to reward—the purchase of long-life products.

Principles for Durability

Products can be designed and produced in such a way as to permit three characteristics crucial for durability: first, the ability to maintain, refurbish, repair, and upgrade them so that their useful life can be extended; second, the ease with which they can be taken apart so that components can be replaced or reconditioned as needed and materials salvaged for recycling or reuse; and third, the potential for remanufacture of products so that the value-added—the labor, energy, and materials embodied in the product when it was first made—can be recaptured. Studies at the Massachusetts Institute of Technology (MIT) and in Germany found that 85 percent or more of the original energy and materials typically are preserved in remanufacturing. Remanufacturing is more labor-intensive than the original manufacturing process and could therefore serve as a particularly appropriate approach in developing countries.[110]

For easy refurbishing and upgrading (so durability does not translate into technological obsolescence), a "modular" approach that permits easy access to individual parts and components is important. Computers serve as an obvious example here: standardized slots will accept components such as modems, sound cards, or memory chips virtually irrespective of which company made them. But the automobile industry, too, offers an illustration: DaimlerChrysler's "Smart" car has been designed with interchangeable body panels and other parts that allow for quick replacement.[111]

Companies like Xerox (in its copiers and printers) and Nortel (in telecommunications) have adopted this philosophy. By working to extend and deepen useful product life, companies can squeeze vastly better performance out of the resources embodied in products rather than selling the largest possible quantity. Although extended producer responsibility (EPR) laws do not as such address the issue of product longevity, they can be an incentive for companies to move in this direction.[112]

Job Implications

What are the job implications of these strategies? When goods do not wear out rapidly, they need not be replaced as frequently. An obvious implication is that fewer goods will be produced. While common sense might suggest that this would mean fewer employees are needed, this is not necessarily the case. To be sure, extractive industry jobs would again clearly be among the losers, but a shift to durability would also open up new opportunities. Using more robust materials, and processing and assembling them into longer-lasting, higher-quality products, implies a more craft-oriented, smaller-batch production process than the current mass-manufacturing practices—it takes more labor, and particularly more skilled labor. (This does not have to signal a return to the past, as modern techniques can help make materials more resistant to breakage and identify spots of structural weakness in products.)

More importantly, though, there will be greater opportunity and incentive to maintain, repair, upgrade, recycle, reuse, and remanufacture products, and thus there will be more job potential throughout the life of a product. These activities are all more labor-intensive and far less energy-intensive than producing new goods from virgin materials. Table I.3-1 offers a rough conceptual exploration of the likely employment implications.[113] A fuller evaluation would require detailed assessments of the specific changes and how they translate into job losses and opportunities for new employment.

Table I.3-1. Employment Implications of Durable, Repairable, and Upgradable Products

Product Life-Cycle Phase	Observation	Possible Job Effects
Design and Engineering	Intense redesign of products (and production processes) required	Positive
Energy and Materials Inputs	Fewer products; therefore, fewer raw material inputs needed but more robust materials required	Negative
Manufacturing/ Assembly	Fewer products; but production more attentive to durability and quality, and likely performed in smaller-batch mode	Mixed
Distribution/ Transport	Fewer products shipped to end consumer, but increased (local) circulation from users to repair shops, remanufacturers, materials salvagers, etc., and back to consumers	Mixed
Maintenance	Revitalizing almost-abandoned functions; labor-intensive	Positive
Re-Manufacturing	Currently limited; more labor-intensive than initial manufacturing	Positive
Upgrading	Currently limited; labor-intensive	Positive
Consulting/ Performance Contracting	Advice on maximizing product utility and extending product-life; guidance on substituting services for goods	Positive
Disposal at End of Life-Cycle/ Reuse and Recycling	Fewer products to be disposed of, but more recycling and disassembly of parts and components for reuse; more labor-intensive than landfilling and incineration	Positive

Source: See Endnote 113 for this section.

Transportation Shifts

An economy that embraces durability will require a transportation system different in its structure and mix of modes, and this, too, would mean changes in employment. The current system handles and delivers raw materials and components and final consumer goods through a dizzyingly complex global network. The resource consumption and environmental impact of this worldwide network are substantial and growing. Instead of today's "making-disposing" system, with its mostly one-way flow of raw materials, products, and waste, a "making-unmaking-remaking" system would emerge—able to collect and take back products that need to be repaired or upgraded and then redistributed to consumers, as well as those disassembled for remanufacturing or for salvaging of parts and materials.

Such a system would probably be focused less on long-distance supplies and deliveries and more on interchanges within local and regional economies. Accordingly, there would likely be fewer long-distance truckers and more local delivery and pick-up van drivers, fewer freight pilots and handlers and more people employed in facilities where old products are sorted and returned to the original manufacturer or to other firms that can make use of components and materials.

A New Service Economy

Most service establishments are directly responsible for very little pollution and environmental degradation. But although nobody in the service sector wields chainsaws to cut down old-growth forests or operates the machinery that turns mountainsides into piles of ores and toxic tailings, this segment of the economy is currently still very much a part of the resource-intensive economy—the grease that lubricates the industrial system. By coordinating, facilitating, and financing resource extraction and processing; by providing distribution channels (wholesale and retail) for unsustainably produced goods; and by shaping real estate development that usually translates into sprawling, resource-inefficient settlement patterns, many service jobs are inextricably linked to oil drilling, strip-mining, forest clear-cutting, paper pulping, and metals smelting.[114]

Today's retail jobs depend on large-scale purchases of "stuff"—in principle, anything that sells, no matter what the quality and durability. Discount retailers in particular have led the trend toward a part-time, low-paid sales force. In such a quantity-focused environment, fewer consumer purchases translate into fewer retail jobs. The challenge is to generate service jobs that facilitate a shift away from our current resource-intensive forms of production and consumption, rather than to reinforce these patterns.

A sustainable economy implies an emphasis on "quality retail," in which the salesperson knows how to sell intelligent use rather than simple ownership. This means advising consumers on the quality and upkeep of products; counseling them on how to extend usefulness with the least amount of energy and materials use; and diagnosing whether upgrades or other changes may maximize the usefulness of a product. Because such a system is not geared to increasing materials use—focusing merely on getting products out of the showroom or off the store shelf—but instead to ensuring consumer utility and satisfaction, it entails jobs with higher skills, and pay. It also implies expanded education and training.[115]

Such changes in the way products are retailed build on an argument that has been put forward by Amory Lovins, co-founder of the Rocky Mountain Institute, since the 1970s: "People do not want electricity or oil...but rather comfortable rooms, light, vehicular motion, food, tables, and other real things." Nor do workers' jobs—outside the extractive and primary-processing industries, at any rate—have to depend on maintaining such a huge quantity of materials flow. Both consumers' and workers' interests can be safeguarded at much lower levels of resource use and with far less environmental impact.[116] In Natural Capitalism, Amory Lovins and co-authors Hunter Lovins and Paul Hawken make the case for "a new perception of value, a shift from the acquisition of goods as a measure of af uence to an economy where the continuous receipt of quality, utility, and performance promotes wellbeing." In such a new kind of service economy (quite unlike what we now mean by the term "service sector"), manufacturers no longer sell products with an "out-of-sight, out-of mind" approach. Instead, consumers obtain desired services by leasing or renting goods rather than buying them outright. Manufacturers retain ownership of the product, are responsible for proper upkeep and repair, take the necessary steps to extend product life, and ultimately recover the item's components and materials for recycling, reuse, or remanufacturing.[117]

Selling Performance

Because corporate revenues and profits would no longer be derived from selling a maximum quantity of stuff, but rather from squeezing the most service and best performance out of a product, companies would have a vested interest in ensuring product quality, durability, upgradability, and reusability. They would have a strong interest in minimizing energy and materials consumption and maximizing the utility of the product. Such a shift would be good for employment because it changes the focus from the input of energy and materials into the production process—which does not generate a significant number of jobs—to making intelligent, and sparing, use of resources. And that would require more skilled people.[118]

There are several examples of companies that have begun to translate the concept of product performance into reality. Agfa-Gevaert, for instance, pioneered the leasing of copier services, in place of selling copy machines. Instead of selling air-conditioning equipment, Carrier Corp. is creating a program to sell "coolth"—the opposite of warmth. The company is also increasingly looking into lighting retrofits, the installation of energy-efficient windows, and other measures at customers' facilities that will help reduce air-conditioning needs and make the provision of coolth easier (and more profitable).[119]

In a similar vein, we see the emergence of "performance contracting." Companies dedicated to this principle measure their success by the degree to which they help their customers—private sector firms, government agencies, hospitals, and others—cut their use of energy, raw materials, and water, and therefore the bills for these inputs. They are paid with a share of the achieved savings. In marked contrast to traditional business interests, it is avoided resource consumption and prevented waste and pollution that makes such companies thrive.[120] In the United States, energy services companies that earn most of their money by delivering efficiency services to utilities, state and local governments, and other customers, are estimated to have had revenues of $3.6 billion in 2006. With the exception of the period 2001–04, they have experienced annual growth of about 20 percent in their business since 1990.[121]

The concept of focusing on performance rather than increasing inputs is catching on even in one of the most pollution-intensive industries: cleaning. Dow Chemical and Safety-Kleen have begun to lease organic solvents to industrial and commercial customers, advising them on their proper use, and recovering these chemicals instead of leaving the customer responsible for disposing of them. A German subsidiary of Dow Chemical, SafeChem, is planning to take this a step further, charging customers by the square meter degreased rather than by the liter of solvents used. Selling a service instead of the chemicals gives SafeChem a strong incentive to use fewer solvents.[122]

Perhaps the most often-cited example of companies reinventing themselves as new types of service providers is Interface, the world's largest commercial carpet manufacturer.[123] (See Box I.3-1.) Although Interface's strategy suggests less carpet manufacturing than in the past, it has not resulted in fewer jobs because volume production has been replaced with a far greater emphasis on quality inspections, upkeep, and remanufacturing operations. While revenues doubled and profits tripled, Interface boosted its employment by 73 percent between 1993 and 1998, to more than 7,700 employees worldwide.[124]

Box I.3-1. The Interface Experience

In the 1990s, Interface launched a transition from selling to leasing office carpets. It remains responsible for keeping the carpet clean, in return for a monthly fee. Regular inspections permit the company to focus on replacing just the 10–20 percent of carpet tiles that show most of the wear and tear, instead of the entire carpet, as in past practice. This more targeted replacement helps reduce the amount of material required by some 80 percent.

Interface has also made strides toward making the carpet material more durable. It developed a new material called solenium that lasts four times as long as traditional carpets, but uses up to 40 percent less raw material and embodied energy. In addition, used carpets can be completely remanufactured into new carpets, instead of being thrown away or "down-cycled" into less valuable products.

The company's accomplishments over the past decade are impressive. Between 1996 and 2007, the amount of waste sent to landfills from its manufacturing facilities decreased by 66 percent. During that time, the company's "ReEntry" program reclaimed a total of 60 million pounds (about 30,000 metric tons) of carpet material that otherwise would have been sent to landfills. Meanwhile, the percentage of recycled and bio-based materials used to manufacture products has increased from 0.5 percent to 25 percent. Energy use per square yard of carpet produced has been cut by 45 percent, and the share of renewable energy has risen from zero to 27 percent. Total greenhouse gas emissions are down 33 percent.

Source: See Endnote 123 for this section.

What is true for Interface and other pioneering firms is likely to hold up more generally. Moving toward a new service economy that radically reduces material inputs does not have to be bad news for jobs. Clearly, there will be less demand for energy and materials than in the past, and this will reinforce the already obvious downward trend of employment in extractive industries and in primary materials processing. But these losses will be more than counterbalanced by manufacturing operations that are focused on producing high-quality products (and therefore more interesting jobs), by job opportunities in repairing and upgrading products, and by new service occupations that help customers get the best possible performance out of the lowest possible quantity of resources. Resource productivity, not additional labor productivity gains, will be key.

Rethinking Consumption

More-efficient and cleaner technologies are essential instruments in the sustainability toolbox—promising to moderate modern economies' draw on resources. And the emergence of a new type of service economy will provide additional maneuvering space in the quest for a more sustainable economy. Sooner rather than later, however, we need to confront the specter of insatiable consumerism itself. There is a danger that the consumer juggernaut will overwhelm even the most sophisticated methods and technologies that can be devised to make consumption lean and super-efficient. Consuming better does not obviate the need to consider moderation in overall consumption levels. It is worth recalling ecological economist Herman Daly's warning that "to do more efficiently that which should not be done in the first place is no cause for rejoicing."[125] And Wolfgang Sachs of the Wuppertal Institute in Germany has cautioned that we need to think as much about sufficiency as efficiency.

How societies go about the task of discouraging "excessive" consumption (at least in the wealthy countries; the world's poor, by contrast, indisputably need to increase their consumption if they are to leave behind conditions of misery) is not part of the remit of this report. But what needs scrutiny is the predominance of highly individualized consumption patterns that inevitably lead to the multiplication of many goods and services on a grand scale—a redundancy that implies far greater material requirements than necessary. The balance of public and private consumption needs as much attention as the development of less-polluting technologies.

Government action is indispensable in overcoming the immense structural impediments to lowering consumption levels and to more public forms of consumption. Nowhere is this more pronounced than in transportation: low-density, sprawling settlement patterns translate into large distances separating homes, workplaces, schools, and stores—rendering public transit, biking, and walking difficult or impossible. While the decision as to what kind of automobile to buy is up to consumers, the more basic decision whether to buy one at all is frequently out of their control. Likewise in housing, homeowners have a range of choices for heating and air-conditioning. But it is in developers' and builders' hands whether a house incorporates adequate insulation and energy-efficient windows; these fundamental decisions dictate heating and cooling needs over the life of the house.

In recognition of these realities, the Organisation for Economic Co-operation and Development (OECD) has referred to an "infrastructure of consumption" that compels people to engage in involuntary patterns of consumption.[126] As important as it is for consumers to choose more-efficient products, this alone cannot overcome these structural constraints. Forward-looking government policies—improved land-use planning, environment-oriented norms and standards, and the creation of a reinvigorated public infrastructure that allows for greater social provision of certain goods and services—will help ensure that consumers are not overly compelled to make consumption-intensive choices.

Another key area where government action is needed is consumer credit. Whereas consumer credit is now geared to maintaining the hyper-throughput economy, which encourages people to carry high personal debts, finance in a sustainable consumption economy will need to devise ways to allow—and to reward—the purchase of efficient, high-quality, durable, and environment-friendly products. These undoubtedly have a higher upfront cost of purchase, but over time such items will be economically more advantageous to consumers than cheaper, flimsier items that must be replaced frequently. Governments could help consumers by offering advantageous credit terms for "green" purchases (and this could be linked to green labeling programs). The Japanese and German governments do this to support the installation of solar roofs on private homes, but many other eco-friendly purchases could be encouraged in the same way. Or, governments can offer targeted rebates for green purchases or energy efficiency upgrades and retrofits.

To further encourage the manufacture and purchase of environmentally benign products, governments could design policies that offer tax rebates for the best-performing products while taxing those that fall short of standards. A graduated system could be constructed in which rates of both rebates and fees are scaled according to how efficient, longlasting, or otherwise environment friendly an item is. Such a blend, known as a "feebate," has been used to some extent vis-à-vis energy producers, but the concept has not yet been implemented in a consumer setting.[127] A feebate system might even be more effective if hitched up with other policies, such as eco-labeling and EPR laws.

A New Approach to Work Hours

Industrial economies are extraordinarily productive—meaning that the same quantity of output can be produced with less and less human work. In principle, this can translate into either of two objectives: raising wages (in line with productivity) while holding working hours constant, or providing greater leisure time while holding income from wages constant. In practice, it has mostly been the former. Most people have been locked into a "work-and-spend" pattern.

Since the rise of mass industrialization in the late 19th century, there has been an ongoing tug-of-war between employers and unions over working hours. Employees have struggled for less work time—in the form of shortened workdays or weeks, extended vacation time, earlier retirement, or paid leave. These efforts were primarily motivated by a desire to improve the quality of life and to create more jobs. While environmental issues have not played a central role, channeling productivity gains toward more leisure time instead of higher wages that can translate into ever-rising consumption also increasingly makes sense from an ecological perspective.

It took close to a century to arrive at the 40-hour workweek in most industrial countries. Most employers have been very reluctant to agree to more reductions, and a shift in the employer-union balance of power, with waning union strength and rising pressure from globalization, has made further change difficult. By and large, a full-time job at something like 40 hours per week is still considered the norm for anyone wanting to be considered eligible for employment with career advancement opportunities.

But the discussion has shifted from fixed weekly hours to introducing greater flexibility, with employers and employees promoting competing notions and interests. Employers are seeking the ability to turn the spigot of labor supply on and off according to fluctuations in the demand for their products. Employee demands center on more individual options to accommodate personal and family needs and to achieve greater "time sovereignty." Americans are increasingly working longer hours than Europeans. Japanese, Koreans, and Chinese work some of the longest hours anywhere in the industrialized world. And of course, many people in the world feel compelled to work long hours simply to make ends meet. But several promising approaches to work time have emerged in Europe.[128] (See Table I.3–2.) These may form the basis for new concepts of how to better share available work.

Table I.3-2. New Approaches to Work Time in Europe

Country	Status
Belgium	Established a "time credit" system that allows individuals to work a four-day week for up to five years and to take a one-year leave of absence during a career while receiving a paid allowance from the state.
Denmark	Pioneered a system of paid educational, childcare, and sabbatical leaves that allows job rotation between the employed and unemployed. (Variants were later put in place by Belgium, Finland, and Sweden.)
Netherlands	In 1982, government, business, and labor agreed on work-time reductions in return for wage moderation. Length of workweek was cut from 40 to 38 hours in the mid-1980s and to 36 hours in early 1990s. Voluntary part-time work expanded dramatically, with part-time workers legally entitled to the same hourly pay, benefits, and promotional opportunities as full-timers. Legislation in 2000 extended the right to reduce hours to all workers, while part-timers can request longer hours.

Source: See Endnote 128 for this section.

The discussion about work-time reductions has progressed in starts and fits and remains controversial. Proponents have principally been interested in the potential benefits that such initiatives would bring with regard to reduced unemployment and gains in quality of life. But this is also an issue that relates to environmental challenges. If the work-and-spend pattern can be broken, and if reduced work hours still allow people to make ends meet—admittedly big "ifs"—then the environmentally destructive impacts of consumerism could be reduced. At the same time, these are issues that will remain applicable only to a portion of humanity. For the majority that struggles to escape poverty, long work hours are, at least for the time being, an inescapable reality.

Certainly, a large and sudden decline in consumer spending would likely send the world economy—premised on endless growth—into a tailspin and cause major unemployment. But moving toward a less consumptive economy more gradually and deliberately would allow time to reorient how the economy functions, giving companies and employees an opportunity to adjust. Smoothing a transition will be a series of investments and technological innovations to accomplish the shift toward sustainability. Promoting renewable energy sources; expanding public transit systems; replacing inefficient machinery, equipment, buildings, and vehicles with far more efficient models; redesigning products for durability—all of these activities amount in effect to an ecological stimulus program for the economy.

It is crucial to retool not only the economy, but also economic thought. Right now, economic actors are primed to respond to quantitative growth signals. The concept of the gross domestic product, in which all economic activities are lumped together whether they contribute to or detract from well-being, still reigns supreme. A sustainable economy needs a different way of measuring human activity and of providing signals to investors, producers, and consumers. It needs a different theory, abandoning the outdated assumption that quantitative growth is unconditionally desirable and embracing instead the notion of qualitative growth.

Most fundamental, though, is a shift in human perceptions of economic value. In ***Natural Capitalism***, Amory Lovins and co-authors Hunter Lovins and Paul Hawken make the case for "a new perception of value, a shift from the acquisition of goods as a measure of af uence to an economy where the continuous receipt of quality, utility, and performance promotes well-being." In such an economy, corporate revenues and profits would no longer be associated with maximizing the quantity of stuff produced and sold, but rather with deriving the most service and best performance out of a product, and therefore from minimizing energy and materials consumption and maximizing quality.[129] And such an economy would offer much broader scope for green employment.

Part II
Employment Impacts

Opponents of strong environmental measures have time and again presented the argument that such policies would spell economic doom. Time and again, however, they have been shown to be wrong. On the contrary, three key truths are emerging:

- Economic activity and employment depend in fundamental ways on avoiding continued resource depletion and safeguarding ecosystems and ecological services.
- If action on urgent environmental problems, especially countering climate change, is not taken, many jobs could be lost to resource depletion, biodiversity loss, increasing disasters, and other disruptions.
- On the other hand, environmental policies not only protect existing jobs against these threats, but also stimulate new businesses and job creation.

The following sections of this report assess the numbers of green jobs that have already been created and are likely to be created in coming years, in six economic sectors: alternative (renewable) energy, the building sector (including appliances and office equipment), transportation, basic industry and materials recycling, food and agriculture, and forestry.

It is worth pausing for a moment to briefly consider the likely employment repercussions of not taking action. In agriculture, animal husbandry, forestry, and fisheries, jobs and livelihoods may be lost as a result of increasing drought, desertification, and climate change. Employment in the tourism industry is feeling the impacts as glaciers recede and ski areas lack snow, or as resorts in warmer zones of the planet are affected by shortages of water or the spread of contagious diseases. Jobs in the insurance sector may be endangered as companies are hard hit by rising claims—although on the other hand, there is also a rising need for experts in risk assessment and damage evaluation. Businesses and employment will suffer in the face of more-frequent and powerful storms and flooding, as buildings, production equipment, and infrastructure are damaged or destroyed. Pandemics linked to the spread of infectious diseases in a warming world could affect labor productivity. Jobs in the energy industry will be affected by countervailing trends, as warmer winters reduce the need for heating, yet hotter summers increase demand for cooling.[130]

Ideally, prevention is far preferable to remedial efforts. However, especially with regard to climate change, this is no longer an option. Scientists and environmentalists have long warned that the world needs to take action to mitigate climate change. Yet political deadlock has delayed timely and adequate responses to the point where mitigation alone is clearly insufficient. Adaptation to the consequences of climate change has become an equally pressing need.

Adaptive efforts could in coming years and decades become a major source of employment. The National Adaptation Programs of Action submitted by several (mostly African) governments to the United Nations Framework Convention on Climate Change (UNFCCC) highlight priority projects. Among others, they include protective measures against rising sea levels and storm surges, reforestation, enhancing the resilience of infrastructure and industries, information dissemination to better prepare vulnerable communities against climate disasters, flood-shelter construction, water provision to coastal communities affected by salt water intrusion, and research into more hardy, drought-resistant and saline-tolerant crops.[131]

Community participation is critical to ensure that proposed measures are appropriate and contribute to improving livelihoods and incomes. So is the provision of adequate funding. With such funding, climate adaptation can become a source of millions of jobs and protect many millions of endangered livelihoods.

Construction of a wind engine by workers. Germany.

1. Energy Supply Alternatives

This section analyzes the economic and employment prospects of alternative sources of energy to the dominant fossil fuel sources—oil, natural gas, and coal. Some governments and others have proposed an expansion of nuclear power as part of the solution. For the purposes of this report, nuclear power is not considered an environmentally acceptable alternative to fossil fuels, given unresolved safety, health, and environmental issues with regard to the operations of power plants and the dangerous, long-lived waste products that result. Being capital-intensive, the nuclear energy industry is also not a major employer, and is thus similarly ill-suited as a solution to the world's employment challenges. Trends in nuclear energy's development—influenced by issues such as safety and cost—contradict rosy assessments. Although it is still growing somewhat, world nuclear generating capacity has slowed down dramatically beginning in 1990 (capacity additions in the 16 years since 1990 are equivalent only to earlier additions in 1986–90).[132]

Advocates for the coal industry have similarly argued that new technologies may give this heavily polluting energy source a new lease on life. "Clean coal" is a frequently used term for efforts to reduce the carbon emissions associated with coal use. But it is a misleading name. From mining to burning coal to produce electricity, this is still an industry with calamitous environmental and health impacts. Coal mining—especially where companies blast away entire mountaintops in order to lay bare deposits of coal—is unalterably environmentally destructive. For many workers, coal mining remains a dangerous and unhealthy occupation.[133]

Still, heavy reliance on coal appears to be an unavoidable reality for a number of years. Not only are there already many coal-fired power plants in operation worldwide, but expansion is particularly rapid in China and to a lesser extent in India and the United States.[134] Representing heavy investments sunk into them, coal-fired power plants constructed today will likely be around for several decades. Thus, any climate-mitigation strategy will have to consider ways of minimizing or neutralizing carbon emissions from already existing coal plants. Carbon capture and sequestration (CCS) might be of help in this regard, though many questions remain concerning feasibility and cost. And an inherent danger of a sequestration strategy is that instead of being a pragmatic measure for dealing with carbon emissions from existing plants, it may well tempt governments, businesses, and labor unions toward an even greater commitment to coal, even though CCS is unlikely to create many jobs. This temptation is reinforced by the fact that captured CO_2, if injected into oil and gas wells, can be used to squeeze more of these resources out of the ground.

With regard to both nuclear power and coal, continued heavy investments may draw critical resources (R&D, investment capital, as well as scientists, engineers, and technicians) away from the pursuit of alternatives such as renewable energy and greater energy efficiency. A Greenpeace report notes that in its 2009 budget request, the U.S. government seeks a 26 percent increase in CCS-related programs to $624 million even as it is asking for a 27 percent cut in renewable energy and efficiency budgets to $146 million.[135] An indication of how expensive CCS projects are likely to be was provided when the U.S. government terminated its participation in the much-touted FutureGen "clean coal"/CSS public-private venture in January 2008, principally due to cost overruns. All told, in 2007 at least 11 CCS projects were scrapped in countries including Canada, Norway, and the United Kingdom.[136]

Given troubling environmental, waste, health, and cost issues with regard to nuclear power and coal, this section focuses on a range of renewable energy sources—wind-generated electricity, solar photovoltaics (PV), solar thermal energy, biomass, geothermal energy, and hydroelectricity. It should be noted that not all fuels derived from biomass necessarily offer meaningful carbon emission advantages over fossil fuels, and some may even impose new environmental costs. A careful distinction within the biofuels sector is thus advisable. A similar word of caution is in order with regard to hydroelectricity: large-scale dams impose huge environmental costs and displace millions of people. They cannot therefore be considered an acceptable alternative. Some reports make a distinction between small- and large-scale hydro projects, but others do not.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Geothermal power.

Moving away from the current heavy reliance on fossil fuels will without doubt have negative job implications in the oil, gas, and coal industries. The section therefore first, and very briefly, addresses employment levels and trends in these industries. In a later section, the report also addresses the issue of transition assistance to workers affected by a future move away from fossil fuels.

The section then considers employment in the emerging renewables industries on the basis of available surveys, studies, and projections. It does so first by having an across-the-board look, examining evidence of currently existing jobs as well as assessing the future job-creation potential. Subsequently, the section addresses each of the major renewables sources in their own right: wind-generated electricity, solar PV, solar thermal, biofuels, geothermal, and small hydropower, with evidence from countries around the world.

In the face of rapidly growing demand for energy, an alternative supply strategy will need to combine alternative sources of supply with greater efficiency. The potential for efficiency gains in buildings, transportation, and selected industries will be addressed in subsequent sections of Part II.

Employment Trends In Extractive Industries

Extractive industries—the fossil fuel sector and other mining industries—do not employ many people. In fact, growing mechanization translates into fewer and fewer jobs with each passing year in most countries, irrespective of environmental efforts.[137] (See Table II.1-1.)

Table II.1-1. Mining Employment in Selected Countries, 1996–2006

Country	1996	2006	Change
	(thousands)		(percent)
China*	9,020	5,580	-38
Romania	241	120	-50
Ukraine**	4,390	4,037	-7
Slovakia	34	16	-52
South Africa†	603	398	-34
United States††	569	687	+21
United Kingdom§	107	103	-4
Malaysia‡	35	27	-22

Note: Includes coal and metals mining and oil and gas extraction jobs.
**Data are for the years between 1996 and 2002. **Data are for 2001 and 2006. †Data are for 2000 and 2006. ††Employment has peaked three times in 1998, 2001 and 2004. §Data are for 1997 and 2005. ‡Data are for 1996 and 2000.*
Source: See Endnote 137 for this section.

The coal industry is increasingly characterized by bigger and fewer companies, larger equipment, and less and less need for labor. The effect has been a steady decline in the number of people employed in coal mining, which accounted for less than 1 percent of the global workforce in 2002.[138] In addition, global mining and quarrying have shown an average decline of more than 20 percent in 1995–2005.[139]

- In Europe, U.K. coal production has declined steeply, and employment evaporated from 229,000 in 1981 to about 5,500 miners today.[140] (Some 4,000 former miners have found jobs retrofitting homes to make them more energy-efficient, but about 100,000 remain long-term unemployed.[141]) And in Germany, productivity gains and rising coal imports translate into a projected decline in employment from 265,000 in 1991 to less than 80,000 by 2020.[142]

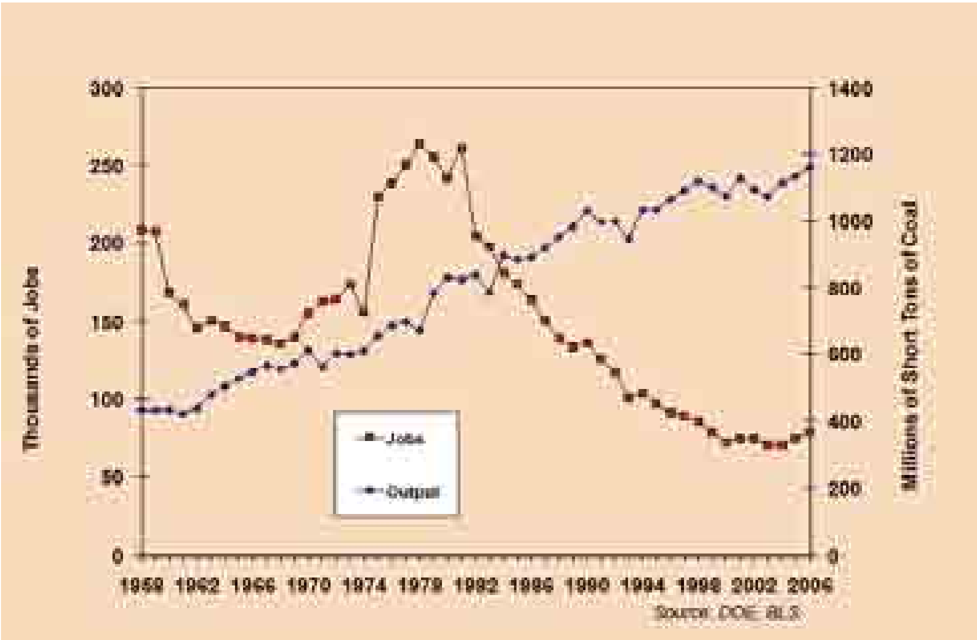
- China—the world's largest coal producer—cut some 870,000 jobs in the second half of the 1990s.[143] The growth of production has slowed in recent years, from 15 percent to 8 percent. Employment in China's quarrying and mining sectors has fallen steadily as well, with a total loss in jobs of 31 percent between 1997 and 2002.[144] But China continues to add huge capacities in coal-fired power plants—209,000 megawatts in 2006 and 2007 alone. Modern plants employ very few workers: one in southern China near the Vietnamese border needs just 270 workers for a 1,200 megawatt facility (compared with older plants that employ up to 1,000 people in a 50 or 100 megawatt facility).[145]

- In the United States, coal production rose by close to one-third during the past two decades, but mining employment was cut in half, to 79,000 in 2006. Production has shifted from more labor-intensive underground mines in the eastern United States to surface strip-mines in the West.[146] (See

Figure II.1-1) Although production is expected to continue to grow, employment is likely to decline by 23 percent through 2014 as more efficient techniques are used in extraction and processing, requiring less direct labor.[147]

- In South Africa, coal production grew by about 10 percent between 1999 and 2005, while total mining and quarrying employment declined from 603,000 to 398,000 jobs over the same period.[148]

Figure II.1-1. U.S. Coal Mining, Output and Jobs, 1958–2006



Similar trends dominate the refining and utility sectors. For example, almost 40 percent of U.S. oil-refining jobs disappeared between 1980 and 1999; another 8 percent decline occurred between 2001 and 2006.[149] In EU countries, more than 150,000 utility and gas industry jobs disappeared in the second half of the 1990s, and another 200,000 jobs—one in five—were projected to be lost by 2004.[150] By a different reckoning, the decrease in employment in Europe's electricity-generating sector is likely to have amounted to some 300,000 jobs since 1997. Market liberalization programs, privatization, and general technical progress (i.e., growing labor productivity) were the driving forces behind this development.[151]

Investment in Renewables

Growing awareness of the threat of climate change, rising prices for fossil fuels, and growing concerns over energy supply security are among the driving factors of increased interest in renewable energy sources. Global investment in renewable energy is exploding. Excluding large-scale hydropower, it has grown from $10 billion in 1998 to $20 billion in 2003, $38 billion in 2005, more than $50 billion in 2006, and an estimated $66 billion in 2007.[152] UNEP's "Global Trends in Sustainable Energy Investment

2007" casts a somewhat wider net and puts investment in sustainable energy worldwide at $70.9 billion in 2006, with a forecast of $85 billion for 2007.[153] Although renewable energy still accounts for only 2 percent of worldwide installed power-generating capacity, it garnered 18 percent of all investment in power-generation facilities and equipment.[154]

OECD countries account for the bulk of global renewables investments (almost 82 percent in 2006, of which the European Union and the United States together had 74.1 percent), compared with 7.5 percent for China, 4.3 percent for India, 3.1 percent for Latin America, and 3.5 for all other developing countries.[155]

A variety of analysts project a continued surge in investments and sales in the coming decades. Based on a scenario developed by the European Renewable Energy Council (EREC), the German environment ministry projects that global capacities for electricity production from renewables will expand from 900 gigawatts (GW) in 2004 to 2,160 GW by 2020 and 4,070 GW by 2030, implying a rise in investments to $343 billion (€250 billion) in 2020 and $630 billion (€460 billion) in 2030.[156]

Clean Edge, a U.S.-based research and advocacy group, believes that global investment in renewables will reach more than $210 billion by 2016. Clean Edge and others forecast substantial further growth:

- Spending on wind power installations is expected to expand from $8 billion in 2003 and $17.9 billion in 2006 to $60.8 billion in 2016.
- Markets for the manufacturing and installation of solar PV modules and components will likely grow from $4.7 billion in 2003 and $15.6 billion in 2006 to $69.3 billion by 2016.
- The biofuels market reached $20.5 billion in 2006 and is projected to grow to more than $80 billion by 2016.
- The markets for fuel cells and distributed hydrogen might grow from $1.4 billion in 2006 to $15.6 billion over the next decade, according to Clean Edge; Roland Berger Strategy Consultants project a $103 billion (€75 billion) market for fuel cells by 2020.
- Geothermal power might become a $35 billion industry by 2020.
- Ocean wave power could become a $10 billion per year industry by 2012.[157]

Deutsche Bank pronounced government efforts to address climate change a "megatrend" investment opportunity. U.S. bank Morgan Stanley believes that global sales from clean energy sources like wind, solar, geothermal, and biofuels could grow to $505 billion by the year 2020, and to as much as $1 trillion by 2030. Under this scenario, Morgan Stanley thinks that solar PV could account for 11.2 percent of global electricity production in 2030 and wind for 9.6 percent, and that biofuels could account for 21 percent of transportation energy use (assuming, however, that overall demand levels are tempered via boosted fuel efficiency).[158]

A key characteristic of renewables trends in recent years is that even very optimistic projections of future growth have been met and surpassed. These are exciting developments in moving toward a more sustainable energy economy. It is interesting to note that wind power (measured in terms of cumulative installed capacity) is so far on a trajectory comparable to that of nuclear power in its initial expansion. World nuclear generating capacity rose from about 5 GW in 1965 to 71 GW in 1975. Wind capacity has expanded from 4.8 GW in 1995 to 74 GW in 2006.[159]

But there are also inherent dangers. As developments in the biofuels sector in particular suggest, a "boom time" atmosphere could potentially lead to undesirable side effects. Dramatic agricultural price increases and questionable land conversions (such as some palm oil plantations in Malaysia and Indonesia) raise the question of food-versus-fuel and global-versus-local CO_2 emissions. An overheated pace of development could lead to boom-bust cycles. And a "bandwagon" effect may bring the entry of companies, venture capital firms, and hedge funds that tend to be more attracted by profit margins than a long-term commitment to alternatives.

The Rise in Renewables Production Capacities

At present, renewables still account for relatively small shares of global fuel and electricity consumption. This means that the present high growth rates will need to be maintained for many years for alternatives to become a mainstay in the world energy economy. (This is an especially challenging task given that total consumption continues to expand: total world primary energy consumption grew 34 percent just between 1990 and 2006—oil use by 24 percent, natural gas by 44 percent, and coal by 36 percent. World demand for electricity has expanded especially fast: about 60 percent during the same period of time.[160])

To date, a small number of countries account for the bulk of renewables installations.[161] (See Table II.1-2.) In wind power, the top five countries represent 72 percent of global capacity; in grid-connected solar PV installations, the top two (Japan and Germany) account for 87 percent; in solar hot water, the top five control 91 percent (and China, the leader, alone accounts for 65 percent); in solar thermal electric installations, the United States alone has almost all the existing capacity; in fuel ethanol, the top two (United States and Brazil) produce 90 percent of global output; and in biodiesel, the top five represent 78 percent of production.[162]

Table II.1-2. Global Production Capacities for Renewable Sources of Energy, 2005 and 2006*

Energy Source	Capacity 2005	Capacity 2006	Leaders (Top 5 Countries)
Electricity Generating Capacity from Renewables *(Gigawatts)*			
Small Hydropower	66	71	China, Japan, United States, Italy, Brazil
Wind Power	59	74	Germany, Spain/United States, India, Denmark
Biomass Power	43	45	United States, Brazil, Philippines, Germany/ Sweden/Finland
Geothermal Power	9.3	9.5	United States, Philippines, Mexico, Indonesia/ Italy
Solar Photovoltaic (grid-connected)**	3.3	5.0	Germany, Japan, United States, Spain, Netherlands/Italy
Solar Thermal Electric Power	0.4	0.4	United States
Ocean (Tidal) Power	0.3	0.3	European Union
Total	182	204	
For comparison: Large Hydropower Total Electric Power Capacity	 750 4,100	 770 n.a.	 *United States, China, Brazil, Canada, Japan/ Russia*
Heating Capacity from Renewables			
Solar Hot Water *(Gigawatts-thermal-GWth)*	88	102	China, Turkey, Japan, Germany, Israel
Biomass Heating *(GWth)*	n.a.	220	
Geothermal Heating *(GWth)*	25	28	
Fuels from Renewables†			
Ethanol *(Billion Liters)*	33	38	Brazil/United States, China, Spain/India
Biodiesel *(Billion Liters)*	3.9	6.0	Germany, France, Italy, United States, Czech Republic

**Cumulative production capacities.*
***An additional 0.3 and 2.7 GW of of -grid capacity was in place in 2005 and 2006, respectively.*
†Annual production.
Source: See Endnote 161 for this section.

This does not mean that alternative forms of energy have limited appeal, but it is an indication of how far ahead the global leaders currently are relative to the rest of the world. As with installed capacity, manufacturing of renewable energy equipment, facilities, and components is also relatively concentrated in a number of countries—many of the same that are leaders in installations. For the time being, most of the associated jobs are therefore being created in a limited number of countries. Countries like China and India are rapidly ratcheting up their involvement in renewables. (Over the last three years, investment in sustainable energy in India has jumped 160 percent, and it has soared 2,033 percent in China, to $6.1 billion.[163]) But to ensure timely diffusion of renewables technologies and related job skills to additional countries, there is a need for policies and mechanisms to accelerate these processes.

Renewables' Employment Potential

This section of the report first considers job findings and estimates across the board for renewables before analyzing individual sources—wind, solar, biofuels—in more detail.

Europe's Potential

The European Union has been in the forefront of renewables development, setting ambitious targets. In coming decades, this policy can be expected to create large numbers of new jobs. A modeling exercise supported by the EU found that under current policies, there would be about 950,000 direct and indirect full-time jobs by 2010 and 1.4 million by 2020. These are "net" numbers—taking into account potential job losses in conventional energy and relating to renewables support mechanisms, which may result in lower spending elsewhere in the economy. Under an "Advanced Renewable Strategy," there could be 1.7 million net jobs by 2010 and 2.5 million by 2020. These results are actually quite conservative in the sense that they cover employment just within the smaller EU-15 (i.e., before expansion), and exclude jobs supported by renewables exports to other countries. About 60–70 percent of the jobs would be in renewables industries (primarily biofuels and biomass processing and wind power), the remainder in agriculture. An analysis by skill level indicates that skilled jobs account for about a third of net employment growth.[164]

Germany—a recognized leader in renewables development—is one of very few countries that have undertaken a detailed effort to quantify the jobs supported by this sector. The country's share of the world market for renewables production equipment and components was 17 percent in 2004.[165] In 2006, more than 70 percent of German-manufactured wind power plants in 2006 were exported.[166] Roughly every third wind turbine and solar PV cell in the world is German-made.[167]

Some 20,000 companies—many of them small and mid-size—can be found in the renewables sector, half of them in solar energy, about 5,000 in biomass, 3,500 in wind power, and 500 in the geothermal field.[168] According to detailed studies commissioned by the German environment ministry (BMU), Germany had 166,000 jobs related to renewables in 2004 and an estimated 260,000 in 2006.[169] (See Table II.1-3.) The ministry expects the share of renewables in primary energy use to grow from 4.6 percent in 2005 to 13.9 percent in 2020, requiring cumulative investments of €130 billion during the 15-year span.[170] This may bring employment in the renewables sector to roughly 400,000 jobs.[171] Roland Berger business consultants project that Germany may have 400,000 to 500,000 people employed in renewables by 2020 and 710,000 by 2030.[172]

*Table II.1-3. Employment in the Germany's Renewables Sector, 1998, 2004, and 2006**

	1998	2004	2006	Expected Growth, 2006–2010** (percent)
Wind power	16,600	63,900	82,100	6.8
Solar energy	5,400	25,100	40,200†	49
Hydropower	8,600	9,500	9,400	n.a.
Geothermal energy	1,600	1,800	4,200	74
Biomass	25,400	56,800	95,400	37
Services	10,000	n.a.	n.a.	n.a.
Subtotal	**66,600**	**157,100**	**231,300††**	**n.a.**
Research, public information, export and other marketing promotion, administration	n.a.	3,400	4,300	n.a.
Expansion of production capacities for renewable energy equipment	n.a.	5,800	23,500	n.a.
Total	**66,600**	**166,300**	**259,100**	**n.a.**

**Data include direct and indirect jobs, based on an input-output analysis. The data for the three years presented are not strictly comparable, as the underlying data collection for these estimates varies.*
***According to a poll of businesses.*
†26,900 jobs in solar PV and 13,300 in solar thermal.
††Of this f gure, 139,300 jobs were in manufacturing and installations (including export sales), 41,800 in operations and maintenance, and another 50,200 in supplies of biofuels.
Source: See Endnote 169 for this section.

Other projections are similarly marked by optimism. In April 2007, the Bundesverband Erneuerbare Energien (BEE, German Federal Association for Renewable Energy) announced that it expected that some 15,000 jobs might be added in 2007 alone, and an additional 60,000 jobs by 2010.[173] Solarportal24 states that Germany's renewables sector may see its turnover grow by 17 percent in 2007, reaching $44 billion (€32 billion). This figure includes domestic investments of $16 billion (€11.7 billion), sales of $16.4 billion (€12 billion), and $11.3 billion (€8.2 billion) in export sales. By 2010, the sector hopes to see its total sales grow to $62 billion (€45.3 billion), propelled primarily by exports. An estimated 45,000 new jobs would likely be created in the process.[174]

Germany's renewables industry has been dominated by small- and medium-sized enterprises, but is now undergoing a phase of consolidation. A survey prepared with financial support from the IG Metall trade union found that although the renewable energy industry offers a rich range of job perspectives and career paths, it is also marked by high performance demands and long hours of overtime—a result of surging markets and shortages of skilled workers. While employee participation in corporate decision making among firms in the industry's supplier chain is well established, it is still less pronounced in the renewable sector itself, especially in the solar industry. About 40 percent of companies had active works councils, with a higher share among larger and older companies. But some companies have opposed the establishment of works councils or union organizing among employees. The study notes that the booming solar industry in eastern Germany goes hand in hand with low-wage strategies. Firms in the renewables sector tend to prefer setting wage levels and work hours at the company level rather than via industry-wide collective bargaining (the exception being suppliers of wind energy companies).[175]

Spain has also seen considerable expansion of its renewables industry in recent years. An assessment conducted by Instituto Sindical de Trabajo, Ambiente y Salud (ISTAS) and the union federation Comisiones Obreras found that almost one out of three enterprises in the sector was created after 2000. Two-thirds of companies expanded their staff within the last five years.[176]

Based on an extensive survey, the study concluded that more than 1,000 enterprises in Spain's renewables industry employ 89,000 workers directly (see Table II.1-4.), and another estimated 99,000 indirectly, for a total of 188,000.[177] Employment has been growing steadily since the 1990s. The study also offers the following important findings:

- Half of the 1,000 companies operate exclusively in the renewables sector; the other half engage in business activities beyond renewables in the fields of manufacturing, engineering, installation, plumbing, air conditioning, and heating.
- Renewables firms are spread evenly throughout different regions of Spain, though with some concentration in already industrialized regions, including Madrid, Catalonia, Valencia, Basque country, and Andalusia.
- The renewables industry appears to offer greater job security (in terms of a higher share of long-term contracts) than is the case in the Spanish economy in general. However, among sub-contractors the share of temporary jobs may be higher. There is high demand for a professional workforce with higher education achievements.

Table II.1-4. Employment in Spain's Renewables Industry, 2007

Industry Segment	Direct Jobs
Wind power	32,906
Solar photovoltaics	26,449
Solar thermal (heat)	8,174
Solar thermal (electricity)	968
Biomass	4,948
Biofuel	2,419
Biogas	2,982
Small hydropower	6,661
Other (hydrogen, geothermal)	3,494
Grand Total	89,001

Source: See Endnote 177 for this section.

China

By dint of its population size and rapid economic growth, China's impact on global energy consumption looms large. To date, the country is heavily reliant on coal. But this strategy has brought about massive air pollution, threatening human health in China's cities, and is contributing a massive volume of carbon emissions. Both Chinese firms and subsidiaries of foreign companies are now quickly expanding a range of renewables. Rapidly expanding its presence in the renewables sector, China is poised to pass the current world solar and wind manufacturing leaders, perhaps as soon as within the next three years. It is already the dominant force in solar hot water and small hydropower.[178]

There are no systematic surveys or other firm statistics indicating the number of people employed in the renewables sector. However, the Energy Research Institute and the Chinese Renewable Energy Industries Association, both based in Beijing, have assembled some rough estimates. Their numbers indicate that close to a million people in China are currently employed in the wind, solar PV, solar thermal, and biomass industries. Close to two-thirds of the jobs are in the solar thermal industry.[179] (See Table II.1-5.)

Table II.1-5. Employment in China's Renewables Sector, 2007

	Wind power	Solar PV	Solar thermal	Biomass	Total
Generation	6,000	2,000	—	1,000	9,000
Manufacturing	15,000	38,000	400,000	15,000	468,000
Service	1,200	15,000	200,000	250,000	466,200
Total	**22,200**	**55,000**	**600,000**	**266,000**	**943,200**
Output Value*	25	50	40	10	125

**Output value expressed in billion yuan (1 billion yuan = $135 million).*
Source: See Endnote 179 for this section.

U.S. Assessments

A variety of studies assessing the employment potential of renewables industries have been undertaken in the United States, both on the national and state levels. For example, here are selected findings of some of the more recent reports:

- A January 2008 study by the Blue-Green Alliance (a joint effort by the Sierra Club and the United Steelworkers union) showed that a strong investment program in renewable energy could create 820,000 jobs.[180]
- A 2004 report by the Apollo Alliance estimated that a 10-year federal investment of $36 billion in biofuels and other renewables could add close to 420,000 jobs.[181]
- A 2002 study by the California Public Interest Research Group (CALPIRG) Charitable Trust suggested that current demand in California would support 5,900 megawatts (MW) of additional renewable

energy capacity by 2010 which, combined with the current 3,163 MW, would allow the state to generate up to 20 percent of its electricity needs from renewable sources by 2017. It would create 28,000 person-years of work in construction jobs and an additional 3,000 permanent operations and maintenance jobs producing 120,000 person-years of employment over a 30-year period.[182]

- A 2003 study by the Environment California Research and Policy Center determined that California's Renewable Portfolio Standard (requiring 20 percent of electricity to come from renewable sources) could create a total of some 200,000 person-years of employment, at an average annual salary of $40,000. More than a third of these jobs would be supported by export sales.[183]

- According to the Solar Initiative of New York, the development of solar electricity in the state to the tune of 2,000 MW by 2017 can support 3,000 direct installation or maintenance jobs and more than 10,000 manufacturing and integration jobs.[184]

- A 2007 analysis by the Union of Concerned Scientists (UCS) found that establishment of a national Renewable Electricity Standard—requiring 20 percent of demand to be met by renewables by 2020—would create 185,000 jobs.[185]

There is broad agreement among these studies that alternative energy creates more jobs than conventional sources do—in other words, a switch from oil, gas, or coal produces a net gain in employment.[186]

A 2007 study carried out by Roger Bezdek for the American Solar Energy Society (ASES) assesses renewables employment on a far broader and systematic basis. It finds that the U.S. renewables sector had $39 billion in revenues in 2006 and employed close to 200,000 people directly and another 246,000 indirectly.[187] (See Table II.1-6.) Assessing future prospects under three scenarios, the report says that by 2030, some 1.3 million direct and indirect jobs could be created under a "business-as-usual" scenario, 3.1 million under a moderate scenario that leads to a 15 percent share of renewables in electricity generation, and 7.9 million under an advanced scenario (nearly 30 percent of electricity generated from renewables). The latter would require strong national policies, including targets, standards, and invigorated R&D.[188]

The ASES numbers are encouraging; however, they are somewhat overstated. For instance, all hydropower is included, even though large dams are now broadly acknowledged as highly destructive. Biomass accounts for 70 percent of the jobs figures, but at least some of the biofuels operations—turning corn crops into fuel in particular—are highly problematic from an environmental point of view (see the discussion later in this report). This does not invalidate the ASES figures, although somewhat of a downward adjustment would appear to be in order. Subtracting the ethanol job figures, for instance, would leave about 290,000 jobs.

Table II.1-6. Employment in the U.S. Renewables Sector, 2006

Industry Segment	Direct Jobs	Direct and Indirect Jobs
Wind power	16,000	36,800
Solar photovoltaics	6,800	15,700
Solar thermal	800	1,900
Hydroelectric Power	8,000	19,000
Geothermal	9,000	21,000
Ethanol	67,000	154,000
Biodiesel	2,750	6,300
Biomass power	66,000	152,000
Fuel cells	4,800	11,100
Hydrogen	4,000	9,200
Total, Private Industry	185,150	427,000
Federal Government	800	1,850
DOE Laboratories	3,600	8,300
State and Local Government	2,500	5,750
Total, Government	6,900	15,870
Trade and Professional Associations, NGOs	1,500	3,450
Grand Total	**193,550**	**446,320**

Source: See Endnote 187 for this section.

Making Sense of the Findings

One problem with the array of existing studies is that they employ a wide range of methodologies, assumptions, and reporting formats, which makes a direct comparison of their job findings—or any aggregation and extrapolation—very difficult or impossible. Some reports posit that a certain percentage of future energy demand will be met by renewables; others assume a given amount of investment in renewables. The percentages, investment totals, and target dates are often different as well. Some studies focus only on a particular segment of the renewables sector, or on the prospects of a particular state or region, whereas others cast a wider net. Moreover, some reports are based on analytical models that focus on direct employment impacts and are likely to under-report total job impacts. Others are based on complex input-output models, which provide a more complete picture by including direct, indirect (i.e., supplier), and induced jobs.[189]

In a 2004 assessment of various studies, Daniel Kammen, Kamal Kapadia, and Matthias Fripp of the University of California highlight another critical issue concerning the different capacity factors of conventional versus renewable industries. They point out that "one megawatt of installed coal capacity does not produce the same amount of electricity as one megawatt of installed solar panels." A coal-fired power plant may operate 80 percent of the time (shut down the rest of the time for maintenance). In comparison, a solar PV facility may generate electricity perhaps only about 20 percent of time—when there is sufficient sunshine. Thus, to produce the same amount of electricity as a coal plant, a solar PV facility would have to have five times the peak capacity. Comparing employment effects per actual output, as opposed to nominal capacity, would mean adjusting the number of manufacturing, construction, and installation jobs accordingly. In presenting jobs per megawatt of capacity figures, some studies make this distinction but others do not, leading to great variations in findings.[190]

Reviewing findings of about a dozen studies in the United States and Europe and taking into account the methodological issues presented above, Kammen, Kapadia and Fripp conclude that in comparison with fossil fuel power plants, renewable energy generates more jobs per average megawatt of power manufactured and installed (see Table II.1-7), per unit of energy produced, and per dollar of investment.[191]The picture is more mixed with regard to jobs created in operations and maintenance and in fuel processing. Coal and natural gas-fired plants require more people to run than relatively low-maintenance wind turbines. Solar PV systems, on the other hand, are more labor intensive. With biomass plants, it depends on the way biomass collection is organized.[192]

Table II.1-7. Estimated Employment per Megawatt, Renewable and Fossil Fuel Power Plants

	Average Employment over Life of Facility (Jobs per megawatt of average capacity)		
	Manufacturing, Construction, Installation	Operations & Maintenance/ Fuel Processing	Total
Solar PV	5.76–6.21	1.20–4.80	6.96–11.01
Wind power	0.43–2.51	0.27	0.70–2.78
Biomass	0.40	0.38–2.44	0.78–2.84
Coal-fired	0.27	0.74	1.01
Natural gas-fired	0.25	0.70	0.95

Note: Based on f ndings from a range of studies published in 2001–04. Assumed capacity factor is 21 percent for solar PV, 35 percent for wind, 80 percent for coal, and 85 percent for biomass and natural gas.
Source: See Endnote 191 for this section.

Based on figures summarized in Table II.1-7, Kammen et al. calculate that deriving 20 percent of U.S. electricity supply by 2020 from renewables could generate between 164,000 and 188,000 jobs (depending on the specific mix of different renewables). Providing this 20-percent share of electricity with coal and gas plants would support a mere 86,000 jobs. Renewables therefore promise a clear net employment gain.[193] Still, the authors point out that the distinct occupational profiles (most employment in coal and gas-fired power plants is in fuel processing and operations and maintenance, whereas most renewables employment is in manufacturing and construction) imply a substantial employment shift, and thus implies a need for transition measures to assist those affected.[194]

Job-per-megawatt rates are of course anything but static: over time, as economies of scale increase and renewables technologies mature, the number of jobs relative to installed capacity will decrease. And the capacity factor of solar PV and wind turbines will vary as well. For instance, offshore wind turbines, with more favorable wind conditions, are expected to achieve a higher factor than onshore installations. In sunny, southern locations, solar panels will be able to produce electricity during longer stretches of time than in northern locations. And as technological advances permit electricity generation even in limited sunlight, this too will increase capacity factors, albeit slowly. These advances will vary greatly from location to location, and from country to country.

Following this general look at existing and potential jobs in the renewables sector, we will now consider developments and prospects in individual areas—principally wind, solar, and biofuels—in greater detail.

Compared with wind, solar, and biofuels, geothermal energy, and small hydropower (typically defined as projects up to 10 MW capacity) appear more limited in their potential globally, although they do play an important role in some countries. Small hydropower is particularly important in China, and geothermal power mostly in the Philippines, Indonesia, Japan, and the United States (California), but employment figures seem unavailable. The European small hydropower sector currently has been stagnant; employment (in construction and operating dams, and at turbine manufacturing companies) runs to about 20,000 people, a number that might grow to 28,000 jobs by 2020.[195] (A report on Spain claims more than 6,600 jobs in small hydropower, and more than 3,000 in geothermal.[196])

Wind Power

Global wind power capacity reached 94,100 megawatts (MW) by the end of 2007, up 27 percent from the previous year and 20 times as much as in 1995. (By April 2008, capacity topped 100,000 MW.) Germany has close to 24 percent of the world's installed capacity at 22,247 MW. The United States is now in second place (16,818 MW) followed by Spain (15,145 MW), India (8,000 MW), and China (6,050 MW). Given China's surge, the Chinese Renewable Energy Industry Association predicts that the country's wind capacity could reach 50,000 MW by 2015. More than 70 nations—from Australia to Zimbabwe—now tap the wind to produce electricity.[197]

In Europe, the market leaders are now being joined by a second wave of countries, including Austria, France, Italy, the Netherlands, Portugal, and the United Kingdom. In Asia, efforts are gathering momentum in Japan, South Korea, and Taiwan. Latin America has only seen limited development to date (Argentina's hopes to create 15,000 jobs during this decade have not been realized, for instance).[198] But the implementation of renewable energy laws and programs in a number of countries should trigger a change, and Brazil and Mexico are gaining momentum. The African continent accounts for less than half a percent of globally installed wind power generating capacity, even though it has good wind potential. Most development to date has taken place in Egypt, with the support of European government aid agencies, and Morocco is also getting some traction.[199]

Total turnover in the international wind market in 2006 was estimated at more than $18 billion (€13 billion).[200] Investments in new wind power generating equipment exceeded $20 billion in

2006 and may surpass $60 billion by 2016. The Global Wind Energy Council (GWEC) forecasts that wind capacity worldwide could reach 135,000 megawatts by 2010 and exceed 1 million MW by 2020.[201]

Employment data by industry publications vary. According to the GWEC, there were some 150,000 wind energy jobs worldwide in 2005.[202] It appears that this includes only direct jobs. Annual surveys conducted by the World Wind Energy Association (WWEA) in Bonn, Germany, concluded there were 235,000 jobs in 2005 and more than 300,000 by the end of 2006. This number includes direct and indirect employment, as well as associated fields such as technical and financial services, and marketing.[203]

© Joerg Boethling / Still Pictures
German Indian joint venture Enercon India Ltd. factory in Daman, India. Employees at factory producing rotor blades from synthetic fibre and epoxid resin for wind turbines.

Global Leaders

Europe dominates the wind power sector both in manufacturing and installations. European wind turbine manufacturers controlled about 90 percent of worldwide wind turbine sales in 1997; they still have an 80 percent market share today.[204] Although having lost market share in recent years, Denmark's Vestas remains the leading manufacturer, with 27 percent of the global market in 2006.[205] Other leading turbine manufacturers are based in Germany, Spain, the United States, and India.[206] The leading four companies controlled 73 percent of the world market in 2006.[207] With regard to installations, the European continent accounts for 66 percent of current global wind power capacity. In Denmark (20 percent), Spain (8 percent), and Germany (7 percent), wind provides a substantial share of total electricity use.[208]

Germany appears to have the most wind energy jobs. The Bundesverband Windenergie (Federal Wind Energy Association) says the number of jobs has climbed from just 1,100 in 1991 to about 70,000 in 2006.[209] As noted earlier, a study commissioned by the German environment ministry estimated the number at about 82,000 people in 2006. And wind power compares favorably in its job-creating capacity with coal- and nuclear-generated electricity.[210]

Denmark has also long been a leader in wind development. But policy support has grown unsteady in recent years, and the number of new installations in the country has been minimal (just 30 MW of capacity was added in 2005 and 2006, whereas Germany added 4,000 MW during that time, India 3,270 MW, and China 1,850 MW). Danish employment, which grew from less than 10,000 jobs in 1996 to about 21,000 in 2002, has since stagnated at that level.[211] Denmark has been bypassed by Spain, which employs 33,000 to 35,000 people in the wind power sector.[212]

Germany and Denmark are testament to the fact that you don't have to have the best wind resources in order to become a leader in the technology to harvest energy from the wind. (Although the United Kingdom, for instance, has more favorable wind conditions than Germany, wind policy has lagged behind, and according to the U.K. government and the British Wind Energy Association, in 2005 there were only about 4,000 jobs in the sector.[213]) While jobs in turbine installations, operations, and maintenance will increasingly be created in the countries with the most favorable wind conditions, employment in manufacturing the turbines and components is not necessarily tied to these locations; rather, it will occur in those countries that provide the best support for continued wind technology development.

Domestic Content

As the environmental and economic benefits of wind power become more obvious, other countries will themselves want to undertake efforts to build a domestic wind power manufacturing base and to secure associated employment. This will be far easier for countries that already have a strong scientific and industrial base.

Currently, the United States still imports most of its turbines and blades from Europe.[214] But a 2004 study by the Renewable Energy Policy Project (REPP) in Washington, D.C., identified some 90 U.S. companies that already manufacture wind turbine components. And according to REPP, the U.S. industrial base would support a commitment to a major wind power expansion: more than 16,000 companies have the technical potential to enter the wind turbine market. The REPP study suggested that the development of 50,000 MW of capacity—about five times today's level—would likely create the full-time equivalent of 215,000 job-years of employment—some 150,000 in manufacturing, 35,000 in installation, and 30,000 in operations and maintenance.[215]

The U.S. Department of Energy's "Wind Powering America" program has set a goal of producing 5 percent of U.S. electricity from wind by 2020. DOE believes that achieving this goal would add $60 billion in capital investment in rural America, provide $1.2 billion in new income for farmers and rural landowners, and create 80,000 new jobs by that year.[216]

In its bid to build a domestic industry, Brazil has required a domestic content of 60 percent for wind equipment and construction. However, government policy has for a number of reasons failed so far to trigger the desired investment in additional manufacturing plants.[217] Brazil has now lifted the domestic content requirement.[218]

India's Suzlon is one of the world's leading wind turbine manufacturers. It has strong international operations and in early 2007 took over a leading German wind company, REpower.[219] Suzlon currently employs more than 13,000 people directly—about 10,000 in India, with the remainder in China, Belgium, and the United States.[220] India's domestic manufacturing of wind turbine components—and thus employment—is gaining strength. Some of its companies derive more than 80 percent of their components from Indian suppliers. Spare parts production and turbine maintenance are helping generate much-needed income and employment. More than half of all Indian wind installations are in the southern state of Tamil Nadu, but Maharashtra, Gujarat, Rajasthan, and Andhra Pradesh are slowly catching up.[221] Most of the turbines produced in India are currently exported, and several of the country's manufacturers are expanding their capacity to meet growing demand abroad and at home.[222]

© Joerg Boethling / Still Pictures
Wind power turbines are part of the landscape in rural India.

Foreign companies—principally Denmark's Vestas, Spain's Gamesa, and U.S. manufacturer GE—have controlled about two-thirds of China's wind turbine market in recent years.[223] But the Chinese government has encouraged the establishment of a domestic turbine manufacturing industry by requiring that 70 percent of components must be made in China and by imposing graduated import duties (3 percent for parts, 8 percent for assembled components, and 17 percent for fully assembled turbines).[224] China's four domestic turbine manufacturers, led by Goldwind, produced 29 percent of the turbines installed in the country in 2005 and 33 percent in 2006.[225] (The 2007 China Wind Power Report, however, mentions a somewhat higher domestic share—25 percent in 2004, 30 percent in 2006, and 41 percent for 2006.[226]) And the country has more than 40 other domestic firms involved in the development of turbine prototypes.[227]

A number of Chinese companies are planning a major expansion of production, seeking to leapfrog to large turbines. But quality remains a challenge; few have so far fully acquired the expertise to produce precise and reliable blades, gearboxes, and other critical parts. Although foreign products may cost more, money and time lost to breakdowns and necessary repairs erode the price difference.[228] China's wind turbine industry still confronts shortages of both experienced wind engineers and a range of components.[229]

In all countries, there are important considerations with regard to internal regional economic balance, and specifically providing economic opportunities for less-advanced regions. In order to access project sites in many provinces in Spain, for example, prospective developers are required to first commit to establishing a manufacturing base in the prospective region. This ensures job creation near areas that are rich in wind energy, such as the otherwise relatively poor province of Navarra.[230] In northern Germany, the structurally weak coastal areas have benefited from wind development. In the United States, reinvigorating the industrial "rustbelt" and providing additional income for rural communities are important considerations. Wind development could be a much-needed antidote to the loss of manufacturing jobs.[231] (See Box II.1-1.)

Box II.1-1. From Rustbelt to Windbelt

The American Wind Energy Association (AWEA) notes in its "Wind Power Outlook 2007": "New contracts for wind energy components such as towers and gearboxes create jobs across the country, even in states that do not have a large wind resource. Many rustbelt communities that have been losing manufacturing jobs now see economic opportunity returning thanks to the high demand for wind turbines."

One example is Gamesa, a Spanish company, which decided to redevelop an abandoned 20-acre (8-hectare) U.S. Steel plant in Bucks County, Pennsylvania. Three state-of-the-art turbine factories now produce high-tech blades, nacelles, and towers, employing more than 300 skilled laborers in a formerly blighted area. In Clinton, Illinois, a long-vacant freight-car plant was reconfigured to produce towers for wind turbines by Texas-based manufacturer Trinity. In Oakley, Ohio, Cast-Fab, an old metal foundry, has been transformed to churn out iron hubs and castings for wind turbines. Wind turbine manufacturers and their suppliers have set up shop in half of the 50 states across the country. Close scrutiny is needed, however, with regard to the supply chain: foreign wind companies may well rely on their existing supply chains rather than build new ones that support local or regional job creation.

In rural areas, wind energy can bring much-needed investment and jobs to isolated communities. The U.S. National Renewable Energy Laboratory reports that investment in wind power offers greater economic benefits in the form of jobs, income, and tax revenues than a fossil fuel power station would. Farmers can reap a "second crop" by setting up turbines in their fields—garnering income that helps them preserve their livelihoods. AWEA observes that this has been beneficial for Sherman County in eastern Oregon, for example—otherwise a typical "one-crop" county. There, the Klondike Wind Farm brought clean power, royalty payments to landowners, a shored-up local tax base, and 80–100 construction jobs.

According to the U.S. Government Accountability Office (GAO), wind power projects provided about $5 million in property tax revenues in 2002 to the school districts in Pecos County, Texas, one of the country's poorest counties. About 30 to 35 full-time permanent operations and maintenance jobs were created. Generally, however, areas with larger populations and a more diversified economic base can expect that more local employment will be created than in areas that are unable to meet certain occupational and skill requirements.

GAO found that while income to farmers from wind power represents only a very small fraction of total net farm income, some individual farmers and rural communities have benefited considerably. Wind lease payments may typically run from $2,000 to $5,000 per turbine per year and "generally assure farmers that they will have a relatively stable income from wind power generation for the life of the lease, which may exceed 20 years." Owning a wind turbine could double or triple the income from leasing, but may be less affordable because of upfront costs.

Source: See Endnote 231 for this section.

Future Prospects

Employment projections to 2020 for the EU-25 countries by the European Wind Energy Association (EWEA) run to 153,400 direct and indirect employees for manufacturing, 27,400 for installation, and 16,100 for maintenance—for a total of close to 200,000. These figures, however, do not include job effects of wind technology supplied to non-EU markets—which is hard to predict, but will in all likelihood be a substantial portion of European firms' wind business.[232]

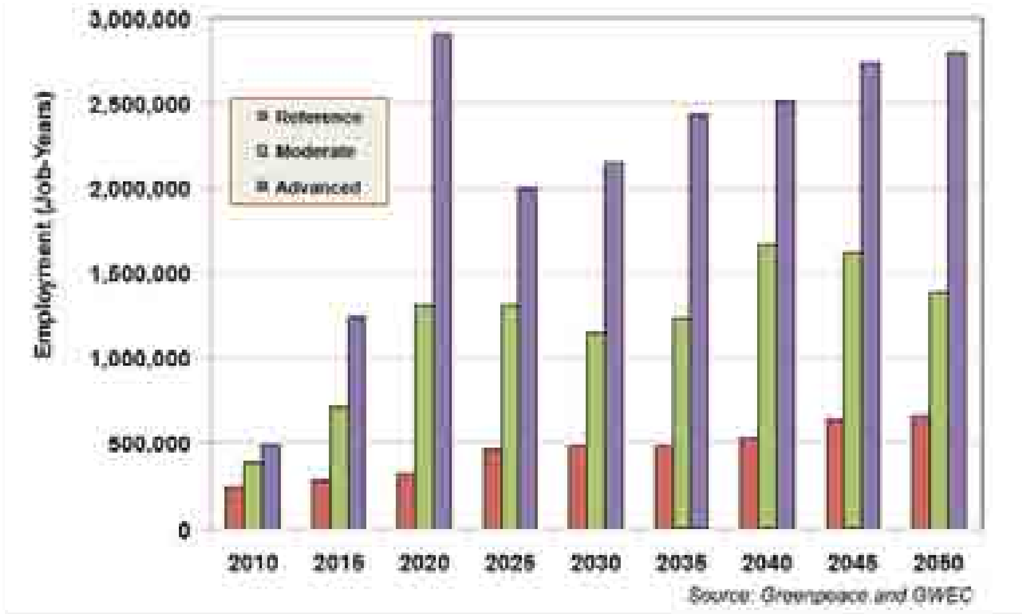
Global Wind Energy Outlook (GWEO), a study published in late 2006 by Greenpeace and the Global Wind Energy Council, outlines three scenarios for future worldwide wind energy development: a conservative "Reference" scenario based on 2004 projections by the International Energy Agency (IEA); a "Moderate" scenario that assumes that targets set for wind development by countries around the world are successfully implemented; and an "Advanced" scenario that posits more far-reaching policies in support of wind and in internalizing costs associated with traditional energy sources.

The capital costs of wind turbines have steadily fallen, but overall investment keeps growing strongly. Under its three scenarios, GWEO projects it to rise from under $16 billion (€12 billion) in 2005 to $40–153 billion (€29–112 billion) by 2050. (Under the Moderate and Advanced scenarios, annual investment actually peaks earlier, at slightly more than $100 billion (€75 billion) in 2040 and $193 billion (€141 billion) in 2020.) The study notes that while these figures may appear large, they need to be seen against the total investment in the global power industry. During the 1990s, annual investment was running at about $216–255 billion (€158–186 billion).[233]

Under the Reference scenario, cumulative capacity would grow from 59 gigawatts in 2005 to 577 GW in 2050, and production would expand from 124 Terawatt-hours (TWh) to 1,517 TWh. Under the Moderate scenario, these numbers rise to 1,557 GW capacity and 4,092 TWh output. And under the Advanced scenario, they would grow even more impressively to 3,010 GW and 7,911 Twh.[234]

The study assumes that for each megawatt of new capacity, 16 jobs will be created in turbine manufacture and supply of components. With rising economies of scale and optimized production processes, this is assumed to decline to 11 jobs per MW by 2030. (This is a global average; labor productivity in the European wind industry is higher, and will presumably remain higher, than that in countries that are just beginning to build their own industries.[235]) An additional five jobs per MW will be generated in wind farm development, installation, and indirect employment. And operations and maintenance will contribute 0.33 jobs for every megawatt of cumulative capacity. With these assumptions, the number of wind jobs is projected to grow to 481,000 in 2030 and 653,000 in 2050 under the Reference scenario; to 1.1 million and 1.4 million under the Moderate scenario; and to 2.1 million and 2.8 million under the Advanced scenario.[236](See Figure II.1-2.)

Figure II.1-2. Global Wind Power Employment Projections, 2010–2050



Solar Photovoltaics

Between 2000 and 2005, the solar photovoltaics (PV) industry averaged annual growth rates of more than 40 percent—one of the fastest growing industries in the world.[237] Global sales revenues of $12 billion (€9 billion) in 2006 are projected to rise to $27.5 billion by 2012.[238] Investment in facilities to manufacture solar cells and modules is expected to total at least $5.5 billion (€4 billion) in 2007–2010, ensuring continued strong performance.[239]

Global production of PV cells rose to a record 3,733 MW in 2007—a more than 20-fold increase over 1998. Its output soaring, Europe has now overtaken Japan as the leading producer. Germany continues to dominate the installation market, with almost half the global market in 2007.[240] China and Taiwan dramatically increased their production, and China is now the second largest producer after Japan (but most of their output—90 percent in the case of China—is for export, principally to Germany and Spain). The U.S. share of global production and installations continues to fall.[241]

On the corporate side, the top 10 producers in 2006 accounted for roughly two-thirds of global production.[242] (See Table II.1-8.) Japanese and German companies are dominant, but in 2007 Germany's Q-Cells took over the number 1 spot from Japan's Sharp. China's Suntech Power has risen rapidly to become the fourth largest manufacturer.[243]

Table II.1-8. Share of Global PV Cell Production, by Geographical Area and Manufacturer, 2006

Global PV Cell Production			
Production by Country/Region		**Production by Manufacturer**	
	Share (percent)		**Share (percent)**
Japan	36.4	Sharp (Japan)	17.4
Germany	20.0	Q-Cells (Germany)	10.1
China	15.1	Kyocera (Japan)	7.2
United States	6.8	Suntech Power (China)	6.3
Taiwan	6.7	Sanyo (Japan)	6.2
Rest of Europe	8.2	Mitsubishi Electric (Japan)	4.4
India	1.4	Motech (Taiwan)	4.4
Rest of Asia	3.7	Schott Solar (Germany)	3.8
Australia	1.3	Solar World (Germany)	3.4
Middle East	0.3	BP Solar (Spain/UK)	3.4
		Top 10 combined	66.6
		Next 6 leading firms	12.3
		All Others	21.1

Source: See Endnote 242 for this section.

A "PV Roadmap" produced by the U.S. Solar Energy Industries Association (SEIA) sets a target of 9.6 GW of installed capacity by 2015, 200 GW by 2030, and 670 GW by 2050, up from 340 MW in 2004. This would dramatically accelerate the pace from SEIA's assumed "baseline" case of just 100 GW by 2050. The Roadmap suggests that employment could rise from 20,000 today to 62,000 by 2015, 260,000 by 2030, and 350,000 by 2050 (these projections are based on a jobs per MW rate that decreases at the same rate as costs are projected to decline). These numbers are far higher than the 95,000 jobs in 2050 under a business-as-usual development.[244]

A Renewable Energy Policy Project (REPP) assessment based on the U.S. PV Roadmap found that 80 percent of the jobs in 2015 would be in manufacturing, the remainder in construction and installation. According to REPP, the existing manufacturing base relevant to PV development (including sheet metal work, semiconductors, electronic equipment, and others) is substantial and widespread, with more than 10,000 U.S. companies in all 50 states. PV development can be a welcome antidote to the loss of manufacturing jobs in recent years.[245]

In China, development is particularly stormy. More than 15 major solar cell manufacturers were thought to employ over 20,000 people in 2006, though comparison with data in Table II.1-5 suggests this figure to be on the low side (and installation and maintenance add more jobs). Production and employment look set to continue their steep rise. Solar PV cell production capacity jumped from 350 MW in 2005 to over 1,000 MW in 2006 and a projected 1,500 MW in 2007; planned additions might bring China's production capacity to as much as 4,000 MW by 2010. Actual production in 2006, at 370 MW, was far less than capacity, however.[246] Looking to the future, the China Solar PV Report 2007 projects that employment in China's PV industry could reach 100,000 by 2020 and perhaps as many as 5 million by 2050. These numbers are based on the assumption that total PV installed capacity might reach 1,000 GW (peak).[247]

Additional employment is found in the supply chain, including production of cells, modules, wafers, and silicon. A growing number of companies are joining at the lower end of the spectrum, which requires less investment and technical know-how. Relatively few companies are involved in wafers and silicon production. Several Chinese firms were expected to add production capacity totaling more than 4,000 tons during 2007 and 2008.[248] There are indications, however, that the breakneck speed with which silicon production is being pursued entails significant pollution dangers, rendering solar development less than green.[249] (See Box II.1-2.)

Box II.1-2. Polysilicon: The Dangers of Stormy Solar Development

Polysilicon is critical to the production of solar PV panels. Given global shortages, soaring world market prices, as well as generous government grants and loans, production in China is now booming with close to two-dozen companies setting up factories. Capacity is expected to rise to 80,000 to 100,000 tons, more than doubling existing global capacities. But it appears that corners are being cut, as companies try to build factories in half the time it usually takes to set up a plant.

These plants produce a highly toxic byproduct, silicon tetrachloride—at least four tons for each ton of silicon produced. Unlike facilities elsewhere, it appears that Chinese firms have only inadequately or not at all invested in equipment to recycle this hazardous substance. Some are stockpiling it in drums. Others, like Luoyang Zhonggui High-Technology Co. (a key supplier to Suntech Power poised to become China's largest silicon producer), apparently are dumping it, rendering land infertile and exposing people in surrounding communities to dangerous concentrations of chlorine and hydrochloric acid.

One reason is to keep production costs low. Shi Jun, head of a polysilicon research firm in Shanghai, estimates that it would cost about $84,500 to produce a ton in an environmentally responsible manner. Many Chinese companies are currently producing the material at $21,000 to $56,000 a ton.

Source: See Endnote 249 for this section.

As China continues to rely strongly on cheap labor, it is likely that the added capacity will further boost the number of solar jobs in the country. However, a cheap labor strategy also implies that these jobs are not well paid and that working conditions may well be precarious—a sharp reminder that green jobs are not necessarily or automatically decent jobs. Renewables development in China and elsewhere needs to place much greater emphasis on workers' needs and rights.

The European Renewable Energy Council put global PV industry employment in 2005 at more than 70,000 people. It expects the industry will create 1.9 million full-time jobs globally by 2020.[250] Solar Generation IV, a joint study by European Photovoltaics Industry Association (EPIA) and

Greenpeace International, estimated existing jobs worldwide at roughly 74,000 in 2006. Some 48,000 of these jobs are in installation and more than 14,000 in manufacturing. The remainder are in research, wholesaling, and supply.[251]

However, in light of various national employment estimates reported in this section, these numbers appear to be quite conservative. As mentioned earlier, a German government-sponsored study estimated PV employment at 26,900 jobs in 2006. But in 2007, the Bundesverband Solarwirtschaft (German solar energy association) put employment even higher—at 35,000 people, surpassing the number of jobs in the country's nuclear industry.[252] Spain follows closely behind, with more than 26,000 jobs in 2007.[253] In China, rough estimates suggest some 55,000 current jobs, and in the United States, there may be some 15,000 to 20,000 jobs. By one estimate, Japan had 9,000 PV jobs in 2005.[254] However, given Japanese companies' leading role in this industry, it seems highly implausible that employment is lower than that in the United States. Japanese firms might be expected to employ a number of people roughly equal to that of German companies. Relying on that assumption, and combining estimates for leading PV manufacturing countries, global PV employment may now come to at least 170,000. This needs to be seen as a rough order-of-magnitude estimate (one problem is that some national estimates include direct jobs only, others indirect jobs as well).

As important as leadership in PV technology is, many jobs are also created in the installation and servicing of PV systems rather than in their manufacture.[255] The technology thus holds promise for economic development and employment in many locations. In Bangladesh, microloan programs have proven successful in introducing a large number of PV household systems in rural areas and creating associated employment.[256] (See Box II.1-3.) And in Kenya, a PV assembly project has even been initiated in Kibera, a notorious slum area of Nairobi.[257] (See Box II.1-4.)

© Grameen Shakti
Solar panel on a roof in Bangladesh. Grameen Shakti project.

Box II.1-3. Solar Entrepreneurs in Bangladesh

In Bangladesh, about 70 percent of the population, mostly in rural areas, does not have access to electricity. Improving their livelihoods requires alternatives to the grid. Grameen Shakti (GS), set up in 1996 as a not-for-profit company, has installed more than 100,000 solar home systems (up from 50,000 in 2005)—one of the fastest-growing solar PV programs in the world. By 2015, GS expects to have installed 1 million solar systems. In households with these systems, women no longer have to clean kerosene lamps every evening, and families are no longer exposed to dangerous indoor pollutants.

GS emerged out of the Grameen micro-lending experience. To make solar systems available to rural communities, it put together financial packages based on installment payments that lowered costs without providing subsidies. GS emphasizes community participation by training youth and women as certified technicians and in repair and maintenance. This offers local employment and generates community acceptance and goodwill. Twenty technology centers have been set up so far.

To date, some 660 women are installing, repairing, and maintaining solar systems, as well as producing accessories; in addition, more than 600 youth have been trained. Providing business education and access to credit will help scale up the program. And in coming years, GS is planning to train more than 5,000 women in repair and maintenance, as well as instruct close to 10,000 school children in renewable energy technologies. GS is aiming to create 100,000 jobs through renewable energy and related businesses. Solar systems are helping to launch new businesses such as community TV shops, solar-charged mobile phone centers, electronic repair shops, handicrafts, and others. Existing businesses can operate at extended hours, helping to increase turnover and employment.

GS introduced a micro-utility system to help the poorest households who cannot afford a complete solar home system. Local entrepreneurs share the power generated with neighbors, who help to pay for the system. Currently, more than 10,000 micro-utility systems are operating in rural areas. In many cases, biogas plants are also shared by multiple households.

Source: See Endnote 256 for this section.

Box II.1-4. Solar PV Assembly in Kibera, Nairobi

The Kibera Community Youth Program (KCYP) initiated a simple solar photovoltaic (PV) assembly project in Kibera, Nairobi, one of the largest slums in sub-Saharan Africa. The project provides young people with employment opportunities in assembling small and affordable solar panels. The panels power radios and charge mobile phones in Kibera, but use of the solar panels made there has also spread to all parts of Kenya. In neighboring countries, numerous groups have requested training to undertake similar projects. KCYP won a World Clean Energy Award in 2007 for its pioneering work.

Kenya has one of the largest and most dynamic solar markets in the developing world. Kenya has about 10 major solar PV import companies, and an estimated 1,000–2,000 solar (non-specialist) technicians. Since the mid-1980s, more than 200,000 systems have been sold in Kenya. Private households account for three-quarters of all solar equipment sales in the country. Product quality, however, has been uneven, with Chinese brands not performing as well as brands imported from France, Britain, and Croatia.

Source: See Endnote 257 for this section.

© KCYP
Kibera Community Youth Program. Nairobi, Kenya.

Future Prospects

A 2006 report by the EPIA and Greenpeace International projected possible PV employment by 2025 to be 80,000 to 100,000 jobs in Germany, 180,000 in the United States, 430,000 in China, and 92,000 in Japan (and 300,000 by 2030). A number of countries that currently do not play a major role in PVs may also see rapidly growing employment in coming years. The report projects a combined 60,000 jobs in 2015 in Australia, Brazil, India, and Thailand, and 250,000 to 330,000 in 2025.[258] Despite excellent potential, Australia in 2004 was estimated to have only 1,155 direct PV jobs and 2,310 indirect jobs. Adequate investments could substantially raise those numbers.[259] India, Malaysia, and South Korea are currently working to attract growing PV investment.[260]

Meanwhile, the 2007 EPIA/Greenpeace International report, Solar Generation IV, projects future worldwide developments via three scenarios: a conservative "Reference" scenario based on assumptions developed by the International Energy Agency; a "Moderate" scenario assuming continued but lower level of political support for PVs; and an "Advanced" scenario positing additional support and dynamic growth. The Advanced scenario leads to a cumulative global capacity of 1,272 GW by 2030, 1,802 TWh of electricity generation, and avoidance of 1.1 billion tons in annual CO_2 emissions. For the Moderate scenario, the figures are 728 GW, 1,027 TWh, and 616 million tons of CO_2. For the Reference scenario, they are a mere 87 GW, 142 TWh, and 77 million tons of CO_2.[261]

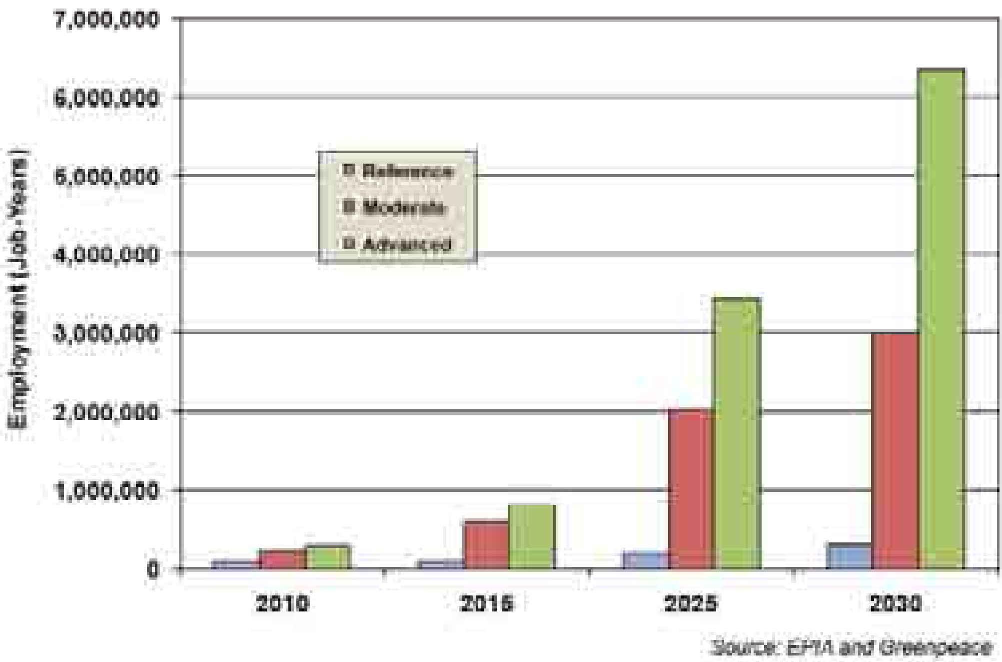
Solar Generation IV points out that much of the PV employment creation is at the point of installation (including retailers and service engineers), thus providing a boost to local economies. Based on industry data, the study assumes that a total of 50–53 jobs might be created per MW of installed capacity, with the following breakdown:

- Manufacturing: 10 jobs
- Installation: 33 jobs

- ❑ Wholesaling of systems: 3–4 jobs
- ❑ Indirect supply: 3–4 jobs
- ❑ Research: 1–2 jobs.

Especially in manufacturing, these numbers will decrease over time with greater automation.[262] EPIA and Greenpeace project that by 2030, 6.3 million, 3 million, and 287,000 jobs, respectively, could be created under the three scenarios.[263] (See Figure II.1-3.)

Figure II.1-3. Global Solar PV Employment Projections, 2010–2030



Solar Thermal

China is the undisputed global leader in solar heating. Increasing its installed capacity from 35 million square meters in 2000 to 100 million square meters in 2006, it accounts for about two-thirds of the global total. More than 10 percent of all households in China use the sun to heat their water. With combined sales revenues of about $2.5 billion in 2005, more than 1,000 Chinese manufacturers employed more than 150,000 people.[264] In light of more recent estimates from the Chinese Renewable Energy Industries Association, however, it appears that this figure is either somewhat dated or otherwise incomplete. There appears to be even greater employment in installations and maintenance. Luo Zhentao, director of the Solar Thermal Energy Utilization Committee of the China Association of Rural Energy Industry, estimates that the solar water heating sector as a whole may employ as many as 600,000 people in China.[265] Clearly, these are rough estimates that require further substantiation via surveys and other efforts.

The Chinese government aims for 150 million square meters of solar water heating systems by 2010 and 300 million square meters by 2020. Some observers say China might reach 400 million square meters of installed capacity by 2020 and 800 million by 2030. Domestic production is expected to more than double, from 20 million square meters in 2006 to perhaps as much as 45 million square meters by 2020.[266]

With such developments, employment could grow substantially. China is likely to continue relying on its cheap labor, even though the currently fragmented field of manufacturers will presumably yield to fewer and larger producers with a degree of job consolidation and somewhat higher labor productivities. As mentioned earlier, this cheap labor strategy is problematic.

The Himin Group is the world's largest solar hot water manufacturer, with 50,000 employees worldwide. Himin produces principally for the domestic market, but the company has begun to target export markets. If Chinese manufacturers can master quality issues and sort out marketing and distribution questions, exports are likely to become a major aspect. Given the considerably lower cost of Chinese systems, European producers might suffer.[267]

Germany has some 19,000 people employed in this industry.[268] Within Europe, Germany leads solar thermal water heating development, accounting for 50 percent of the market in 2006—way ahead of Austria, Greece, France, and Italy.[269] Spain currently has about 9,000 jobs.[270] In 2006, the Italian solar thermal industry provided almost 2,000 full time (direct and indirect) jobs, with 3,000 jobs forecast for 2007 (assuming one full-time job per 70 kilowatts-thermal (100 square meters) installed).[271]

© T. Mohr / Still Pictures
Solar thermal collector. Font-Romeu, France.

According to the European Renewable Energy Council (EREC), employment in the European solar thermal sector currently exceeds 20,000 full-time jobs (a figure that appears highly conservative, given that the combined national estimates for Germany, Spain, and Italy alone would indicate employment of about 30,000). Given the industry's dynamic expansion, eventually—in a few decades—it might employ more than half a million people. EREC points out that nearly half the solar thermal jobs are in retail, installation, and maintenance: "These works are necessarily local, and create jobs mainly in small and medium sized enterprises, directly in the areas where the solar thermal market develops."[272]

A number of solar thermal concentrating plants are under construction or in the planning stage—typically in desert areas or other very hot locations—in Algeria, China, Egypt, Israel, Mexico, Morocco, South Africa, Spain, and the United States. Companies and their suppliers are preparing for a boom in this industry. Spanish companies seem well-placed: Abengoa and Acciona are building new plants in the U.S. states of Arizona and Nevada, respectively. Ausra, a U.S. subsidiary of Australian company Solar Heat and Power, is building a factory to make mirrors for solar thermal plants; the facility will double global capacity.[273]

Biofuels

Much of the emphasis in biomass in recent years has been on biofuels for transportation purposes. Biofuels can be produced from a variety of feedstocks—including corn, soybeans, sugar cane, palm oil, other plants, and agricultural wastes—utilizing a range of processes. A November 2007 New York Times article notes that rising world oil prices have created an incentive to examine an even broader range of methods. Both biological and chemical processes for turning corn stalks, wood chips and other logging wastes, straw, and garbage into fuel have recently attracted a flood of investment capital.[274]

World production of biofuels rose some 20 percent to an estimated 54 billion liters in 2007—accounting for 1.5 percent of the global supply of all liquid fuels. Fuel ethanol production—derived primarily from sugar or starch crops—rose to 46 billion liters, and biodiesel production—made from vegetable oils or animal fats—climbed to 8 billion liters. The United States and Brazil account for 95 percent of the world's ethanol production.[275] Germany dominates biodiesel output.[276] Brazil is so far the only country where biofuels currently account for a sizable portion of total transportation fuel use—just under 22 percent 2005.[277] In the United States, ethanol use in motor fuels grew to 6.9 billion gallons (26 billion liters) in 2007, equal to less than 5 percent of gasoline consumption.[278]

Although it was recently surpassed in output by the United States, Brazil has been a leader in ethanol development since the 1970s. In the 1990s, the government worked with farmers to help reduce sugarcane production costs and improve yields, and required a 20–25 percent ethanol share in all regular gasoline. Industry has reduced ethanol feedstock and production costs. Savings in avoided oil imports of nearly $50 billion since the 1970s exceed investments and subsidies almost by a factor of 10.[279]

Brazil currently accounts for about half of global ethanol exports. The country is planning to increase sugarcane production by 55 percent over the next six years, and much of the ethanol derived is destined for Europe and the United States. In Asia, Malaysia and Indonesia account for most of the world's palm-oil production. Although only a small share currently goes to transport fuels, the two countries aim to capture 20 percent of the European biofuel market by 2009. Other developing countries, including Tanzania and Mozambique, are similarly hoping to gain a slice of the expanding European market.[280]

Boon or Bane?

There is vigorous and contentious debate over the economic and environmental merits of biofuels, including the question of direct competition with food production. Currently, biofuels account for just 1 percent of the world's arable land, but the U.N. Food and Agriculture Organization (FAO) projects that this could increase to as much as 20 percent by 2050.[281] Following a rush by many governments, companies, and even nongovernmental organizations to embrace biofuels as a climate savior, a spate of more recent reports has begun to cast a more critical eye.

A report for the OECD Round Table on Sustainable Development cautions that, "the rush to energy crops threatens to cause food shortages and damage to biodiversity.[282] The 2007/2008 edition of the U.N. Development Programme's Human Development Report concludes that, "The expansion of plantation production has come at a high social and environmental price. Large areas of forest land traditionally used by indigenous people have been expropriated and logging companies have often used oil palm plantations as a justification for harvesting timber."[283]

A number of factors determine key outcomes such as cost, net energy and carbon balance (i.e., how the energy yield of biofuels compares with needed energy inputs), and other environmental impacts such as potential air and water pollution, deforestation, and threats to biodiversity. Among these factors are the type of land used (rainforests, woodlands, peat forests, crop-growing areas, savannahs, wetlands), choice of feedstock, type of agricultural operation (small-scale versus large monocrop plantations), and processing methods. Some feedstocks (such as sugar cane) require substantial amounts of water, while others (jatropha) take far less, and processing of energy crops may cause dangerous agrochemical runoff. Corn-based ethanol, the dominant biofuel in the United States, appears to be particularly problematic in light of its energy and carbon balance.

The complexity of circumstances produces a range of cost and benefits in pursuing biofuels projects. Environmental and human impacts also depend on such key factors as whether biofuels will be produced on large-scale plantations (that are likely to be industrialized monocultures) or smaller plots of land; whether these fuels are destined for local use or for export markets; how much influence local communities have vis-à-vis corporations and government agencies as well as how much of the income these communities can garner.

Backers of biofuels projects tend to argue that pitfalls can be minimized or avoided if the right kinds of technical and policy decisions are made. While this is undoubtedly true, there is a considerable danger that prudence will be set aside, for at least two reasons: panic and profit. One, as the world faces a rising threat of potentially catastrophic climate change, there may well be overwhelming pressure to pursue biofuels (and other alternatives—suitable or not) at a grand scale, even if the interests of local communities have to be sacrificed in the process. Two, as the gold rush-like atmosphere of recent years' biofuels development suggests, the human needs, especially of the poor and marginalized, all too easily lose out to profit interests.

Environmental and human impacts of biofuels projects need very close scrutiny. As the brief discussion below indicates, biofuels projects clearly create employment. However, not all biofuels-related jobs can be counted as green or decent. As a matter of fact, current studies suggest that most of these jobs fail either test (and some biofuels projects entail serious costs in terms of livelihoods and food security for communities in developing countries).

Job Prospects

Biofuels development entails jobs both in the agricultural sector and in processing industries. Brazil's ethanol industry is said to employ about half a million workers. In the United States, the ethanol industry is estimated to employ between 147,000 and 200,000 people from farming to biofuels plant construction and operation.[284] Testifying before the U.S. Senate in September 2007, Daniel Kammen, director of the Renewable and Appropriate Energy Laboratory of the University of California at Berkeley, points to projections that every billion gallon of ethanol production may create 10,000 to 20,000 jobs.[285]

Other countries are also hopeful that biofuels can create a significant number of jobs:[286]

- France hopes its proposed biofuel program may generate 25,000 additional jobs by 2010.
- Spain has slightly more than 10,000 jobs (4,948 in biomass for heat generation; 2,419 in biofuels; and 2,982 in biogas).[287]
- Colombia's ethanol blending mandate may add 170,000 jobs in the sugar ethanol industry over the next several years.
- In Venezuela, an ethanol blend of 10 percent might provide 1 million jobs in the sugar cane ethanol industry by 2012.
- The World Bank estimates that a region-wide blend of ethanol—10 percent of gasoline and 5 percent of diesel—could yield between 700,000 and 1.1 million jobs in sub-Saharan Africa.
- In Nigeria, cassava and sugarcane crops might sustain a biofuels industry and create more than 200,000 jobs.[288]
- Chinese officials think that, long term, as many as 9 million jobs could be created through large-scale processing of agricultural and forestry products into fuels—some 6 million jobs in agriculture and industry for biodiesel, and 2.9 million for bioethanol.[289]
- Indonesia and Malaysia are the leading palm oil producers, and a growing share of palm oil is being diverted to biofuels production. Malaysia, the largest producer, has an estimated a half million

people employed in this sector (and another 1 million people whose livelihoods are connected to it)—many of them Indonesian migrant workers.[290] Indonesia is planning a major expansion and, according to the Singapore Institute of International Affairs, is projecting some 3.5 million new plantation jobs by 2010.[291]

The labor intensity of biofuels harvesting compares favorably with conventional fuels. On average, biofuels require about 100 times more workers per joule of energy content produced than the capital-intensive fossil fuel industry.[292] Much depends on the choice of feedstock, however—which itself is determined by local availability, yield, and overall cost. Oilseed crops in developing countries hold the most promise for job creation because they must typically be harvested manually rather than with the help of machinery. The castor oil, or momona, plant is a particularly labor-intensive crop. India is the largest producer and exporter of castor oil worldwide, followed by China and Brazil.[293] In Brazil, harvesting castor oil requires 0.3 jobs per hectare, compared with jatropha (0.25), palm (0.2), and soybeans (0.07).[294] India's National Biodiesel Program says that a jatropha farm could provide employment equal to 313 person-days per hectare in the first year of plantation and 50 person-days per hectare over the next 30–40 years.[295] Jatropha holds promise elsewhere in the world as well.[296] (See Box II.1-5.)

Box II.1-5. Jatropha Project in Mali

Beginning in 1999, the Mali Folkecenter Nyetaa embarked on a large-scale, 15-year jatropha-fueled rural electrification project in Garalo, southern Mali. The project was nominated for the 2007 Clean Energy Awards. Some 1,000 hectares of jatropha plantations will produce feedstock for a 300 kilowatt power plant providing clean energy to more than 10,000 people. Generators were installed in May 2007.

Jatropha curcus, a shrub-like oilseed plant, is not only sufficiently resilient to grow under arid conditions, but it can help restore eroded land. In Mali, the jatropha-based biofuel will replace imported diesel, immunizing the area against the economic shocks of increasing fossil fuel prices and insecurity of supply. Unlike numerous export-driven biofuel programs, the Garalo project puts local needs and livelihoods first. It has potential for building a vibrant and dynamic economy in remote villages in Mali, providing local added value, local employment, and local income generation.

The lessons learned can be useful in other developing countries—particularly elsewhere in Africa, where biofuels development can benefit the rural poor if the right kinds of policies, especially protecting and improving land rights, are adopted.

Source: See Endnote 296 for this section.

Work in biofuels processing typically requires more technical skill and thus is likely to offer better pay than feedstock production and harvesting. Brazilian workers in ethanol refining receive about 30 percent more than laborers involved in sugarcane harvesting.[297] But the number of jobs that may be created in processing is far lower than those in harvesting biofuels crops—and will vary from country to country. In the U.S. state of Iowa, instead of the hoped-for several hundred jobs, each 50 million gallon refinery has on average created only about 35 direct jobs and another 100 indirect jobs.[298]

Small-Scale versus Large-Scale

A 2007 Worldwatch Institute assessment of biofuels for the German government made it clear that biofuels can be pursued in starkly different ways: "At their best, biofuel programs can enrich farmers by helping to add value to their products. But at their worst, biofuel programs can expedite the very mechanization that is driving the world's poorest farmers off their land and into deeper poverty.[299]

Ownership of processing plants is a critical element for ensuring that biofuel revenues are retained in the local or regional economy, rather than flowing out to international investors. In the United States, farmer cooperatives controlled close to 40 percent of biofuels refining capacity at the beginning of 2006. However, this may have been the high point. Just 18 months later, their share had shrunk to 34 percent, and it is expected to decline further. The next generation of biofuels technologies may be up to five times more expensive and thus largely beyond the financial reach of cooperatives.[300]

Around the world, similar questions abound. Small-scale, labor-intensive biofuels programs can benefit small farmers and agricultural laborers and boost the fortunes of rural areas. And, as a February 2008 assessment for the International Fund for Agricultural Development (IFAD) notes: "The labour-intensive biofuel production capability of the developing world's small farmers appears to be relatively more environmentally friendly than large-scale, commercial, monocropping operations in the developing world."[301]

But a future marked by plantation-style, capital-intensive monocultures will have the opposite result. If governments back a rapid scaling-up of biofuels production, they will de facto favor large farm operators, processors, and distributors, because doing so requires more mechanized, capital-intensive operations. Already, farmers around the world are being squeezed by seed and fertilizer companies, manufacturers of tractors and other farm machinery, food processors, and middlemen. It is uncertain at best whether biofuels development can be expected to break with this dominant pattern.

A November 2007 briefing note by Oxfam International acknowledges that under the right conditions, biofuels can "offer important opportunities for poverty reduction by stimulating stagnant agricultural sectors, thus creating jobs for agricultural workers and markets for small farmers." Oxfam notes that the first biodiesel cooperative was launched in Brazil in 2005, providing improved livelihoods for around 25,000 families.[302]

But the briefing note also cautions that Brazil's sugarcane industry has historically been marked by exploitation of seasonal laborers and by the takeover of smaller-scale farms by large plantation owners, often by violent means. And increasing reliance on mechanical harvesting has translated into falling employment in the country's sugarcane sector, from 670,000 in 1992 to 450,000 in 2003.[303] By 2008, the number of sugarcane field workers was estimated at just 300,000. São Paulo state, where almost 80 percent of ethanol production takes place, is trying to improve working conditions and aiming to eliminate manual cane cutting over the next few years. Cane cutters are increasingly facing stagnant wages and unemployment. Poorer northern states feel the repercussions in the form of reduced remittances from migrant laborers.[304]

The hugely inequitable distribution of land, wealth, and associated power in Brazil is a major problem, and the Landless Rural Workers Movement has identified biofuel expansion as "the principal enemy" of agrarian reform. A 2007 report by the Global Forest Coalition argues that "the massive inflow of investment has permitted the 'sugar barons' (a handful of very wealthy land-owning sugar producers) to consolidate and expand their control over Brazilian sugar and ethanol production in partnership with multinational agribusiness. Companies like Archer Daniels Midland, Bunge, and Cargill (which now owns the country's biggest ethanol refinery in São Paulo, along with an associated 36,000 hectares of plantation) control much of Brazil's soy production."[305]

Working conditions within the sugarcane sector in Brazil—where some 200,000 people work as harvesters—are notorious, marked by crowding, poor hygiene and nutrition, and violence by company security guards against workers. Many find themselves in a form of debt peonage that results from exorbitant charges for transportation, accommodation, and food by employers. These are not decent jobs by any stretch of the imagination.[306] In many other developing countries, plantation labor standards are also typically dismal, marked by exploitation and even forced labor.[307] (See Box II.1-6.)

Displacements and Industry Consolidation

A concerted drive to produce biofuels on a huge scale could lead to the clearance of rainforests and other critical ecosystems and to the displacement of poor communities. "Published reports show that as much as 5.6 million square kilometres of land—an area more than ten times the size of France—could be in production of biofuels within 20 years in India, Brazil, Southern Africa, and Indonesia alone."[308] The chair of the U.N. Permanent Forum on Indigenous Issues has warned that 60 million indigenous people may be driven off their land to make way for biofuel plantations.[309]

A February 2008 assessment for IFAD agrees that, "there is risk of appropriation of land by large private entities interested in the lucrative biofuels markets. The poor, who often farm under difficult conditions in remote and fragile areas and generally have little negotiating power, may be tempted to sell their land at low prices or where land is 'de jure' owned by the state (typical in most African countries) find their land allocated to large, outside investors."[310]

In Colombia, the government supports expanding land devoted to palm oil cultivation from 300,000 to 700,000 hectares over the next four years.[311] Monoculture plantations of both oil palm and sugar cane are being massively expanded in various parts of the country, including the coastal, biodiversity-rich Choco rainforest. Reports indicate that soldiers and paramilitary groups are evicting and killing people to make room for plantations. [312] A 2007 report by the London-based NGO Christian Aid charges that, "there is an increasing body of evidence that state institutions are involved in this land grab. For example, the InterAmerican Commission for Human Rights has recognized the links between Urapalma [an oil palm plantation company], the paramilitaries, and the army." Some 300,000 hectares of land are cultivated by legitimate companies, but perhaps another 100,000 hectares are controlled by companies associated with paramilitary groups that have driven farmers off their land.[313]

Box II.1-6. Exploitation of Plantation Labor

While large-scale biofuels development may generate many jobs in sugarcane and palm oil plantations, the working conditions bear close watching. Oxfam International notes that the prevailing piece-rate system leaves many Brazilian sugarcane plantation workers earning just a little more than $1 per ton and effectively discriminates against women who are unable to cut as much as men. Workers sometimes end up in debt bondage effectively amounting to slave labor. Living conditions are often squalid. The Brazilian government has been combating abuses vigorously through its labour inspection services and the labour courts.

In Indonesia, the International Labour Organization found that poverty and low income of plantation workers are common: "There are frequent reports of denial of rights at work, poor quality employment, high levels of unemployment, unsafe working conditions and lack of income security, and inadequate representation of agricultural/plantation workers in social dialogue."

Intimidation and procedural obstacles emasculate effective labor rights for plantation workers. Medan-based company PT Musim Mas accounts for 20 percent of Indonesia's palm oil exports and operates the world's largest palm oil refinery. It refused to negotiate with Kahutindo, an independent union formed in 2004, over demands that minimum labor standards be implemented and that contract workers be treated fairly at a plantation and processing plant in Pelalawan, Riau province. According to the International Union of Food, Agricultural, Hotel, Restaurant, Catering, Tobacco and Allied Workers' Associations (IUF), the company fired 701 union members in retaliation for a strike in September 2005; police and soldiers assisted the company when it forcibly expelled workers and more than 1,000 family members from plantation-estate housing and schools.

Plantation workers have few rights, especially as Indonesia and Malaysia (a dominant palm oil producer) have not signed key ILO Conventions. Indonesian migrant workers laboring on Malaysian plantations are particularly vulnerable to predatory practices and forced labor. Regulations and monitoring are also weak or non-existent when it comes to the dangerous agrochemicals that many plantation workers are exposed to.

According to Oxfam, female workers on Indonesian oil palm plantations are routinely discriminated against in the form of lower wages than those paid to male workers. Also, "women are often drawn into unpaid work in order to help their husbands meet production quotas." On Malaysian plantations, women are recruited to spray dangerous herbicides and pesticides—often without proper training and safety precautions.

Source: See Endnote 307 for this section.

Indonesia and Malaysia have ambitious plans for expanding their oil palm plantations for biofuels purposes. Yet estimates of employment by such plantations vary enormously. And a 2006 study in Sambas, West Kalimantan (Indonesia), found that some 200,000 hectares of plantation land employed just under 2,000 people, compared with more than 200,000 small farmers who found subsistence and employment on 80,000 hectares of land—almost 260 times the employment potential.[314]

And if past and present are prologue to the future, an expansion of plantations will occur largely at the expense of the livelihoods of rural communities. In West Kalimantan, for instance, more than 5 million indigenous people, whose livelihoods are tied to intact forests, are at risk of displacement by palm oil expansion.[315] Losing Ground, a February 2008 NGO investigation of the human rights impacts in Indonesia, notes that when oil palm companies seek to acquire land, they often "hold out the promise of providing employment for local communities and indigenous peoples. However, these promises often fall short and communities are left feeling deceived when it becomes apparent that many of the jobs created are temporary since plantation establishment requires much higher labour inputs than later plantation harvesting and management and that many of the jobs created are for casual day labourers who benefit from few of the protections afforded those with contracts. Additionally, wages for contracted work are frequently at or below the minimum wage, while the minimum wage itself often does not meet government's own standards for a decent living wage."[316] It is not surprising that "the plantation sector is the most conflict-prone sector in Indonesia." Local NGO Sawit Watch reported that in 2006, more than 350 communities were involved in land conflicts over the proposed or ongoing expansion of palm oil plantations.[317]

A range of African countries, including Benin, Ethiopia, Ghana, South Africa, Tanzania, Uganda, and Zambia, are planning to convert large tracts of farmland and forests to biofuels plantations. In Tanzania, thousands of small-scale rice and corn farmers have been evicted to make room for sugarcane and jatropha plantations. A Swiss company has its eyes on some 400,000 hectares in the Wami Basin, where more than a thousand small-scale rice farmers face displacement.[318]

What will happen to those driven off their land? "Many will end up in slums in search of work, others will fall into migratory labour patterns, some will be forced to take jobs—often in precarious conditions—on the very plantations which displaced them," warns Oxfam.[319] In Ethiopia, a drive to open land to foreign biofuels investors threatens to affect the livelihoods of many of the country's subsistence farmers. Plans by Uganda's government to clear half of the Mabira Forest Reserve, located at the edge of Lake Victoria, for sugarcane plantations for ethanol were halted by protests in October 2007. Likewise, the clearing of rainforests for oil-palm plantations on Bugala and Kalangala islands in Lake Victoria spurred strong local and international opposition, bringing the project at least to a temporary stop.[320]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Burning sugarcane plantation before cutting, Brazil.

There is growing consolidation in the biofuels sectors of many countries. Brazil's sugar ethanol industry may eventually be controlled by just six or seven large milling companies, compared with about 250 today. The country's biodiesel sector is already dominated by five producers, and a single company, Dedini, has built the bulk of Brazil's ethanol distilleries and biodiesel facilities[321] In China, there are only four companies that make the specialized precision boilers that are required for biomass power plants that burn corn and cotton stalks.[322] U.S. corporate giants Archer Daniels Midland (ADM) and Cargill are planning on major roles in ethanol and biodiesel plants in the United States and Europe, in soybean oil production in Brazil, and in trans-shipment facilities in Central America and the Caribbean. In Europe, too, large producers and distributors look to dominate the lucrative downstream portion of the biofuels industry.[323]

In coming years, cellulosic biofuels, derived from wood, grasses, or the non-edible parts of plants, may hold considerable potential. They would also help minimize a food-versus-fuel tradeoff. However, they require more capital-intensive, expensive production facilities, which makes it more likely that large corporate players will dominate this new field. Indeed, Brazil's Dedini, Dow, Dupont, Shell, PetroCanada, Volkswagen, and DaimlerChrysler are all showing interest—and will likely try to garner the bulk of profits for their proprietary technologies. The outcome will determine how much benefit—jobs, livelihoods, and revenues—will ultimately accrue to farmers and local economies.[324]

© Jim West / The Image Works / TopFoto
A bottle of ethanol and some of the materials ethanol can be made from at the National Renewable Energy Laboratory, operated by the US Department of Energy. Scientists are developing economical processes for making cellulosic ethanol from materials such as corn stalks, poplar, switchgrass, and other non-edible plants. Golden, Colorado.

A wild biofuels boom could come at a steep environmental and human price. The numbers of existing and projected jobs (easily 1 million now and possibly climbing to at least 10 times that much in the future) need to be interpreted carefully, and close scrutiny of environmental impacts and labor standards is required.

Much of biofuels development to date has been focused on exports to automobile-centered nations. By contrast, biomass projects that focus on the needs of communities in poorer countries are few and far between, even though the jobs and livelihoods benefits may be more pronounced.

According to a Woods Hole Research Center report, India could create some 900,000 jobs by 2025 in biomass gasification. Of this total, 300,000 jobs would be with manufacturers of gasifier stoves (including masons, metal fabricators, etc.) and 600,000 in biomass production, processing into briquettes and pellets, supply chain operations, and after-sales services. Another 150,000 people might find employment in advanced biomass cooking technologies. These numbers do not include employment generated in biomass collection and biomass plantations.[325]

In Bangladesh, Grameen Shakti plans to construct 200,000 biogas plants (with waste from cows and poultry used as feedstock) by 2012. It has so far helped to construct some 1,000 plants in two years (providing electricity and alternatives to expensive kerosene for rural households), and there is growing interest among small business owners in using biogas for electricity. Further, the organization sees potential for as many as 2 million improved cook stoves; it has already trained more than 600 local youth in making, selling, and repairing such stoves, and set up 10 manufacturing units for parts such as metal grates and chimneys.[326]

Summary

A range of findings and estimates covering individual aspects of the renewables sector has been presented above. Table II.1-9 summarizes the most salient employment figures discussed in this section. These are both global estimates and combinations of data for individual countries for which numbers are available. The table suggests that current global renewables employment runs to about 2.3 million. It should be noted that this is an incomplete figure as global figures are not available for all renewables.

The section stressed that technological leadership in developing viable renewables rests with a rather limited group of countries. Not surprisingly, some of the most advanced economies are part of this group. But developing countries play a role a well. Via their strong role in solar thermal and biomass development, China and Brazil account for a large share of the global total. And although both countries have fulfilled leadership roles in developing the technologies behind these renewable sources of energy, many of their jobs are found not in R&D or in manufacturing, but in installations, operations and maintenance, as well as in biofuel feedstocks. This suggest that other developing countries—Kenya was mentioned as one particular example in the solar field—can also hope to generate substantial numbers of jobs.

Table II.1-9. Estimated Employment in the Renewable Energy Sector, Selected Countries and World, 2006

Renewable Energy Source	World*	Selected Countries	
Wind	300,000	Germany	82,100
		United States	36,800
		Spain	35,000
		China	22,200
		Denmark	21,000
		India	10,000
Solar PV	170,000	China	55,000
		Germany	35,000
		Spain	26,449
		United States	15,700
Solar thermal	624,000-plus	China	600,000
		Germany	13,300
		Spain	9,142
		United States	1,900
Biomass	1,174,000	Brazil	500,000
		United States	312,200
		China	266,000
		Germany	95,400
		Spain	10,349
Hydropower	39,000-plus	Europe	20,000
		United States	19,000
Geothermal	25,000	United States	21,000
		Germany	4,200
Renewables, Combined	2,332,000-plus		

**Countries for which information is available.*

Given strong and rapidly rising interest in these energy alternatives, future years may well see employment soar—possibly as high as 2.1 million in wind energy and 6.3 million in solar PV by 2030, and on the order of 12 million jobs in biofuels-related agriculture and industry. Installation and maintenance of solar PV systems in particular offer tremendous job growth. With regard to the impact of biofuels development on the agriculture sector, however, there are many questions that remain to be addressed and that will determine not only the quantity of jobs, but also their quality and broad impacts on rural livelihoods and economies.

The renewables sector is a possible source of large-scale green employment, but a conducive policy environment is essential for translating this potential into full-fledged reality. Leaders in this field will naturally regard renewables as part of national competitive economic strategies. For instance, as discussed earlier, Germany views its investment in wind and solar PV as a crucial aspect of its export strategy. The intention is to retain a major slice of the world market in coming years and decades. Thus, most German jobs in these industries will depend on sales of wind turbines and solar panels abroad. This is of limited issue while few countries possess the requisite scientific and manufacturing know-how, and while the markets for wind and solar equipment are experiencing rapid growth. But over time, the interest of new entrants to the renewables sector will inevitably clash with those who seek to dominate world markets.

In the solar thermal sector, once Chinese companies overcome quality problems, they are poised to capture a major portion of the global market with their low-cost products. While this is good news for Chinese workers, it could be bad news for European workers. In other words, as these still-new industries mature, many of the difficult issues that characterize conventional industries—competitiveness, wages, trade rules, etc.—will increasingly mark the renewables sector as well.

This report has pointed out several times that green jobs and decent jobs are not necessarily one and the same, and this point is worth repeating here. Today, far more information is available about quantities of jobs than about their quality. But to make the term "green jobs" meaningful, considerations such as wages, working conditions, and workers' rights will have to become an integral aspect of future policies and strategies. Only then can we truly speak of fair and sustainable development. Governments, communities, businesses, and labor unions all have a role to play in ensuring a satisfactory outcome.

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Initiatives for energy efficiency and renewable energy have had priority in Denmark for over 25 years. The Danish plans and initiatives have resulted in development of new technologies and of successful use of energy efficiency and renewable energy. Aarhus, Denmark.

2. Buildings

Globally, buildings are responsible for between 30 and 40 percent of all primary energy use, greenhouse gas emissions, and waste generation.[327] The 2007 IPCC report identifies buildings as having the single largest potential of any sector for the reduction of greenhouse gases: the capacity to reduce projected emissions 29 percent by 2020.[328] Because of these two realities—the large environmental footprint and the capability to significantly reduce emissions—buildings have emerged as a critical area for climate change mitigation and the move toward environmental sustainability.

Fortunately, most of the changes required in the shift from conventional building practices toward energy-efficient buildings can be done primarily with existing technology with little or no net cost. Perhaps more importantly for businesses, individuals, and policymakers, energy-efficient measures in buildings have the potential of having a negative net cost over time, as the initial investment pays back over a period of time and can be reinvested back into the community. Energy efficiency leads to positive economic and employment growth.

The building and construction sector employs more than 111 million people worldwide, or approximately 5 to 10 percent of total employment at the country level.[329] Changes in how buildings are designed, built, and operated, along with how building components are manufactured and energy is used, are likely to affect job numbers and types of employment.

This section of the report explores the growing body of evidence that links energy-efficiency measures to employment opportunities and new jobs. Efficiency measures discussed include more comprehensive measures such as green buildings and retrofitting as well as individual building equipment and components, including: water heaters, cooking equipment, domestic appliances, office equipment, electronic appliances, heating, ventilation and air conditioning systems, and lighting. Macroeconomic studies of these energy-efficiency measures show an overall net increase in jobs. This section will highlight some of these major efficiency studies and draw upon them to assess the future job potential of the green building sector.

The section does not give a global quantitative number for the number of jobs created in green building. Certainly in some areas of the world, such as the United States and the European Union, it is possible to estimate employment numbers based on previous studies and emissions-reduction targets, but in most areas of the world, there is not enough data to report exact numbers. Instead, this section aims to show general trends in the building sector and to make the connection between increased investment in green building measures and increased employment creation.

The Environmental Impact

When buildings are viewed as a whole, they are one of the world's largest users of energy and emitters of greenhouse gases. In the European Union, buildings use as much as 40–45 percent of all energy.[330] They also use large amounts of raw materials and water and generate immense quantities of waste and pollution. The building sector consumes more electricity than any other sector worldwide. In the United States, buildings account for 39 percent of total energy use, 39 percent of CO_2 emissions, 68 percent of electricity use, and 12 percent of water use.[331]

These percentages include not only the energy used to operate the building, but also the stored or embodied energy it takes to produce the building materials (steel, glass, aluminum, and cement), building components (tile, glass, carpet), and the energy required to transport the materials to the building site. It is important to note that despite the intensity of building materials used in construction and the long distances traveled to the construction site, the largest percent of energy use by far, approximately 80–85 percent, occurs during the operational phase for heating, cooling, ventilation, lighting, water heating, and to run appliances.[332]

There are major differences in building emissions between the developed and developing world. These emissions are by far the highest in developed countries where people light, heat, and cool larger areas of residential and commercial space and use electrical appliances. Per capita, the top three countries with the largest CO_2 emissions from buildings are the United States, Australia, and Canada.[333] While there are variations both between and within countries, overall, in developed countries, 60 percent of the operational energy is used for heating and cooling purposes.[334] This is followed by 18 percent for water heating, 6 percent for refrigeration and cooking, 3 percent for lighting, and 13 percent for other purposes.[335]

While the global North tends to use energy for heating, cooling, ventilation, water heating, lighting, and domestic appliances, about one-third of the world's population does not have access to electricity. In rural areas of China, India, and Africa, biomass is the main energy source for over 70 percent of the population.[336] In 2007, approximately 2.4 billion people used biomass as their primary energy source; by 2030, this number will increase to 2.6 billion.[337] The extensive use of firewood, animal dung, crop waste, kerosene, and paraffin for heating and cooking contributes to poor indoor air quality, health issues, and environmental degradation. The use of wood biomass contributes to growing deforestation and desertification.[338] In both the developed and developing world, energy use in buildings is unsustainable, and future projections show large increases in energy consumption.

Projected Growth of the Building Sector

Studies of the OECD countries indicate that energy consumption in buildings has increased continuously since the 1960s and is likely to continue into the future.[339] In the International Energy Agency countries, average home size increased by 17 percent from 1990 to 2004, and energy consumption rose by 29 percent.[340] In the United States, average new homes now reach 210 square meters (approximately 2,200 square feet), more than two times the average home size in Western Europe and Japan.[341]

Larger spaces require additional lighting, heating, and cooling and are generally followed by the rise of additional household appliances, which have become the fastest growing area of energy use in the residential sector.[342] From 1990 to 2004, even though four out of five of the major large appliances—refrigerators, freezers, washing machines, and dishwashers—increased their efficiency, there was still a 50 percent increase in energy use of household appliances, with the United States, France, and Finland increasing their use by 70 percent.[343] This is largely attributed to the rise in ownership and use of air conditioners and small electrical appliances, including mobile phones, audio equipment, personal computers, and other electronics. (Many of these new smaller appliances still do not have energy-efficiency standards. The use of standby power in appliance also contributes to 1 percent of total carbon emissions.)[344]

In countries like India and China, where expansion of the middle class and urbanization is occurring rapidly, the emissions and energy use of buildings are projected to increase dramatically. More than 50 percent of all new building construction is now taking place in Asia, mainly in China. In the next two decades, 300 million Chinese are projected to move into urban centers, and China alone will add 2 billion square meters (21.5 billion square feet) of new construction each year, doubling its building stock by 2020.[345] The building sector in China is expected to grow by 7 percent annually; India and Southeast Asia will grow 5 percent.[346] The rapid pace of construction taking place in Asia is unsustainable, and unless traditional building and construction methods are altered, they will contribute immense amounts of energy, material, and water waste and contribute significantly to global climate change.

Energy Efficiency

The 2007 IPCC report states: "most studies agree that energy-efficiency will have positive effects on employment, directly by creating new business opportunities and indirectly through the economic multiplier effects of spending the money saved on energy costs in other ways."[347] The positive result of both environmental improvements and employment increases from energy efficiency measures is known as the "double dividend."[348]

European Union

One of the first studies to link employment and energy efficiency was a 1992 study by Jochem and Hohmeyer that looked at general energy-efficiency programs in West Germany between 1973 and 1990. The study found that approximately 400,000 new jobs were created during this time due to energy savings of 4.1 exajoules per year, which amounted to 100 new jobs per petajoule of primary energy saved.[349] Other studies in the late 1990s in Europe and North America also reported a net increase of jobs, but kept the figure closer to 40–60 new jobs per petajoule of primary energy saved. (The explanation for the decrease in jobs per petajoule of energy saved is increased labor productivity.)[350]

In 2000, a study conducted by the British Association looked at four different sectors—residential, schools, manufacturing, and public administration—and made not only conclusions about energy efficiency in general but also conclusions specific to the residential building sector. This study looked at 44 energy-efficiency investment programs in 9 EU countries (Germany, the United Kingdom, France, Spain, Finland, Austria, the Netherlands, Ireland, and Greece), 20 of which were in the residential sector. The study, which used input-output modeling (I-O), case studies and macroeconomic modeling, found that in the majority of cases (38 out of 44), additional employment was created. (In two of the cases, employment growth would have occurred without the investment, and in four cases the results were inconclusive due to insufficient data.)

More specific to the residential sector, the study determined that for every €1 million ($1.37 million) spent in energy-efficiency programs, 11.3 to 13.5 full-time equivalent jobs were created.[3351] Jobs were created mainly in the installation and delivery of new efficient materials or equipment, but also in management, administration, auditing, and research and development.[352] Finally, the study concluded that because the numbers were small, although they were positive, employment creation should be viewed as an added benefit to energy-efficiency programs rather than the main driving force.[353]

United States

An abundance of studies in the United States link energy efficiency with employment. The U.S. National Action Plan for Energy Efficiency (NAPEE) lumps energy efficiency and renewable energy together and estimates that a $7 billion per year investment would generate 298,000 jobs annually.[354] A 2005 study in the Midwest proposes a 1 percent reduction in natural gas and electricity consumption resulting in 30,000 new jobs and $16 billion in saved costs from 2006–2010.[355] And a 2002 report conducted by the Southwest Energy Efficiency Project (SWEEP) analyzed the potential job creation in Arizona, Colorado, Wyoming, Utah, Nevada, and New Mexico. The High Efficiency Scenario, which increases efficiency 33 percent by 2020 and reduces emissions 26 percent by 2020 (compared with the base reference scenario) projected 58,400 jobs and $28 billions in savings between 2003 and 2020.[356] The program calls for a total investment of $9 billion over the same period. Energy-efficiency measures focused mainly on the building sector (appliances, air conditioners, lamps and lighting, efficient design, and construction of residential and commercial buildings) but also included transport (efficient motor systems) and industry (in general). The authors of the study concluded that the improvements were technologically feasible but were not being used.[357]

Defining Energy Efficiency

Defining the energy-efficiency sector is a vexing problem, since most of the relevant activities, investments, revenues, and forms of employment are not found in distinct and thus easily identifiable factories or industries. Rather, they are embedded in a broad range of existing industries such as vehicle manufacturing, construction, lighting, heating and cooling equipment, electronics, consumer appliances, and so on. When discussing energy efficiency, a fundamental difficulty is to decide what constitutes an efficient product or piece of equipment. Ratings of eco-labeling programs such as Blue Angel in Germany or Energy Star in the United States can in principle serve as a yardstick for this purpose. But they serve different purposes, due to different levels of strictness, and thus may or may not be suitable indicators whether a given car, light bulb, window, piece of machinery, etc. is "efficient" or "inefficient."

A 2007 study for the American Solar Energy Society (ASES) makes a comprehensive effort to capture all relevant elements of what might be thought of as the "energy-efficiency industry." Among other items, ASES includes manufacturers of insulation materials, energy services and energy audit companies, recycling (collection and processing), reuse, and remanufacturing activities in a working definition. It relies on the U.S. Environmental Protection Agency's Energy Star ratings to determine the share of lighting products, appliances, windows and doors, and electronic and industrial equipment that could be considered efficient, and on LEED-certification for building construction.[1] In the automobile sector, it counts vehicles that score at least 10 percent better than the Corporate Average Fuel Economy (CAFE) standards as energy efficient.[358] Table II.2-1 shows a list of U.S. goods and industrial equipment that are labeled energy efficient by the ASES study.[359]

Table II.2-1. Selected U.S. Goods and Industrial Equipment Considered Energy-Efficient

Category	Share Considered Energy-Efficient (percent)	Standard Applied
Lighting and Appliances, of which:	20	Energy Star
• Light bulbs (CFLs)	<5	
• Clothes washers	15	
• Refrigerators	23	
• Room air conditioners	28	
• Dishwashers	40	
Windows and doors	40	
Computers, copiers, fax machines, VCRs	90+	
Televisions	50	
Audio electronic equipment	40	
Heating, ventilating, and air conditioning	30+	
Industrial and related machinery	10	ASES estimate
Residential and non-residential housing	3	LEED Certification
Vehicles	15	CAFE + 10 percent

Source: See Endnote 359 for this section.

The ASES study is a laudable and much-needed effort to define the efficiency sector in a systematic manner and to establish baseline data that could make future studies more comparable. It concludes that in 2006, there were 3.5 million direct jobs in energy efficiency-related activities in the United States, plus another 4.5 million indirect jobs, for a total of just over 8 million. The biggest chunk is accounted for by the recycling industry, with 3 million direct and indirect jobs. Manufacturing of nondurable products contributes 1.2 million jobs; miscellaneous durable manufacturing 0.9 million; companies producing computers, copiers, and fax machines 0.7 million; and construction 0.5 million. Sketching three scenarios (base, moderate, and advanced) for future developments,

1 LEED stands for Leadership in Energy and Environmental Design. It is a rating system developed by the U.S. Green Building Council.

the study suggests that energy efficiency could offer 15 million, 17.8 million, or perhaps even 32.2 million jobs, respectively, by 2030.[360]

The ASES methodology is based on the assumption that existing U.S. government standards and efficiency ratings are sufficiently indicative of (currently) achievable energy efficiency. At least in some respects, however, this is a somewhat questionable assumption, and it follows that the ASES job results are, in part, overly generous.

Types of Jobs

Energy-efficient measures in the building sector lead to direct, indirect, and induced jobs. Jobs are created directly in the building sector. This is significant because most of the sector is comprised of small and medium-sized enterprises: 90 percent of global construction still occurs in microfirms that have 10 or less employees.[361] Even the largest companies in the sector are small in comparison to the leading multinationals in other major industries like energy, banking and investment, and retail. The jobs created in the building sector are mainly performed directly at the development site, and therefore are typically local.[362] Indirect jobs are created mainly in the manufacturing sector. And induced jobs are created as money that would have previously been spent on energy is freed up and re-spent in the community. Not only are jobs created in building operations and construction, but they are also created in manufacturing, administration, and consulting.

It is important to note that many of these studies point to a more equitable distribution of wealth since the money saved is invested back into the local economy. "The positive employment and income results are due primarily to the relatively low labor intensity of the energy sectors (coal, oil and gas extraction, fuel refining and electric and gas utilities) compared to the economy as a whole. Conserving energy reduces the energy bills paid by consumers and businesses, thereby enabling greater purchase of non-energy goods, equipment, and services. The result is a shift of economic activity away from energy supply industries and towards sectors of the economy which employ more workers per dollar received."[363]

Traditional energy services, which are generally managed in centralized urban areas, are replaced by jobs that can occur within all communities. The number of jobs in the manufacturing, construction, education, services, finance, and agriculture sectors are more labor intensive than the energy sector and stand to benefit from energy-efficiency measures. The Apollo Alliance estimates that for every $1 million invested in the United States, 21.5 new jobs are created from energy efficiency, as compared to only 11.5 jobs for new natural gas generation.[364] Because these new jobs are performed at the local level and are often done by small enterprises, energy-efficiency programs are especially important for underdeveloped regions and areas of high unemployment rates.[365]

There are some variations between studies on what percentage of jobs are created directly from energy-efficiency measures and how many are related indirectly to energy savings and the re-spending of those savings. One study from the American Council for an Energy-Efficient Economy (ACEEE) showed that 90 percent of jobs were indirect and 10 percent were direct.[366] Another study from Europe showed that one-third of jobs created by energy-efficient measures were direct and two-thirds were indirect. Despite the differences in their conclusions, both studies show that the majority of jobs are created indirectly through savings that is redirected back into more energy-intensive sectors.

Job Losses

Not all job news is positive. Although most sectors of the economy stand to gain employment and to benefit from energy savings, some jobs in energy-intensive or energy-producing fields will likely be eliminated. Energy efficiency means a reduction in the production of carbon-based energy and energy- intensive products, which directly translates to a demand for workers in those sectors. Workers in coal, oil, gas extraction, and fuel-refining industries are likely to see a reduction of jobs in these sectors.[367] This shift from energy-intensive and -producing fields to other sectors requires a just transition for workers.

Green Buildings

Energy-efficient buildings, also known as green or high-performance buildings, drastically reduce emissions, material, and water use and have the potential to reduce energy by up to 80 percent or more. Green buildings reduce their energy load by integrating efficient systems (heating, cooling, lighting, water); use alternative energy sources (passive solar, alternative energy sources); retain energy (efficient insulation and windows, thermal mass); and use recycled, reused, or low-energy building materials.

Eleven countries, which have the potential to oversee 50 percent of all new global construction, are currently members of the World Green Building Council.[368] Dozens of other countries are considering or are in the process of forming green building councils, many of which are in emerging and developing countries.[369] (See Table II.2-2.) The councils adopt energy-efficiency standards for buildings. The most recognized programs are BREEAM (United Kingdom), CASBEE (Japan), Green Star (Australia, New Zealand), and LEED (United States, Canada, India), Passivhaus (Germany, Australia, United Kingdom), Minergie (Switzerland), and Haute Qualité Environnementale (France). In total, 21 countries have at least one established green building certification standard.

Table II.2-2. Countries with Green Building Councils

Established Councils	Emerging Councils
Australia*, Brazil*, Canada*, India*, Japan*, Korea**, Mexico*, New Zealand*, Philippines, Taiwan*, United Arab Emirates*, United Kingdom*, United States*	Argentina, Chile, China, Egypt, Germany, Greece, Guatemala, Hong Kong, Israel, Nigeria, Panama, South Africa, Switzerland, Turkey, Vietnam

**Current member of the World Green Building Council*
***In the process of joining the World Green Building Council*
Source: See Endnote 369 for this section.

In the United States, there are currently over 40,000 LEED-Accredited Professionals involved in design, construction, operations, or maintenance.[370] In addition, there are 1,500 LEED accredited professionals in India, 900 Green Star professionals in Australia, and 1,197 BREEAM-licensed assessors in the United Kingdom. These numbers have been increasing and are projected to rise further as green building takes over a larger share of the construction market.

The Apollo Alliance New Energy for America report projects that 827,260 jobs could be created in the United States through investment in high-performance buildings, both retrofitting and new green construction. The plan requires an $89.9 billion dollar investment to improve financing for green buildings, provide tax incentives, invest in research and development, and promote new building codes and standards.[371]

New green construction does allow for the possibility of some new jobs due to the increased investment in the construction phase. But most of the jobs created through green building practices are likely to occur from energy savings and reinvestment. The types of jobs will need to be redefined in terms of new skills, training, or certification requirements; however, many of these jobs are likely to be performed by people who are already working in the building sector.

Redefined jobs include green building architects and designers, who as part of the green building sector must consider the entire life cycle of the building and reduce raw material use, emissions, and water use and improve energy efficiency, indoor air quality, and occupant health. Because green buildings are designed as single, integrated systems, the architects and designers must understand the various components involved in green building: efficient heating, cooling, lighting, cooking, appliances, and insulation; passive solar, thermal mass, renewable energy sources; and low-impact building materials. Understanding the green building process and local or national green standards requires additional knowledge, training, and certification. In most cases, these new green design jobs replace already existing ones.

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The Centre for Alternative Technology, showing polytunnel, geodesic dome and on the right, a photovoltaic roof for generating electricity. Wales, near Machynlleth, UK.

© Martin Bond / Still Pictures
Ecological houses at eco-village with earth sheltering (at rear), turf roofs and various active & passive solar features. Dyssekilde, near Hundestad. Denmark.

A shift away from traditional housing to green construction also provides a unique opportunity to meet Target 11 of the United Nations' Millennium Development Goals (MDGs), which aims to alleviate slum conditions for 100 million people by 2020.[372] (See Box II.2-1.) New developments in technology, such as solar panels and solar water heating, reduce the costs of alternative energy sources and lessen the dependence on traditional energy infrastructure. In addition, because most of the work involved in building sustainable housing is done through the delivery, installation, and construction, the vast majority of jobs created will occur at the local level and provide additional opportunities for employment.

Box II.2-1. Green Building, Slums, and the Millennium Development Goals

The world's present urban population now reaches over 3.2 billion people, or half the global population. The vast majority of this growth has occurred in less-developed countries. The rate at which people in developing countries are moving into urban centers is five times the rate at which new housing stock is constructed. The end result has been massive numbers of informal settlements and the explosion of slums. Currently 1 billion people, mainly in Africa, Asia, and Latin America, live in urban slums and lack durable housing, sufficient living space, clean water, and sanitation. By 2050, it is estimated that an additional 4 billion people, almost the entire expected projected world population growth from now until then, will live in urban areas. Eighty-eight percent of this projected growth is expected to occur in low- and medium-income countries.

The United Nations' Millennium Development Goals, which aim to alleviate 100 million people from slum conditions, are far from being met. A shift away from traditional housing to green construction may provide a unique opportunity to meet these targets. Certain infrastructure costs can be bypassed by new developments in technology. For example, dependence on an electricity grid may no longer be necessary with the installation of solar panels and solar water heating. By reducing energy costs, this makes the development goals more feasible for municipalities and residents.

Along with the growth in urban population has been the growth of the world's labor force. Since most of the work involved in building sustainable housing is done through the delivery, installation, or construction, the vast majority of these jobs will occur at the local level and can provide employment for people in these communities.

Source: See Endnote 372 for this section.

Despite the overall social, economic, and environmental benefits, sustainable building practices remain a niche market. The cost of green building or the perceived cost is still a major barrier. A 2007 report by the World Business Council for Sustainable Development reported that despite the increasing knowledge and understanding about green buildings, key decision makers still overestimate the cost. The 1,400-person survey found that the average guess for the additional cost of building green was 17 percent, when the actual amount is closer to 5 percent. A 2003 report by the U.S. Green Building Council put the increase at as little as 2 percent.[373] Other more conservative estimates for the most efficient buildings are around 10 percent. These additional costs, although sometimes initially prohibitive, are paid back over 2–7 years. After the initial payback period, they become a negative cost, as the savings over time are greater than the initial increase in investment.

Other barriers to greening the building sector include: short term profit motives over long-term savings, fragmentation within the building sector, lack of education, lack of available resources, and lack of mandatory standards.[374]

Retrofitting

According to the IPCC, retrofitting and replacing equipment in buildings has the largest potential within the building sector for reducing greenhouse gases by 2030.[375] Even with the continued growth of the building sector, most of the structures that will be built in 2030 have already been built. This is why retrofitting plays such a critical role in reducing emissions.

Retrofitting buildings directly increases employment because without an attempt to make the building more efficient, the work would not have been done. Types of jobs that are likely to be created directly in the retrofitting process are auditors, engineers, estimators, project managers, and various jobs in the constructions trades including pipe fitters, sheet metal workers, HVAC technicians, engineers, electricians, and general construction workers.[376] Most of these jobs are created during the initial construction or investment period and are likely to stimulate the local economy because they are performed at the work site.

The most ambitious building retrofitting project to date is the German Alliance for Work and the Environment's initiative to retrofit German homes. The Alliance is a collaborative effort between the German government, unions, NGOs, and employers' federations. From 2001–2006, an estimated $5.2 billion (€3.8 billion) of public subsidies stimulated close to $20.9 billion (€15.2 billion) in investment and has resulted in 342,000 apartment retrofits as of March 2006—exceeding the initial goal of 300,000 apartment retrofits.[377] An estimated $4 billion was saved through additional tax revenues and reductions in unemployment benefits, along with 2 percent of annual emissions attributed to buildings in Germany.[378] Energy-efficient measures included improving heat insulation of roofs, windows, and walls; introducing advanced heating technologies and controlled air ventilation systems; and using renewable energy such as PV or solar thermal systems.[379]

© M. Renner, 2005
Solar thermal panels on the Ocean View Guesthouse. Sri Lanka.

The German Alliance for Work and the Environment estimated that 200,000 jobs would be created; however, a 2004 assessment of the German Alliance for Work and the Environment showed that only 25,000 full-time equivalent (FTE) additional jobs were produced. Another 116,000 were saved between 2002 and 2004 during a recession in the construction sector. Even though these numbers are lower than expected, the job numbers are still fairly substantial, with around 140,000 new or saved jobs. These results along with the additional revenue and savings prompted the German government to not only renew the project, but even increase the money allotted for the program. In 2005, Germany increased the funding of its building retrofit program to almost $2 billion (€1.4 billion) per year.[380] For every $1.4 billion (€1 billion) invested in the program, 25,000 additional jobs are expected.[381] In 2006, an estimated 145,000 additional FTE jobs were created.

A 2005 Ecofys study of the 10 European Union new member states—Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia—projected 50,000 to 185,000 jobs by retrofitting the existing residential building stock. The program calls for a minimum of $2.2 billion (€1.6 billion) per year for large apartment buildings and up to $6.4 billion (€4.7 billion) per year to incorporate all houses.[382]

The Canadian government estimates implementing a retrofitting program on a national scale would result in 5,600 to 7,840 person-years of employment at the local level. This is 20 jobs for every $1 million invested, or 1 job for every $50,000. A potential investment of $280–392 million dollars invested in energy-efficiency improvements could reduce greenhouse gases by 800 kilotons per year. After the initial payback of 5 to 7 years, this would save the government $56 million dollars per year.[383]

The Clinton Climate Initiative (CCI) recently launched its Energy Efficiency Building Retrofit Program in 16 of the world's largest cities: Bangkok, Berlin, Chicago, Houston, Johannesburg, Karachi, London, Melbourne, Mexico City, Mumbai, New York, Rome, São Paulo, Seoul, Tokyo, and Toronto. This project involves five major banks, and four of the largest energy service companies (ESCOs) are providing $5 billion in funding for retrofitting of municipal buildings and providing incentives for private building owners to retrofit existing buildings.[384] (See Box II.2-2.) They also created the C40 Large Cities Climate Leadership Group to provide support for energy-efficiency programs in 40 megacities in both developing and developed countries.

Box II.2-2. Energy Service Companies (ESCOs)

Businesses that develop, install, and finance energy-efficiency projects are called ESCOs, or Energy Service Companies. ESCOs pay for the initial capital investment and are paid back over time through the energy savings, therefore covering the initial upfront costs and making energy-efficiency programs attractive to building owners. Since the 1970s, ESCOs have provided funding for $20 billion worth of projects worldwide, of which approximately $7 billion has gone for labor employment. The Lawrence Berkeley National Laboratory estimates that ESCOs have provided $4 billion in energy-efficiency investment in the United States, of which 25 to 30 percent is spent directly on labor to design, install, operate, and maintain efficiency programs in the building sector. This area has enormous potential to grow and create jobs.

Source: See Endnote 384 for this section.

Other major retrofitting projects are emerging. In 2005, Chinese officials announced that using existing technology, the country will transform all existing buildings into energy-saving buildings by 2020 and reduce energy use by as much as 65 percent.[385] In Berlin, the BEA (Berlin Energy Agency) created energy-efficient incentives at no cost to the building owners. New York City's PlaNYC commits 10 percent of the city's energy budget, $81.2 million dollars in 2007, to retrofit municipal buildings—which amounts to 5,000 new jobs in the building sector.[386] Table II.2-3 shows some additional municipal energy targets.[387]

Table II.2-3. Selected Municipal Energy Targets in the Building Sector

City	Target
Baden-Württemberg, Germany (southwestern state)	20 percent of heating from renewable sources in newly constructed residential homes
Berlin, Germany	30 percent decline in energy use in public buildings by 2010; solar water heating incorporated into 75 percent of new buildings annually
Copenhagen, Denmark	Energy audits for all buildings exceeding 1,500 square meters; all new buildings must rely on district heating (electric heating banned)
Leicester, United Kingdom	50 percent decline in municipal building energy use by 2025 (from 1990 level)
Oxford, United Kingdom	10 percent of homes to use solar hot water or PV by 2010
Seattle, Washington	LEED standards for all buildings over 5,000 square feet (465 square meters)
Berkeley, California, USA	Green building standards for all sold, renovated, or transferred homes
Portland, Oregon, USA	LEED Gold Standard for all new city-owned construction
Tokyo, Japan	5 percent renewable energy use in large municipal facilities

Source: See Endnote 387 for this section.

The European Trade Union Confederation reports that it would cost $4,300 billion (€3,145 billion) to retrofit the EU's residential building sector in order to reduce CO_2 emissions by 75 percent. The ETUC report creates two time periods under which this 75 percent reduction could take place. In the 2050 scenario, 1.38 million full-time equivalent jobs would be created; in the 2030 scenario, 2.59 million full-time equivalent jobs would be created. These ambitious EU scenarios require that governments play a key role in funding energy-efficiency programs which will in turn help fund new employment and stimulate economic growth. The other, less-ambitious scenarios would result in less job creation. The Business as Usual (BAU) and Eurima scenarios, which reduce emissions by 8 percent and 16 percent respectively, would create 20,000–62,500 full-time equivalent jobs for BAU and 160,000–500,000 full-time equivalent jobs for the Eurima scenario.[388] Comparing these scenarios demonstrates that the larger the investment and the faster that these programs can be implemented, the larger number of jobs that can be created.

Energy-Efficient Building Components

Jobs in the green building sector, both new construction and retrofitting, are likely to stimulate jobs in the manufacturing of green building components and systems, including: efficient waste, lighting, HVAC, water filtration, and insulation systems, and energy-efficient appliances. PV panels, solar water heaters, small wind turbines, or geothermal heat pumps are often used to provide alternative energy sources for green buildings and will add to green manufacturing jobs.

Urbanization, the growth of the middle class in developing countries, the trend for bigger homes, and the desire for more electrical appliances and technology will add to the growth of these industries. Energy-efficient appliances use more skilled labor than manufacturing inefficient ones.[389] The U.S. Department of Energy predicts that standards for clothes washers, water heaters, and fluorescent lamp ballasts would create 120,000 jobs in the United States through 2020.[390] The Apollo Alliance estimates that an investment of $3.5 billion to modernize appliance standards would result in 29,876 jobs and create $5.89 billion in personal income.[391]

In India, replacing traditional cook stoves with recently developed advanced biomass cooking technologies in 9 million households could create 150,000 jobs. (These numbers do not include employment generated in biomass plantations.) Advanced biomass cooking techniques are especially important for the reduction of the negative health effects and respiratory diseases associated with using traditional cooking biomass (animal dung, wood, crop waste) inside poorly ventilated homes. This improvement could be especially significant for the health outcomes of women and children.[392]

With regard to the cost of funding green building projects, it is important to note that energy-efficiency programs are the most affordable kind of emissions-mitigation projects. The McKinsey Global Institute has identified lighting, insulation, air conditioning, and water heating as being four of the five most cost-effective ways to reduce emissions. (The only program not related to buildings is increasing the efficiency of commercial vehicles.)[393]

Lighting

Lighting is one of the lowest hanging fruits for energy-efficiency measures because the transition can occur at relatively low costs with already existing technology and provides immediate results. A global switch to replace one in five light bulbs by 2030 would decrease carbon dioxide emissions by 400 million tons.[394] Energy-efficient light bulbs are cost effective over the long term. The total cost of burning 10,000 hours of light is $34 (€25) for CFLs as opposed to $116 (€85) for incandescent bulbs.[395]

Traditional light bulbs are already being replaced by more energy-efficient light bulbs and lighting systems. Australia announced in early 2008 that it would ban the sale of all incandescent bulbs by 2010, and the U.S. state of California has proposed a similar bill for 2012. European Union leaders have proposed to create efficiency requirements for offices and street lighting by 2008 and for lighting in private homes by 2009, which would save the EU 20 million tons of carbon emissions yearly.

Between 1995 and 1998, Mexico carried out the first large-scale energy-efficiency lighting program in a developing country by replacing old lighting with 1 million compact fluorescent bulbs in households. This program, called ILUMEX (Illumination of Mexico), demonstrated positive economic returns for residents, the power sector, and communities. It helped generate direct and indirect jobs and trained indigenous people to work on large-scale efficiency programs. Smaller lighting programs have also been implemented in Belize, Bolivia, Brazil, Costa Rica, Cuba, Ecuador, Peru, and Venezuela.[396]

Manufacturers of CFLs and LEDs (light emitting diodes) are likely to see tremendous growth in these areas. The three major multinationals that have traditionally dominated the incandescent lighting market—Philips, GE, and Sieman's Osram Sylvania—are also anticipating a switch away from incandescent lights to more efficient ones. Philips has announced that by 2016 it will no longer sell incandescents. And GE and Siemen's Osram Sylvania are designing new types of lights to replace today's standard bulbs. Philips and Sylvania already lead the LED market, with a 50 percent share.[397] In the photonics industry, which has five major markets (one of which is LED lighting and displays), the estimated number of jobs is expected to grow in the European Union from 500,000 in 2003 to 1.5 million in 2010.

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Variety of designs Energy saving lamp. It uses 20W of electricity but produces 100W of illumination. 80% lower electricity consumption compared to traditional bulbs. Lasts 10 years when used an average of 3 hrs per day.

Conclusion

The aforementioned energy-efficiency measures in the building sector—green building, retrofitting, and building components (including water heaters, cooking equipment, domestic appliances, office equipment, electronic appliances, heating, ventilation and air conditioning systems, and lighting)–have great potential to both reduce greenhouse gas emissions and create jobs. But they remain underutilized. New green building initiatives are also a step in the right direction, but only represent a small fraction of the potential in this sector. (Canada reported that just 150 building projects (1.5 percent of total construction costs) were registered as LEED in 2005, and the 2007 ASES study concluded that only 3 percent of buildings in the United States qualified for LEED certification.)

For the most part, these retrofitting programs and green building initiatives are confined to a handful of countries in the global North. Aside from the German retrofitting program, the Clinton Climate Initiative, and a few other emerging projects, the amount of capital available for green building, retrofitting, and energy-efficient measures pales in comparison to the amount needed to make a significant dent in emissions. Table II.2-4 is a list of key policy recommendations specific to the building sector. It is not intended to be all-inclusive, but focuses instead on the most important initiatives in this area.

Table II.2-4. The Way forward

Type of Policy	Policy
Standards	• Establish minimum green building standards for all new construction. This is especially important in the developing world, and especially in China, where almost half of all global construction is taking place. It is more cost ef ective to build new green construction than to retrofit projects at a later time. • Create regularly updated minimum standards and standardized labeling for equipment and appliances (water heaters, HVAC, cooking, appliances, lighting, electronics, office equipment, windows, and others). More than 50 countries currently have either standards or labeling programs, which have resulted in energy savings, but much more is needed. Inefficient lighting programs must be phased out.
Financing	• Create financing programs for retrofitting. Buildings have an extremely long lifetime, often more than 50 years, but this lifespan is shrinking. Reverse the trend by renovating and retrofitting old buildings as opposed to building new. These projects are extremely labor intensive and will result in a large number of building and construction jobs. • Target programs that have immediate results and are very cost ef ective, especially lighting programs, air conditioning, water heating, and building insulation. Provide incentives and funding opportunities for people to make these changes • Support a global ef ort to scale up new green building, retrofitting, and energy-efficiency programs in the developing world. Establish funds for energy-efficiency programs in developing and emerging economies.
Research and Development	• Increase R&D funding to explore more energy-efficient buildings (e.g., passive houses and zero-emission buildings). Current funding is much too little: in the United States, federally funded research for buildings amounts to just .02 percent of the annual construction budget. The U.S. Green Building Council suggests that the National Institutes of Health and National Science Foundation increase their research budgets to 2 percent for buildings.

The sheer number of buildings that need to be retrofitted is staggering. The United States and European Union alone have 250 million such homes. Based on the results of the Apollo Alliance and European Commission studies, greening the building industry in the two regions would create almost 2 million jobs (3.5 million jobs using the ETUC study's Advanced Scenario of a 75 percent CO_2 reduction in the residential building sector by 2030). Although exact figures are unknown, it is easy to imagine that a worldwide transition to energy-efficient buildings could create millions or even tens of millions of jobs and would green existing employment for many of the estimated 111 million people already working in the sector. Furthermore, greening municipal, commercial, industrial, and residential buildings will radiate out to people who work in these energy-efficient buildings.

A hydrogen fuel cell-powered electric bus in service crossing Tower Bridge in London. Part of the Clean Urban Transport Europe (CUTE) demonstration project testing 27 such pollution-free buses in nine European cities.

3. Transportation

The transportation sector is a cornerstone of modern economies and an important source of jobs. Characterized by a heavy reliance on cars and trucks—and increasingly airplanes—for both passenger and freight movement, transportation is a major consumer of fossil fuels, an important source of urban air pollution, and a big contributor to climate change. Internal combustion engines accounted for 95 percent of world transport energy use in 2004, when the transport sector claimed 26 percent of total world energy use and was responsible for 23 percent of energy-related greenhouse gas emissions.[398]

The challenge to make transportation sustainable is rapidly magnifying. The sector's carbon emissions are projected to rise by more than 30 percent by 2010 compared with 1990 levels—the fastest increase of any economic sector.[399] Ever-more cars on the world's roads are being driven ever-longer distances, and there is an ongoing shift from less fuel-intensive and less-polluting public means of transportation toward private cars and trucks. Air traffic is growing by leaps and bounds, but it is by far the most fuel-intensive mode—and thus extremely difficult to make more green at present or projected levels of activity. This section will address aviation briefly but will focus primarily on ground transport.

Aviation

On the passenger side alone, world air travel has exploded—rising from 28 billion passenger-kilometers in 1950 to 3,720 billion passenger-kilometers in 2005.[400] Aviation fuel efficiency can be improved via better technology and air traffic management. New aircraft today are 60–70 percent more fuel-efficient than those designed 40 years ago.[401] A further 20 percent gain by 2015 over 1997 levels seems attainable, and perhaps a 40–50 percent gain by 2050. But the IPCC cautions that such improvements are insufficient in view of aviation's rapid annual growth of about 5 percent.[402] Additional changes are needed, including alternative fuels and lower aircraft speed. The International Air Transport Association (IATA) has called for 10 percent of aircraft fuel to be from alternative sources by 2017.[403] The jobs of scientists and engineers who develop more efficient planes can be regarded as green, but given the massive energy use in comparison with all other modes of transportation, the bulk of the aviation sector's employment would be difficult to characterize as green even with additional efficiency gains.

During take-off, planes use a large share of fuel—up to 25 percent of the total fuel consumption on short flights—and produce the most harmful emissions. Yet it is precisely short-distance flights that are expected to account for 90 percent of all departures by 2023 (17,000 of 25,000 new planes to be built according to current plans are for short-haul purposes).[404] A climate-sensitive transportation policy will need to reduce the number of such short flights and encourage passengers to switch to high-speed rail instead, which produces only a fraction of the emissions. Such priorities would give a boost to greener employment. Changes in priority need to be considered both by leisure travelers (especially short flights for weekend getaways and similar purposes) and business travelers.

Business travelers account for a substantial share of flights. In addition to making considered choices as to the mode of transportation when traveling to conferences and business meetings, they may be able to shift to increasingly capable virtual-conferencing services when face-to-face meetings are not essential. Such services also offer business and employment opportunities in their own right. Companies like Credit Suisse and Bell Canada are actively pursuing alternative options.[405]

In a sustainable economy, there will be fewer jobs in airplane manufacturing and air travel services than today. But from a macro-economic perspective, this is not necessarily a negative development. Many jobs in the aviation industry are effectively heavily subsidized, via exemptions from fuel duty, value-added tax, and duty-free rules. In the United Kingdom, where broadly defined up to 200,000 people are employed in the aviation industry, one study found that subsidies per aviation job run to about $90,000 (£45,000) per year, or a total of $18 billion (£9 billion). The foregone tax revenue would be sufficient to generate an equal number of jobs elsewhere in the economy. In fact, aviation subsidies finance job loss in other parts of the transport sector that do not benefit from equally generous treatment.[406] A shift toward more sustainable transport is feasible, but it requires careful planning and transition measures.

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Lufthansa Technical Department. Turbine workshop. Philippines, Manila.

Road Transport

Road transport currently accounts for 74 percent of total transport CO_2 emissions and for the majority of transportation jobs.[407] Thus, a move toward sustainability in this sector is especially critical.

Production of passenger cars and light trucks continues to surge, reaching 74 million units in 2007, up ninefold from 1950. North America, Western Europe, and Japan have long accounted for the bulk of motor vehicle production and ownership. In 2004, they had 552 million passenger and commercial vehicles, or two-thirds of the total world fleet of 826 million.[408] The United States alone consumes nearly half of global motor gasoline use (44 percent in 2004).[409]

But developing countries are ratcheting up their involvement as well. China and India still account for only about 5 percent of the global fleet, but they are gearing up to boost their production and ownership. China's passenger car production has rapidly expanded from 100,000 in 1991 to 6.7 million in 2006, when it overtook Germany to become the third largest car producer, to 8.1 million in 2007.[410] India is currently the 11th largest producer, and its domestic passenger car sales have doubled to 1.4 million since 2002.[411] At the beginning of 2008, Tata Motors introduced the Nano, billed as "the world's cheapest car"—though production runs are planned to be modest for now, this potentially brings car mobility within reach of hundreds of millions of people in India and perhaps elsewhere in the developing world.[412]

A broad array of measures can help to reduce transportation's environmental footprint, ranging from relatively narrow technical changes to broad, systemic solutions. Alternative fuels, hybrid gasoline/electric vehicles, plug-in electric vehicles, and hydrogen/fuel cell-powered cars are in various stages of development.[413] Such technological developments could portend many job opportunities in the future.

Greater fuel economy not only limits energy consumption, but translates directly into reduced emissions of carbon dioxide. It can also help to reduce a vehicle's air pollutants, although fuel economy and low emissions do not always go hand in hand.[414] Indeed, some vehicles are fuel-efficient but do not score well on emissions, and vice versa. This is only to a certain degree an issue of engine technology; producing cleaner fuels (especially with lower sulfur content) is also critical. Stringent standards to limit emissions of air pollutants are needed in both regards. Japan and the United States, followed by the European Union, have the most stringent emission limits. China is introducing regulations that echo those of the E.U. But high-sulfur fuels threaten to negate the benefits of these rules.[415]

© Bubsaba Kajejit-UNEP / Still Pictures
The Eta.Paholyotin Road, Chatujak, traf c congestion. Bangkok, Thailand.

A more fundamental change is a shift in transportation modes, reducing the reliance on cars and trucks and increasing the use of buses, trams, and light rail in urban or sub-urban settings, and railways for inter-city transportation. This will bring associated shifts in employment. Reorienting the transportation sector toward greater sustainability requires not only a different mix of transportation modes, but also far-reaching changes in land use and land-use planning. Denser cities and shorter distances reduce the overall need for motorized transportation. They also make alternatives like public transit, biking, and walking more feasible.

Even though a sustainable transportation policy may ultimately lead to fewer jobs in car and truck manufacturing and related fields such as fuel refining and distribution, it offers more jobs in manufacturing of buses, light rail, subways, and railways; in the provision of the required infrastructure for these modes of transportation (including tracks, signals, stations, etc.); and in planning, running, and maintaining transit systems (bus drivers, conductors, and other operators; route planners, maintenance staff, etc.). Public policy needs to address the inevitable transition from one to the other in order to smooth the process for those whose jobs will be reoriented or lost.

It is not always an either-or choice between automobiles and public transportation. A sophisticated modal mix suggests that there are proper roles for both. Initiatives have emerged in growing numbers of cities that offer an alternative to the strictly private automobile. Car-sharing programs offer individual mobility while reducing the number of vehicles in circulation. Managing car-sharing programs offers additional employment. At present, however, such efforts are still too limited in number and scale to permit any reliable projections of their future job potential. In Germany, car-sharing enterprises employed a marginal 250 people in 2004.[416]

Hybrids and Diesels

As automakers and governments search for ways to reduce the environmental impact of transportation, the hunt is on for alternative fuels. This report has already discussed green job opportunities in biofuels. What follows here is a brief look at gasoline/electric hybrids and diesel vehicles, before assessing employment related to fuel efficiency more broadly.

Hybrid vehicles are generally seen as a key means to achieve higher fuel efficiency. In principle, they can certainly deliver on that promise, although driving cycles and habits can have a major influence on actual fuel-economy performance. Because hybrids encompass an electric engine in addition to a conventional gasoline motor (plus a battery to power the extra motor), these cars require additional inputs and thus their production entails more employment than a regular car.

In 2007, a total of 541,000 hybrids were produced worldwide, most of them by Toyota.[417] Following Toyota's success with the Prius (in the decade since introducing the model, the company has manufactured 1 million hybrids, increasing its production to a projected 2007 figure of 430,000), more and more manufacturers are joining the hybrid bandwagon, especially in the United States.[418] In the 2007 model year, 2.2 percent of U.S. light-duty vehicles were hybrids.[419] A forecast for 2015 projects that hybrids (850,000 vehicles) might account for 5 percent of total U.S. sales, or possibly as much as 11 percent (2 million vehicles).[420]

It must be noted, however, that automobile companies are increasingly introducing so-called "muscle hybrids"—using the technology more to boost acceleration and horsepower than to improve fuel economy.[421] To the extent that this will be the dominant application of hybrid technology, the market penetration of hybrids can only within limits be regarded as a proxy for estimating green automobile production and jobs. In a similar vein, the IPCC has expressed concern that fuel economy technologies generally "can be used to increase vehicle power and size rather than to improve the overall fuel economy and reduce carbon emissions."[422]

The development of hybrids and plug-in electric cars will likely be a boon for manufacturers of batteries (such as nickel metal hydride and lithium ion) as well as for companies involved in creating an infrastructure for recharging and servicing electric cars. If batteries can be made sufficiently cheap, reliable, safe, and recyclable, this may lead to the creation of a substantial number of jobs. Companies in this emerging industry include independents such as Ener1, A123 Systems, and Johnson Controls, but also subsidiaries of South Korea's consumer electronics giant LG and Germany's Continental, a tire producer.[423]

© Martin Bond / Still Pictures
Electric car charging station powered by solar energy. City Hall, Santa Monica, California, USA.

Diesel engines typically consume 30 percent less fuel than gasoline engines and emit 25 percent less CO_2. For that reason, it is not surprising that European countries (and also increasingly South Korea and India) are favoring diesel-powered vehicles. Diesel engines account for 50 percent of all cars sold in Europe.[424] Consulting firm J.D. Power and Associates projects that global demand for diesel light vehicles will nearly double from 15 million in 2005 to 29 million in 2015.[425]

Diesel engines have long been notorious polluters. Existing fleets of heavy trucks and buses running on diesel remain major contributors to dangerous urban air pollution. Evolving engine technology and cleaner fuels have rendered diesel passenger cars substantially cleaner, especially with regard to sulfur dioxide emissions. But they still emit far more nitrogen oxides and particulate matter than their gasoline counterparts.[426] Diesel-powered vehicles continue to perform poorly on the American Council for an Energy-Efficient Economy's (ACEEE) annual ranking of vehicles due to the high levels of environmentally damaging nitrogen oxides and particulate matter they release, despite greater fuel efficiency.[427]

Although hybrids and modern diesels clearly are promising technologies, only under certain conditions can they be seen as unambiguous proxies for a greener auto industry. Strong rules and standards would appear to be critical in this regard.

Lean and Clean

Leadership in pursuing fuel economy is essential to the future viability of the automotive industry. Companies that lag in this regard run the risk that their vehicles will increasingly fall short of fuel-economy mandates and, as fuel prices rise, lose favor with consumers. In the drive toward a greener economy, leading on fuel economy will increasingly help maintain and create jobs in the automotive sector; lagging behind endangers jobs.

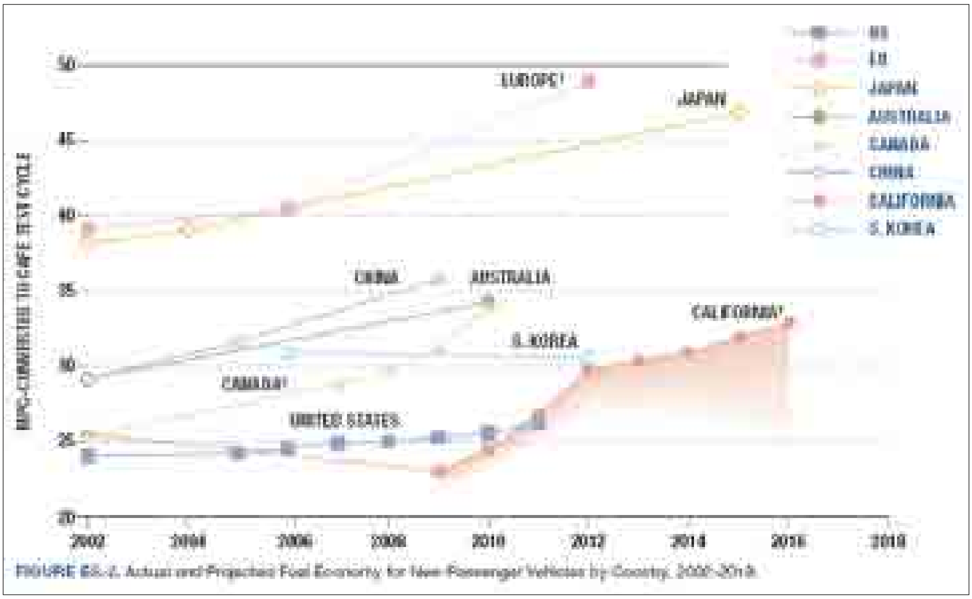
Most immediately, developing fuel-efficient engines and transmissions will be a boon for scientists and technicians that develop relevant technologies at car companies, suppliers, government laboratories, and universities.[428]

Beyond the field of R&D, however, how many of the world's auto-manufacturing jobs can be considered green in this context? Efficiency is a relative concept, with inherent difficulties in setting an unambiguous threshold that separates gas sippers from gas guzzlers. Current practice is by and large inadequate relative to the need to dramatically reduce transportation's environmental footprint. Thus, the threshold needs to be ambitious.

For a particular vehicle model to be considered efficient, it would have to perform well vis-à-vis best practice internationally. And over time, the threshold above which a vehicle (and by implication the jobs needed to build it) can be regarded a reasonable shade of green would have to be on an upward sliding scale—guided less by an "as is" approach than by "what could be." The implication, of course, is that a job that may be considered green today may not be seen that way in the future as technological development opens up new vistas in terms of energy and materials efficiency and waste avoidance. "Green jobs" is a dynamic, ever-changing concept—at least until the economy is on a far more sustainable footing than is the case today.

A 2007 report by the International Council on Clean Transportation (ICCT) concludes that worldwide, Japanese and European car factories produce the most efficient vehicles available today. The United States ranks at the bottom—the result of corporate and consumer choices and a lack of governmental action, rather than technical obstacles.[429] (See Figure II.3-1.) A number of countries, including China, South Korea, Canada, and Australia, range somewhere in between; China in particular is working to increase vehicle efficiency. Comparable fuel-efficiency data are not available for some other countries that rank among large or emerging producers, such as Brazil and India.[430]

Figure II.3-1. Actual and Projected Fuel Economy for New Passenger Vehicles, by Country, 2002–2018



Source: See endnote 429 for this section

Below, we offer calculations of jobs in the Japanese, European, South Korean, and U.S. auto industries that can be considered a shade of green. It is important to note the following:

- In the absence of global criteria, the calculations are based on national/regional standards and reporting categories. Using fuel economy as the key criterion may yield sharply different results than calculations based on air-pollutant emissions standards (as the example of Japan suggests, where we offer such figures).
- The calculations are focused on passenger cars only, which account for the large majority of motor vehicles worldwide. But similar assessments will need to be made for commercial vehicles as well, especially trucks that contribute heavily to air pollution.
- The calculations are based on the percentage of cars sold that meet certain fuel efficiency or other standards, and assume that an equivalent share of a country's auto industry employment is required to produce these cars. Due to a lack of data, the calculations do not distinguish between domestic production and imports. If a larger share of a country's fuel-efficient fleet is produced abroad than domestically, then the calculations offered here overstate that country's number of green jobs.

The resulting numbers need to be understood as rough approximations. There is also a larger challenge: making individual vehicles use less fuel and emit fewer pollutants reduces their environmental impact, but if the number of vehicles on the world's roads keeps growing, these gains will be reduced or nullified. Whether one can then still speak of green jobs is open to judgment. From a comprehensive point of view, such structural questions can be as important as more narrow fuel-economy technology questions.

Fuel Economy and Low-Emission Targets in Japan

The Japanese government established fuel-economy targets for passenger cars of 16.8 kilometers per liter (39.5 miles per gallon), to be reached by 2015.[431] This standard translates into CO_2 emissions of 125 grams per kilometer (g/km), according to the ICCT.[432] The average fuel economy of new cars manufactured in Japan rose from 12.4 kilometers per liter in 1996 to 15.5 kilometers per liter (36.5 miles per gallon) in 2006, exceeding the previous 2010 target of 15.1 kilometers per liter (equivalent to 153.8 g/km).[433] In 2005, 86 percent of passenger cars sold met or surpassed the 2010 fuel efficiency target.[434]

According to the Japan Auto Manufacturers Association (JAMA), in fiscal year 2006 Japanese firms sold close to 89,000 hybrid passenger vehicles in Japan, plus another 7,000 alternative fuel vehicles. They also shipped close to 3 million vehicles that were certified as meeting air pollutant emission standards of 75 percent below 2005 limits—a category used in car labeling for Japanese consumers.[435] The combined total represents 53 percent of all motor vehicles sold domestically that year.[436] If that share is applied to Japan's automotive manufacturing workforce of 952,000, then as a rough approximation, Japan might be said to have 434,000 vehicle manufacturing jobs that are a shade of green.[437] (See Table II.3-1.) However, as noted above, a car that meets fairly stringent air-pollutant limits does not necessarily fare as well with regard to carbon emissions. Hence, these figures need to be seen with caution (and, as additional calculations below suggest, are likely too generous as a proxy for green employment).

Table II.3-1. Estimated Jobs Producing Low-Emission Vehicles in Japan, 2006

	Vehicle Production/ Employment Number of vehicles produced*
Domestically-produced vehicles sold in Japan	5,618,499
Of which:	
Hybrid and alternative fuel vehicles**	95,945
Low-emission vehicles†	2,893,028
Subtotal, all clean vehicles	2,988,873
Share of hybrid & low-emission vehicles (percent)	53
	Number of employees
Automobile manufacturing workforce‡	952,000
Percent of hybrid & low-emission vehicles, pro-rated vis-à-vis workforce total	434,070

**Excluding motorcycles.*
***Includes natural gas and diesel-alternative LPG vehicles.*
†Highest-achieving group; vehicles with emissions 75 percent below Japan's 2005 exhaust emissions standard.
‡Includes employment in vehicle manufacturing, as well as parts and accessories production.
Source: See Endnote 437 for this section.

Carbon Limits in Europe

In 1998, the European Automobile Manufacturers Association (ACEA) entered into a voluntary agreement with the European Commission to reduce the amount of carbon emitted by new passenger cars. The objective was to reduce the 1995 level of 186 grams of CO_2 per kilometer to 140 grams per kilometer by 2008 (and optionally to 120 grams by 2012). The 2008 target is equivalent to a fuel efficiency level of about 5.8 liters per 100 kilometers (gasoline) and 5.25 liters per 100 kilometers (diesel). JAMA and the Korea Automobile Manufacturers Association (KAMA) agreed to meet this target by 2009.[438]

European Commission staff has issued reports monitoring the carmakers' commitment, and their findings are the basis for calculations here of the number of jobs in manufacturing cars for the E.U. market that could be considered a shade of green.[439] Using thresholds of 120 and 140 grams of CO_2 per kilometer, this results in job numbers of 150,000 and 526,000, respectively, for model year 2004.[440] (See Table II.3-2.)

Table II.3-2. Estimated Jobs Producing Fuel-Efficient Vehicles in Europe, 2004

	Vehicle Production / Employment Number of vehicles	
Vehicles sold in Europe by ACEA members	11,484,785	
Of which:	Vehicles emitting ≤ 120 gCO_2/km: 879,401	Vehicles emitting ≤ 140 gCO_2/km: 3,085,165
Share	7.5 percent	26.3 percent
	Number of Employees	
Passenger car manufacturing workforce	2,000,000	
Percentage share of "clean" vehicles, pro-rated vis-à-vis workforce total	150,000	526,000

Source: See Endnote 440 for this section.

According to the European Federation for Transport and Environment (EFTE), among European car companies French and Italian firms fared best in 2006 in terms of offering vehicles with higher fuel efficiency and lower carbon emissions, whereas German-produced vehicles actually had higher emissions than in 2005.[441]

Some 6.3 percent of Japanese-made cars sold in the European Union in 2004 met the 120-gram limit. If we postulate that this ratio holds up for all Japanese cars, not just those sold in the EU, this would imply that about 62,000 Japanese auto-manufacturing jobs can be considered relatively green. Using the more lenient standard of 140 grams (which 21.4 percent of the cars met) yields a figure of about 204,000 jobs.[442]

Just 4.3 percent of South Korean cars sold in Europe met the 120-gram limit in 2004. Similar assumptions and calculations as for the European and Japanese carmakers suggest that just over

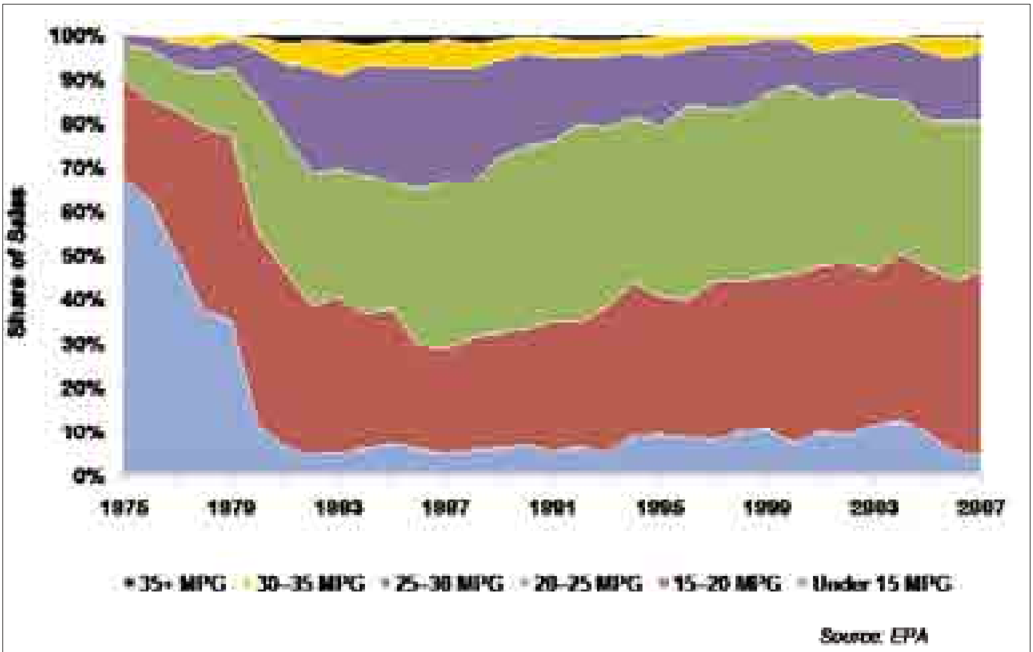
10,000 out of South Korea's 247,000 auto industry jobs could be seen as green. Under the 140-gram limit (met by 29.1 percent of South Korean cars), the number would rise to close to 72,000 jobs.[443]

The United States: Lagging Behind

The United States is among the leaders in setting tough norms for vehicle air-pollutant emissions. In sharp contrast, however, the country has scorned higher fuel efficiency for more than two decades, and its automakers have churned out vehicles with ever growing weight, horsepower, and acceleration.[444] The U.S. corporate average fuel economy (CAFE) standard for new cars has remained essentially unchanged at 27.5 miles per gallon since the mid-1980s; the standard for new "light trucks" (which includes so-called sport utility vehicles, or SUVs) is at 21 mpg.[445]

Figure II.3-2 illustrates these developments.[446] Following the first oil crisis of the early 1970s, the number of cars sold that achieved no more than 15 miles per gallon declined dramatically—from 67 percent in model year 1975 to just 4.5 percent in 1982. The bulk of car sales were in the 15–20 mpg interval in 1978–1985, and in the 20–25 mpg interval until 2003. But vehicle sales in higher-efficiency groups remained very limited. And low gasoline prices and the introduction of SUVs led even to a partial reversal of earlier gains.[447]

Figure II.3-2. U.S. Light Vehicle Sales, by Fuel Economy Segment, 1975–2007



Note: MPG = miles per gallon.
See endnote 446 for this section

How many U.S. auto industry jobs can be regarded as green? A 2007 study for the American Solar Energy Society (ASES) defines vehicles that score at least 10 percent better than the CAFE standards as energy-efficient. About 15 percent of U.S. car production meets that requirement, and on that basis the report counts 380,000 direct and indirect vehicle-manufacturing jobs as part of the energy-efficiency industry.[448] However, in light of much higher Japanese and European achievements and seen against the tremendous need to boost fuel economy from current levels, a 10 percent premium on top of CAFE would not appear to be a meaningful gauge.

An analysis by the U.S. Environmental Protection Agency (EPA) shows that just 1.2 percent of all U.S. light vehicles in the 2007 model year could be categorized as truly fuel-efficient—that is, achieving at least 35 miles per gallon. (None of the cars sold in 2007 fell into the 35–40 mpg interval; 0.2 percent achieved 40–45 mpg, and 1 percent achieved 45–50 mpg.) For passenger cars alone, excluding SUVs, the share of cars above 35 mpg was 2.3 percent.[449] Using this percentage as a proxy for gauging the number of auto-manufacturing jobs that could be considered green, we arrive at a more realistic estimate of about 13,000 (direct jobs only).[450]

Are the calculations presented here—based on carbon limits and fuel economy, respectively—comparable to each other? As mentioned above, a fuel economy level of 39.5 mpg translates into CO_2 emissions of 125 grams per kilometer. Thus, the most efficient 1.2 percent of cars sold in the United States in 2007 can be assumed to meet the European threshold of 120 grams. Hence, the calculations of green jobs are roughly comparable.

One limitation of the U.S. data is that the EPA fuel efficiency analysis does not distinguish between cars produced in the United States and those imported. Differences between domestically produced cars and those sold in the United States by foreign companies have narrowed in recent years. On average, the sales-weighted corporate average fuel economy for passenger cars is very similar for domestic and foreign manufacturers.[451] However, one of the most efficient models sold in the United States, the Toyota Prius, is produced in Japan only, and thus the back-of-the-envelope calculation presented here may even somewhat overstate U.S. employment in manufacturing fuel-efficient cars.

The United States could do far better. Back in 2001, a study by the American Council for an Energy-Efficient Economy (ACEEE) showed that aggressive implementation of even conventional technologies could raise average new car and light truck fuel economy in the United States to 41 mpg—at a cost far less than the value of the fuel saved.[452] The Apollo Alliance suggested in 2004 that a concerted strategy to build highly efficient cars might yield close to 130,000 jobs.[453]

Investing in fuel efficiency offers economic benefits that reach beyond jobs in the automobile sector itself. For instance, a 2007 Union of Concerned Scientists (UCS) report assesses the impacts of moving toward a fleet average of 35 mpg in the United States. Such a policy could generate 241,000 more jobs throughout the economy by 2020. Greater fuel efficiency offers substantial savings to consumers (annual net savings rise to $37 billion by 2020, after taking into account the higher purchasing cost of more efficient cars). These savings are assumed to be spent in sectors of the economy that are more labor-intensive than the energy industry, thus leading to a net job gain. The UCS study finds that 23,900 new jobs would be created in the automotive industry itself, via investments in tools and machinery to produce more efficient engines, transmissions, lighter auto bodies, better tires, and so on.[454]

The Global Picture

The estimates presented here for U.S., European, Japanese, and South Korean car manufacturers cannot, of course, be directly compared with each other, as the calculations are based on different standards, calculations, and test cycles used to monitor performance. But the calculations above suggest that relatively green auto-industry jobs may number about a quarter million (and possibly on the order of 800,000, under more lenient definitions). Either figure is still quite small relative to the automobile manufacturing industry's global employment: 8.4 million jobs.[455]

Other countries that account for large chunks of the world's vehicle production and employment include China (with 1.6 million employees), Russia (755,000), Brazil (289,000), and India (270,000).[456] But similar calculations for them do not seem feasible at the moment. China and India are targeting small car production (with China's Chery compact model reportedly achieving a fuel rate of 27 km/l, equivalent to 63 mpg).[457] Both are following European emission standards, though with a time lag of some years.[458] And gasoline and diesel fuels are much dirtier, and thus more polluting, than those available in the United States, Japan, and Europe.

Given that, among the global leaders, jobs in producing the most efficient and cleanest cars available account for single-digit shares of total employment, it would appear that green jobs in other countries are still extremely limited at the moment. But there is considerable room for improvement and for creating more sustainable jobs in many countries. Thailand, for instance, has launched a promising initiative.[459] (See Box II.3-1.)

To create large numbers of greener jobs in the auto industry, a concerted international fuel-efficiency strategy is needed—with mandatory targets, accelerated technology diffusion mechanisms so that the most efficient and cleanest engine designs are introduced in timely fashion, incentives for consumers to purchase the most efficient models, and large-scale investment to generate additional breakthroughs in cleaner engine technologies and fuels.

Automotive Materials

Another aspect of cars' environmental footprint—and thus the question which jobs in the present or in future can be considered green—concerns the multitudes of materials that are incorporated in today's vehicles. An ACEEE report points to impacts associated with the extraction of raw materials; production of plastics, batteries, and steel; and disposal after a car has been scrapped: "Large quantities of materials of many types are used in the production of every car, and this results in significant air and water pollution. Mercury and other toxic materials are used in quantities sufficient to make cars a significant source of those materials and a hazard for workers."[460]

Box II.3-1. Thailand's Eco-Car Initiative

Thailand's government decided in June 2007 to grant tax incentives to auto manufacturers that produce small, fuel-efficient "eco-cars." The excise tax rate was set at 17 percent (compared with the typical 30–50 percent), and eco-car manufacturers will receive up to eight years of exemption from corporate income tax payments and machinery import duties. In order to receive tax breaks, a company must produce cars that do not surpass a certain engine size (1,300 cubic centimeters for gasoline engines and 1,400 cc for diesels), consume 5 liters per 100 kilometers (47 miles per gallon) or less, generate no more than 120 grams of CO_2 per kilometer, and meet Euro-4 emissions standards. Companies must make a minimum investment, produce at least 100,000 cars by the fifth year of production, and produce at least 80 percent of parts domestically.

Japanese companies Suzuki and Nissan are planning to produce 138,000 and 120,000 such cars, respectively per year. Honda is planning to double its production to 240,000 units. Thailand's Board of Investment (BOI) is to consider similar proposals from Mitsubishi Motors, Toyota (which was initially skeptical about this initiative), Volkswagen, and India's Tata Motors in January 2008. The cars are to be sold not only on the domestic Thai market, but also in other Asian countries, Australia, and Africa. Thailand could thus become a regional hub of "eco-car" production. Sudjit Inthaiwong, deputy secretary-general of BOI, says, "We are hoping the eco-car will be our next global niche."

Having seen output and sales boom since the late 1990s, Thailand produced some 299,000 cars and 896,000 commercial vehicles (mostly small pickup trucks) in 2005. But domestic demand weakened in 2006 and 2007. While partly designed to overcome the slump and attract new investment, this initiative has the potential to green a substantial share of the country's car industry and thus a portion of the 182,000 jobs in the sector.

The degree of greening will depend on whether the new eco-cars (whose retail prices would be reduced by the preferential excise tax rate) will displace conventional vehicle sales (a fear expressed by several companies) or will simply boost car ownership rates in Thailand. It appears that pickup trucks, which are taxed at a far lower rate than eco-cars, will remain popular. This raises the question whether an eco-car initiative is best focused on small cars only, or would better be applied to a broader class of vehicles.

Source: See Endnote 459 for this section.

Lightweight, high-strength materials (such as aluminum, plastics, magnesium, and certain types of steel) can be of enormous help in reducing fuel consumption. At the same time, the production of such materials has its own environmental impacts. In 2004, a typical car sold in the United States weighed roughly 2 tons. About 55 percent of the weight was accounted for by a variety of steels; iron, aluminum, and plastics accounted for about 8 percent each.[461] Automotive materials use accounted for 28 percent of total U.S. aluminum consumption in 2005, 25 percent of iron, 22 percent of zinc, 14 percent of steel, 11 percent of copper and copper alloys, and 5 percent of plastics.[462] Because vehicles elsewhere are typically less heavy, for most other countries these shares are likely to be considerably smaller.

The bulk of automotive materials is produced by industries that are among the most energy-intensive—and least labor-intensive. Measures to reduce energy use, as well as the generation of toxics and other wastes, in supplier industries is critical in the quest for greener transportation-related jobs. Scrap or recycled materials accounted for 25 percent of the aluminum industry's worldwide production in 2004, limiting its energy use and thus its environmental footprint. However, that is a lower share than was prevalent during the 1980s and 1990s. The rate of recycling in the steel industry, meanwhile, has risen quite remarkably in recent years, accounting for about a third of world production.[463]

Vehicle weight is an important consideration in fuel-efficiency. To some extent, this means a shift from conventional steel to high-strength varieties and growing reliance on aluminum and plastics. But to the extent that lighter, more efficient vehicles translate into less demand for various materials overall, it also means a degree of job loss in some supplier industries.

Transportation and the Wider Economy

Many more jobs are found in servicing and maintaining motor vehicles than in manufacturing the vehicles themselves. Leaving aside public transportation (discussed further below), they include fuel refining, wholesaling, and retailing; trucking and other freight services; and automobile sales, rentals, parking, and repair services. Their relative importance varies widely from country to country. In a heavily automobile-dependent country like the United States, these jobs add up to roughly 6.5 million jobs, compared to about 1 million in vehicle and parts manufacturing. In Japan, they amount to about 4 million.[464]

Jobs in refining and fuel wholesaling/retailing may never qualify as green jobs, although a switch to cleaner fuels (low sulfur content, etc.) might lend at least a tinge of green. With regard to many other transportation jobs such as vehicle retailers or truckers, their hue of green depends strongly on the degree to which the vehicles themselves are efficient and clean.

Particularly with regard to trucking services, however, there is a need to reassess the way in which the global economy is developing. So-called "just-in-time" production systems are biased toward frequent, precisely timed deliveries of materials and parts to factories instead of warehousing of supplies. And both production and consumption now depend on shipments of raw materials, intermediate goods, and final products over ever-longer distances. Highly complex production, shipping, and retailing networks have emerged on an increasingly global scale, with varied impacts on employment, wage levels, and the economic viability of communities and regions.

The onslaught of ever-growing transportation volumes threatens to overwhelm gains from improving fuel efficiency and limiting pollutants on a per-vehicle basis. Companies like Wal-Mart (with its policy of global sourcing and especially its policy of searching for cheap products, with potential negative impacts for labor and the environment) are major drivers and symptoms of this phenomenon. When products are shipped around the world in "sending coals to Newcastle" fashion, improving the fuel efficiency of vehicles or planes—or improving the energy efficiency of stores, as Wal-Mart has pledged to do—can only have limited impact.[465] Ultimately, a more sustainable economic system will have to be based on shorter distances and thus reduced transportation needs. This is not so much a technical as a fundamental systemic challenge.

Urban Mobility

Sustainability in the transportation sector will require a transition to greater reliance on public transport; that is, a modal shift away from the heavy and unbalanced reliance on cars and trucks. In urban settings, investment in transport infrastructure—light rail and tram tracks, bus lanes, stations, platforms, bike paths, traffic signals, etc.—creates construction and maintenance jobs. But as the International Labour Organization explains, "while the short-term boost to employment is welcome, especially in high unemployment regions, it is not the primary objective of investment in transport infrastructure, which is to secure long-term gains in the form of increased competitiveness and the creation of durable employment. Second, efficient transport systems are essential for the operation of the labor market to ensure the widest access of workers to employment. Some of the unemployment in many countries derives from poor planned transport systems which can be an obstacle to the mobility of workers even over comparatively short distances—for example, within a single urban centre."[466]

© M. Renner, 2005
Motorcycles in Medan, Indonesia.

Likewise, in a 2005 report by its Africa division, the World Bank emphasizes that well-functioning and sustainable transportation services are crucial for economic development and job generation throughout much of the economy: "An efficient and effective urban transport system is a powerful tool for improving the efficiency and accessibility of the labor market, and providing better access to education and health services." However, many cities in developing countries, particularly in sub-Saharan Africa, lack reliable and affordable urban transport systems.[467] In fact, inadequate transport can be a major drag on family incomes and livelihoods. Elsewhere, the Bank concludes that, "between 8 and 16 percent of urban household income is typically spent on transport, although this can also rise to more than 25 percent for the poorest households in very large cities."[468]

In developed countries as well, transport investment priorities and settlement patterns have a huge impact in terms of people's access to jobs and economic opportunity. Addressing the situation in the United States, the Apollo Alliance notes that, "sprawl and urban disinvestment have separated low income and minority residents from areas of job growth and drained resources for education, government services, and maintenance of existing neighborhoods."[469]

As this statement makes clear, under the right circumstances, transportation can be the lifeblood of cities. But the wrong transportation choices can drain vitality and employment from communities.

Sprawl not only has tremendous environmental consequences. Low population densities and other circumstances tend to render labor union organizing far more difficult, thus undermining worker strength and wages. So-called "smart growth" strategies can help preserve farmland and open space, keep transportation manageable and housing affordable.[470]

Public Transport

Although there are no comprehensive global employment statistics, public transportation—and in particular urban transit—is a major employer. In the United States, transit agencies employed about 367,000 people in 2005, up from 311,000 people in 1995.[471] New York City alone has some 47,000 employees operating the bus and metro system. In Paris, RATP (Régie Autonome des Transports Parisiens de France) employs 43,600 people. STIB (Société Transport Intercommunaux de Bruxelles) in Brussels, Belgium, employs more than 6,000 people.[472]

According to the International Association of Public Transport (UITP), an estimated 900,000 people are employed in urban public transport in the 25 member states of the European Union. UITP has 2,900 members from 90 countries, and national statistics from these countries suggest that the number of direct jobs in public transport amounts to about 1–2 percent of total employment. In European economies, public transit investments seem to have a multiplier effect of 2 to 2.5. But in countries that focus intensely on public transport, such as Switzerland, every direct job is linked to as many as 4.1 indirect jobs. Studies in Europe and the United States show that about 30 jobs are created for each $1.4 million (€1 million) invested in public transport infrastructure, and 57 jobs for the same level of investment on the transit operations side.[473]

Public transit is less energy- and carbon-intensive than automobiles.[474] (See Table II.3-3.) Seen from this perspective, jobs in public transit (and in manufacturing trams, buses, and rail equipment) can, in principle, be regarded as green.

Table II.3-3. Energy Use by Urban Transport Mode

Transport Mode	Vehicle Production	Fuel Use	Total
(megajoules per passenger-kilometer)			
Light Rail	0.7	1.4	2.1
Bus	0.7	2.1	2.8
Heavy Rail	0.9	1.9	2.8
Car (Gasoline)	1.4	3.0	4.4
Car (Diesel)	1.4	3.3	4.7

Source: See Endnote 474 for this section.

However, many cities rely on old and highly polluting diesel buses. This is especially true in developing countries. A 2005 survey of about 170 cities by the International Association of Public Transport found that even in the European Union, diesels account for about 90 percent of all urban buses. (Alternatives are particularly prevalent in Helsinki and Athens (CNG), Vienna (LPG), and Luxembourg (biodiesel, hybrids).[475] CNG offers pollution-reduction benefits and is already fairly widely used outside of Europe. China leads the way with more than 32,000 CNG-powered buses, followed by India (12,000) and South Korea (11,400). Egypt, Iran, and Japan also have sizable fleets.[476] Authorities in India's capital, New Delhi, announced that 6,100 new CNG buses would be introduced between late 2007 and 2009 and that 18,000 new jobs were expected to be created.[477]

Switching to cleaner diesel fuel also offers substantial reductions in air-pollutant emissions.[478] And in principle, there are also many job opportunities in retrofitting buses, which reduces particulate matter from diesel dramatically (although very old models are best retired from service altogether). To make these alternatives happen at a meaningful level and in timely fashion requires substantial financing.

In developed countries, the growing preference for private automobiles and the associated sprawl and lengthening of travel distances crowds out public transit. As ridership declines, cities are often forced to cut back on service or density of available networks. In developing countries, public transportation systems struggle with an onslaught from two sides. One, there is a proliferation of private automobiles that serve only a relatively small share of the population but take over growing amount of space. Two, various two- and three-wheeled for-hire taxis owned by licensed and unlicensed private operators are crowding the streets even more, siphoning off passengers from bus and light-rail lines and massively contributing to air pollution.[479]

A green transportation strategy can create many new manufacturing and operating jobs, but it will require massive investments in public transit. One promising response to these challenges are so-called Bus Rapid Transit systems—which, if set up and managed appropriately, can be an important part of green transport employment.

Bus Rapid Transit, or BRT, systems offer a sustainable solution to many cities' traffic and air pollution challenges. Originating in Curitiba, Brazil, BRT systems now exist in more than 70 cities around the world, including Beijing, Bogota, Glasgow, Jakarta, Los Angeles, Mexico City (see Box II.3-2), Sydney, and Toronto.[480] Many more are planned for cities like Accra, Cape Town, Lagos, Medellin, New Delhi, and Shanghai. Key BRT features typically include dedicated or preferential bus-only lanes, special boarding platforms, high-capacity vehicles using clean propulsion technologies, integration with other routes and transit services, and focused urban development planning. By providing efficient and clean transportation, successful BRT systems around the world have stimulated economic development and job creation along their routes.[481]

Box II.3-2. BRT in Mexico City

In May 2002, Mexico City authorities committed to set up a Bus Rapid Transit (BRT) system with the assistance of EMBARQ—WRI Center for Sustainable Transport, the Global Environment Facility (GEF), the Japanese government, and other institutions. Called Metrobus, the BRT system was initiated in a corridor along one of the busiest thoroughfares in the capital, Insurgentes Avenue. Seeking a low-energy, low-emissions solution, the city tested new bus engines and fuels, and it supported a pilot project to retrofit diesel-powered buses with pollution-control devices.

So far, some $70 million has been spent on buses, infrastructure, planning, and design. The cost is a fraction of what a metro line with equivalent passenger capacity might cost. By 2006, Metrobus operated 80 new buses along a 20-kilometer line with 36 stations. It provides faster and better service than conventional buses, with less pollution. Drivers who used to work for private bus concessionaires before becoming Metrobus drivers now belong to the formal employment sector, with enhanced income security and benefits such as social security, retirement insurance, and vacations.

Source: See Endnote 480 for this section.

In BRT systems, the frequency of service is carefully calibrated, and therefore bus breakdowns and other operational failures need to be minimized. This in turn implies that buses must be kept in excellent condition. Hence, BRT systems offer a substantial number of maintenance jobs. Maintaining high-quality service also means it is critical to ensure good working conditions for drivers, who need to be well trained and are expected to take responsibility for their performance. Thus, jobs for drivers and mechanics must be decent and well-paying.[482]

Well-functioning and reliable public transport—whether BRT or others—is critical not only for strictly environmental reasons but also to guarantee equity of access to affordable transport between the rich and poor, and between men and women. Particularly for women, safety is a critical aspect.

Two Strokes and You're Out

Passenger cars are far from the only type of vehicle that poses a significant environmental challenge. In the developing world, many people cannot afford a car. Instead, vehicles with two-stroke engines—motorcycles, motorcycle taxis, and various three-wheelers—are ubiquitous. Large numbers of people and their families depend on income generated with the help of such vehicles in typically informal transport services.

But these vehicles generate huge emissions of air pollutants, with a heavy toll on human health and the environment in many cities. Short of replacing the two-strokes with other transportation modes, retrofits offer substantial improvements in fuel efficiency and considerable promise as a source of green jobs.[483] (See Box II.3-3.) Stepped-up financing is essential for retrofits to happen on a sufficiently large scale and for jobs to be created. The economics of retrofits does depend on fuel prices.

Box II.3-3. Engine Retrofits in Southeast Asia

A traditional two-stroke engine can emit as much pollution as 50 modern automobiles. These engines, ubiquitous in many developing countries and used for both personal transport and taxi services, are among the world's largest sources of vehicle emissions. Envirofit, a U.S.-based independent nonprofit company, works to develop and disseminate direct-injection retrofit kits to improve the efficiency of two-stroke engines. Retrofits eliminate the carburetor and inject fuel directly into the engine. Fuel consumption is reduced by 35–50 percent, and emissions of air pollutants are cut by as much as 90 percent. Envirofit's work was recognized in 2007, when it became a winner of the World Clean Energy Awards.

Envirofit runs pilot projects in Vigan and Puerto Princesa, two cities in the Philippines. Apart from the health and environmental benefits, the fuel efficiency offered by retrofits can mean big savings for drivers of two-stroke motorcycle taxis there, and thus a big boost for their livelihoods. The retrofit kits pay for themselves in fuel savings within 10 months. To make the upfront costs affordable, however, the cities provide micro-financing, recognizing that many local taxi drivers have little disposable income.

According to the Asian Development Bank (ADB), there are some 100 million two-stroke vehicles in Southeast Asia alone. Large numbers of such vehicles can also be found elsewhere, especially in South Asia. The challenge is thus enormous, but so is the potential for green jobs. Envirofit works with local partners to develop self-sustaining businesses to install and service the kits, and it plans to expand into Bangladesh, India, Pakistan, and Sri Lanka.

Source: See Endnote 483 for this section.

But changes are also needed when these vehicles are first produced. China and India are among the leading producers of two-wheelers.[484] India's production of two-wheelers has doubled from 4.3 million in 2001–02 to 8.4 million in 2006–07. Output of three-wheelers has risen from 213,000 to 556,000 over the same period.[485] Against this rapidly rising wave of production, reducing the environmental and health impact of scooters, mopeds, and motorcycles is both a major challenge and business and green job opportunity. Major challenges need to be overcome, however. As long as fuel prices stay low, there is little incentive and revenue to produce cleaner fuels and engines.

Non-Motorized Transport

Non-motorized transport modes have the unfortunate distinction of being overlooked by most traffic planners and economists. But they fulfill an important function in all societies. For short distances, they are an easy and non-polluting, quintessentially green, mode of transport. In poorer countries, they are often a critical source of income for those providing low-cost pedicab transportation services. More broadly, rural areas require affordable transportation in order to escape poverty. For those in urban areas who lack public transport because it is unaffordable, unreliable, or sidelined by policies favoring private automobiles, there may not be any other mobility option for accessing markets, jobs, and other economic opportunities.

Worldwide, some 105 million bicycles were produced in 2004. But this level of output was reached as early as 1988 and production has since fluctuated, going as low as 86 million in 2001. The industry offers employment in dozens of countries, but just five producers—China, India, the European

Union, Taiwan, and Japan—account for 87 percent of global production. China alone produced 58 percent of all bicycles in 2004. Production of electric bicycles—with a small electric motor that assists pedaling uphill or allows riders to cover longer distances more easily—is booming, reaching about 12 million units in 2005. Almost all of them were manufactured in China.[486]

No good global employment statistics appear to exist for this industry, or for associated businesses such as rental services.[487] Bicycles can be simply a personal means of transport or, when they are used as a cycle rickshaw, support a livelihood in many of the world's poorer cities.[488] (See Box II.3-4.) Greater availability of financing is a key aspect of replicating and scaling up such initiatives in many parts of the world.

In Uganda, for example, "boda bodas" (bicycle taxis) provide convenient short-distance transport. Uganda had about 200,000 boda bodas in 2000, compared with 70,000 motorcycle taxis. In both Uganda and Kenya, they provide employment for large numbers of previously unemployed youth.[489] Starting in 1990, the Ngware Bicycle Transport Group pioneered the business of organized bicycle taxi services in Kisumu, Kenya, successfully creating jobs and offering affordable, non-polluting access to education and health services for residents.[490]

Box II.3-4. Rickshaws and Livelihoods in India

The Institute for Transportation and Development Policy (ITDP) has helped introduce modern bicycle rickshaws in India. Their numbers have grown from 20,000 in 2003 to more than 300,000 today. The new design weighs 30 percent less and a multi-gear system makes pedaling considerably easier. According to a survey, these changes have led to increased incomes of 20–50 percent because rickshaw operators were physically able to work longer, and improved comfort and safety attracted new passengers, including some who previously rode highly polluting motorized rickshaws. Not only do the livelihoods of operators improve, but manufacturing the modernized rickshaw in India may open new green job opportunities. ITDP is now similarly helping to modernize the becak (a three-wheeled rickshaw) used in Indonesia.

Source: See Endnote 488 for this section.

A physically handicapped rickshaw driver in an auto rickshaw in Bangalore city. Karnataka, India.

Rail

Rail transport is more fuel-efficient and more labor-intensive than road transport.[491] German studies suggest this is true for track construction relative to road construction as well. Indeed, highway construction generates the fewest jobs of any public infrastructure investment.[492] Yet, in many countries, trends in inter-urban transport have been strongly in favor of road vehicles, moving away from rail transport for both passengers and freight.

In the European Union (EU-25), for instance, at roughly 4.9 million kilometers the road and motorway network accounts for 95 percent of all transport routes. Road length grew by 22 percent between 1990 and 2003, whereas the railway network shrunk by 8 percent to under 200,000 kilometers.[493] A total of 8.2 million people were employed in all transport services combined in 2004. Railway transport—far less fuel-intensive and polluting than trucking and other road transport—accounted for just 11 percent, or 900,000 jobs. Rail employment has fallen in the last few decades; in just the short span of time between 2000 and 2004, the number of jobs was cut by 14 percent even as value-added grew 3 percent.[494] Road passenger and freight transport, by contrast, keeps growing, representing just over half the total, or 4.3 million jobs. (Air transport, the most fuel-intensive mode, contributed 5 percent, or 400,000 jobs.)[495]

China's rail network grew by 24 percent in 1992–2002, but due to boosted labor productivity, employment was cut almost in half, from 3.4 million to 1.8 million. India's network grew only 1 percent, but due to radically different policies, employment stayed almost the same, falling from 1.7 million to 1.5 million over the same period of time. China's rail system is primarily focused on freight transport, whereas India's is oriented more toward passenger services.[496]

In African countries, a World Bank report notes that, "the changed role of rail...over the last thirty years has seen it move from a situation where many of the systems were carrying a high share of their country's traffic to one in which their market share has declined, their assets have steadily deteriorated, their quality of service has reduced, and they are in many instances only a minor contributor to solving the transport problems of the continent." Railway privatization—between 1993 and 2005, 13 rail concessions were granted, with another seven in progress—has been offered as a solution to badly run-down systems. Investment has risen, but given that it has been financed through gifts and concessional loans, may not be sustainable. Increased labor productivity has led to reduced railway employment.[497]

In 2004, transport equipment manufacturing employed about 3 million persons in the EU-25, accounting for 9 percent of the EU-25's manufacturing workforce. The manufacture of motor vehicles, trailers, and semi-trailers represented more than two-thirds of these jobs.[498] The manufacture of railway and tramway locomotives and rolling stock in the EU-25 employed just 140,000 people in 2003, or half a percent of all industrial employment.[499]

The shift away from rail has been a matter of policy choice, and a turnaround is possible. New priorities would entail substantial job opportunities. Employment potential in different countries depends on a range of factors, including labor productivities, availability of capital, the ability to furnish the needed construction and equipment through domestic companies, and others. Even though the United States, for instance, has long neglected passenger rail systems, a 2004 report argued that a 10-year federal investment program in new high-speed rail as well as rail maintenance could create close to a quarter million jobs.[500]

© RIA Novosti / TopFoto
The Krasnoyarsk Electric Train Maintenance Depot.

Implications of a Modal Shift

We have assessed the potential for greening auto industry jobs through fuel efficiency and surveyed employment in public transport. But what would happen if a substantial modal shift occurred away from heavy reliance on cars? Would it lead to a net gain or net loss of jobs? Unfortunately, there are few comprehensive studies in this regard.

Assessments of alternative passenger transport policies conducted in Germany and Britain, though dated now, offer useful insights. They suggest that an alternative transport policy offers not only savings in fuel consumption but also important job opportunities. A 1998 study by the Öko-Institut in Freiburg, Germany, compared a "business-as-usual" scenario with an alternative scenario for the 1995–2010 period designed to cut German CO_2 emissions by a quarter. Although it allowed for an increase of 21 percent in passenger kilometers traveled by all modes, it posited a substantial change in the "modal split," with railroad and urban public transit travel volume more than doubling and bicycle use growing by 72 percent, while distances traveled by car would decrease by 8 percent. (Also, automobiles were projected to become far more fuel-efficient.)[501]

The study found that a loss of 130,000 jobs in automobile manufacturing and related sectors would be more than offset by 338,000 new jobs, for a net addition of 208,000 jobs. These results were based on cautious assumptions, so that actual net employment benefits may well be higher. Still, some of the lost jobs would be well-paid ones, and in major car-producing areas the local employment impacts could be significant. The study assumed that higher gasoline taxes would help bring about the shift toward public transport. Close to half the additional tax revenues of about $13 billion would finance new infrastructure and financial support for public transport, and thus jobs in mass transit. The remainder, returned to taxpayers, was assumed to be re-spent on typical consumer purchases, and to be responsible for three-quarters of the total net job gain. However, if the surplus tax revenues were used to cut wage costs instead (by reducing employers' social security contributions), the net employment effects were thought to range as high as 400,000 new jobs.[502]

A study conducted by ECOTEC for Friends of the Earth Great Britain in 1997 assessed the impact of promoting far greater use of railways and buses (70–80 percent higher in 2010 than in 1990), as well as bicycling and walking, while reducing reliance on car use. The study assumed that the total number of passenger kilometers traveled would decline by 11 percent from 1990 levels. It concluded that at least 130,000 new direct jobs could be created by 2010, more than offsetting the loss of an estimated 43,000 jobs in automobile maintenance and repair. In addition, measures to encourage the use of less polluting, more efficient automobiles (natural gas, electric, and hybrid vehicles) and to promote leasing rather than car ownership, were found to possibly create another 35,000 jobs (because of greater attention to upkeep, leased cars lead to more maintenance jobs).[503]

A 2007 study jointly financed by the European Commission and several European governments—Climate Change and Employment—notes that the ECOTEC study "is to this day the most complete in measuring the employment effects linked to the implementation of sustainable-development transport policies."[504] Most attention in the intervening years has rather narrowly gone to alternative fuels, rather than broader transportation issues. And the real-world trends have of course continued to favor cars and trucks over rail and other alternatives. As Climate Change and Employment notes, business-as-usual scenarios essentially foresee more of the same in coming years, with predictable outcomes in terms of employment—favoring jobs related to trucking and other private road uses, and disfavoring rail and other public transport options.[505]

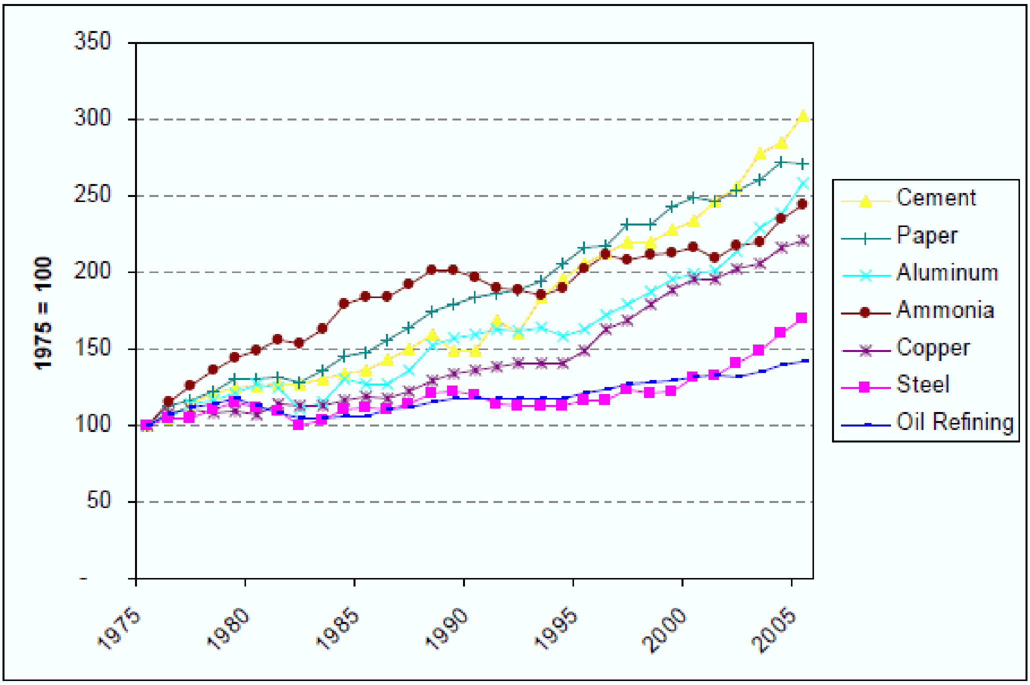
For a scenario more in line with a future of green jobs, a major turnaround in transportation priorities and land use policies will be required—not just in Europe, but in other regions of the world as well. This implies a re-balancing of rail-versus-road choices, a shift in subsidies and other forms of financing, and a shortening of travel distances for passengers and freight. With such a shift, there is enormous scope for sustainable mobility and sustainable employment worldwide.

Irrigating Caribbean Pine saplings at sawmill for pencil production from FSC wood. Brazil.

4. Basic Industry

The industrial sector of the global economy uses some 160 exajoules (EJ) of global primary energy, equivalent to 37 percent of total energy use worldwide.[506] Industries producing basic materials—iron and steel, chemicals, cement, aluminum, and pulp and paper—are among the most energy-intensive industries. North America, Europe, and Japan (as well as South Korea more recently) have long been dominant in these sectors. But during the past decade or so, major changes have occurred. In particular, China has dramatically increased its output, serving not only a fast-growing domestic market but also export markets, and pushing global production up considerably.[507] (See Figure II.4-1.)

Figure II.4-1. Global Production of Seven Energy-Intensive Industrial Commodties, 1975–2005



Source: See Endnote 507 for this section.

It may be difficult to regard these heavy industries as "green." However, reducing their environmental impact, and especially their carbon footprint, is a critical task. We can think of such efforts in terms of the shades-of-green approach. (Another aspect not discussed here is that polluting factories are often located near poor communities that have little influence over such matters, and thus often suffer the deleterious health effects. The so-called "cancer alley"—a concentration of chemical factories in the U.S. state of Louisiana—comes to mind. Greening these industries needs to embrace not only questions of decent employment, but also environmental justice.)

Energy-intensive products like steel, aluminum, cement, and paper are the lifeblood of modern societies. Short of foregoing some of the services and conveniences that these items offer, boosting energy and materials efficiency, curtailing pollution, and enhancing use of scrap for recycling are key to bringing these industries' environmental footprints more into balance with environmental needs.

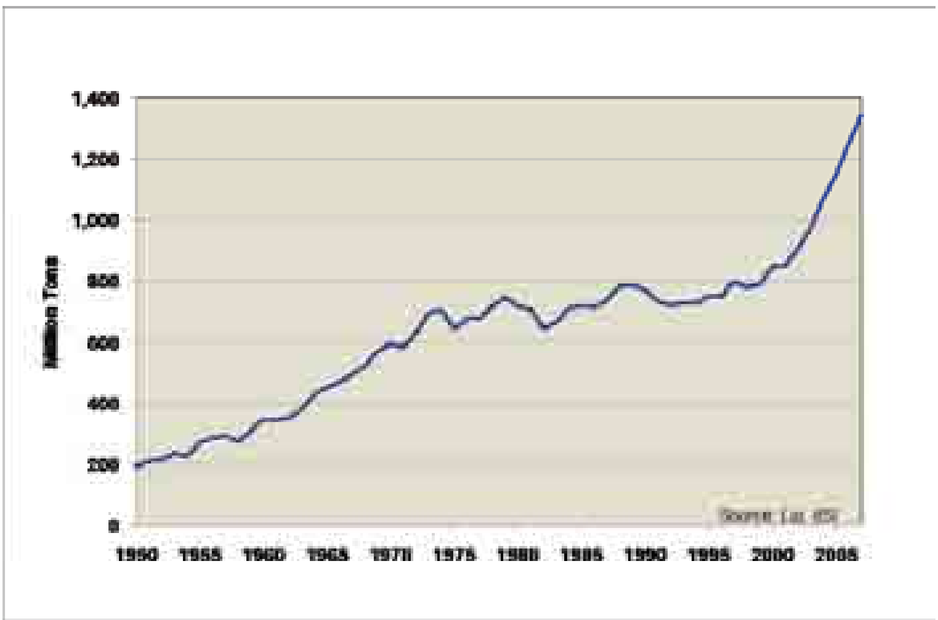
Using secondary materials offers substantial energy savings relative to producing them from scratch. The energy savings for different materials are as follows: aluminum (95 percent), copper (85 percent), plastics (80 percent), steel (74 percent), lead (65 percent), and paper (64 percent). Producing steel from recycled scrap reduced air pollution by 86 percent. Producing paper from recycled stock instead of virgin pulp reduces water pollution by 35 percent and air pollution by 74 percent.[508]

The following analysis of selected industries offers a sketch of efforts to green these industries, and the implications for green employment.

Iron and Steel

World steel production is rising steeply, reaching more than 1.3 billion tons in 2007. This is 71 percent higher than in 1999, when the current expansion started. Following a long post-World War II expansion, output had leveled off at a range of 650 to 750 million tons between the early 1970s and late 1990s.[509] (See Figure II.4-2.)

Figure II.4-2. World Steel Production, 1950–2007

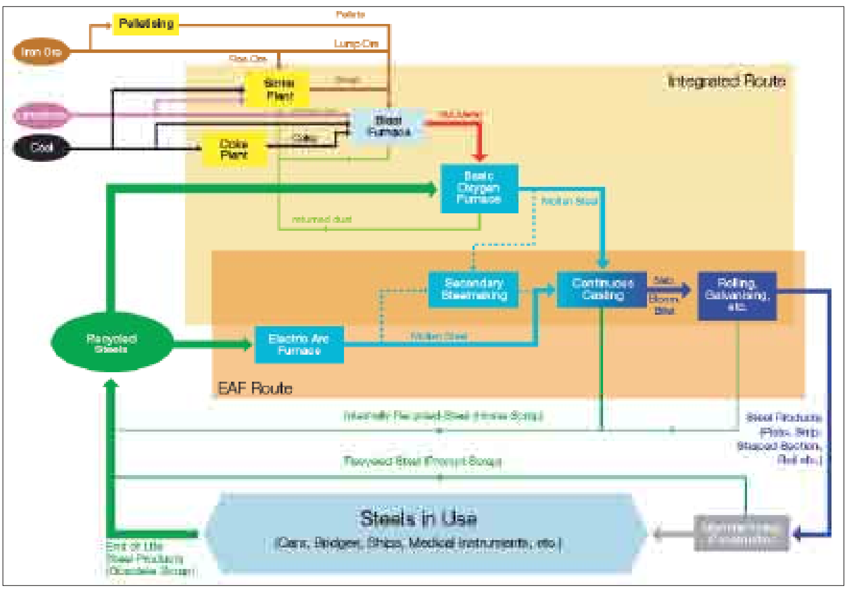


China's steamroller economy is the major engine behind soaring global production, but Asia in general has been the most dynamic steel-producing region during the past decade. Boosting its production from 66 million tons in 1990 to 489 million tons in 2007, China became the leading producer in 1996. It is followed at a considerable distance by Japan (120 million tons), the United States (98 million), Russia (72 million), India (53 million), South Korea (51 million), and Germany (49 million). The 27 member states of the European Union combined produced 210 million tons in 2007.[510] In 2006, China overtook Japan, Russia, and the European Union to become the largest steel exporter.[511]

Steelmaking is a highly energy-intensive process. Because the industry consumes large volumes of coal, it emits a significant amount of carbon dioxide (CO_2). According to statistics compiled by the International Energy Agency (IEA), total final energy use by the iron and steel industry was 21.4 EJ in 2004, or about 20.2 gigajoules per ton (GJ/t) of steel.[512] On average, producing one ton of primary steel results in emissions of about two tons of CO_2. Altogether, steelmaking accounts for 5–6 percent of anthropogenic CO_2 emissions, and 27 percent of the total emissions of the world's manufacturing sector.[513] (The International Iron and Steel Institute, IISI, reports slightly different figures—average energy intensity of 19.1 GJ per ton of crude steel produced, and 1.7 tons of CO_2 emitted per ton produced.[514])

Steel is produced by two main methods.[515] (See Figure II.4-3.) Blast furnaces and basic oxygen furnaces use iron ore, coal, and limestone, as well as recycled steel. Electric arc furnaces use primarily recycled scrap iron and steel, and electricity. Blast furnaces account for about two-thirds of world steel production (but about 90 percent of CO_2 emissions), and electric arc furnaces for about one-third. Outdated and highly polluting open-hearth furnaces contribute a diminishing share. They accounted for about 2–3 percent in recent years.[516]

Figure II.4-3. Primary Steel Production and Recycling



Source: See Endnote 515 for this section.

Reducing Energy Use and Environmental Impacts

Technological advances over the past two to three decades have led to improved energy efficiency, greater use of byproduct gases and materials, enhanced steel recycling, and substantial reductions in CO_2 emissions per ton produced.[517] Among European firms, for instance, carbon emissions per ton were cut more than 50 percent in 1975–2000.[518] Yet these per-unit gains are offset by surging production.

A 2007 International Energy Agency (IEA) report discusses a variety of processes and factors that have a key bearing on energy use and carbon emissions.[519] (See Table II.4-1.) The IEA concludes that if the best technologies currently in use were applied worldwide, the steel industry's annual energy consumption of 21.4 EJ (in 2004) could be reduced by 2.3–2.9 EJ, or 11–14 percent. CO_2 emissions could thus be reduced by 220–270 million tons per year. This figure does not include effects of closing outdated plants, more efficient operation of coke ovens, or recovery of waste heat from sintering plants. These measures, along with boosted steel recycling, could raise the total of avoided primary energy use to some 5 EJ. (And using steelmaking slag as a substitute for clinker in cement production could avoid another 140–185 million tons of CO_2 emissions in that industry.)[520]

Table II.4-1. Energy and Carbon-Emission Implications of Steelmaking Processes

Process	Observations
Iron Ore Agglomeration	• About a quarter of all iron ore is of sufficient quality to be used directly without agglomeration. Another quarter is pelletized (especially suitable for low-quality ores, such as those in the United States). Sintering is used for more than 50 percent of all iron ore, and is the most efficient process. • The energy needs of a blast furnace depend to some extent on the quality of the ore. The higher the metal content, the lower the energy needs. China's iron ore has very low metal content, whereas that in Brazil, India, and Australia has high metal content.
Coal and Coke Quality/ Charcoal	• China accounts for more than half of global coke production; its coal is of mixed quality. Australian coal is of much higher quality than Russian and U.S. coal (resulting in higher usage). • Coal injection reduces the need for coke and reduces CO_2 emissions. • Brazil makes heavy use of charcoal in iron production. While this does not result in energy efficiency gains, it can reduce CO_2 emissions substantially—if the charcoal is produced in a sustainable manner (more than half was produced from tree plantations, the rest from native forests). The efficiency of charcoal making in Brazil is far below that for coke production from coal.
Coke Oven	• About 90 percent are so-called slot ovens. Old beehive ovens (important in China, where they account for one fifth of coke production, and in Brazil) are less efficient, but modern variants are also being introduced. • For slot ovens, Japan and Germany have the most efficient plants, but China is introducing installations that are close to OECD levels of energy consumption. • Overall efficiency can be improved if a coke oven is fired with blast furnace gas, and coke oven gas (COG) is put to higher-quality use, such as power generation. In China, under half of coke producing plants recovered COG in 2005, still leaving considerable room for improvement.

Table II.4-1. Energy and Carbon-Emission Implications of Steelmaking Processes (...cont'd)

Process	Observations
Blast Furnace	• There are considerable dif erences in energy efficiency among dif erent types of furnaces. Larger ones have lower heat losses than smaller ones, and the installation of heat recovery equipment is more cost ef ective. In China, smaller furnaces emit up to 25 percent more CO_2 than large ones. The government aims to close all furnaces with capacities of less than 300 cubic meters (with 7–8 percent of total capacity and CO_2 emissions) by 2010. • Top-Pressure Turbines (TRT) of er reduced CO_2 emissions. They are widely used in Japan, for instance; half of China's production capacity was equipped with TRT in 2004. • Combined gas turbines and steam cycles of er important efficiency gains. • Water-cooled blast furnace slag (ash residues from coal, coke, and ore) can be used as clinker substitute in cement making, resulting in significant CO_2 emission reductions (used predominantly in Europe, Japan, and China). Air-cooled slag (used mostly in the United States) of ers limited CO_2 benefits.
Electric Arc Furnace (EAF)	• Scrap steel accounts for about 80 percent of feedstock. Most EAF installations use a three-electrode design, but the lower energy requirements of two-electrode designs have sparked renewed interest in many countries. • A range of factors, such as raw material composition, power input rates, and operating procedures, af ect energy consumption. The average electricity use of EAFs decreased by about 10 percent between 1990 and 1999.
Direct Reduced Iron (DRI) Production	• DRI accounts for about 5 percent of global steel production (used principally in the Middle East, Latin America, and India). Most countries use natural gas as a feedstock. • India—the leading DRI producer and fast expanding—relies on coal (implying higher CO_2 emissions). India's DRI plants exhibit a wide range of energy efficiency (most plants are small, limiting economic viability of efficiency equipment).
Steel Finishing	• The amount of finishing energy depends on the product (with steel for cars and white goods requiring both hot and cold rolling, and thus more energy). • Thin slab or strip casting processes reduce steel rolling energy needs significantly. Less than 10 percent of world production is currently based on this technology, though some companies achieve much higher rates. • Germany has raised its steel yield (reducing manufacturing waste and thus less energy) from 65 percent in 1960 to almost 88 percent in 2005. The yield in other countries is often considerably lower.

Source: See Endnote 519 for this section.

The most efficient or otherwise waste- and pollution-minimizing practices described in Table II.4-1 can arguably be seen as representing at least a shade of green. Japan and Europe appear to be performing well in this regard. China is lagging behind in many ways, but is trying to improve its record. Yet sufficiently detailed employment data do not seem to exist to permit a quantification of green jobs.

One instance where job figures are available is ferrous slags that are valuable byproducts of iron and steel making (see last item in the "blast furnace" category in the table).[521] In the United States, 21 million tons of iron and steel slag were recovered from iron and steel mills or reprocessed from old slag piles in 2005, up from 17 million tons in 2001. These activities provided employment for about 2,600 to 2,700 people in recent years.[522] Under the assumption that labor productivities elsewhere are comparable, extrapolating U.S. data to other countries suggests that slag recycling worldwide might employ some 25,000 people. Particularly in China, however, labor productivities are much lower, making this a very conservative job estimate.

Energy intensity and carbon emissions vary greatly from country to country, and from one company to another. By late 2004, at least five of the largest 10 steel producers had developed annual environment/sustainability reports, with four of the five adhering to, or drawing on, sustainability reporting standards developed under the Global Reporting Initiative.[523] Three companies— European-based ArcelorMittal, Dofasco (a Canadian subsidiary of ArcelorMittal), and Posco (South Korea)—have been listed on the Dow Jones Sustainability Index. ArcelorMittal says it has reduced the CO_2 footprint of its European operations by more than 20 percent since 1990.[524] Through energy-savings projects and closely monitored energy management, Turkish steel maker Erdemir (one of the 60 largest steel companies worldwide) has improved its energy consumption by 38 percent since 1982.[525] In South Korea, POSCO has developed a simplified, cheaper, and more efficient steelmaking process.[526] (See Box II.4-1.)

Box II.4-1. Simplifying Blast Furnaces at POSCO

South Korea's POSCO, the fourth-largest steelmaker in the world, has developed a process called FINEX that eliminates the need for sintering and coking processes in steelmaking. This results not only in lower capital investment and production costs, but also improved energy efficiency and fewer pollutants. Tests at a demonstration plant in 2003 indicated reductions of sulfur oxides (SOx), nitrogen oxides (NOx), and dust emissions by 92, 96, and 79 percent, respectively—compared with traditional blast furnace methods. Carbon dioxide emissions are almost 20 percent lower. POSCO initiated construction of a 1.5 million ton/year plant in 2004, which was to come online in 2007.

Plant capacity is equivalent to about 5 percent of the company's total production. The company also expects to break ground in 2008 for a full-scale commercial facility at its Indian subsidiary. It is not clear how many jobs the FINEX plant will create, but based on information about the company's existing capacity and workforce, the number might be in the range of 700–800.

Since 1990, the company has reduced its overall CO2 emissions per ton of crude steel produced by 6.8 percent. Between 1997 and 2006, POSCO cut SOx emissions by one-third and NOx emissions by about one-fifth per ton of steel produced. The company is also recycling 98.8 percent of the slag and other by-products it generates, making them available as valuable raw materials for other industries. This record suggests that a considerable portion of the company's 13,400-strong workforce can be considered a shade of green.

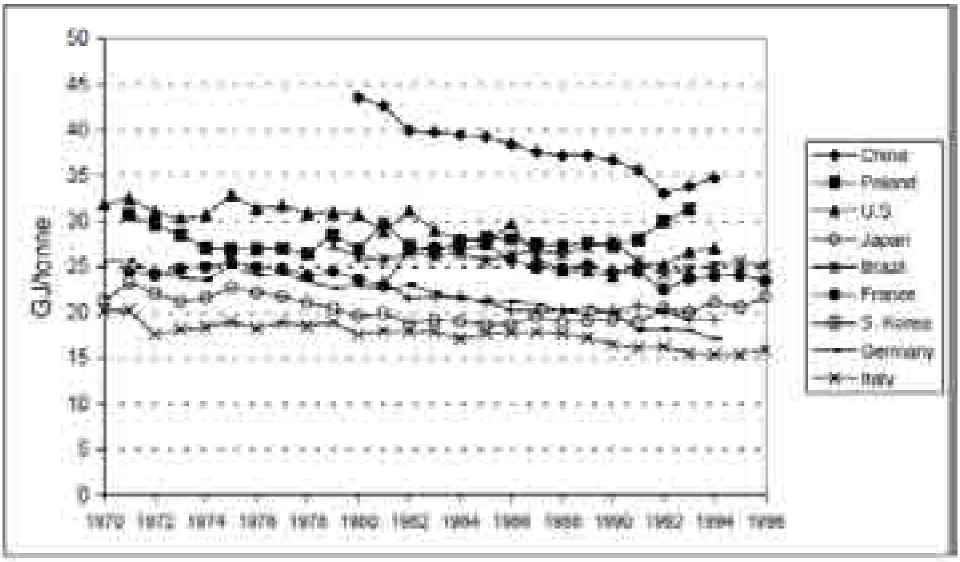
Source: See Endnote 526 for this section.

It is difficult to quantify the number of jobs at these companies and facilities that might be considered a shade of green. While particular aspects of a steel plant may be most critical to reducing its environmental footprint, there may not be an easy way to separate out the number of employees associated with that part of the overall operation. Thus, in place of a perhaps vain quest for a precise tally of green job numbers, it is important to establish clear categories and benchmarks for what can reasonably be considered green enterprises and green workplaces. This is true not just in the steel industry but other sectors as well.

A Wide Range of Efficiency

An analysis published in 2000 suggests that in the period 1970–1996, steel mills in Italy, Germany, South Korea, and Japan were the most energy efficient worldwide.[527] (See Figure II.4-4.) France, Brazil, and the United States were less efficient. China consumed far more energy than any of the other countries, though it also made major strides forward, which continue today.

Figure II.4-4. Energy Consumption per Unit of Steel, Selected Countries, 1970–1996



Source: See Endnote 527 for this section.

China, India, Russia, and Ukraine together account for about half of global steel production, but a much larger share of CO2 emissions. On average, their efficiency is notably lower than that achieved in OECD countries. Russia and Ukraine are still relying strongly on outdated open-hearth furnaces (which contribute 20 and 34 percent, respectively, of their total output).[528] Steelmaking in India carries a heavy environmental burden due to the use of low-quality coal resources. And China still contends with old blast furnaces, inefficient coking plants, as well as low-quality ore.[529] It is unlikely that many steel industry jobs in these countries can be considered green.

On the whole, steel industry efficiencies among OECD countries are fairly similar. In fact, the IEA argues in a 2007 report that "data are not sufficiently detailed to allow a ranking."[530]

Data by the Japan Iron and Steel Federation, however, suggest that: "Japan's steelmakers are already widely recognized by many multinational organizations as the world's most energy efficient. Japan ranked first in the 'Asia Pacific Partnership (APP) Concerning Clean Development and Climate,' an organization made up of public and private-sector individuals from seven countries, including the U.S., China, India and Japan. Japan also received high marks from the International Iron and Steel Institute (IISI).... Moreover, Japan's leadership in energy efficiency is backed up by quantitative data in a thesis by the Research Institute of Innovative Technology for the Earth (RITE)."[531]

Comparing steel industry energy consumption internationally (in terms of tons of oil equivalent per ton of crude steel produced), a January 2008 report by RITE concluded that Japan is 15–20 percent more efficient than its competitors in Europe.[532] (See Table II.4-2.) Japan's lead is due to the extensive use of exhaust heat recovery equipment and a high rate of utilizing byproduct gases. Furthermore, a 2007 survey found that Japanese steel companies use energy conservation equipment at a higher rate than their competitors.[533]

Table II.4-2. Energy Ef ciency in the Steel Industry, Selected Countries

	Tons of Oil Equivalent per Ton of Crude Steel
Japan	0.59
South Korea	0.63
Germany	0.69
France	0.71
United Kingdom	0.72
United States	0.74
Canada	0.75
China	0.76
India	0.78
Australia	0.79
Russia	0.80

Source: See Endnote 532 for this section.

China

China accounts for approximately 50 percent of the world's steelmaking-related CO_2 emissions.[534] This is substantially higher than the country's share of world steel production (26 percent in 2004, 34 percent in 2007). Chinese steel makers on average still use one-fifth more energy per ton than the international average. Data compiled by the IEA show that on average, China used more energy use per ton of steel in 2004 than the international average in 1994.[535]

© Sinopictures / Viewchina / Still Pictures
Labourers work at a steel and iron factory. Wuhan, Hubei province, China.

Since the late 1990s, China has bought dozens of steel factories from Western countries like Germany, France, and Luxembourg, dismantling and shipping them piece by piece. But much of it is outmoded equipment. In effect, Western countries outsourced their polluting industries.[536] The New York Times described the four-square-mile (10 square kilometer) area occupied by Hangang, a steel company in southern Hebei Province, as: "a working museum of the industrial age. Its oldest coal-powered furnace, with its corroded, protruding shoots and shafts, might have belonged to Andrew Carnegie. The newest, part of a big expansion, uses waste heat to generate power, a technology that saves energy. The European castoffs fell somewhere in between."[537]

But China has also made considerable strides to improving its environmental record. A September 2000 Internatinal Labour Organization (ILO) report noted that open-hearth furnaces were being taken out of service, along with smaller, inefficient blast furnaces. As part of a modernization effort, new electric arc furnaces have been installed and more stringent regulations introduced.[538] There is thus a wide range of performance among Chinese plants. Some facilities are efficient in international comparison, and are working to reduce environmental impacts.[539] (See Box II.4-2.)

Box II.4-2. China Steel Corporation's Zero-Waste Program

China Steel Corporation (CSC), the world's 25th largest steel producer, generates more than 400,000 tons of sludge annually. Zinc-rich wastes are generated during the process of electro-galvanizing—which coats crude steel with zinc to prevent corrosion. After CSC launched a Zero-Waste Program, it succeeded in July 2001 in finding a long-term customer for its high-zinc sludge. This allowed the company to raise its sludge-recycling rate from 76 percent in 1999 to 100 percent today. Now, CSC separates the sludge based on zinc and oil content and decides on the most appropriate recycling route. High-zinc sludge is sold to zinc smelting companies. The remainder is mixed with power plant coal fly-ash and sold as inexpensive raw material to cement companies.

Source: See Endnote 539 for this section.

Steel Recycling

A considerable portion of global steel production is now based on recycled steel. Recycling saves 40 to 75 percent of the energy needed to produce virgin steel and thus helps to reduce CO2 emissions.[540] And it of course obviates the need for a share of iron mining, further reducing the industry's environmental footprint. Hence, the share of scrap steel used in different countries and by different companies can plausibly be regarded as one key indicator of greening this industry and providing jobs that are a shade of green.

There are three sources of recycled steel: "home" scrap that emanates from within the steel mill, "prompt" scrap derived from the production of finished goods, and "obsolete" scrap from products once they reach the end of their life cycle.[541] The IEA notes that "the amount of steel that is stored in capital stock is more than 10 times annual steel production and it is still increasing continuously."[542] In principle, the recycled content of steel can be close to 100 percent, as there are no technical limitations, relatively limited processing losses, and recycled steel is as strong and durable as steel newly made from iron ore. However, the time span within which old steel becomes available for recycling ranges from a few weeks to several months to many years or even decades. Relative to the rapidly rising demand for steel products, there is currently not enough steel scrap available.

In most sectors, including the automotive industry and construction, steel recycling rates are between 80 and 100 percent.[543] A typical passenger car uses approximately a ton of steel.[544] The United States has achieved a recycling rate higher than 100 percent for automotive steel (meaning more steel was recovered from old cars than used in manufacturing new ones), 98 percent for construction beams, 90 percent for appliances, and 65 percent for rebar and other construction materials.[545] Worldwide, 65 percent of steel cans are recycled, representing more than 5 million metric tons in 2005. The can-recycling rate has been rising in recent years, and some countries reach a rate of 85 percent or higher.[546]

Even though the total amount of scrap steel has increased significantly, its share in total steel production has actually fallen slightly. The IEA says this is due to rapid growth of steel demand, improved plant production yields (limiting home scrap), and the surge in steel production in China, which has very limited scrap reserves.[547] According to the International Iron and Steel Institute, 383 million metric tons of steel was recycled worldwide in 2002, equivalent to 42.3 percent of crude steel produced that year.[548] By 2004, recycling had risen to 452 million tons, or 42.7 percent of total production.[549] By 2006, even though recycling continued to rise to 496 million tons, its share declined somewhat—equivalent to 41.3 percent of 1.2 billion tons of steel produced. Nonetheless, scrap use in 2006 avoided an estimated 894 million tons of CO2 that would have been generated by producing an equivalent amount of steel from virgin ore.[550]

Table II.4-3 shows that Turkey, the United States, South Korea, the CIS countries, Germany, and Japan rely to a significant degree on scrap for their steel production.[551] According to the IEA, Spain also has a strong position in scrap-based steel production.[552] On the whole, developing countries have a lower share, because their steel recycling systems are still limited and thus less scrap steel is available. A 2007 paper prepared for United Nations Industrial Development Organization (UNIDO) puts the share of secondary steel at 4 percent in India and 10 percent in China (a lower share than what IISI statistics suggest).[553] In Brazil, the share of scrap steel is 25 percent. However, the country's largest producer, the Gerdau Group (at 16 million tons the world's 14th-largest steel company), relies mostly on scrap. Its Açominas plant in Minas Gerais recovers 98 percent of the energy contained in byproduct gases, covering 75 percent of the facility's energy needs.[554]

The U.S. iron and steel scrap recycling industry recovered 71 million tons of scrap in 2007. Taking imports and exports into account, 66 million tons were available for domestic use. This industry employs an estimated 30,000 people.[555] U.S. scrap recovery was equivalent to about 13 percent of the global total in 2006. Under the assumption that companies in other countries employ a comparable number of people for scrap recycling, this would yield a global figure of 225,000 jobs. Of course, this can be seen as no more than a back-of-the-envelope calculation, as labor productivities vary widely from country to country. Although China's recycling rate is quite low, the overall size of its steel industry and its comparatively low labor productivity suggest that it employs a rather large number of people in recycling. (In 2001, China's steel labor productivity was less than one-tenth that typical of developed countries, though this ratio may have narrowed somewhat since then.[556])

Table II.4-3. Total and Recycled Steel Production, Selected Countries, 2005

Country*	Total Steel Production	Scrap Steel Recovered Domestically	Recycled Steel Used in New Production**	Share of Recycled Steel†
	(Million metric tons)			(Percent)
China	356	50	60	17
CIS‡	113	65	50	44
Japan	112	54	47	42
United States	95	66	57	60
South Korea	48	19	25	52
Germany	45	21	20	44
Brazil	32	8	8	25
Turkey	21	4	18	86
World§	1,146	434	442	39

**India is one of the leading steel producers (46 million tons in 2005). But because IISI does not report Indian scrap consumption, it is not included in this table. **Includes domestic recovery of scrap steel plus net imports. †Recycled steel (domestic recovery and net imports) as a share of total steel production. ‡Principally, Russia and Ukraine. §For the world as a whole, domestic scrap and total scrap available should be the same, as all exports must equal all imports. However, IISI statistics show a discrepancy in these numbers, presumably due to gaps in reporting.*
Source: See Endnote 551 for this section.

Employment Trends

World steel industry employment data are limited, and somewhat contradictory. According to the ILO, the iron and steel sector accounts for about three-quarters of the 6–7 million jobs worldwide in basic metal production.[557] That would mean a workforce of roughly 5 million. But since employment is falling in most countries, the total must be lower today. Figures for China, meanwhile, are unclear. A 2000 ILO study mentions a 1.2 million workforce.[558] But a 2001 article in the China Business Review put the number at 3 million.[559]

After World War II, steel production and employment expanded massively. But by the mid-1970s, production reached a plateau, and rising productivity translated into fewer jobs. During the last quarter of the 20th century, the global steel industry underwent significant restructuring and shed more than 1.5 million jobs.[560] (See Table II.4-4.)

Table II.4-4. Employment in the Steel Industry, Selected Countries and Years

	1974	1990	2000
	(thousands)		
Japan	459	305	197
United States	521	204	151
Taiwan	n.a.	73	83
Brazil	118	115	63
South Korea	n.a.	67	57
South Africa	100	112	56
European Union, of which:	996	434	278
Germany	232	125	77
France	158	46	39
Italy	96	56	39
United Kingdom	197	51	29
Spain	89	36	22
Total*	2,335	1,388	885

**In addition to the countries listed above, the total includes Canada, Australia, and Yugoslavia. Eastern Europe's steel industry employed about 120,000 people in 2004.*
Source: See Endnote 560 for this section.

Today, steel is no longer a labor-intensive industry. It is marked by rising globalization, ongoing consolidation, substantial gains in labor productivity through automation and computerization, and strong competition, particularly from Asian producers.[561] Among producers in North America, Europe, and Japan, there is concern about cheap wages in competitors like China.[562] (See Table II.4-5.) However, labor tends to be a minor cost factor, accounting for about 3–5 percent of cost among Western European companies, which pay the highest wages worldwide.[563] The outlook for Europe and North America is for further employment retrenchment. In Europe, a business-as-usual strategy will likely lead to the further loss of 80,000 to 120,000 jobs (out of some 370,000 currently) over the next 20 years or so.[564] U.S. steel employment, at about 154,000 jobs—is expected to decline 25 percent during 2006–2016. Generally speaking, low-skilled jobs are far more liable to be lost to automation, while remaining jobs require more education and training.[565]

Concerns about climate change could lead to further changes with negative employment effects. In fact, steel companies and unions in Western countries are concerned that the Kyoto Protocol or a successor agreement may function as a job killer if developing countries like China and India are not mandated to make their own carbon emission reductions. The industry temptation is to move carbon-intensive operations to parts of the world not subject to Kyoto rules. Outsourcing is driven by a number of factors, including weak environmental and labor standards and enforcement, but also the fact that governments—often desperate to attract foreign investment—are willing to offer generous tax terms or other inducements.

Table II.4-5. Steel Industry Wages, Selected Countries, 2000 and 2005

	2000	2005		2000	2005
	(hourly compensation in U.S. dollars)			(hourly compensation in U.S. dollars)	
Germany	22.70	34.10	Spain	10.70	17.60
Sweden	20.20	29.70	South Korea	8.20	14.10
United Kingdom	16.70	26.00	Taiwan	6.20	6.40
France	15.50	25.30	Czech Republic	2.80	6.10
Australia	14.40	24.60	Brazil	3.50	3.20
United States	19.70	23.80	Mexico	2.20	2.50
Canada	16.50	23.70	China	0.60	1.10
Italy	13.80	21.70	India	0.60	0.90
Japan	22.00	21.40	Ukraine	0.30	0.80

Source: See Endnote 562 for this section.

At the same time, however, a proactive policy to bring about a low-carbon future can help retain jobs. A 2007 European study argues that further reductions in carbon emissions (from about 2 tons CO2 per ton of steel to 1.2 tons) are achievable; East European producers in particular have ample room for such reductions. A low-carbon steel strategy would link allocation of carbon emission rights to industry R&D efforts, set standards for CO2 emissions for production processes and products, transform the reduction of greenhouse gas emissions into a conditional profit opportunity for manufacturers, introduce regulations that ensure that imported steel has the same carbon cost as European steel, and reinvigorate the social partnership in the steel industry. The study estimates that such a strategy could save 50,000 jobs.[566] The European Commission is currently supporting a long-term initiative to commercialize breakthrough steelmaking processes.[567] (See Box II.4-3.)

Making steel mills greener and more competitive is a must for job retention. At the same time, it must also be acknowledged that more energy efficient mills do not necessarily employ many people. In the United States, electric arc furnaces (which require far less energy than blast furnaces) are characterized by a lean workforce. They now produce more than 50 percent of the country's steel, up from 25 percent two decades ago, and are expected to continue to gain market share.[568]

Box II.4-3. ULCOS: Europe's Ultra-Low CO2 Steelmaking Initiative

The European Steel Technology Platform, inaugurated in March 2004 with the support of the European Commission, has initiated a cooperative project to develop technologies to make the steel industry sustainable in the face of the climate crisis. ULCOS (Ultra-Low CO2 Steelmaking) is intended to develop breakthrough steelmaking technologies with the potential to reduce CO2 emissions by at least 50 percent. ULCOS aims to develop and commercialize these technologies over the next 20 to 50 years.

A large consortium of 48 partners from 13 European Union countries has been brought together, led by Arcelor-Mittal and a core group of EU steel producers. The consortium includes steelmakers, suppliers, universities, as well as research laboratories specializing in biomass, carbon capture and storage (CCS), alternative energy sources, and energy economics.

ULCOS-I (2004–09) has a budget of \$74 million (€54 million), funded by industry and the European Commission (through its 6th Framework Programme and the Research Fund for Coal and Steel). From 2004 to 2006, it undertook a detailed screening of technologies and energy sources, from improved blast furnace to plasma ore melting and from fossil fuels to biomass or green electricity. From a list of 80 technologies, four were selected for closer investigation (the top-gas recycling blast furnace, incorporating CCS in its core; smelting reduction of iron ore with CCS; natural gas pre-reduction and electrical melting with CCS; and direct electrolysis of iron ore). By 2009, these technologies will be put to the test in ULCOS-II—a five-year industrial-scale demonstration program. A final selection will then take place on the basis of technological, process, economic, and environmental criteria. The world's most ambitious R&D effort to reduce steel-related CO2 emissions, ULCOS-II will likely have a budget of more than \$400 million (€300 million).

It remains to be seen what the employment implications of this initiative will be. On one hand, successful development of low-carbon steel is likely to help in the retention of steel industry jobs in Europe. On the other hand, the march of labor productivity growth will hardly be halted, so that a gradual reduction in employment numbers is still possible. ULCOS is not a job generation or retention program as such.

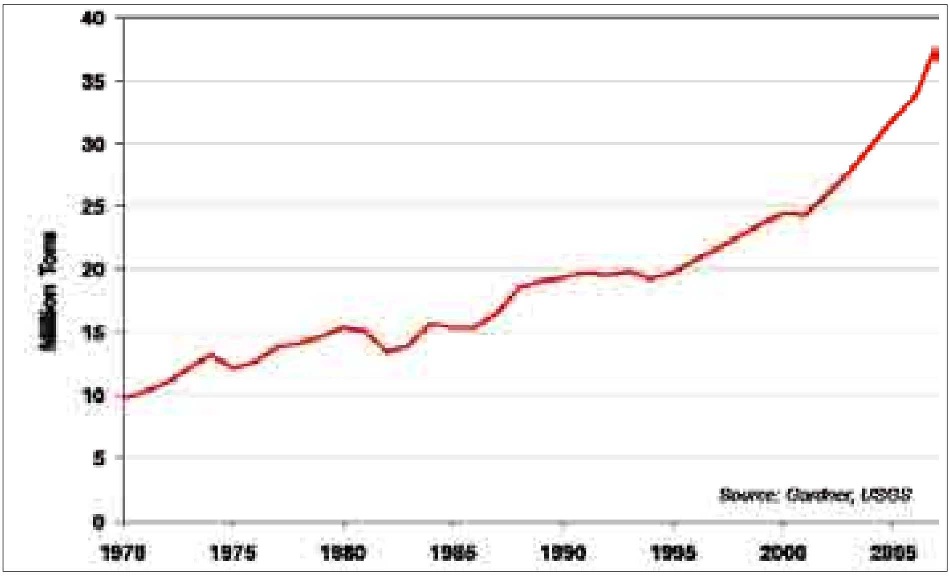
Source: See Endnote 567 for this section.

Steel industry employment data are incomplete, and data collection for many aspects of this industry is still in its infancy in many developing countries. This limits the extent to which even rough green job calculations can be undertaken beyond the numbers suggested here.

Aluminum

World primary aluminum production has grown from about 2 million tons in 1950 to an estimated 38 million tons in 2007 (see Figure II.4-5), plus at least another 10 million tons from secondary production based on scrap recycling.[569] Aluminum output has been surging in the last few years, and primary production is projected to reach around 60 million tons by 2020.[570] This lightweight yet strong metal is primarily used in the aerospace industry, automotive industry, buildings/construction, and in packaging.

Figure II.4-5. World Primary Aluminum Production, 1970–2007



Source: See Endnote 569 for this section.

Even as output grew, dramatic changes occurred in the lineup of major producing countries, along with a substantial consolidation of companies. Whereas in 1960, the United States accounted for slightly more than 40 percent of primary aluminum produced worldwide, its share is now down to 7 percent.[571] U.S. primary production peaked in 1980, and secondary output in 1999.[572] Employment is now at 60,000, down from a peak of 77,800 in 1998.[573] China, on the other hand, has surged to take a commanding 32 percent share in 2007. Russia, the second largest producer, accounts for 11 percent, and Canada for 8 percent. Other leading producers are Australia, Brazil, Norway, and India.[574]

Energy Use and Intensity

Accounting for roughly 3 percent of global electricity use, the aluminum industry is among the most energy-intensive sectors of the world economy.[575] Smelting (electrolysis) takes the biggest chunk of energy, followed by process heating.[576]

The industry is a large emitter not only of carbon dioxide (in 2005, producing 1 ton of aluminum generated 10.5 tons of CO2 equivalent, including emissions from transportation and ancillary processes), but also a major source of perfluorocarbons (PFCs)—greenhouse gases far more potent than CO2.[577] Aluminum smelting and bauxite mining also contribute a range of other wastes and air and water pollutants.[578]

According to the International Energy Agency, more than 60 percent of the electricity consumed by aluminum smelters worldwide in 2005 was produced from hydropower plants.[579] Large-scale hydro imposes substantial costs on surrounding ecosystems and communities. Coal-generated electricity accounts for roughly one-third of the industry's total energy consumption.[580] Natural gas and nuclear power contribute most of the remainder. But the precise breakdown, and thus the environmental footprint, varies by region.[581]

The industry has become steadily more energy-efficient. Worldwide average energy use in smelting was more than 50,000 kilowatt hours (kWh) per ton in 1900, about 25,000 kWh in 1950, and about 16,000 kWh in 2000.[582] An international comparison shows that improvements have been made in all regions of the world.[583] (See Figure II.4-6.) However, substantial further improvements are both needed and possible.[584] (See Box II.4-4.)

Figure II.4-6. Electricity Consumption in Aluminum Smelting, by Reion, 1980–2006

Source: See Endnote 583 for this section.

Box II.4-4. Energy and Greenhouse Gas Emissions Initiatives at Alcoa

Alcoa is the world's leading aluminum producer, accounting for 11 percent of global primary output with operations in 43 countries that employ some 129,000 people. The company generates approximately 25 percent of its own electricity needs. It emits about 34 million tons of CO2 equivalent; another 27 million tons are associated with electricity purchased from power companies.

In 1998, Alcoa set a target to reduce its direct greenhouse gas emissions 25 percent below 1990 levels, and achieved its goal in 2001. Changes in the way the company manages the smelting process have also led to a cut in emissions of perfluorocarbons (PFCs) of more than 75 percent since 1990.

In 2004, Alcoa launched the Greenhouse Gas Network in 2004 to further reduce emissions. Via a Web-based information system, the network establishes benchmarks, challenges each to become a leader in emissions reductions, and helps stimulate sharing of best practices among the company's smelters and refineries. At some facilities, a portion of each employee's annual incentive payment is tied to environmental performance.

In 2002, Alcoa launched an Energy Efficiency Network (EEN), involving more than 450 employees worldwide. EEN teams conduct energy efficiency assessments at individual facilities; identify, document any strong energy practices they observe, and alert other Alcoa plants to the associated benefits; and provide technical support. By mid-2005, assessments had been completed at more than 50 plants, confirming nearly $80 million in annual savings potential and capturing annual savings exceeding $20 million. Alcoa did not initially pursue projects with a payback period of more than one year, but is now beginning to invest in such longer-term projects.

Source: See Endnote 584 for this section.

Secondary Production: Proxy for a Greener Industry

As is the case with steel, a major way in which the aluminum industry can be greened is through boosting secondary production. Recycling aluminum is cheaper and far more energy efficient than manufacturing the metal from bauxite ore. Recycling aluminum scrap (by remelting it) uses only 5–10 percent the amount of energy it takes to make aluminum from scratch.[585] And by reducing the need for mining bauxite, scrap recycling has inherent additional environmental benefits.

Aluminum scrap is derived from two different sources. So-called "new" scrap emerges directly from the manufacturing process (process scrap, defective products, etc.); "old" scrap is derived from post-consumer or obsolete products.[586] Scrap separated by alloy (or even better, scrap from specific products used for manufacturing the same products) is preferable, as it requires less processing, avoids impurities, and thus can be used more reliably and efficiently.[587]

© Renner
Recycling aluminum.

According to a 2003 International Aluminum Institute analysis, since 1888 a total of 660 million tons of aluminum have been produced worldwide. Of that total, some 460 million tons, or two-thirds, is still in productive use—and thus potentially available for recycling.[588] Another assessment puts the amount of material in use worldwide that will eventually become available for recycling at 400 million tons.[589] This is equivalent to more than 10 times current primary production per year.

Secondary production depends not just on installing appropriate processing equipment, but also on the flow of recovered materials. Different aluminum products have vastly different life spans and recycling rates, affecting availability and price of scrap supplies.[590] (See Table II.4-6.) There are considerable differences from region to region and from country to country. In Europe, for instance, Norway and Sweden boast the highest recycling rates while Portugal's is very low.[591] In North America, only 52 percent of recovered beverage cans were recycled in 2005, down from a peak of 67 percent in 1992. By comparison, the global recycling rate averages 63 percent.[592] Brazil has the highest recovery rate in the world for aluminum cans. As in India, recycling is driven by endemic poverty.[593]

Table II.4-6. Estimated Global Aluminum Product Life and Recycling Rates, by Major End Market

	Average Product Life	Average Recycling Rate
	(years)	(percent)
Building and Construction	25–50	80–95
Transportation (Cars)	10–15	90–95
Transportation (Aerospace)	15–25	90–95
Transportation (Marine)	15–40	40–90
Transportation (Trucks, Buses, Rails)	15–30	50–90
Engineering (Machinery)	10–30	30–90
Engineering (Electrical)	10–50	40–90
Packaging (Beverage Cans)	0.1–1	30–90
Packaging (Foil)	0.1–1	20–90

Source: See Endnote 590 for this section.

Government regulations are critical. Where they are weak or absent (such as in Greece, Britain, Ireland, Eastern Europe, and Russia) recycling ratios tend to be low, while they are very high in Switzerland, Scandinavia, and Germany. In the European Union, a packaging waste directive mandates overall recycling rates of 50 percent for aluminum and steel by the end of 2008; an end-of-life vehicles directive requires a material recovery rate of more than 85 percent from old cars by 2006 and a recycling rate of more than 80 percent.[594]

International trade is an increasingly important factor in scrap markets as well. The European Union has moved from being a net scrap importer in the 1990s to a net exporter. Large quantities are being shipped from Europe and North America to China and India, causing shortages in the exporting countries and threatening disruptions in their supply chain.[595]

World secondary production of aluminum has grown steadily from very modest beginnings. It was about 2 million tons in 1970 and 4 million tons in 1980. It is now at least 10 million tons, although some sources estimate the global total to be as high as 12 to 14 million tons.[596] The portion of secondary production relative to the industry's overall output is roughly a quarter.[597] (See Table II.4-7.)

Employment statistics for this industry are surprisingly sparse. According to one estimate, it directly employs more than 1 million people worldwide.[598] It is unclear, however, how inclusive this figure is and how the boundaries are drawn. Other estimates say that China alone employed as many as 1 million people in its aluminum fabrication industry in 2002.[599] Secondary production is likely to employ considerably fewer people per unit of output than primary production does.

Table II.4-7. Primary and Secondary Aluminum Production, Selected Countries, 2007 and Earlier Years

	2007 Production			Share of Secondary Production (percent)				
	Primary	Secondary	Total					
	(million tons)			2007	1994	1990	1980	1970
China	12.0	2.4	14.4	17	7*	1	1	1
Russia	4.2	n.a.	n.a.	n.a.	n.a.	17†	9	n.a.
Canada	3.1	0.19	3.29	6	4	4	6	0
United States	2.6	3.11	5.71	54	48**	37	25	20
Australia	1.9	0.13	2.03	6	4	3	12	10
Brazil	1.7	0.25	1.95	13	7	5	15	n.a.
India	1.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Norway	1.1	0.35	1.48	23	5	1	2	3
Japan	‡	1.15	1.16	99	97	96	42	31
Venezuela	0.6	0.02	0.65	2	5	2	n.a.	n.a.
Germany	0.5	0.84	1.36	62	44**	43	36	8
World	**38.0**	**10.47**	**48.47**	**22**	**n.a.**	**n.a.**	**n.a.**	**n.a.**

**1996 data. **1995 data. †1989 data. ‡Japan produces only a few thousand tons of primary aluminum.*

Source: See Endnote 597 for this section.

Table II.4-7 shows that different aluminum-producing countries have a wide range of secondary production capacities. The United States, Germany, and Japan have boosted the share of secondary production. China is rapidly increasing not only its primary output, but also its secondary production. Producers like Russia, Australia, Canada, Brazil, and Venezuela have not invested much in secondary facilities, largely explained by their access to abundant domestic energy (hydropower and coal) resources.

Country Experiences

Japan's experience is unique in that it has almost completely abandoned domestic primary production, switching instead to secondary production and imports.[600] Driven by rising demand in the automobile sector, domestic shipments of secondary aluminum alloy rose from 0.9 million tons in 2001 to 1.1 million tons in 2007. Japan also imported a roughly equal quantity of secondary aluminum, as well as primary aluminum.[601] According to the Japan Aluminum Association, as of December 2004, the country's aluminum industry employed 12,739 workers at 78 plants.[602] These jobs can plausibly be considered green jobs.

In the United States, secondary production expanded 55 percent between 1990 and 1999, but subsequently declined by 16 percent.[603] (See Table II.4-8.) Primary production is stagnant, and imports are skyrocketing.[604] During the past 40 years, the U.S. aluminum industry has cut its energy intensity by nearly 58 percent. However, a 2003 study for the U.S. Department of Energy found that even after this reduction, "the industry consumes nearly three times the theoretical energy required. Significant opportunities for further energy improvements still remain."[605] The potential gross energy savings (with reference to year 2000 data) amount to a stunning 141 billion kWh, out of 185 billion kWh/year used.[606] U.S. aluminum industry employment has hovered around 60,000 people in recent years.[607] Roughly 10 percent (6,071 people) were employed in secondary aluminum production at 127 companies in 2002, most of them small and medium-sized firms employing between 20 and 250 people.[608]

Table II.4-8. Primary and Secondary Aluminum Production in the United States, Selected Years

	Primary Production	Secondary Production	Total Aluminum Industry Employment
	(million tons)		(thousands)
1980	4.7	1.6	27.2
1990	4.0	2.4	77.9
1999	3.8	3.7	76.3
2004	2.5	3.0	57.5
2007	2.6	n.a.*	60.0

**Secondary production from old scrap only was 1.3 million tons in 2007.*
Sources: See Endnote 603 for this section.

In the European Union, secondary aluminum production tripled from 1.2 million tons in 1980 to 3.6 million tons in 2003. It surpassed primary production—which increased by 12 percent during the same period of time—in the mid-1990s.[609] By 2006, the more than 5 million tons of secondary production provided about 40 percent of total output.[610] In 2003, EU aluminum recycling conserved 16.4 million tons of bauxite, and avoided 1.5 million cubic meters of waste products in landfills. One ton of recycled aluminum saves 1.3 tons of bauxite residues, 15,000 liters of cooling water, 860 liters of processing water, and 2 tons of CO2 and 11 kilograms of sulfur dioxide emissions.[611] Unlike the EU, Central European countries are still producing a larger quantity of aluminum from scratch than from scrap.[612] (See Table II.4-9.) In 2003, the European aluminum recycling industry provided more than 10,000 direct and indirect jobs, according to its own estimates. Most companies in this sector are medium size.[613] The industry's estimate for the total workforce in Western Europe is about 255,000 persons.[614]

Table II.4-9. Primary and Secondary Aluminum Production in Europe, 2003

	EU-15	Western and Central Europe*
	(million tons)	
Primary Production	2.6	4.9
Secondary Production	3.6	4.0
Total Production	6.2	8.9
Net Imports	3.6	2.7
Total Supply	9.8	11.6
	(percent)	
Share of secondary production relative to total production	58	45
Share of secondary production relative to total supply	37	34
	(number of plants)	
Primary Production	21	38
Secondary Production	235	276

**Europe excluding former CIS except Baltic states.*
Source: See Endnote 612 for this section.

China has massively increased its primary aluminum production—expanding output from 2.6 million tons in 1999 to 12.6 million tons in 2007—and thus becoming the dominant producer worldwide.[615] Reports indicate that a considerable share of its facilities were outdated before this period of rapid growth.[616] However, the industry is undergoing massive investment to add even more capacity and to update old technology and equipment.[617] The government adopted a policy to shut down small-scale, high-cost, and polluting (Søderberg) smelters by 2007.[618]

Meanwhile, China's secondary aluminum production is also increasing, to more than 2.4 million tons in 2007, according to the China Nonferrous Metals Industry Association (CNMIA). It had reached 2.35 million tons in 2006 and more than 1.9 million tons in 2005.[619] Compared to the environmental and resource impact of primary production, China's secondary aluminum industry saved an estimated 25.7 million tons of coal equivalents, 1.5 billion tons of water, and avoided the discharge of 1.2 billion tons of solid wastes as well as 413,000 tons of sulfur dioxides.[620]

Wang Gongmin, a leading CNMIA official, has expressed confidence that domestic supplies of scrap will increase further as the country develops a domestic recycling industry, including collection, recovery, and distribution facilities. The Chinese government is encouraging development in the aluminum recycling sector. It intends to increase consumption of secondary aluminum to 25 percent of total consumption by 2010 from 17 percent at present. The cancellation of export tax rebates for primary aluminum and other measures may eventually make secondary production key to exports as well.[621]

China relies heavily on fast-rising scrap imports, running to 1.77 million tons in 2006 and even higher in 2007.[622] Between China's domestic scrap supplies (mostly manufacturing scrap rather than post-consumer) and imported scrap, it is possible that as much as 40 percent of the country's total output of aluminum is based on scrap recycling.[623] However, this is a somewhat speculative figure.

If we apply the current 17 percent share of secondary production to China's estimated aluminum workforce of 1 million, this would yield a figure of 170,000—assuming secondary production takes as many workers as primary production. But even though China's labor productivity is far lower than that prevalent in Western countries (in 2003, it was estimated that the production value per aluminum worker in China was about 25 times lower than elsewhere), this figure is likely too high because secondary production does not require as many workers as primary production does.[624] If the U.S. experience bears any relevance (here, secondary production accounts for 54 percent of total output, but jobs in secondary production represent only 10 percent of the aluminum industry workforce), then China's secondary production workforce may be more on the order of 30,000 to 40,000.

Green Aluminum Jobs

Outside of China, green jobs in the aluminum industry appear to be fairly limited. Most of Japan's employment of about 12,000 falls in this category, a roughly equal number in Europe, and some 6,000 in the United States. Employment numbers in other countries are unknown, but so far, the quantities of secondary materials involved suggest very small numbers. Worldwide (excluding China), there may be some 30,000 secondary production jobs.

Clearly, the aluminum industry—which has always been a capital-intensive industry—cannot generally be expected to be a major source of green jobs. But as was stated at the beginning of this section, greening this sector of the economy by relying more strongly on recycled metals is imperative in light of its carbon emissions and other environmental impacts. Substantial changes have already taken place, but it is also clear that greater energy efficiency gains and additional strides in expanding aluminum recycling are both possible and necessary.

Huge amounts of aluminum are bound up in a broad range of products, and this quantity should increasingly enable the world to build an industry that is far more centered on recycling than on virgin production. For all the accomplishments to date, primary aluminum production continues to rise. To make the industry more sustainable and thus achieve a deeper "shade of green," secondary production will need to become the dominant aspect of the industry in coming years and decades.

Cement

Concrete is one of the most common and important building and construction materials utilized throughout the world at the present time, due in part to the availability of the raw materials needed to produce it and its viability as a structural element. Concrete is used in infrastructure to build roads, factories, homes, underground water pipes, bricks, blocks, and other structures.[625] Cement is the main ingredient in concrete, which "is used as a material in quantities second only to our use of water."[626]

Over the past 10 years, cement production has grown by 4 percent per year.[627] In 2000, cement production totaled 1.5 billion tons.[628] Estimates from the World Business Council for Sustainable Development (WBCSD) put production for 2007 at approximately 2.5 billion tons.[629] Cement production is expected to double by 2050, reaching more than 5 billion tons.[630]

The Environmental Impact of Cement

Given rising production and consumption of cement, it is necessary to recognize its major environmental impact. Table II.4-10 summarizes some of the main concerns that affect the environment, society, and the economy.[631] It is important to adopt and standardize more sustainable cement and concrete production, transportation, and end-of-life uses on a global level in order to decrease these negative impacts.

Table II.4-10. Main Concerns of Cement and Concrete Production

Environmental Impact	Societal Issues	Economic Issues
• Natural resource and land use (quarrying limestone and other materials, water use) • Waste products from concrete production (water, cement slurry, discarded cement, excess production) • CO2 emissions, energy consumption, other pollutants	• Land use, utilization of scarce resources • Poor working environment (noise, dust, accidents) and health issues • Landfilling with the risk of leaching of heavy metals	• Transportation issues: Local versus imported materials • Cost of recycling cement

Source: See Endnote 631 for this section.

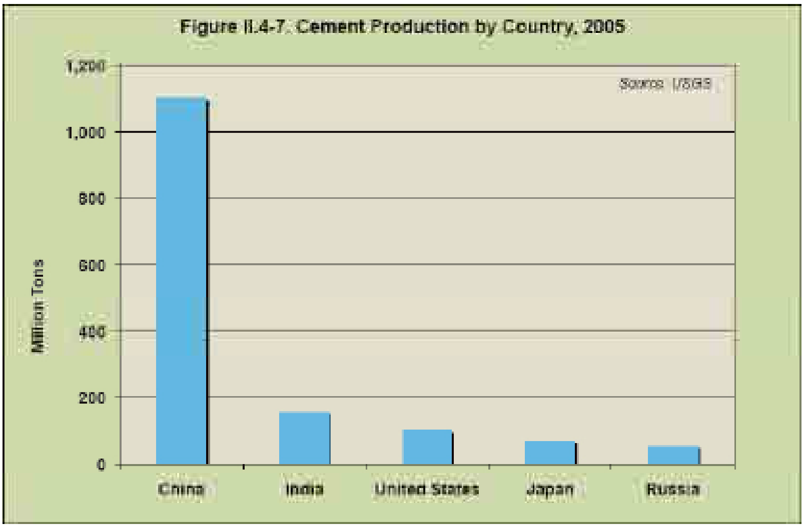
There are many concerns linked to cement production, including the production of greenhouse gases (GHGs), consumption of large amounts of energy and natural resources, dust and other pollutant emissions, disturbance of land during quarrying, and production of waste products.[632] However, this section will focus mainly on reducing GHGs by creating a more energy efficient and sustainable industry.

Cement is responsible for approximately 5 percent of all GHGs emitted worldwide.[636] These emissions come from the chemical reaction caused when converting limestone into cement (50 percent), burning fuel (40 percent), transportation (5 percent), and electricity used in manufacturing operations (5 percent).[634] For each ton of cement produced, average emissions per country range from 0.73 tons to just under 1 ton.[635] At these rates, carbon dioxide (CO2) emissions will reach nearly 4–5 billion tons per year in 2050 from the cement industry alone.

Cement Production

Cement is produced in 150 countries worldwide, and China is now the global leader.[636] Reports of its cement production and consumption vary by source, but most estimates put China at 41–47 percent of total global production.[637] Figure II.4-7 shows the four largest producers worldwide.[638]

Figure II.4-7. Cement Production by Country, 2005



Note: Production measured in billions of tons.
Source: See Endnote 638 for this section.

Many other countries are home to cement production facilities as well. South Korea, Russia, Spain, Thailand, Brazil, Italy, Turkey, Indonesia, Mexico, Germany, Iran, Egypt, Vietnam, Saudi Arabia, and France each produce between 21 and 51 million tons annually.[639] The world's remaining countries produced a combined total of 400 million tons.[640]

China has been the world's largest cement manufacturer since 1985.[641] In 2000, the country produced an estimated 576 million tons, or 36 percent of the world's total.[642] Production recently exceeded 1 billion tons, just under half of the world's total.[643] Cement consumption is also rising in China and is expected to reach 1.3 billion tons, or about half of the world's total, by 2010.[644]

The cement industry in India has grown to the second largest in the world, producing 145 million tons in 2005.[645]Fifty-nine major cement companies own 116 plants and produce the majority of cement in India.[646] Nearly 300 local "mini" cement plants are scattered through India and take advantage of limestone reserves.[647] The United States ranks third in cement production, producing 101 million tons in 2005.[648]

More Sustainable Cement Practices

According to the Battelle report, Toward a Sustainable Cement Industry, "the cement industry as a whole is not yet on a sustainable path in any of the dimensions of the 'triple bottom line'—society, economy and ecology"[649] Between 1994 and 2003, the CO2 intensity of cement production declined by 1 percent per year, but this small decrease was outweighed by increased production.[650] More sustainable production methods will need to be adopted industry-wide if the cement industry is to reduce its carbon emissions and energy use.

A 2007 International Energy Agency report observed that cement manufacturing has the greatest potential for reducing CO2 emissions compared to other industrial sectors. By adopting existing best technology industry-wide, the industry could reduce its CO2 emissions by 480–520 million tons per year and its total energy use by 28–33 percent.[651]

The raw materials required in cement production are calcium (typically limestone) and silicon (typically clay or sand). These materials are finely ground, mixed, and heated in a rotary cement kiln, which uses extremely high temperatures (about 2700° F), in order to create pellets called "clinker." Currently, half of the industry's CO2 emissions come from the chemical reaction caused by turning the limestone into clinker; the other half comes from energy used to make the cement, and to transport and quarry the materials and final product.[652] CO2 emissions can be reduced by making the cement manufacturing process more energy efficient and by using different materials to produce clinker.

Emissions vary depending on the manufacturing process used and type of production plant. The most widely used manufacturing processes for cement are called wet, semi-wet/semi-dry, and dry. The energy intensity of these processes ranges from 3.4 to 5.3 gigajoules per ton, with the wet production being the most energy intensive and the dry process being the least.[653] The dry process consumes less water and uses about half the energy of the wet production process.[654] Production plants include the vertical shaft kiln and rotary kilns. Early cement production relied on the use of vertical shaft kilns, characterized by low thermal efficiencies and high emissions levels.[655] Rotary kilns use new technology to increase the thermal efficiency and reduce the amount of energy needed for cement production.

Energy efficiency in the industry is gained as new cement plants are built. Inefficient, outdated processes are mainly found in small, regional plants.[656] Manufacturers in countries or regions with stagnant levels of demand still rely on inefficient technologies, such as small-scale vertical kilns and the wet production process. Efficiency improvements are generally being made in countries with an increasing demand for cement. More-efficient rotary kilns utilize the dry production process and are replacing inefficient vertical shaft kilns.[657] New plants built in developing countries are larger, cleaner, and more efficient than those built 10 to 30 years ago in developed countries.[658] For example, India's cement production has increased greatly in the past 20 years, and the country has some of the most efficient cement kilns.[659]

Limestone, used primarily because of its low cost and abundance, is also very energy intensive and is responsible for high levels of CO2 emissions. Replacing some of the limestone (up to 15 percent) used to make cement clinker with other materials could result in reductions of up to 240 tons of CO_2 per year.[660] Ideally, materials used to substitute for limestone should have a chemical reaction that produces less CO_2, and should be readily available. Selecting raw materials that are not readily available and need to travel far distances may be undesirable from both an environmental and economic perspective.[661]

Alternatives that should be considered as a partial substitute to limestone (up to 15 percent) include fly ash, furnace slag, and pozzolanas (materials containing reactive silica and/or alumina).[662] These are considered to be among the best options due to their availability, ability to create quality cement, and CO_2 reduction possibilities.[663] Other possible alternatives to limestone include clay, calcium sulfates, iron oxides, silica, coal ash, sodium carbonates, and sodium chloride.[664]

Slag, a byproduct of the iron and steel industry, is recognized as a sustainable input to the cement clinker process, but remains underutilized in the industry. Currently only 60 million tons of slag is used for concrete each year; the IEA identifies an additional 120–160 million tons that could potentially be used.[665] The use of slag during the clinker process increases the production of cement by 15 percent without creating additional carbon emissions. The outcome is a reduction in CO_2 emissions per ton of cement, with potential carbon savings of 90–135 million tons per year.[666]

Reliance on coal as the primary energy source is another practice that inhibits the transition to more energy-efficient practices. Coal burning as the cement fuel source is common in China and other countries. Most often, the decision to rely on coal for energy is driven by the availability of local resources or limitations in transportation of other materials.

According to an analysis in 2000, Japan had the lowest CO_2 emissions per ton of cement (0.73), followed by Australia and New Zealand (0.79). Japan's top ranking was the result of energy-efficiency measures. The European Union's emissions were 0.84 tons of CO_2 per ton of cement. The United States scored the worst with 0.99 tons of CO_2 per ton.[667] (See Table II.4-11.)

Table II.4-11. CO_2 Emissions per Ton of Cement Produced, Selected Countries, 2000

Country or Region	CO2 Emissions per Ton Produced
Japan	0.73
Australia and New Zealand	0.79
Former Soviet Union	0.81
Western Europe	0.84
China	0.90
Korea	0.90
Canada	0.91
India	0.93
United States	0.99

Source: See Endnote 667 for this section.

Recycled Cement

The option for more sustainable cement practices carries through the entire life cycle of cement. Recent assessments of cement durability suggest that the life of cement may have been overestimated; some concrete buildings or structures may only last for 50–70 years.[668] As outdated structures face demolition, the option to recycle the remaining concrete provides a practical disposal option.[669]

Recycling cement involves crushing existing concrete from construction and demolition wastes into concrete aggregate so it can be used in place of sand or gravel. (Construction aggregates are components of concrete and include sand, gravel, recycled concrete, slag, or crushed stone.) A 2005 survey by the Construction Materials Recycling Association found that the United States recovers 140 million tons of concrete each year.[670] Re-use in the European Union varies from 10 percent in Italy and Spain to 90 percent in Belgium and Denmark.[671]

The most common application for recycled concrete is in road construction. Recycled concrete pieces are used for road sub-bases and then covered with new concrete or asphalt. Because the makeup of recycled concrete varies, this option is currently best for low-technology uses where high performance is not the goal of the material.[672] Recycled concrete can also be recycled back into new concrete as a substitute for other aggregates. However, it is not considered to be among "best available technologies" because water absorption increases and mechanical performance decreases when compared to concrete made with natural aggregates.[673] More research is needed to understand the possible uses and resource savings of recycled cement.

Employment in the Cement Industry

About 850,000 people work in the cement production industry worldwide.[674] The labor intensity of cement production is relatively low compared to other building and construction materials industries such as iron, steel, aluminum, and wood. The number of people employed in industries related to cement is much higher. Many of these jobs are in the construction industry and are discussed in the building sector.

The Multinationals

Most of the large employers in the cement industry operate in multiple countries. Among the largest producers and employers are Cemex, Lafarge Corporation, and Holcim. Employment levels at each are discussed below.

Cemex operates in 50 countries located on four continents and maintains trade relationships with over 100 countries.[675] Cemex's largest industries include Mexico (15 cement plants), the United States (12 cement plants), Spain (8 plants), and Colombia (6 plants).[676] The company is the largest supplier in Venezuela and the market leader in Croatia (3 cement plants each).[677] Worldwide, Cemex employs more than 50,000 people.[678]

Lafarge is a French-based building materials company that focuses on four products: cement, aggregate, concrete, and gypsum. The cement production process employs 42,000 people at 166 production sites spread across 46 different countries.[679] In 2007, the company's sales reached $17 billion.[680] Figure II.4-8 shows countries and regions in which Lafarge owns and operates cement plants.[681] Table II.4-12 further illustrates the breakdown of employees worldwide in the company's cement production sector.[682]

Figure II.4-8. Cement Plants Owned and Operated by Lafarge

Source: See Endnote 681 for this section.

Table II.4-12. Lafarge Employees and Share of Sales, by Region, 2006

Region	Number of Employees	Share of Company Sales (percent)
Western Europe	22,330	17
North America	16,170	14
Sub-Saharan Africa	12,320	12
Asia	10,010	28
Central and Eastern Europe	6,160	16
Mediterranean Basin	5,390	7
Latin America	4,620	6

Source: See Endnote 682 for this section.

Holcim is a Swiss company that produces cement, concrete, aggregate, and other products. It has locations in more than 70 countries worldwide and a market presence on every continent.[683] The company employs approximately 90,000 people overall, with a smaller number working directly in cement production.

Other large employers in the cement industry include Heidelberg Zement (Germany), Italcementi (Italy), Cementos Portland Valderrivas (Spain), Cimpor (Portugal), Corporación Uniland (Spain), CRH plc (Ireland), Taiheiyo Cement (Japan), Titan Cement (Greece), RMC (United Kingdom), The Siam Cement Group (Thailand), Votorantim Cimentos (Brazil), Ash Grove Cement (United States), Cementos Molins (Spain), Cimentos Liz (Portugal), Grasim Industries Ltd (India), Secil Cement Company (Portugal), and Shree Cement Ltd (India). Many of these companies are involved in the WBCSD's Cement Sustainability Initiative, a global effort by 18 major cement companies to reduce the environmental impact of cement.[684]

China

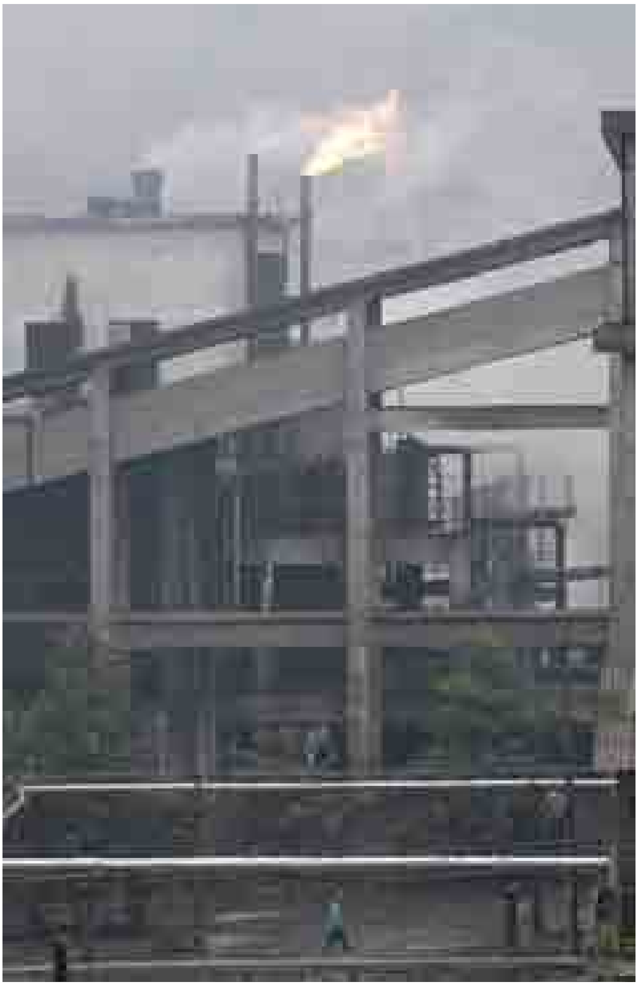
On a country basis, China has the largest number of cement plants and workers. In 2000, there were between 8,000 and 9,300 cement production plants of various sizes in China.[685] Of these, 570 produced between 275,000 and 1 million tons of cement annually, and only 10 produced more than 1 million tons.[686] About 50 percent were located in rural township enterprises and produced less than 30,000 tons per year.[687]

China's largest cement company is Anhui Conch Group Co Ltd., which currently has 16,685 employees.[688] A 2005 merger between Lafarge and Shui On Construction and Materials Ltd., now Lafarge Shui On Cement, is the new cement leader in southwest China.[689] The company employs 11,000 people.[690] Other large cement companies and the number of employees are listed in Table II.4-13.[691]

Table II.4-13. Employment Levels at China's Top 10 Cement Companies

Cement Company	Number of Employees
Anhui Conch Group Co Ltd	16,685
Lafarge Shui On Cement	11,000
Jilin Yatai Cement	8,455
Hauxin Cement	7,228
Jidong Cement	6,000
Gansu QiLianShan Cement	5117
Hebei Taihang Cement	2,113
Henan Tongli Cement	1,379
Tianshan Cement	1,206
Ningxia Saima Industrial Co.	900

Source: See Endnote 186 for this section.



© Sinopictures / Viewchina / Still Pictures
A labourer walks inside a cement plant in Baokang, China.

Employment Trends

Over the past few decades, employment in cement production in both the European Union and the United States has decreased. From 1999 to 2005, the EU-25 lost 6,290 jobs, or approximately 13 percent of its cement workforce. In 2008, the U.S. cement industry employed 20,800 workers, a decline of 29 percent from 1982 levels.[692] This reduction is due mainly to increased efficiency achieved by automating the production process and to the closure of small cement plants.[693]

Excluding China, the average number of employees needed per million tons of cement produced declined from 555 in 1980 to 272 in 2000.[694] In the past, China has been largely excluded from this increase in productivity. Due to the abundance of cheap labor, the country did not make capital investments comparable to those undertaken in many developed countries. Chinese cement plants remain very labor intensive. A report conducted by Battelle and commissioned by the World Business Council for Sustainable Development states that in some instances, they require 10 times the amount of workers in developed countries.[695]

Yet this is beginning to change. The Chinese National Development and Reform Commission recently announced plans to consolidate cement manufacturing into 60 key cement companies, in order to meet energy-efficiency requirements and to compete with the world's largest cement producers.[696] As a result, many of the plants with outdated technology or small capacity have been, or are slated to be, closed.[697] The consolidation and energy-efficiency improvements are likely to cause significant employment problems, including unemployment and retraining costs.[698]

Green Cement Jobs

In 2007, the Chinese government released new standards in the cement industry in order to reduce energy use. These guidelines, which are a part of a joint project between the Chinese government and the United Nations Development Programme, aspire to reduce energy use in the building and industrial sectors. In the cement industry, they are expected to reduce energy use by up to 15 percent by 2010.[699] Similar energy-efficiency initiatives have been undertaken by the three largest cement companies, Cemex, LaFarge, and Holcim. Cemex plans to reduce its emissions by 25 percent by 2015; Lafarge and Holcim aim to reduce theirs by 20 percent each by 2010.[700]

Technological improvements, which include replacing vertical shaft kilns with rotary cement kilns that utilize the dry production process, are needed to make cement production plants more efficient. Using alternative or recycled materials would also lead to a greener industry. Energy-efficient plants, both newly constructed and retrofitted, require fewer workers. Often times, a large plant that is highly automated can be effectively run by 200 or fewer employees.[701] The cement industry is not expected to be a major source of new employment. More likely, it is likely to continue the existing downward trend of employment.

Although the number of jobs needed for a more energy-efficient cement industry is likely to be reduced, these jobs could be considered a pale shade of green. Using existing technology, the industry has the capacity to reduce emissions by around 20 percent. Jobs that remain in this more efficient industry will be more technological and will require higher levels of skills and enhanced training programs for workers. Some new, short-term employment would be created through construction projects, but this would not replace the number of jobs already being lost.

Despite improvements in the cement industry, the rising global demand for cement will likely outweigh any emission reductions achieved through energy efficiency. Overall, the industry is expected to increase its CO2 emissions. The 20 percent reduction is a good short-term goal, but it will likely not be enough to counteract demand. The cement industry will only become sustainable if the building industry finds completely new ways to create and use cement or eventually figures out how to replace it altogether.

Pulp and Paper

The digital revolution did not lead to the "paperless office." Instead, there has been an increase in paper production over the past several decades, and paper has become a major source of export for many countries. Half of all paper products are packaging, wrapping, and paperboard, another third are printing and writing paper, and the rest are newsprint, household, and sanitary paper.[702]

In 2004, global pulp and paper production totaled 355 million tons.[703] Paper use is rising at a rate of 3.6 percent annually.[704] The United States and European Union consume the most paper per capita, but growth in the industry is due primarily to China and India's rapidly expanding economies. This upward global trend is expected to reach 600 million tons annually by 2020.[705]

In 2006, the United States was the largest producer with 83.3 million tons, or 23.1 percent, of paper and paperboard.[706] It was followed by China (15.9 percent), Japan (8.1 percent), Germany (6.2 percent), and Canada (5 percent).[707] (See Table II.4-14.) Not surprisingly, China tripled its production between 1990 and 2004.[708] China, which is home to one-fifth of the world's population but has only 4 percent of the world's land mass, imports large amounts of pulp from the United States and other countries to keep up with its growing demand.[709]

Table II.4-14. Paper and Paperboard Production by Country, 2006

Country	Paper and Paperboard Production (million tons)	Share of Total (percent)
United States	84.32	23.1
China	57.98	15.9
Japan	29.47	8.1
Germany	22.66	6.2
Canada	18.18	5.0
Finland	14.15	3.9
Sweden	12.07	3.3
Korea	11.04	3.0
Italy	10.01	2.7
France	10.01	2.7

Source: See Endnote 707 for this section.

The pulp and paper industry comprises many large corporations that operate at the global or regional scale. In 2006, the top 100 pulp and paper companies earned a combined total of $23 billion.[710] Even with recent restructuring, International Paper remains the industry's largest company. Table II.4-15 shows net earnings and employment data for the top 10 producing companies in 2006.[711]

Table II.4-15. Top 10 Paper Product Companies: Pulp, Paper and Converting Operations, 2006

Company Rank 2006	Net Sales in Paper (billion dollars)	Total Number of Employees
1. International Paper (USA)	21.1	60,600
2. Stora Enso (Finland)	16.2	45,631
3. Procter & Gamble (USA)	12.0	125,000 (est.)*
4. Svenska Cellulosa (Sweden)	11.2	51,022
5. UPM-Kymmene (Finland)	10.8	28,704
6. Oji Paper (Japan)	9.7	19,560
7. Weyerhaeuser (USA)	9.5	46,700*
8. Smurfit Kappa Group (Ireland)	8.7	40,000
9. Kimberly-Clark (USA)	8.7	55,000*
10. Nippon Paper Group (Japan)	8.5	12,584 (est.)

** Number reflects total employees for company, many of which are not involved in paper products.*
Source: See Endnote 711 for this section.

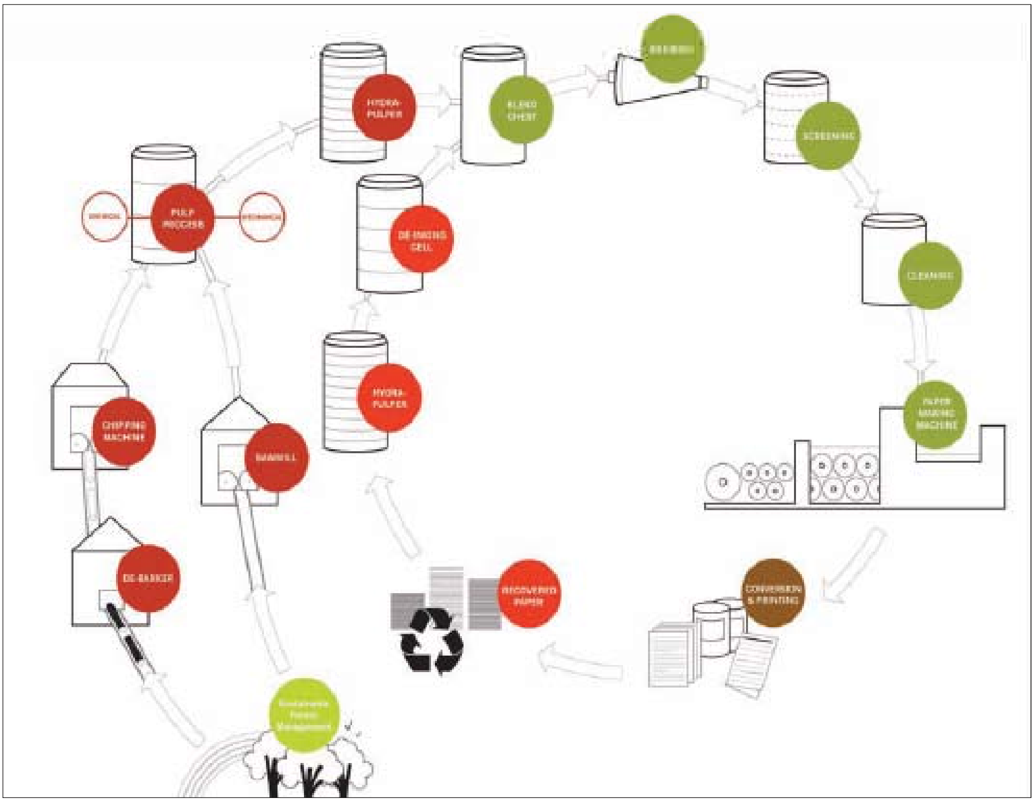
Paper's Environmental Footprint

Creating a sustainable or green paper industry is a major challenge. Over the past few decades, there have been several major attempts to make the industry more environmentally sustainable. One of the most well-known changes occurred in the 1990s as oxygen, which pollutes less, replaced chlorine in the bleaching process. The industry has also made considerable gains in using recycling content, and somewhat lesser improvements in energy efficiency.

Even with these improvements, papermaking remains one of the most resource-intensive industrial processes. Primary inputs for paper include large amounts of fiber, water, chemicals, and energy. The pulp and paper industry is the fourth largest industrial user of energy following the chemical, steel and iron, and cement industries, accounting for approximately 5.7 percent of total industrial energy use.[712] Figure II.4-9 illustrates the basic components involved in paper manufacturing, which include debarking, chipping, pulping, blending, refining, screening, cleaning, papermaking, and printing.[713] Depending on the type of paper mill, pulping and drying are often the most energy-intensive phases. Immense quantities of water are used during the pulping and the cleaning processes.

There are four major types of pulp: chemical, mechanical, recycled, and non-wood. Chemical pulp is used largely for printing and writing paper and paperboard; mechanical pulp is generally used for newsprint. Both processes are increasingly being replaced by recycled pulp. In 2004, recycled pulp had the largest share of global pulp production, with 159 million tons, compared with 128 million tons of chemical pulp, 36 million tons of mechanical pulp, and 17 million tons of non-wood pulp—for a total fiber supply of 339 million tons.[714]

Figure II.4-9 Stages of the Papermaking Process



While chemical pulping requires more energy than mechanical pulping, it is largely self-sufficient as it uses its black liquor byproduct as its main energy source. Mechanical pulping, which uses less energy overall, relies on outside electricity. In many ways, mechanical pulping is preferable to chemical pulping because it produces a higher yield and uses less water. Mechanical pulping requires only half the wood that chemical pulping does to produce the same amount of paper. The drawback to mechanical pulping is that it creates a much lower grade pulp. Recycled pulp, although it is generally dependent on fossil fuels, is more efficient in terms of overall energy use, material use, and CO2 emissions. Non-wood pulp and paper is generally less efficient and highly polluting, but helps reduce the pressure on forests.

Energy Efficiency

In 2007, the IEA reported on the state of energy efficiency and CO2 emissions in the paper industry in developed countries. According to this analysis, from 1990 to 2003, the pulp and paper industry in the OECD countries decreased its CO2 emissions and heat energy consumption by 9 percent, but reduced its electricity consumption by pnly 3 percent.[715] Several countries made considerable improvements. Korea and Japan made significant progress in heat reduction; Norway and Germany reduced electricity use, but to a lesser extent.[716] Countries with the largest decrease in CO2 emissions were the United Kingdom, Korea, and Germany, an attribute caused largely by an increase in using recycled pulp.[717] Increasing its use of biomass, Japan decreased its emissions by almost 10 percent.[718] (See Box II.4-5.) Additional efficiency gains were made in the industry during this time, but these improvements have been overshadowed by the demand for faster machines and specialty papers, both of which are more energy intensive than traditional ones.[719]

Box II.4-5. Japan Paper Association's Voluntary Action Plan

In 1997, the Japan Paper Association (JPA), an organization representing Japan's leading pulp and paper manufacturing companies and covering 88 percent of paper and paperboard production, established a Voluntary Action Plan in order to reduce the industry's environmental footprint.

The two main objectives were to reduce fossil fuel consumption per unit of production by 10 percent from 1990 levels and increase forest plantation area by 550,000 hectares by 2010. To help meet these targets, the industry started promoting energy-efficient equipment and the use of biomass, recycled waste for fuel (specifically tire waste), and the use of natural gas to power mills. In 2004, the JPA amended the plan by slightly increasing its goals and introducing a CO2 emissions reduction target. The modified plan aims to reduce fossil fuel consumption by 13 percent from 1990 levels, increase forest plantation to 600,000 hectares, and cut CO2 emissions by 10 percent from 1990 levels by 2010.

An internal analysis of the reductions showed that by 2005, fossil fuel use had decreased by 13.5 percent, total energy use by 4.7 percent, and CO2 by 9.2 percent below 1990 levels.[720] These improvements are explained mainly by the increase in biomass usage, which reduced fossil fuel consumption and associated carbon emissions.

Source: See Endnote 718 for this section.

The International Council of Forest and Paper Associations made similar findings. Between 1990 and 2000, the ICFPA reports CO2 emissions reductions in the range of 8 to 37 percent, depending on the country, as well as energy savings of 31 percent in the European Union, 36 percent in Canada, and 7 in Japan over this period (between 1990 and 1999 for Canada).[721] These gains were due to energy efficiency, use of low carbon fuels, and greater use of biomass.[722] (The ICFPA was formed in 2002 by the forestry and paper and pulp industries to discuss forest management and environmental sustainability. Areas of focus include: sustainable forest management, prevention of illegal logging, reducing CO2 emissions, and improving water quality and efficiency, among others. The Council represents 75 percent of the world's paper production.[723])

Comparing levels of efficiency between individual countries and mills is somewhat difficult due to the wide range of mills and products. Efficiency ratings sometimes tend to reflect what the country produces rather than how efficient the mills are. For example, Germany, France, and Italy have the highest efficiency for electricity use, but they also have few pulp-making facilities, which use more electricity than paper mills. Norway and Sweden's low rating for electricity use can be attributed to high levels of mechanical pulp. Similarly, Sweden, Norway, Finland, and Canada generate the lowest CO2 emissions per ton, but this is due mainly to their use of hydroelectric power and biofuels.[724]

For OECD countries, China and India's mills are among the most inefficient. These countries also tend to have small plants and depend on coal for power, although some of the most modern and most efficient mills are now being built in China.

© M. Renner, 2008
Supplies of wood chips at Hokuetsu Paper Mill in Niigata, Japan.

Non-Wood Pulp Mills

China and India also produce a large proportion of non-wood pulp, which requires two times the energy usage of wood pulp and three times that of recycled pulp.[725] Non-wood facilities are located almost exclusively in developing countries where non-wood fibers, such as wheat, hemp, rice, bamboo, and sugar cane, are readily available and paper consumption is relatively low.

Many of these mills rely on outdated technology and are highly polluting. They also rely on a very short growing season and have a limited, seasonal production timeframe. The production facilities are generally small, typically producing less than 100,000 tons annually. Because of these inefficiencies, many are being replaced by modern wood pulp mills. China, which traditionally used non-wood pulp for the majority of its paper production, has been closing many of these mills. In 2004, only 27 percent of China's pulp came from non-wood sources, a sharp decline from 53 percent in 1990.[726]

While modern non-wood pulp and paper production reduce pressure on forest ecosystems and could make an important contribution to green employment, they account for only 5–8 percent of the global paper market.[727] They are not expected to meet the pulp needs of the growing industry. Each year, 42 percent of all industrial wood harvested is used by the pulp and paper industry, only a small fraction which comes from certified forests.[728] By 2050, this share is expected to grow to more than half of all wood harvested.[729]

Recycling

When viewed as an entire system, including all energy, resources, and waste, recycling emerges as the most sustainable practice in the pulp and paper industry. Recycling makes an indirect contribution to mitigating climate change as forests that may have been used to produce paper are left untouched, leaving the carbon sinks intact. Moreover, recycling addresses the problem of landfills. Paper comprises approximately one-third of all municipal solid waste and creates large amounts of methane.[730] (With so much focus on CO2 emissions, the greenhouse gas methane is often overlooked or ignored. It is important to note that even though there is significantly less methane in the atmosphere; methane has 23 times the heat trapping capacity as CO2.) Using recycled pulp can significantly reduce energy consumption, greenhouse gas emissions, water use, and solid waste. Table II.4-16 illustrates the environmental benefits of using recycled paper.[731]

Table II.4-16. Benefits of 100% Recycled Content Compared with 100% Virgin Forest Fiber

Environmental Indicator	Copy Paper (percent reduced)	Newsprint (percent reduced)
Total Energy Consumption	44	39
Net Greenhouse Gas Emissions	37	51
Particulate Emissions	41	N/A
Wastewater	46	17
Solid Waste	49	55
Wood Use	100	100

Source: See Endnote 731 for this section.

In 2005, the IEA reported that 45 percent, or 159 million tons, of pulp production was recovered pulp.[732] In 2007, a report by the Environmental Paper Network reported that 37 percent of U.S. pulp and 25 percent of Canadian pulp is produced from recovered paper.[733] This is roughly one-third of the fiber content in North America. Recovered pulp includes mill broke, pre-consumer, and post-consumer fibers. Products with the high post-consumer rates are newspaper, corrugated cardboard, paperboard, and tissue. Printing and writing paper is still lagging far behind other products, although there have been some recent breakthroughs with major multinationals pledging to increase their recycled content.[734] (See Table II.4-17)

Paper recycling collection has made considerable improvements over the past several decades due to widespread adoption of recycling policies by national and local governments in most developed countries. Between 1970 and 2004, the global paper collection rate increased from 24.3 percent to 45.3 percent.[735] Germany, Japan, and South Korea, which have strong national policies on recycling, have some of the highest recycling rates. Europe remains the strongest region with a recycling rate of 63.4 percent in 2006.[736] (See Box II.4-6.) In 2007, the American Forest and Paper Association reported a 56 percent paper recycling rate for all paper—up from 51.5 percent in 2005—and set a new target of 60 percent recovery by 2012.[737] Canada also reported an all-time high of 58 percent in 2007.[738] In 2005, China imported 17 million tons of recovered paper, mainly from the United States and the European Union.[739]

Table II.4-17. Examples of Green Paper Practices by Major U.S. Multinationals

Company	Environmental Policy or Practice
Office Depot	In 2004, Office Depot's post-consumer waste content reached an average of 26.9 percent, an increase of 90 percent from 2003. Office Depot was the first office-supply company to set its own internal environmental performance standards.
Staples	In 2008, Staples, the world's largest office supply company, became the first multinational to adopt the standard practice of using Forest Stewardship Council certified recycled paper in all of its 1400 US copy and print centers.
FedEx Kinkos	FedEx Kinkos sells more than 50 kinds of post-consumer recycled paper, including 12 100 percent post-consumer paper, 2 non-wood paper, and 16 FSC certified options. FedEx Kinkos has more than 20,000 employees.

Source: See Endnote 734 for this section.

Box II.4-6. European Declaration on Paper Recycling

In 2000, the European Paper and Board Industry and Recovered Paper Collectors and Merchants signed the European Declaration on Paper Recycling, which set a target of 56 percent paper recycling by 2005. The Declaration was designed to improve the entire recycling process from paper recovery and sorting to manufacturing, converting, and printing. Initial targets have been met, and in 2006, the European Declaration increased its target to a 66 percent recycling rate by 2010. This declaration covers the EU-25 plus Bulgaria, Norway, Romania, and Switzerland. This voluntary commitment is supported by both the European Commission and the business community.

Source: See Endnote 736 for this section.

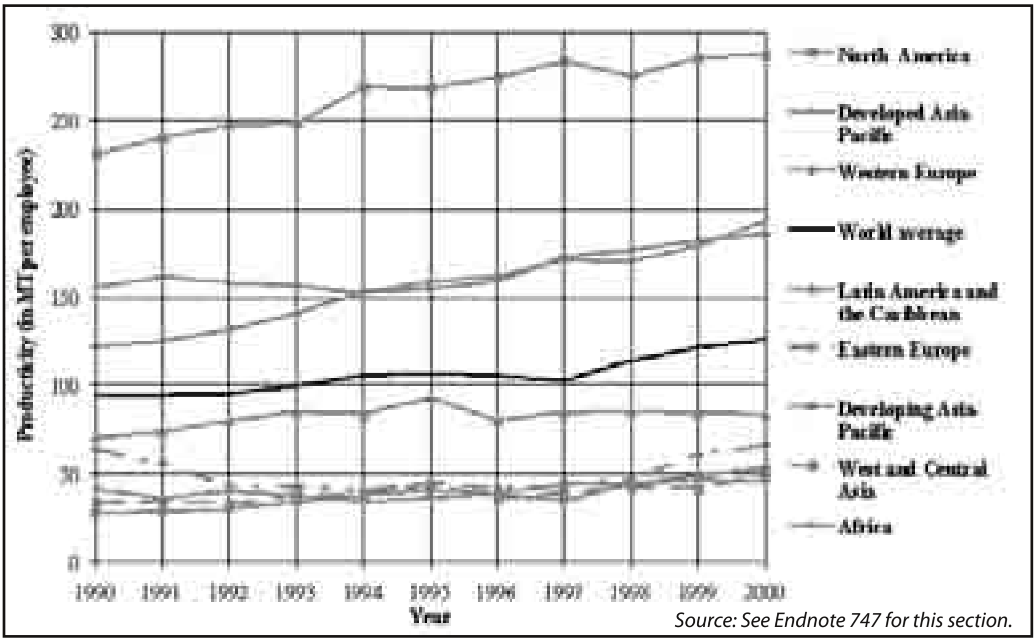
Recovery rates are highest for newspaper and corrugated cardboard, but there is still tremendous potential to recycle office paper. "If we take into account paper that cannot be recycled such as cigarette papers, archives, or papers used in construction materials, then the maximum theoretical recycling rate for paper would be 81% instead of 100%."[740] Given the global paper collection rate of 45.3 percent in 2004, an additional 35 percent of paper could be collected and recycled.[741]

Green Jobs in the Pulp and Paper Industry

Despite rapid growth in the industry, employment levels have remained relatively flat with a slight decrease in employment. In 2000, the pulp and paper industry provided jobs to 4.1 million people worldwide, down from 4.3 million in 1990.[742]From 1970 through the mid-1990s, employment in the U.S. pulp and paper industry was relatively stable, at between 650,000 and 700,000 people, even though production nearly doubled.[743] Since the mid-1990s, the industry has experienced a slight decrease in employment. In 2001, employment was 612,650, with 177,450 working in pulp, paper, and paperboard mills.[744] In 2006, according to the U.S. Department of Labor, there were 473,330 employed in the industry, with 137,960 people working in pulp, paper, and paperboard mills.[745]

Similarly to industries previously discussed, industrialized countries have developed new technologies to increase productivity and reduce labor costs. Labor productivity in North America, Western Europe, and Japan is three times higher than in developing countries.[746] Between 1990 and 2000, labor productivity increased not only in developed countries, but in all regions.[747] (See Figure II.4-10.)

Figure II.4-10. Labor Productivity in the Pulp and Paper Industry, by Region, 1990–2000



Source: See Endnote 747 for this section.

The IEA further identifies an additional energy reduction of 1.3–1.5 exajoules (15–18 percent) per year and 52–105 million tons of potential CO2 savings through advanced technology, more integrated mills, recycling, and combined use of heat and power.[748] As countries, particularly developing and emerging countries, make technological and efficiency improvements, the number of people working in the industry is likely to decline—even with the increased demand for paper. The jobs that remain in this more efficient sector could be considered a shade of green, and in many cases these efficiency improvements will be necessary in order to retain jobs.

Non-wood pulp and paper production remains a major source of income and employment. Farmers in Asia and Africa sell their agricultural waste to mills to help subsidize their income. The shift away from non-wood pulp and paper manufacturing will result in the loss of income for farmers as well as actual job losses. Estimates for the number of jobs lost in China are as high as 1 million.[749] Some of these losses could be replaced by new employment, but the number of jobs in modern chemical mills is unlikely to counteract job losses from non-wood pulp closures.

If these non-wood pulp and paper mills were upgraded and made more efficient, they would be a major source of green employment. A 2006 study by the International Finance Corporation, funded by the Finnish Ministry of Trade, and Industry, analyzed the potential for a more sustainable non-wood pulp and paper industry in China. The study concluded that by modernizing pulping and chemical recovery processes, China could significantly reduce pollution, energy consumption, and water consumption, while maintaining employment for 8 million people in the industry.[750]

Recycling is the fastest growing source of new green employment for the pulp and paper industry. Recycling is an important source of employment because it is labor intensive and creates more jobs than incineration and landfilling.

Although employment data for paper recycling are generally lumped in with recycling employment in general (including glass, steel, aluminum, plastic, etc), there are some data specifically concerning paper. In 2000, 9,765 jobs in paper reprocessing (along with an additional 5,450 in general recycling collection and 1,624 in general sorting) were reported in the United Kingdom.[751] The World Bank estimates that in 2002, Brazil collected 3 million tons of paper and had 28, 347 jobs specifically in paper recycling.[752] The U.S. EPA estimates that 150,000 people are employed in the paper recycling manufacturing.[753]

The EPA identified another 192,875 people employed in general recycling collection and processing, with a large percentage of these in paper recycling. An extremely rough estimate of those jobs attributed to paper could be calculated by weight. In 2006, paper comprised 44 million out of 81.8 million tons, or 53.7 percent of all recycled materials. Using this figure, a rough estimate for the number of paper collectors and processors would add another 103,500 people for a total of 253,500.[754] (This is approximately one-quarter to one-fifth of the entire U.S. recycling industry. Depending on the source, total employment estimates of this entire industry are between 1.1 million and 1.3 million.)[755] Similar or slightly higher employment figures would be expected for the European Union, which recycles more paper than the United States: 52.5 million tons in 2004 and 58.2 tons in 2006.[756]

With increased population growth, urbanization, and consumption, waste is projected to increase drastically over the next few decades. China's waste alone will increase 150 percent by 2030, and paper waste is growing faster than any other material.[757] This presents a unique challenge and opportunity for countries to adopt strong recycling policies and promote job creation in the recycling industry. The number of paper recycling jobs is expected to increase in both the formal and informal economies. Yet the growth in the recycling industry does not come without a tradeoff. Recycled paper still requires some virgin wood inputs, although the overall amount of new raw materials should be reduced. Jobs in the forestry sector will still be necessary, but there are likely to be fewer jobs in logging. Because logging is highly mechanized and not very labor intensive, the number of gained jobs in recycling should outweigh any losses in logging jobs.

Recycling

Recycling makes an important contribution to reducing energy consumption and associated pollution of air and water. But recycling practices vary widely across the planet. Some are subject to strict laws and others are essentially unregulated; some involve manual sorting, others are highly automated; some are sophisticated in terms of materials recovery, separation, and processing, but others are not. Recycling operations—and associated reprocessing and remanufacturing activities—are run by municipal governments, private companies, neighborhood associations, and others.

This makes for a broad diversity of jobs, in terms of required skills, health and occupational conditions, and wage levels. Due to this diversity, there is no single, complete tally of the number of jobs involved worldwide. Employment may not be formal in nature, or jobs data are otherwise typically hard to come by at community-based recycling and composting programs, such as one implemented in Dhaka, Bangladesh.[758]

As noted earlier, the extent to which materials are recycled and recovered depends strongly on local and national laws. In adopting directives on packaging and electronics waste, for instance, the European Union has become a pioneering force. Particularly the concept of requiring companies to take back their products at the end of the life cycle has had significant influence in other parts of the world.

Existing estimates from a variety of sources tend to offer an incomplete picture of the number of jobs involved in recycling operations—either capturing only certain types of recycling operations or covering only some of the countries in the world. For instance, the Bureau of International Recycling (BIR) in Brussels, Belgium, reports that it has members in 60 countries worldwide, but clearly they represent only a fraction of the companies and other entities in the field. BIR estimates that its members process 500 million tons annually, including ferrous and non-ferrous metals, stainless steel and special alloys, paper, textiles, plastics, and rubber. With an annual turnover of $160 billion, federation members employ more than 1.5 million people.[759] This figure is but a fraction of worldwide recycling employment, and presumably excludes most of the developing world. As is true for so many other sets of data, there is a tremendous North-South reporting gap.

A new report analyzing the situation in the United States alone concludes that recycling generates revenues of $236 billion annually and offers employment to 1.1 million people at 56,000 public and private facilities. (A $37 billion payroll translates into average wages of about $34,000 per employee—which is below the national average wage level of about $43,000 for 2006.[760]) This is up from $4.6 billion in sales and just 79,000 jobs in 1968. Although landfilling and incineration still involves larger volumes, recycling now generates more than twice the revenue of the waste management industry since recycling recovers great economic value bound up in discarded products and equipment.[761]

Recycling rates in the United States still vary substantially. Up to two-thirds of steel and non-ferrous metals are being recycled, as is 51 percent of paper, but only 17 percent of plastics. (Plastics recycling is down from 40 percent in 1994, dragged down by the explosion of the bottled-water market, which is marked by low recycling rates.). According to the U.S. Environmental Protection Agency, the national average recycling rate of roughly 30 percent saves about 256 billion barrels of crude oil, the equivalent of fueling 22 million cars each year.[762]

Remanufacturing is the largest segment of the U.S. recycling industry, with estimated revenues of $180 billion, or about 75 percent of the total. Companies processing, sorting, and compacting recyclables generate $41 billion in sales (18 percent). Those that refurbish existing products have $16 billion in sales (6 percent). Interestingly, the aspect most visible to the public—curbside collection, along with recovery facilities and material wholesalers—has just $2 billion in revenue (1 percent).[763]

A key difficulty in accounting for recycling jobs is boundary setting. Different studies and organizations may use different criteria. In the U.S. context, for instance, the figures mentioned above appear very comprehensive. Other sources report on a narrower segment of recycling, but the precise differences are not always clear. The Institute of Scrap Recycling Industries, for instance, reports that its members process more than 145 million tons of recyclable material each year into raw material feedstock for manufacturing. This $65 billion business (2006 data) employs some 50,000 people. In terms of quantities involved, iron and steel account for the bulk, with 81 million tons. This is followed by paper (54 million tons), aluminum (5 million), copper (2 million), and stainless steel and lead (each 1.4 million). But zinc, glass, plastics, tires, and electronics are also among the valuable materials recovered. The scrap recycling industries run a lucrative export business with destinations in 143 countries; scrap is the United States' second largest export category to China, valued at $15.7 billion in 2006.[764]

The same is likely to be true in other countries. In the United Kingdom, the British Metals Recycling Association reports an annual turnover of $12 billion (£6 billion), 15 million tons of materials recovered, and some 8,000 direct employees. Like its U.S. counterpart, British recyclers sell most of their materials abroad, principally in China, India, and Turkey.[765] While international scrap trade allocates supplies where they are needed, arguably, the energy needed for long-distance shipments dims the environmental shine of the recycling industry.

A 1999 British study by Waste Watch put employment in the collection, sorting, and reprocessing of paper, glass, steel, aluminum, and plastic at slightly above 17,000, but acknowledges limits in job estimates due to poor and patchy data collection. The study projected that a 25 percent national recycling rate (up from between 10 and 20 percent in the early 1990s) could create about 25,000 jobs, and a 30 percent rate some 45,000 jobs.[766]

Different methodologies in tallying employment, plus different approaches and diverging labor intensities in materials collection and recovery, make it almost impossible to compare countries across the world or to compute a reliable global total. Figures for Brazil—the global leader in aluminum can recycling—indicate this reality vis-à-vis the U.K. figures. In 2006, the most recent year for which data are available, some 10.3 billion cans were collected in Brazil. The country achieved a recycling rate of 94 percent, climbing sharply from 46 percent in 1990. By comparison, Japan reached a rate of 91 percent, the Scandinavian countries 88 percent, and Western Europe as a whole about 58 percent. Aluminum can recycling provides employment for close to 170,000 people in Brazil. Recycling saves the country 1,976 GWh/year of electricity that would have been required to produce recycled aluminum from scratch—sufficient to supply a city with over 1 million inhabitants for one year.[767]

According to a 2005 survey, Brazil has close to 2,400 companies and cooperatives involved in recycling and scrap trading, most of them small or micro-sized. According to the non-profit associations Brazilian Micro and Small Business Support Service (SEBRAE) and the Entrepreneurial Commitment for Recycling (CEMPRE), in 2004 the country recycled 96 percent of aluminium cans, 49 percent of steel cans, 48 percent of PET plastics, 46 percent of glass packaging, 39 percent of tires, and 33 percent of paper. Sebrae and Cempre estimate that the recycling sector employs some 500,000 people in Brazil.[768]

Studies show that recycling is not only preferable to landfills and incineration on an environmental basis, but also creates more jobs. A study of the three U.S. cities of Baltimore, Washington, D.C., and Richmond found that 79 jobs were required for every 100,000 tons of materials collected and sorted, and another 162 jobs for processing, for a total of 241. This is 10 times the job potential of waste disposal.[769] Earlier studies have come to similar conclusions. Recycling 1 million tons of material in the U.S. state of Vermont generates 550 to 2,000 jobs, compared with 150 to 1,100 for incineration and 50–360 for landfills. In New York City, recycling similarly has the upper hand as a job creator.[770]

Are Recycling Jobs Decent Jobs?

While recycling is of great value in terms of resource conservation, it can entail dirty, undesirable, and even dangerous and unhealthy work, and it is often poorly paid. In many developing countries, recycling work is performed by an informal network of scrap collectors, also known as “waste pickers” or “scavengers,” who collect the recycled materials for revenue. Efforts to form cooperatives have raised the pay levels and standards in many countries. In Brazil, 90 percent of recyclable material is collected by scrap collectors, who have organized themselves into a national cooperative movement with 500 cooperatives and 60,000 collectors.[771] In 2005, Brazil’s Belo Horizonte state inaugurated the first recycling plant to be run by associations of independent catadores de lixo—trash scavengers. The plant is intended to end the exploitation of the trash pickers by unscrupulous middlemen and provide an increase in their income of about 30 percent.[772] Colombia has an estimated 100 scrap cooperatives which recover over 300,000 tons of material each year.[773] In Cairo, the informal garbage collectors known as Zabaleen have achieved remarkably high recycling rates.[774] (See Box II.4-7.)

Box II.4-7. Cairo's Zabaleen

In Cairo, an estimated 70,000 people work as Zabaleen, or informal garbage collectors, providing a cheap door-to-door service by hauling away household trash with the help of donkey carts or small trucks. The Zabaleen then sort out usable materials and sell them to community micro-enterprises that prepare them for reuse, or manufacture such items as bags and mats, shoe heels, coat hangers, or tourist souvenirs—creating local jobs and incomes. Organic waste is fed to pigs, and the pork meat is subsequently sold to tourist facilities. A Recycling School instructs some 100 children how to collect and reuse trash. Children can track the quantity of recyclables they collected with the help of a computer.

The Zabaleen collect about one-third of Cairo's trash. They recycle 85 percent of what they collect, leading Wael Salah Fahmi, a professor of architecture and urban design at Helwan University, to claim that the Zabaleen have created "one of the world's most efficient resource-recovery and waste-recycling systems." Their success has led Beirut, Bombay, and Manila to emulate their system.

At the same time, it is important to note that many of the Zabaleen face a difficult existence, but have few livelihood alternatives. Typically, an entire family, including small children, helps sort the materials. Sorting through the garbage entails health risks. The Zabaleen live in seven densely populated garbage-collector settlements. Fahmi notes that the settlements are characterized by "a high incidence of animal epidemics, illiteracy, poor environmental conditions, and low incomes."

In the 1980s, Muqattam (the largest Zabaleen settlement), received World Bank and international donor support through the Zabaleen Environmental Development Programme (ZEDP). Living conditions (housing, water supply, sewage disposal, electricity, and road infrastructure), along with education and health programs, improved considerably. Community-based recycling enterprises were established and a simple composting plant was set up. On the other hand, community participation was found to be lagging, and outsiders' involvement at times failed to reflect the needs of the whole community. Within the community, the gap between rich and poor has grown wider.

More recently, Cairo's municipal government has attempted to put the trash collectors out of business. It has contracted with sanitation companies from Spain and Italy, which collect another third of Cairo's trash, but requires them to recycle only 20 percent of waste collected. The bulk is dumped in desert landfills. Many residents continue to prefer the Zabaleen's door-to-door service and have successfully sued to have extra garbage collection fees charged by the companies nullified. The continuation of what Professor Fahmi describes as an "intricate relationship between community, environment and livelihood" is jeopardized by efforts to privatize waste services and by government policies to move Zabaleen activities further out of the city.

Source: See Endnote 774 for this section.

China, which surpassed the United States in 2004 with a total of 190 million tons of waste, has a mix of formal and informal collectors.[775] About 1.3 million people are employed in the formal waste collection system; there are an additional 2.5 million informal workers or scrap collectors, a large chunk of whom could be considered to be engaged directly in paper recycling.[776] By 2030, China is expected to generate 480 million tons of waste, 10 percent of which is estimated to be recoverable paper.[777]

A prominent example of dangerous recycling work is ship dismantling—a major employer mostly in South Asia. The European Commission estimates that worldwide, between 200 and 600 large ships annually are broken up after having reached the end of their useful life. Many thousands of people, often migrant workers, are employed in this sector. But this is an industry marked by great environmental and human health hazards, high accident rates, and lack of protection for workers. The ships contain valuable steel and other scrap metal, but also many hazardous materials, including asbestos and polychlorinated biphenyls (PCBs).[778]

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The garbage people of Muqattam. In Cairo you have several garbage cities. The garbage collectors go from house to house to collect all garbage. In the garbage area it get sorted and recycled. Pigs are eating the organic garbage. Cairo, Egypt.

In consumer electronics, a proliferation of products and extremely short product life cycles make for an extremely high turnover of equipment and mountains of electronics waste. While longer product life spans and greater durability are preferable from an environmental perspective, the proliferation of gadgets allows and necessitates growing recycling. Discarded items like computers, mobile phones, and iPods are often shipped to developing countries. There, untrained workers break and burn them and sort materials, typically without proper equipment and protection against health hazards posed by various toxins.

China is a major destination for e-waste, receiving up to 70 percent of global shipments in addition to substantial amounts of domestic discards. Another 20 percent goes to India, Pakistan, Bangladesh, and Myanmar.[779] According to a 2007 study by the Öko-Institut in Freiburg, Germany, "the Chinese WEEE-recycling industry is one of the biggest of its kind worldwide," noting that it handles 1.76 million tons annually of domestic e-waste and unknown amounts of imported materials, many of them shipped illegally. (WEEE stands for Waste Electronic and Electrical Equipment Directive, adopted by the European Union).[780] Recycling Magazine puts the quantity of e-waste dismantled annually at 3.7 million tons.[781]

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Shipbreaking yard in Mumbai. India.

China's electronics recycling industry is thought to employ about 700,000 people, of whom 98 percent work in informal settings. Some 440,000 are involved in collection, 125,000 in disassembly, 140,000 in materials recovery, and about 600 in final disposal. Guiyu (Guangdong Province) and Luquiao (Zhejiang Province) are the two largest recycling centers, with about 155,000 and 13,000 jobs, respectively.[782] Employees involved in manual disassembly are most exposed to health-threatening working conditions.

The sector consists mostly of small, informal enterprises, typically family-owned workshops. The industry is fast-growing and anarchic. This makes it difficult to enforce safety, labor, and environmental rules, even though the government has adopted regulations similar to the WEEE rules in force in the European Union.[783] Studies in Guiyu have found very high levels of heavy metals and organic contaminants in samples of dust, soil, river sediment, surface water, and ground water. The proximity of many recycling centers to agricultural land means that contaminants can easily enter the food chain.[784]

The Öko-Institut report notes that, "the Chinese WEEE-recycling industry is widely associated with severe health and safety risks for workers involved in this sector. These risks mainly stem from improper techniques during the recovery of raw materials like the open burning of wires and the chemical treatment of PCBs and electronic parts. Especially in the informal structures of the Chinese WEEE-recycling industry only very few basic precautionary measures are applied to protect workers' health. As a result, occupational effects include diseases of the skin, stomach, respiratory tract and other organs."[785]

Salaries, to the extent information is available, are low, and most employees are not covered by health insurance, unemployment, or pension plans. This is a particular problem for the migrant workers who account for one-half to two-thirds of the recycling workforce. Not surprisingly, the employee turnover rate is high, and labor protection is low.[786]

Electronics recycling is but one aspect of a larger industry. Other recycling operations appear to be marked by similar conditions. In Guangdong Province, plastics recycling is mostly done by very poor people, including migrant laborers. According to Recycling Magazine, in total some 10 million people are believed to be involved in recycling in all of China. The magazine notes: "Whereas in the Western world [recycling] is linked with protecting the environment and ruled by regulations, China's recycling is about earning money: how to do this inexpensively and a source for acquiring new resources."[787]

While recycling offers the benefit of recovering resources that otherwise would have to be mined and processed at considerable environmental expense, the procedures prevalent in most of China's recycling sector themselves impose considerable human and environmental costs. Particularly the manual disassembly jobs cannot be described as green jobs.

China and the United States are among the major economies in terms of materials use and thus in terms of actual and potential recycling employment. Estimates for these two countries run to some 11 million jobs. In Europe and other OECD countries, recycling is likely to contribute substantial additional jobs, particularly given the EU's packaging and electronics directives. For many countries, employment data appear not to be available. And as mentioned earlier, many community recycling efforts are likely to be informal in nature. Increasing recycling rates beyond current rates will create substantial additional jobs worldwide, but the quality of many of these jobs is a major concern and may warrant targeted research and operational interventions in the future to promote and facilitate decent work in this rapidly growing sector.

Remanufacturing

Remanufacturing is becoming a serious business, particularly in areas like motor-vehicle components, aircraft parts, compressors, electrical and data communication equipment, office furniture, vending machines, photocopiers, and laser toner cartridges. According to the Fraunhofer Institute in Stuttgart, Germany, remanufacturing operations worldwide save about 10.7 million barrels of oil each year, or an amount of electricity equal to that generated by five nuclear power plants. They also save a volume of raw materials that would fill 155,000 railroad cars annually.[788]

According to a 2003 estimate, remanufacturing was a $40 billion business in the United States, but as indicated above it may now be considerably larger.[789] An estimated 480,000 people were employed by companies in this sector.[790] Walter Stahel of the Product-Life Institute in Geneva, Switzerland, estimated in 2000 that the remanufacturing sector in European Union member countries accounted for about 4 percent of the region's GDP.[791]

Xerox and Canon (which began remanufacturing photocopiers in 1992) are among the companies that have pushed this concept.[792] (See Box II.4-8.) A French producer of automotive drive shafts that began remanufacturing operations in 1976 has been able to reduce energy use by 24 percent and cut total costs by 50 percent for each remanufactured drive shaft compared with newly manufactured ones, even as labor costs rose. The company found that remanufacturing is twice as labor intensive and involves higher levels of job skills.[793] But clearly, there is enormous room for expansion of this activity.

Box II.4-8. Remanufacturing at Xerox

Xerox is one of the pioneers of the remanufacturing concept, having embarked on an Asset Recycle Management initiative in 1990. This program led Xerox to design its products from the very beginning with remanufacturing in mind and to make every part reusable or recyclable. As a result, 70–90 percent of the equipment (measured by weight) that is returned to Xerox at the end of its life can be rebuilt. The company developed a photocopier of which every part is reusable or recyclable; by 1997, more than a quarter of its copiers were remanufactured, and Xerox was aiming to boost this to 84 percent.

Like some of its competitors, Xerox also remanufactures spent cartridges for copy machines and printers. In 2001, it rebuilt or recycled about 90 percent of the 7 million cartridges and toner containers returned to it by consumers. All in all, the company estimates that environment friendly design has kept at least half a million tons of electronic waste out of landfills between 1991 and 2001.

Source: See Endnote 792 for this section.

Rice cultivation in Asia.

5. Food and Agriculture

The search for green employment opportunities in agriculture is faced with several formidable obstacles. The worlds of agriculture are many and varied, and the range of activities is vast—so much so that any findings may be highly particularistic and ultimately misleading. Moreover, specific and focused research on the subject of green employment in agriculture is quite sparse. And while the interest in sustainable agriculture has grown in recent years, employment is not always a central theme or consideration. Perhaps a further challenge is the rapid and dramatic changes currently taking place in the way food is produced, sold, and consumed, which makes agriculture something of a moving target (or a series of moving targets) as far as this type of research is concerned. All told, the obstacles to sustainability are perhaps far more formidable in the case of agriculture than they are in any other economic sector, and the possibilities for green employment need to be viewed against a set of extremely challenging scenarios.

This section of the report is divided into four parts. The first part looks at the environmental footprint of the global food system. The second offers a highly compressed "plough-to-plate" scan of the present global food system, with the emphasis on changing employment patterns.[2] In the absence of existing studies that focus on green job creation in agriculture, the intention here is to provide a survey of the challenges to green jobs posed by the present system, in order to better frame the discussion on green alternatives. The third part looks at the potential for green job creation (and retention) in food and agriculture within the present framework. And the fourth part steps outside the existing agro-industrial model to examine the job-creation potential of local food systems, organic production, urban agriculture, and small farming systems.

What is Sustainable? – Competing Visions

The separation of Parts 3 and 4 speak to the fact that there are conflicting visions of sustainability in agriculture. On the one hand, there are those—such as the World Bank and the World Trade Organization (WTO)—who view the present liberalized and increasingly global food system as providing a path from poverty for hundreds of millions of rural dwellers, but who nonetheless recognize that it is a system that needs to do much more in order to become truly environmentally and socially sustainable.[794] For companies like Monsanto and BASF, biotechnology can (and is) helping farmers take great strides toward sustainability by raising yields through genetically modified seeds while at the same time reducing environmentally damaging inputs, such as nitrogen.[795] According to Jürgen Hambrecht, BASF's chief executive, "There is this conflict of nutrition on one side, and renewable resources protecting the climate of the earth, and the only solution is biotechnology."[796]

On the other hand, there are many farmers' organizations, NGOs, and others in civil society who regard the existing global food system as fundamentally unsustainable and who propose a more radical change of course—a course that recognizes that the traditional knowledge and skills of farmers are the key to solving the major problems of the existing food system and to meet the challenges of increasing demand.

2 Here, the word agriculture is used to mean the growing of food, whereas "food system" is used to describe the whole "plough to plate" reality, including the transportation, sale and consumption of food.

A discussion on green jobs in agriculture is therefore situated in a much broader debate around the overall performance of the current global food system—a system that has been subject to considerable scrutiny and criticism in recent years. The productivity of agriculture has increased impressively in recent decades.[797] According to the United Nations Food and Agriculture Organization (FAO), over the past 40 years, per capita food production has increased by 25 percent, and food prices in real terms have fallen by 40 percent.[798] But still roughly 850 million people suffer from food insecurity, and a similar number are obese.[799] Every year, 5 million children die of hunger.[800] According to the World Bank, three out of every four people in developing countries—900 million individuals—live below the $1 per day poverty line in rural areas, and most depend directly or indirectly on agriculture for their livelihoods.[801] Moreover, the demands on the global food system will increase dramatically as the Earth's population rises (around 50 percent by 2050) and as diets move toward more meat and processed foods. In this scenario, global food production will need to triple by 2050 without using more land or water.

Meanwhile, the pressure on small farmers and producers has turned agriculture into a major political battleground. The WTO's Agreement on Agriculture has triggered massive protests by organizations of small farmers all over the world who feel their livelihoods are threatened by liberalization, falling commodity prices, the power of buyers and retailers, and rich-country subsidies that benefit agribusiness.[802] In India, the contradictions are captured in the fact that 38 million tons of surplus grain is stored in close proximity to 320 million malnourished citizens, and farmer suicides number tens of thousands.[803]

The industrial model of agriculture, along with rich-country subsidies to agribusiness, has been identified as one of the primary drivers of urbanization globally, which then spurs a cycle of urban unemployment or underemployment when economic development does not keep up with the growing urban labor supply. Policies that keep farmers on their land, and facilitating green production practices, could generate employment and income both in agriculture and in non-farm occupations.

The Environmental Footprint of Global-Industrial Agriculture

Agriculture has an immense environmental footprint, one made larger in recent decades as it has become more intensive and industrialized. The overuse of water; the increasingly pervasive use of chemicals; the contamination and genetic manipulation of food; the spread of animal diseases and waste due to livestock intensification; and the reduction of biodiversity are all well documented features of today's intensive agriculture.

Today, agriculture accounts for 15 percent of global greenhouse gas (GHG) emissions, according to emissions inventories submitted to the United Nations Framework Convention on Climate Change (UNFCCC). According to the Stern Review, fertilizers are the largest single source of emissions from agriculture (38 percent of the total), followed by livestock (31 percent). Nearly 75 percent of emissions from agriculture are generated by developing countries. Emissions from agriculture are expected to rise almost 30 percent from 2005–2020.[804]

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View of rice terraces, Vietnam.

UNFCCC data show that developing-country agriculture and deforestation contribute an estimated 22 percent and up to 30 percent of total emissions, more than half of which is from deforestation caused largely by agricultural encroachment (13 million hectares of annual deforestation globally).[805] In its 2001 report on mitigation, the Intergovernmental Panel on Climate Change (IPCC) estimated the level of GHGs attributable to agriculture at 20 percent, driven by fossil fuel use, emissions generated from rice paddies, land use change, biomass burning, enteric fermentation, and animal wastes.[806]

The overuse of water through irrigation (but also industrial use) is a particularly formidable barrier to environmental sustainability. A major factor here is the global growth in the consumption of meat, which raises the demand for feed, a commodity that is particularly water intensive to produce. Livestock numbers are expected to double by 2020, according to the IPCC.[807]

Rich-country subsidies, too, are having a simultaneous effect on both employment and the environment. In 2001, the United States accounted for two-thirds of the world's corn exports.[808] With the onset of NAFTA, the price of corn in Mexico plunged nearly 50 percent, bankrupting many Mexican farmers. To compensate for the fall in price, others expanded production and began using hillsides, causing erosion.[809] This illustrates the connection between poverty, precariousness, and environmental degradation. As UNEP observes, "Poverty contributes to land degradation as the poor are forced onto marginal lands with fragile ecosystems and in areas where land is increasingly exploited to meet food needs without adequate economic and political support to adopt appropriate agricultural practices."[810]

The cheap corn from the United States has hurt Mexican farmers who grow maize on small- to medium-sized plots in difficult environments using low levels of technology. Maize also contributes significantly to biodiversity, as more than 40 natural varieties of maize are grown in Mexico. Meanwhile, U.S. corn is chemical-intensive and grows on 20 percent of harvested land. The run-off from production is a major source of water pollution, affecting drinking water throughout the Corn Belt and contributing to an aquatic "dead zone" in the Gulf of Mexico that is the size of Ireland. U.S. corn also depends heavily upon herbicides and insecticides, despite using genetically altered seed. According to one study, the threefold increase in corn exports to Mexico has led to 100,000 additional tons of nitrogen, phosphorous, and potassium-based loadings to U.S. waters each year.[811]

The "New Agriculture"

In recent decades, the sharp fall in the prices of grains, sugar, and coffee has led producers to move toward higher-value exports like fruit, wine, and flowers.[812] Some of these high-value products are also more energy and chemical intensive than many low-value products. The International Labour Organization, the International Union of Food and Agricultural Workers (IUF), and others have documented in detail how many workers in the "new agriculture" are required to labor under hazardous conditions and often live in extreme poverty.[813]

The levels of accidents and fatalities endured by waged agricultural workers due to such things as exposure to chemical and pesticide poisoning (the latter claims 40,000 lives every year) is enough to suggest that these jobs are far from green, at least not from a worker health and safety perspective.[814] The World Bank and other agencies advise smallholders to enter the "new agriculture" to serve growing global food demand and to achieve better returns on production. The FAO notes that, "Smallholders who fail to gain a foothold in this globalized marketplace risk finding themselves consigned to a permanently marginalized minority, excluded from the food system both as producers and as consumers."[815]

The expansion of this less-sustainable "new agriculture" is in many cases having a detrimental effect on more sustainable types of production. In Mexico, government officials who are responsible for promoting high-value exports have universally viewed the avocado sector as exemplary.[816] This "green gold" has been so successful that growers are increasingly buying up communal (ejidal) lands. They are denuding forests to grow avocado trees and planting the trees in place of other crops, even on lands that cannot support avocado production for climatic or ecological reasons.[817]

Globalization, "Food Miles," and the Environment

As agriculture has become more intensive and industrial, it has also become more global. In 1998, the value of agricultural goods traded across borders reached $456 billion, three times more than 20 years earlier.[818] The global nature of food production has added to air, sea, and road traffic—worsening pollution, compromising health, and further contributing to global warming. A U.K. study estimates that CO2 emissions attributable to producing, processing, packaging, and distributing the food consumed by a family of four amount to roughly eight tons a year.[819]

While not all trucks on today's roads are carrying food, many are. A 1999 study of California's produce transport industry reported that 485,000 truckloads of fresh fruit and vegetables left the state each year, traveling between 100 to 3,100 miles to reach their destination.[820] In the United Kingdom, the importation of food quadrupled between 1992 and 2007, and 31 percent more food was flown into the country in 2006 than in 2005, according to the Department of Environment, Food and Rural Affairs (DEFRA).[821] There was a 7 percent rise in urban transport in 2005–06 caused by individuals taking more and longer shopping trips.[822] A 2005 DEFRA study on food miles discovered that food transport now accounts for 25 percent of all Heavy Goods Vehicle (HGV) kilometers in the United Kingdom, and that food transport produces 10 million tons of CO2 annually.[823]

The "food miles" issue has understandably drawn attention to the global reach of food supply chains. However, the environmental impact of the domestic movement of food overland is still far more significant than food moving across national borders. A U.K. study shows that agricultural and food produce accounts for 28 percent of goods transported on U.K. roads, imposing estimated external costs of $4.7 billion (£2.35 billion) per year. The contribution made by sea and air transport is currently trivial owing to low volumes—barely 1 percent of the domestic road costs. Policies that attempt to reduce food miles may result in losses in jobs in the freight or input supply industries. However, proximity alone may not be a good measure of sustainability, as a long journey on water has a lower impact than a shorter one by road.[824]

The growth in marine freight does, however, add to environmental damage through ship wastes, dredging, spills, and the discharging of bilge water. Intercontinental cargo ships also bring in non-native plant and animal species that can cause major public health and environmental problems and further contaminate urban harbors and ship channels with heavy metals and pesticides.[825]

Food Waste

A large portion of all food produced by the food system is never eaten and is discarded. Not only are the carbon and chemical inputs that went into the production of this thrown-away food unproductive, but the discarded food also continues to generate potent GHGs such as methane as it rots in landfills.[826]

Food waste is generated at all points of the global food system. Large retailers have the market power to reject produce if it does not conform to certain standards pertaining to shape, color, and packaging. When standards are not met, farmers and producers are left with unsold crops that are often destroyed. Even if eventually purchased by retailers, supermarkets routinely "cull" foodstuffs that are blemished or have passed a sell-by date. Consumers also waste large amounts of food, especially in wealthier countries where food prices have fallen steadily in recent decades.

A study by the U.S. Department of Agriculture estimates that the United States wastes close to 44 million tons of food each year. Most of this goes to landfills, where it decomposes and causes GHG emissions. A 1999 study by the California Integrated Waste Management Board found that just over half of the state's 5.6 million tons of discarded food came from commercial sources such as restaurants, hotels, and schools, and just under half—2.7 million tons—was generated by residences.[827]

In the United Kingdom, homes waste 3.3 million tons of food annually, although the total consumer and industrial wastage may be as high as 17 million tons.[828] Previous research by the Waste and Resources Action Programme (WRAP) revealed that U.K. consumers throw away 6.7 million tons of food each year, equivalent to a third of food bought. Most of this could have been eaten, and 40 percent (by weight) of this avoidable food waste consists of fruits and vegetables, worth almost $6 billion (£3 billion). Nearly 90 percent of this fruit and vegetable waste is fresh produce, about 1.4 million tons, and most is thrown away as a result of not being used in time.[829]

The level of waste appears symptomatic of the excesses of consumption engendered by the global "lifestyle divide," whereby 20 percent of the world's population is responsible for 90 percent of total personal consumption—while 1.3 billion people struggle to live on $1 per day.[830] However, the absence of adequate regulatory frameworks, systems of collection, and well-resourced public educational programs probably also play a role in elevating the levels of food that are ultimately wasted.[831]

The environmental footprint of the global food system is formidable, and the true extent of the damage it causes to human health and the planet can hardly be exaggerated. Any possibilities to create green employment in food and agriculture must therefore be pursued as a matter of urgency.

Employment Trends

Any effort to create green jobs in food and agriculture must confront the fact that labor is being extruded from all points of the system, with the possible exception of retail. Starting at the base of the supply chain, the proportion of people making their main living from agriculture is in sharp decline. In 2006, 36.1 percent of the Earth's population, or around to 1.3 billion people, were employed in growing food and raising livestock, compared with 44.4 percent in 1995. Productivity improvements throughout the global food system have, along with the globalization of food, generally reduced employment levels in agriculture and related industries, at least as a proportion of the whole.[832]

In industrial nations, the number of people employed in agriculture has plummeted by more than 80 percent in some regions since 1950, according to the FAO.[833] In the developing world, agricultural employment has not kept pace with population growth, although rural non-farm employment has increased quite dramatically. Roughly one in four rural workers is employed full time in the non-farm rural sector.[834] According to one study, Kenyan smallholders derive approximately 40 percent of their income from off-farm activities, of which 7 percent comes from remittances, 12 percent from commercial activities, and 21 percent from salaries or wages.[835]

Despite these trends, agriculture remains the world's second largest source of employment.

Consolidation

Today's food system is dominated by the market power of increasingly fewer large companies. The 10 largest firms in agriculture control about 80 percent of a world market valued at $32 billion, according to an ILO study.[836] Just two companies distribute 80 percent of the world's grain.[837] And in the United States, just six companies accounted for 42 percent of the food retail market in 2001, a jump from just 24 percent in 1997. [838] A similar pattern of consolidation is visible in many parts of the developed and developing world.[839]

The level of horizontal integration through consolidation has proceeded at enormous speed, but so has the level of vertical integration as retailers connect with the production and processing stages of the food system. The market share of the large retailers and suppliers has also resulted in a shift in the balance of power away from small farmers and producers and toward large retailers, resulting in lower returns to those who plant and grow the food.[840] (See Box II.5-1.) These trends and developments have been well documented and will not be detailed here, except to point out that employment patterns within the global food system are also undergoing a process of change. It is in the context of this consolidation and change that the search for green jobs must be conducted.

Box II.5-1. Agricultural Employment in the United States

The United States presents a good example of the decline of agricultural and related employment in the advanced economies. Employment in agriculture and its various subsectors was 3.3 million in 2000, or around 2 percent of the economically active population. Some 2.5 million farmworkers are hired to work in the country, most of whom are Mexican and work seasonally.

Livestock production has seen the most significant employment losses (roughly 200,000 jobs) during the past decade as a result of consolidation. The number of hog farms, for example, fell dramatically from 191,000 in 1992 to 109,000 in 1997, according to the U.S. Agricultural Census. The actual number of pigs, however, climbed from 57 million to 61 million over the same five-year period.

The number of U.S. farms with cattle and calves has also showed a marked decline. This decline coincided with a dramatic change in the slaughter concentration of the largest four firms, which grew from 28.4 percent of slaughtered cattle in 1980 to 67.3 percent in 1995. The quality of work in the meat industry has also deteriorated as employment has shifted from higher-paid butchers to lower-paid slaughterers and meatpackers in meatpacking plants.

In addition to those working in agriculture and related subsectors, 1.66 million people were employed in food and related products in 2000, down from 1.82 million in 1989. This decline occurred at a time when the U.S. labor force grew from 117 million to 135 million workers. Employment levels in dairy, canning, beverage industries, and sugar and confectionary products all showed moderate or serious declines. This downward trend has accelerated the long-term decline of the leather trades, such as footwear. In 1990, 152,000 people were employed in these trades; by 2000 the number had slumped to 92,000.

The decline in employment in farming and food manufacturing stands in marked contrast to the growth in retail employment. In 1994, 13.5 million people were employed in retail, growing to 15 million a decade later. The U.S. Department of Labor expects retail employment to grow to 16.7 million in 2014. Some of this increase is being driven by the sale of ready-to-eat foods, especially in larger retail establishments. Superstores, warehouse "box retailers," and drugstores captured 31.6 per cent of food sales in 2005, up from 17.1 percent in 1994. This trend has been led by Wal-Mart, which in 2002 became the largest food retailer. In 2005, Wal-Mart employed 1.3 million workers in the United States, up from 700,000 in 1995. In response to the gains made by Wal-Mart and other superstores in food marketing, traditional groceries and supermarkets have merged and consolidated their own operations in an effort to cut costs and remain competitive.

Source: See Endnote 840 for this section.

Global Trends

The trend toward consolidation and the growing market power of retailers that is occurring in the United States is also happening at the global level, and in some cases even more obviously so. Small "greener" farmers are losing out to large capital-intensive producers and suppliers. This process has contributed to rural unemployment and accelerated urbanization.[841] And whereas in the industrial countries the rural-to-urban shift took many decades, in the developing world the process of urbanization is moving at a pace two or three times faster.[842] In China, 81 percent of workers were employed in agriculture in 1950; in 2000, the figure was 50 percent.[843]

Significantly, at the global level there has been a tendency for people to move directly from agriculture into service employment, thus confounding the expectations of mainstream development theorists. In 2006, 42 percent of the world's employment was in services. While the quality of service-economy jobs varies enormously, a large number of them are informal and low paying.[844] Moreover, those leaving the rural areas are often very likely to relocate to one of the many "new cities" where slum conditions are increasingly the norm.[845] The environmental hazards for those leaving the countryside for the cities are frequently worse than the ones they left behind. These escapees from rural hardship often confront the lack of safe water and sanitation, and find themselves in close proximity to pollutants from manufacturing, food processing, and building construction.[846] And rural communities in both the global North and South also suffer difficulties as the social fabric built up around farming over generations disintegrates.[847]

Waged Employment (and Unemployment) in Agriculture

The number of wage-earning employees in agriculture is about 450 million globally, although many smallholders also work for wages for some or part of the time. The trend toward waged employment is generally upward, although in some countries there has been a growth in informal labor contracts that has intercepted or reversed the trend toward waged labor.[848] Employment in soy and palm oil production has increased, but the employment gains in these instances are often small, especially given the amount of land used for these crops. Soybean production is particularly capital-intensive. A 1,000 hectare soybean farm employs only three people.[849] There are also concerns about decent jobs in agriculture.[850] (See Box II.5-2.)

© Mark Edwards / Still Pictures
Oil palm plantation nursery, spraying pesticides between rows of trees.

Box II.5-2. Decent Work Deficits in Agriculture

The International Union of Food and Agricultural Workers (IUF) points out that any discussion on green jobs should recognize that the agricultural sector has much to do to ensure decent work in agriculture and address the many decent work deficits. The IUF has consistently pointed to the fact that in many countries it is difficult for agricultural workers to exercise their basic human right to belong to a trade union. Consequently, agricultural employment is characterized by low pay, long hours, and precarious contracts.

ILO statistics also identify agricultural as one of the most dangerous industries to work in (alongside mining and construction), with many workplace fatalities and occupational accidents and diseases. The ILO reports that 70 percent of all child labor takes place in agriculture alone. These are major deficits that have to be addressed if the agricultural industry is to have the sort of skilled workforce it needs to deliver sustainable agriculture and truly green jobs.

In many of the world's richest countries, agriculture is explicitly excluded from national systems of labor relations. Poverty wages are the rule. Only 5 percent of the world's 1.3 billion agricultural workers have access to any kind of labor inspection system or legal protection of their health and safety rights. Agricultural workers are twice as likely to die at work than are workers in any other sector. Among these fatalities are an annual 40,000 deaths from exposure to pesticides. Every year, an estimated 3 to 4 million people engaged in agricultural work suffer severe poisoning from the hazardous pesticides they are forced to use, including work-related cancer and reproductive impairments.

Agriculture consumes more water than any other human activity, yet agricultural workers are routinely denied access to potable water. Despite enormous advances in productivity, agriculture remains a space of hunger, illness, and premature death.

Source: See Endnote 850 for this section.

Furthermore, the feminization and "casualization" of the waged agricultural workforce has grown in recent years, thus allowing for flexibility for larger growers while increasing precariousness for workers.[851] This is particularly evident in the rapidly expanding new export industries like cut flowers, where casualization has become the norm and many of the workers are women.[852] The cut flower industry is a major employer of mainly women workers in countries like Columbia (130,000 directly and indirectly), Ecuador, Tanzania, (9,000 workers in horticulture), Zambia (10,000–12,000) and Kenya (56,000 directly in cut flowers).[853] Ethiopia has also emerged as a major exporter of cut flowers in recent years and in the process has created about 50,000 new jobs.[854]

© Christophe Smets / Luna / VISUM / Still Pictures
One of the 50000 workers in the sector of the cut roses of Kenya take care of young seedlings in a flower farm located around the lake Naivasha for a salary of approximately 30 euros per month, Kenya.

The "new agriculture" may not be green, but it does generate employment. Because participating in global supply chains is often more lucrative for farmers, this may add to the employment benefits. In Guatemala, studies found that lettuce farmers participating in modern supply chains hire 2.5 times more labor than those who do not, and this labor is typically sourced from local asset-poor households. Studies of tomato growers in Indonesia and kale growers in Kenya find similar results.[855]

Global value chains can generate quality employment in some instances, but they can also be vehicles for passing on the costs and risks to the weakest links in the chain. Sometimes, under pressure from investors (among others), governments in poorer countries have allowed labor standards to be defined by the demands of supply chain flexibility, including easier hiring and firing, more short-term contracts, fewer benefits, and longer periods of overtime.[856] Women agricultural workers are particularly affected by these arrangements.

Employment benefits generated by global value chains are also confined to a relatively small number of countries. In many countries and regions, the employment picture is far less positive. Trade integration is a two-way process, and countries that export fruit, vegetables, and cut flowers are often importing cheap corn and other staples. According to one ILO study, "trade integration can also lead to job dislocation, increased informality and growing income inequality."[857]

Young people in particular are having a difficult time finding gainful work in rural areas. The ILO observes that in 2005, young people accounted for an estimated 65 percent of agricultural employment. However, low and precarious incomes and the lack of useful work experience are driving many to look for work in cities, despite the great disadvantages they face in urban labor markets. In Africa, the number of unemployed youth grew by almost 30 percent between 1995 and 2005.[858]

Food Miles = More Truck Drivers

The globalization of food has made a significant contribution to the growth of certain jobs, most obviously in aviation, trucking, shipping, and related infrastructure such as road and airport construction. For example, in the United States, more than 100,000 logistics-sector jobs have been added in Southern California alone since 1990[859] In 1965, the country was home to 787,000 registered combination trucks; in 1995, there were almost 1.8 million.[860] Today, there are 2.8 million truck drivers nationwide and the number is increasing at around 3 percent per year.[861]

Overall, the trade, transport and utilities sector in the UnitedStates is projected to grow by 10.3 percent between 2004 and 2014. According to the U.S. Department of Labor, transportation and warehousing is expected to increase by 506,000 jobs, or 11.9 percent, through 2014. Truck transportation will grow by 9.6 percent, adding 129,000 new jobs, while rail transportation is projected to decline—a negative trend in terms of both GHG mitigation and air quality issues. Trucks, due to their size and limited maneuverability, also account for a greater share of congestion delays, thus making these problems even worse.[862] The warehousing and storage sector is projected to grow rapidly at 24.8 percent, adding 138,000 jobs.[863] However, the recent sharp increase in fuel costs may mean that these projections will require some modification.

The growth in transportation by sea has not produced additional employment in all instances. Containerization, along with technological change in the world's ports, has made transportation by sea less labor intensive. In the United States, direct employment in water transportation declined from 232,000 in 1960 to 174,000 in 1995. However, as employment contracted the amount of food traveling by boat grew from 215 million tons in 1986 to 303 million tons in 1995.[864]

Employment and the Retail Revolution

The restructuring and consolidation of the food system has also had an impact on urban labor markets and the shape of business activity in towns and cities. Local-level food processing, brewing and baking, and other industries and trades have shown a marked decline in many regions of the world.[865]

Despite the overall growth in retail employment, there is evidence that food superstores lead to serious net job losses in the food retail sector (and other smaller retail operations, such as chemists.)[866] The U.K.-based National Retail Planning Forum reports that many of the new superstore jobs are also part-time, lower paying, and generally of poorer quality.[867] Another report from the United Kingdom notes: "A job that is lost at an independent store cannot simply be replaced by one job at a supermarket. Superstores benefit from economies of scale and computerization, and are designed that the individual employee can shift the maximum number of products per customer visit. Asda has the highest number of sales per employee, at £104,490 pa. This is compared to Tesco - £91,591, Sainsbury - £85,986, and Safeway, £94, 897."[868]

Nevertheless, in the advanced economies the proportion of food workers involved in manufacturing and retail today dwarfs the numbers of farmers operating at the base of the supply chain. In the United Kingdom, food and grocery chain workers numbered 2.3 million in 2004, of which 44 percent were in retail and just 4 percent in agriculture.[869] The food and grocery chain is one of the country's largest employers, providing at least 2.8 million permanent jobs, or 11 percent of all U.K. jobs.[870]

In the developing world, supermarkets are growing at a spectacular pace. They now control 55 percent of food retailing in South Africa; 60 percent in Argentina and Mexico, and 50 percent of fresh-produce retailing in Brazil.[871] In Latin America, East Asia (excluding China and Japan), Northern Central Europe, and South Africa, "the average share of supermarkets in food retail went from mere niche—roughly 10 to 20 percent of food retail circa 1990—to dominate the market with 50 to 60 percent of food retail by the early 2000s." Southeast Asia and Southern Central Europe appear to be heading in a similar direction.[872]

The growth of supermarkets in the global South is having a marked effect on farmers, and some maintain that this effect is bigger than that of trade liberalization.[873] Leading supermarket chains have shifted away from the wholesale markets where small farmers make their living, and toward procuring food through a few medium-to-large firms that can deliver a consistent quality product at large volumes. The World Bank acknowledges that, "For smallholders, being competitive in supplying supermarkets is a major challenge that requires meeting strict standards and achieving scale and delivery." It concludes that some farmers in certain regions may need to "transition out of agriculture" and move into "the provision of environmental services."[874]

The consolidation of retail has meant that farmers and producers often receive dwindling returns on their produce, as large retailers are in a position to lay down "take it or leave it" conditions.[875] Retailers are also in a position to dictate terms to processors and distributors and even large food manufacturers, which results in manufacturers being more concerned to serve the interests of the retailers and less concerned to maintain a good relationship with farmers.[876]

Opportunities for Green Employment in the Existing Food System

World Bank, IPCC, and WTO approaches

Ever since the United Nations Earth Summit in Rio de Janeiro in 1992 and the adoption of *Agenda 21*, the idea of "sustainable development" has become firmly embedded in policy discourse. Among other things, *Agenda 21* articulated what sustainability would mean for agriculture, emphasizing the need to conserve and manage natural resources in ways that preserve these vital resources for future generations. The extent and severity of the degradation and depletion of natural resources, and the dangers of pesticides, fertilizers, and other inputs, has been documented in numerous reports and studies, such as UNEP's *Global Environmental Outlook*.[877]

Reports released in recent years by leading agencies have echoed these concerns, examining issues of environment and sustainability in agriculture. In its *World Development Report 2008*, the World Bank offers a range of proposals to advance sustainability. Regarding climate change, the IPCC's 2000 report *Land Use, Land Use Change and Forestry* makes proposals on how altered agricultural practices can aid GHG mitigation and contribute to carbon storage. These proposals have been developed in subsequent reports. In a 2007 report, the FAO addresses adaptation to climate change in agriculture, forestry, and fisheries.[878] Finally, the United Nations Development Programme's *Human Development Report* for 2007–08 has much to contribute on climate change, the human development challenges facing the developing world, and the need for a much higher level of international action.[879]

Limited Attention to Employment

It is important to note that employment issues do not feature frequently in these reports, and specific details pertaining to jobs—green or otherwise—are almost invariably absent. The World Bank's *World Development Report* discusses and details employment trends and prospects for rural workers and smallholders in the context of the changing dynamics of the global food system, but the proposals it makes for sustainability are not accompanied by any explicit considerations with regard to employment. The report does, however, invite speculation with regard to the employment potential of these proposals and provide an agenda for future research on the issues. The same is somewhat true of the work of the IPCC and the FAO. In its *Fourth Assessment Report* on climate change, the IPCC acknowledges that certain GHG mitigation practices in agriculture show synergy with goals of sustainability, such as increasing soil carbon, which also improves food security.[880]

Some rural development and anti-poverty policies are also synergistic with mitigation, such as water management and agroforestry. Employment gains can be expected here, but there are few details. Importantly, UNEP notes that, for poorer countries, "the priorities of jobs, employment, and addressing stagnant economies" have prevailed over integrated planning to prevent or reduce land degradation—thus drawing attention to the fact that environmental concerns are often low on the agenda in countries that are struggling economically.[881] In a similar vein, the IPCC notes how existing policies to slow tropical deforestation have had minimal impact due, in part, to "countervailing profitability incentives."[882] In other words, people are getting paid to cut down trees, or they can make money in the business of doing so.

The World Bank generally approves of the present structure and trajectory of the global food system, but calls for the right mix of market measures and government interventions to encourage better land and resource use as well as better management of modern farm inputs.[883] It maintains that agriculture will become more sustainable when more capital, knowledge, and labor are directed toward improved natural resource management. However, these activities have not yet been developed through private markets, which means that powerful incentives will need to be put in place to pull business toward these activities, or they will depend on high levels of public investment and a more "command-and-control" approach.

Natural Resource Management and Preservation

The World Bank's proposed improvements in natural resource management appear to have employment-creating potential. Activities like terracing or contouring of land, building irrigation structures, etc., are labor intensive and are urgently needed to prevent further resource depletion and degradation. Employment could also be generated as part of the broad effort to raise water productivity—a high priority area given the unsustainable use of water in many parts of the world. The Bank proposes removing subsidies that makes water inexpensive (or sometimes free), reasoning that if users were required to pay for water, they would have an incentive to use it more sparingly and judiciously. This would stimulate on-farm investments in field leveling and drainage, which would also generate employment.[884]

Substantial public investments in off-farm infrastructure are also required, supported by water management institutions staffed by people with the necessary background in hydrology. Additional investments will be required to store and save water, thus creating employment in producing, installing, and maintaining the necessary equipment.[885] The move toward integrated water management, which involves canal lining and micro-irrigation, also involves labor inputs. Other sources of work include rehabilitating dams, barrages, and embankments that improve the flow of rivers. There also appears to be employment potential in combating soil erosion via tree planting and straightforward stone bunding.[886] The IPCC has developed a similar list of mitigation measures.[887]

Reducing Harmful Inputs, Managing Livestock

The greening of high-input farming is critical to achieving sustainability as well. Here, modern inputs like fertilizers and pesticides can, according to the World Bank, be administered in a way that sustains high yields without damaging the environment. According to some estimates, approximately 25 percent of pesticide use is prophylactic and administered "just in case" a particular species appears in the field.[888] Such inputs could be reduced by methods of integrated pest management and also removing government subsidies on pesticides and fertilizers where they exist.

High-input farming has reduced both biological and genetic diversity, but farmers could be encouraged to rotate and diversify their crops—thus reducing the need for pesticides and fertilizers. Here, the employment implications are also positive. This kind of farming is knowledge intensive and requires research and extension systems "that can generate and transfer knowledge and decision-making skills to farmers rather than provide blanket recommendations over large areas."[889] Developing the ecological literacy of farmers could, therefore, create significant employment.

Managing intensive livestock systems is another challenge. For the World Bank, a key goal is to move intensive livestock facilities away from ecologically sensitive areas, and to prevent others from taking their place. Employment growth is not an obvious outcome here, although the general lack of sufficient and adequately trained inspectors in intensive livestock could be solved by training and employing more of them.

Payment for Environmental Services

Payment for environmental services (PES) is another strategy that appears to have very significant green employment potential. A description of the full range of these services is not possible here, but they include activities such as watershed and forest protection. These activities generate universal social benefits, such as clean drinking water, stable water flows to irrigation systems, carbon sequestration, and protection of biodiversity. The World Bank maintains that providers of these services should therefore be compensated through payments from beneficiaries of these services, and that the social and ecological benefits far outweigh the cost of paying for the services.[890]

The FAO's *State of Food and Agriculture* report for 2007 explores PES in considerable depth.[891] It concludes that this approach can contribute to alleviating poverty, although PES-related problems do exist, such as the high administrative cost of involving small farmers. The experience of PES to date has been relatively limited. In the OECD countries, farmers have been compensated for foregoing more intensive and more profitable farming practices in order to prevent soil erosion and other forms of environmental degradation. And in Central and South America, silvopastoral practices have been developed in Columbia, Costa Rica, and Nicaragua to conserve forests. In these latter cases, the incomes of cattle farmers typically rose by 10–15 percent, suggesting that PES can establish a "win-win" relationship between poverty reduction and environmental protection—a situation that could generate more employment in rural areas as a result of farmer re-spending or taking on additional paid help.

Several studies in the developed countries point to real employment benefits of PES. In the United Kingdom, the English Countryside Stewardship Scheme has created jobs for farmers, contractors, and other small rural businesses.[892] The Tir Cymen scheme in Wales was created to promote sustainable farming in three areas of rural Wales. This scheme produced 204 casual jobs and 62 person-years of environmental work. A government study found that if the scheme were replicated across Wales, it would generate 1,230 years in full-time jobs. A 1997 study found that wildlife conservation supported 10,000 full-time jobs in Britain.

These examples suggest that a global shift toward PES could generate very large numbers of jobs, especially when administered as public works projects. An impressive example of job creation is South Africa's "Working for Water" program. This public project has provided work for 25,000 previously unemployed people in the removal of high water-consuming invasive vegetation.[893] However, converting land from agricultural production to forestry will release labor, while moving from silviopastoral production systems from conventional systems is likely to absorb it. The FAO warns against making blanket assumptions that PES programs will assist the poor or stimulate employment.[894] Moreover, PES programs are still few in number and quite small scale, and most exist in developed countries. The public sector has been the main driver of these programs thus far, and here is where there appears to be potential for further growth.

Agriculture, GHG Mitigation/Adaptation, and Jobs

The Stern Review on the Economics of Climate Change notes that, compared to other sectors, relatively little thinking has been dedicated to reducing emissions from agriculture.[895] The Review's proposals focus on more efficient use of fertilizers to cut nitrous oxide emissions; reducing methane from animals by administering nutritional supplements and capturing the methane for fuel, and stopping the burning of crop residues. Some of the World Bank's proposals referred to previously may also contribute to the effort to limit GHGs. As mentioned earlier, the IPCC has developed its own list of priorities with regard to mitigation practices.

Exactly what these proposals might mean for employment remains an open question. To the extent that any employment that helps mitigate GHGs or assists adaptation to climate change can be categorized as a "green job," then growth potential appears more likely in some areas than others. Certainly, changes in agricultural land management, such as conservation tillage, agroforestry, and rehabilitation of degraded crop and pasture land could create jobs.[896] However, some proposed changes may reduce labor inputs.

For example, conservation tillage can make a major contribution to GHG mitigation and also enrich soil and improve yields. The global loss of soil carbon due to agriculture has been estimated at around 55 gigatons from 1,600 million hectares of cropland. This soil carbon loss can be reversed by techniques that increase the rate of carbon input into agricultural soils. Some conservation techniques reduce the period of bare fallow and also plant cover crops to stop erosion and soil loss. Other conservation techniques include tillage practices that reduce aeration of the soil, such as no till, ridge till, or chisel plough planting. Conservation tillage is thought to have potential to store at least 25 gigatons of carbon over the next 50 years if these methods were applied to all cropland.[897]

Conservation tillage, however, is sometimes presented to farmers as a way of *reducing* labor inputs. It also uses half as many tractors to cultivate a field as conventional tillage, which means lower fuel consumption and decreased material inputs. However, conservation tillage also requires specialized equipment, such as grain drills, straw choppers, and spreaders for combines that uniformly dispense residues for easy double-crop planting, as well as row cleaners that brush aside heavy residue concentration.[898] If conservation tillage became far more widely practiced by farmers, then demand for these technologies would presumably increase and manufacturing jobs would grow accordingly. However, demand for equipment germane to conventional plowing (such as tractors) would weaken, and jobs could be lost as a result. In general, mitigation efforts promise to stimulate the development of technology to improve production, biomass utilization (including biofuels), and organic agriculture, all of which have employment potential in terms of the research, development, and deployment.[899]

The implications for employment are also unclear in the case of developing low-emission rice and even low-emission livestock breeds. These proposals could create jobs in agricultural R&D but may have little employment impact, positive or negative, on the ground.

Adapting to climate change could create employment as well. For example, new irrigation schemes in dryland farming would create work, as might retrofitting existing ones as part of the adjustment to greater variability of rainfall. Climate information and forecasting, as well as R&D into crops adapted to new weather patterns, could also generate specialized and high-skill employment. However, according the World Bank, "The cost of modifying irrigations schemes, especially when those depend on glacial melt...or regulation of water flow by high-altitude wetlands, could run into millions if not billions of dollars."[900] Spending of this magnitude would be expected to create employment, but this has to be weighed against the areas of the economy that may be deprived of investment capital in order to free up revenues for these and similar strategies for adaptation. Contributions to existing adaptation funds are under $300 million a year and the UN's "Nairobi Framework" is expected to provide no more than 10 percent of the funds needed for adaptation.[901]

Funds for Mitigation and Adaptation Are Insufficient

These proposed climate-friendly alterations to farming-as-usual may create many green jobs, but making them happen on a significant scale will require considerable resources at a time when both public and private investment in rural areas in developing countries is worryingly low. The low investment problem has not been helped by the fact that the financial commitments for adaptation to climate change made by rich-country governments as signatories to the UNFCCC in the early 1990s have not been met. Thus, the UNDP concludes that, "To date, international cooperation on adaptation has been characterized by chronic under-financing, weak coordination and a failure to look beyond project-based responses."[902]

The lack of funding is having a particularly negative impact on agriculture in the developing world, where climate change is already having an effect. As for the mitigation measures needed in agriculture, the IPCC observes that little progress in implementation has been made because of the costs involved, along with various institutional and educational barriers.[903] The mitigation potential of the world's forests is also being impeded by "the lack of institutional capacity, investment capital, technology, [and] R&D and transfer."[904]

Meanwhile, the contrast in the amounts being spent on climate change adaptation efforts in the rich versus poor countries could not be more stark. The United Kingdom, Germany, the Netherlands, Italy, and the United States have spent billions of dollars on flood defenses and other protection measures, creating thousands of jobs in the process. However, only $26 million has been spent multilaterally for adaptation measures—the equivalent of one week's worth of spending on flood defenses in the United Kingdom, according to UNDP. The lack of adaptation spending not only impedes the development of green jobs, it can lead to many existing jobs being lost and livelihoods wrecked (particularly in agriculture) as a result of climate events.

The lack of funding for adaptation in the developing world has called into question the effectiveness of various funds established under the UNFCCC's Global Environmental Facility. Leaving aside the failure of donors to honor the pledges they have made, the funds distributed have been project-based and have not been integrated into a broader strategy to advance sustainable development. The funds have therefore had minimal positive impact on the overall situation.

An effective global adaptation financing strategy is clearly needed. The UNDP has estimated that adequately financing climate-proofing development investments and infrastructure will require $44 billion per annum by 2015. A further $40 billion a year will be needed to adapt poverty reduction programs to climate change. Climate-related disaster response could add another $2 billion. This total of $86 billion would require developed countries to mobilize just 0.2 percent of GDP in 2015—or roughly one-tenth of what they currently spend on defense.

Growing Green Professionals?

A concerted effort to adequately fund both adaptation and mitigation efforts would create career opportunities and employment for a new generation of "green" professionals. Not all of these positions will be tied to agriculture, but some will, and others will relate to agriculture in some way. The Perth Biodiversity Project in Western Australia is one example where a growth in green professionals has been documented. The project is a local government initiative to improve the conservation of biodiversity in the Perth Metropolitan region. It is largely funded by the Natural Heritage Trust and involves 29 participating local governments. Perth local governments spent a total of $5.14 million on salaries and activities related to biodiversity conservation in the 2000–01 period, as well as an estimated $21 million on other environmental protection and $16 million on natural resource management activities. This created employment for environmental and biodiversity officers, and the local governments dedicate 41 full-time equivalent officers to on-the-ground bush regeneration.[905]

A 2002 survey, however, identified training needs and skills shortages in environmental occupations in Australia, particularly in bush regeneration, organic agriculture, environmental impact statement preparation, and environmental assessment and monitoring. If such shortages are evident in Australia, they are likely to be more evident in the developing world, where the resources to develop them are even scarcer.[906] The study showed a marked increase in the number of "environmental workers" being hired, especially in the private sector. Among the occupations experiencing the highest growth were those concerned with "Earth repair" and "resource renewal."

Along these lines, UNEP maintains that a prerequisite to achieving sustainable land use is adequate government support for national land resource institutions and for building up the capacities of land resource planners, farmers, and managers at local and national levels.[907]

Offsetting Trends?

Taken together, the above proposals are part of an effort to make existing agriculture more sustainable. Under this scenario, jobs may be gained, but they may also be lost—indicating that additional research into the employment implications is clearly necessary. Paradoxically, the projected increase in energy intensification in agriculture is such that it becomes possible to imagine a growth in green jobs within a system that actually becomes more environmentally unsustainable as time goes on. In its 2001 report on climate mitigation, the IPCC documents the global trend toward energy intensification in food produced on arable lands, projecting a "4 to 7 fold increase in current commercial energy inputs into agriculture, particularly in developing countries."[908]

According to the IPCC, "The present challenge is to offset this trend by introducing more efficient production methods and greater adoption of new technologies and practices. Whilst reducing energy intensity, agriculture must also become more sustainable in terms of reduced nutrient inputs, lower environmental impacts, and with zero depletion of the world's natural resources such as fish and topsoil."[909] In its *Fourth Assessment Report*, the IPCC sees the potential to reduce GHG emissions per unit of food production—provided the mitigation measures it proposes are implemented. But even then, absolute emissions in agriculture will continue to rise as global food demand grows.

Proposals to Green Retail, and a Civil Society Critique

Leaving aside their freight transport arrangements and the issue of "food miles," today's large retail establishments consume an estimated six times as much electricity as factories, largely for lighting and refrigeration.[910] Increasingly, supermarkets and superstores are proposing measures to limit their own environmental footprint and to promote sustainable practices, but this is no easy task. In 1999, Sainsbury's built what it described as the most environmentally responsible supermarket in Britain. The 35,000 square foot (3,255 square meter) store was designed to reduce energy consumption by up to 50 percent compared to a standard store of similar size and operation. The store created 380 jobs, although it is not clear how this number would have changed had the store been constructed in a conventional way.[911]

In 2006, Tesco, the largest food retailer in the United Kingdom, generated 4.13 million tons of carbon dioxide equivalent (CO2e) globally. The country's food retail sector is estimated to emit 9.2 million tons CO_2e annually, plus approximately 2.4 million tons of CO_2e from associated distribution. Tesco is proud of its efforts to reduce its carbon intensity, noting that, "our footprint in tons of CO_2e has not changed materially since the 05/06 financial year despite a 10.9% increase in sales and a 17.2% increase in selling area." Tesco has begun to build "environmental stores in which we test low-carbon technologies to establish their suitability for wider roll-out" and to "self-generate energy from renewable sources such as solar, wind, biomass and geothermal."[912] The employment implications of these early efforts to "green" food retail (and retail more generally) require further analysis.

In 2005, the world's largest retailer, Wal-Mart, unveiled a new store outside Dallas, Texas, that combined a host of renewable energy technologies, including solar PV arrays, two small wind turbines, a biofuel boiler to recycle and burn recovered oil from store operations, and a long list of energy-saving and sustainable design principles. The company announced that it would invest $500 million to achieve a variety of goals, including: reducing its stores' GHGs by 20 percent in seven years; increasing its fleet's fuel efficiency by 25 percent in three years and doubling it in 10 years; designing a 25 percent more energy-efficient store within four years; reducing packaging; and pressuring its worldwide network of suppliers to follow its lead.[913] Wal-Mart's sustainability commitments include being supplied by 100 percent renewable energy, eliminating 30 percent of energy use in stores by roughly 2012, and selling more organic produce. The company also plans to reduce its CO_2 output by 20 million tons.

Wal-Mart's proposals have elicited a sharp reaction from many civil society organizations. According to one calculation, the company's GHG emissions through its supply chains and retail operations totaled 562 million tons—almost half the amount generated by France in 2004—thus putting into perspective the proposed emissions cuts. Wal-Mart's plan to sell more organics has also been attacked by watchdog organizations for pricing out other organic producers and for misrepresenting conventional food products as organic. Indeed, just about all of the company's sustainability commitments have been severely criticized. Given the potential implications for the retail sector, Wal-Mart's efforts to meet its targets will be monitored closely in the years ahead.

Overall, large retail companies can be expected to develop more systems for sustainability. Unilever, along with Danon and Nestlé, pioneered the Sustainable Agricultural Initiative (SAI) to promote the development of sustainable agricultural practices along the food chain. Organized around the slogan "People-Planet-Profit," the SAI Platform conducts various activities around knowledge building and management, awareness raising, stakeholder involvement, and giving support to the implementation of sustainable practices in agriculture both within the supply chain as well as in compliance with trade policies and regulations.[914] Unions are presently discussing a "social auditing" dimension to these initiatives, whereby civil society organizations such as unions and agricultural NGOs play a role as inspectors concerned with workers rights, health and safety, and living conditions.[915]

Reducing Food Waste—Uncertain Employment Opportunities

Supermarkets could probably do more to prevent methane-generating food waste. It is unclear, however, just how many jobs this might create or preserve. In the U.S. state of New Jersey, 25 Shop Rite supermarkets together divert 3,000 tons of organic waste for off-site composting and rendering. Composting responsibilities are integrated into employee job descriptions, but the scheme does create jobs for employees of rendering companies.[916] On the West Coast, the California Integrated Waste Management Board employs around 400 workers to deal with 5.6 million tons of discarded food.[917] Over half of this waste—2.9 million tons—comes from commercial sources such as restaurants, hotels, and schools, and measures could be taken to manage and reduce this food waste in ways that could, in principle, create employment.

Landfill gas-to-energy (LFGTE) programs have been developed as a means of converting methane generated by decomposing organic materials such as food into useable energy, thus stopping the release of this powerful greenhouse gas. In principle, the widespread development of LFGTE could generate considerable employment. Of the estimated 2,500 landfills currently operating in the United States, approximately 340 have landfill gas projects and a further 60 of the projects are under construction.[918] The IPCC reported 1,150 such plants operating globally in 2003.[919]

According to a U.S. Department of Energy survey, LFGTE projects currently utilize about 10 percent of the potential LFG available in the United States. The survey estimates that applying the controlled bioreactor technology to half of the waste currently being landfilled could provide more than 270 billion cubic feet of methane gas per year—meeting about 1 percent of the country's electricity needs.[920] LFGTE is capital intensive and reduces emissions through engineered gas extraction and recovery systems consisting of vertical wells and/or horizontal collectors.[921] Nevertheless, its widespread deployment appears to have some employment potential.

LFGTE is not the only way of dealing with methane and food waste, and its use has been severely criticized in some quarters.[922] The IPCC has cited capture rates of just 20 percent in some cases, far lower than the 75 percent rate claimed by some waste management companies. Civil society groups have expressed concern that the often-subsidized waste industry has a monetary incentive to landfill as much garbage as possible, to decompose it as quickly as possible, and to claim that the capture of greenhouse gases from landfills is a sustainable way to create alternative energy sources. A more sustainable approach might be to ban the dumping of decomposable material into landfills, especially given the fact that capture rates will never be 100 percent and that accelerated decomposition may actually increase the release of methane into the atmosphere.

In the European Union, landfill gas recovery is mandated at existing sites, while the landfilling of organic wastes is being phased out via a recent directive. The IPCC notes that aerobic composting is probably more appropriate from a cost perspective and therefore might be a better option in the developing world. Even waste scavenging and informal recycling can make an important contribution to mitigation, the IPCC notes, since "low technology recycling activities can also generate significant employment through creative microfinancing and other measures to essentially pay people to sort through garbage."[923]

In the United States, existing recycling and yard waste collection and composting programs could be expanded to include food scraps and soiled paper. Over 120 cities in North America are already in the process of diverting all organic material from landfills. In addition to preventing the creation of uncontrolled GHGs, these programs create their own benefits such as soil stabilization and improvement through composting. Recycling leads to indirect energy savings and reduced GHG emissions.

Consumers also waste a lot of food, and yet obesity has increased alongside the growth of entire industries around diet and exercise. In a sense, public education on food waste reduction and on better use of food in the homes could be a source of green employment in schools, government agencies, and NGOs.

Beyond the Agro-Industrial Model

In this final section, we examine the employment implications of a radically altered, "post-industrial" global food regime, based on "grow local" policies and practices and small farm production. We come at this question from two angles or perspectives. The first is in the developing world, where large numbers of small farming systems continue to grow food and raise animals for themselves and local communities. Here, the issue of green jobs revolves around securing local food economies, preserving what is already relatively green and perhaps making it greener still. According to the ILO, the evidence suggests that the development of rural small and medium enterprises is likely to be pro-poor, as these tend to be labor-intensive in nature—thus reducing unemployment, helping to smooth income seasonally, and bidding up local wages. These enterprises tend to generate more employment per unit of capital than big firms and typically produce goods and services that are affordable to the poor, thereby increasing their access to goods and services that otherwise might not be available to them.[924]

The second angle or perspective focuses on the developed countries, where today just a tiny fraction of the economically active population makes its living from farming, and where rural communities are often in an advanced state of disintegration.

Small Farming Systems

Small farm-based agriculture involves a qualitative shift in farming methods away from dependency on environmentally harmful inputs—such as fossil fuel-based energy, chemicals, and fertilizers—and toward methods that utilize more human labor, farmer expertise, and community experience. The system rests on the better use of locally available natural resources (such as water harvesting, irrigation scheduling, and reclamation of formerly unproductive land), the intensification of microenvironments in the farm system (such as gardens, orchards, and ponds), diversification through adding new regenerative components, and making better use of non-renewable inputs and technologies.

Of course, there exists no neat barrier between this model of agriculture and the agro-industrial model. Small farmers often use pesticides and fertilizers, just as large growers use traditional farming methods. But there is usually a huge political gulf between those who see small farming as a sustainable solution to most of the problems generated by agro-industrial model, and those who feel that small farmers have little choice but to adapt to the productive agro-industrial system or leave agriculture altogether.

Small farmers' organizations and agricultural workers' unions stress that land reform, access to markets, affordable finance, and other resources are all essential to sustainability.[925] They also emphasize the need for a new and fairer set of rules to govern international trade and to control the market power of the large growers and retailers. In any discussion on employment, environment, and sustainability generally, these questions are seldom far from view even if, for the purposes of this report, they have been left aside. Questions have been raised regarding the productive potential of small farming systems. Some studies show that small farm productivity can rise dramatically in the case of rain-fed crops, and significantly in the case of irrigated crops. With the latter, farmer experimentation with redesign of nutrient, water, and soil management can improve per-hectare food production levels still further. In addition, farmers have shown their capacity to increase total farm production by bringing formerly unproductive lands into cultivation, by using intercropping and manuring, biopesticides and biofertilizers, as well as harvesting enough water for an extra irrigated crop during formerly unproductive seasons.

The small-farm model entails a shift toward biodiversity farming that uses the complementarities and synergies that result from the right combinations of crops, trees, and animals in integrated agricultural systems.[926] According to WWF, the contribution of small farming to environmental sustainability will be invaluable: "Highly diverse systems, as opposed to commercial monocultures, have repeatedly been shown to be more resilient—and more productive. Farming based on expensive energy-intensive artificial inputs will be both vulnerable to fuel price rises and will further add to the problems of climate change and environmental vulnerability."[927] Overall, this kind of sustainable agriculture is based on a far more careful use of natural resources in a way that is regenerative—restoring water tables, maintaining soil fertility, and fostering biodiversity. It also makes use of the knowledge and skills of farmers.[928]

The Developing World

Small farmers play a critically important role in the developing world. In Brazil, for example, more than 70 percent of the food consumed is produced by small farmers, and small properties with less than 200 hectares generate more than 14.4 million jobs in the countryside, or 86 percent of rural employment. Meanwhile, in Cuba, economic circumstances following the collapse of the Soviet Union necessitated a return to small-scale agriculture, which proved to be quite successful.[929] (See Box II.5-3.)

The 1996 Brazilian agricultural census showed that, using the average productive strategies of small-scale agriculture, every eight hectares cultivated produces one rural job, whereas large-scale mechanized farms require an average of 67 hectares per unit of rural employment.[930] In banana production, an IUF study shows that 2,000 workers are employed for every 1,000 hectares dedicated to bananas; however, in Columbia, where palm oil production has grown dramatically and displaced banana plantations, 1,000 hectares employs just 100 workers.[931]

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Man watering crops with a hose. 30% of Havana's vegetables are grown on waste land in the city. All produce is grown organically, the government cannot af ord to impost fertilizer and pesticides, Havana, Cuba.

Box II.5-3. The Cuban Experience

The Cuban experience perhaps best illustrates the possibilities of both urban agriculture and small farm production systems. In 1989, Cuba's agriculture was totally dependent on oil, fertilizers and pesticides from the Soviet Union and its allies; an estimated 57 percent of the island's caloric intake was imported, as was 80 percent of all protein and fat. The collapse of the Soviet Union brought this system to an abrupt halt, forcing Cuba to transition from a conventional high-input, monocrop-intensive agricultural system to smaller organic and semi-organic farms.

To respond to the changing food supply, an Urban Agriculture Department was established in Havana to develop urban growing in a city that had relied on imports or rural production for decades. At first, per capita daily caloric intake dropped from 2,908 calories in 1989 to 1,863 calories in 1995, a decline of 36 percent. But by mid-2006, caloric intake had rebounded to 2,473—a recovery due almost entirely to the changes in Cuban agricultural methods. Today, urban agriculture provides 50 percent of the caloric intake for Havana's 2.5 million people.

Source: See Endnote 929 for this section.

Local Production and Climate Change

The impact of climate change on agriculture in the poorer regions of the world is already obvious, as worsening droughts, rising sea levels, and more-intense storms affect people's ability to grow food. However, the adaptation potential of local food systems has not always been recognized. According to WWF, "the conservation and development of local agricultural biodiversity is crucial in the face of climate change. In Andean communities, farmers help each other where government support is missing."[932]

Despite scarce resources and underfunding, farmers and communities are taking adaptation measures into their own hands. The UNDP documents numerous cases where local populations in different parts of the developing world are strengthening dykes and embankments, and where farmers and growers operating in water-stressed rained environments already invest their labor in small-scale water harvesting.[933] Women farmers in Bangladesh are building "floating gardens" to grow vegetables in flood-prone areas.

Paying farmers to keep rainforests intact also helps the fight against climate change. According to the Working Group on Climate Change and Development, "Every hectare contains about 200 tons of carbon, and developing countries could be granted carbon credits for those rainforests that they save from destruction. These credits can be traded on the international market under the Kyoto protocol, giving tropical countries and local landowners an incentive to keep their forests. A hectare of rainforest might cost $300 to clear for pasture, and then be worth only $500 to its owner. At current market values for carbon, the same hectare of rainforest, if left intact, could be worth thousands of dollars."[934]

Urban Agriculture and Cooperatives

Urban agriculture is an important expression of sustainable methods. As the Cuban experience illustrates, the expansion of urban farming could generate much-needed employment, particularly in cities with high levels of underemployment and informal labor. Already, urban agriculture has been expanding "more rapidly than urban populations, and in many countries more rapidly than their economies."[935]

Urban agriculture takes place on both public and private land, and in 1993 it involved more than 800 million urban dwellers. In São Paolo, Brazil, agriculture is a major planned land use is the city's metropolitan master plan, adopted in the 1990s. Urban agriculture is not, however, unambiguously green. The improper use of chemicals has contributed to land, air, and water pollution. However, the activity recycles organic matter, and solid wastes can be composted and used to fertilize soils. A 1996 study in Zimbabwe found that the expansion of urban agriculture reduced municipal costs for landscape maintenance and waste management, and created hundreds of jobs.[936]

Cooperatives are also very important to any model of sustainability. Globally, cooperatives employ around 100 million people, many in rural areas. More than 50 percent of global agricultural output is marketed through cooperatives.[937]

Green Job Potential in Organic Farming and Local Food Systems

The global market for organic products reached $38.6 billion in 2006, with the vast majority of products being consumed in North America and Europe, according to the International Federation of Organic Agricultural Movements.[938] Research cases provide some evidence that organic farming and local food systems generate positive-sum employment gains while also protecting the environment. For example:

- A study of 900 food businesses in Devon in the United Kingdom showed that producers involved in the local economy hired more workers on average than those not involved locally. The study found that 38 percent of producers have created new jobs, at an average of 0.5 per farm, with 3.4 full-time equivalents (FTE) per farm compared to 2.34 regionally.[939]

- A study of 1,144 organic farms in the United Kingdom and the Republic of Ireland showed that organic farms employed one-third more FTEs per farm than conventional farms. In these countries, organic agricultural land amounts to 4.3 percent and 1 percent of the total farm area, respectively. If 20 percent of farmland became organic in both countries, this would bring 73,200 new jobs in the United Kingdom and 9,200 in Ireland, according to the study.[940]

- An input-output analysis of organic apple production in the U.S. state of Washington found that, for every $1 million in sales, organic apples generated 29.4 FTEs, whereas conventional farms generated 25.9 FTEs.[941]

Other studies show that purchases from local growers through such means as organic box schemes (where organic food is delivered to individual doorsteps) generate considerably more income for local economies than does food purchased from supermarkets. The studies detail how the multiplier effects of extra income sustain and expand a range of employment in the local areas. A study in the U.S. state of Iowa claims that if people living in the state purchased 10 percent more of their food from local growers, they would cut the state's CO_2 emissions by 3,590 tons per year and generate much-needed income for farmers. Another study showed that consuming domestically grown food in Japan would be equivalent to a 20 percent energy savings per household.[942]

Similarly, a U.K. study on Queens Market, a local food market in East London, found that "the Market provides twice as many jobs per square foot of retail as supermarkets...[and] delivers twice as many jobs per square metre as a food superstore." It reported that the market provides 581 jobs, with 308 of the people employed living in the immediate local area. Jobs at the market were also "more varied than those at a food superstore, involving a richer skill set and greater opportunities to start a business and to acquire business knowledge."[943]

While the studies of organic farms and local food systems do not always deal with the quality of the work created, the farms employing the most workers above the average were mixed farms, suggesting that workers would perform a variety of tasks in these establishments. This is in contrast to livestock and dairy farms, where the jobs dividend between organic and conventional farms is almost zero and the work would probably be less varied. In general, more sustainable farming practices tend to be knowledge-intensive. While this would appear to raise demand for adequately trained workers, it also raises the need for, in the words of the World Bank, "research and extension systems that can generate and transfer knowledge and decision-making skills to farmers." There is a need for the requisite levels of ecological literacy to better understand interactions in complex ecosystems.[944]

The U.K.-Ireland study also suggested that, in the case of organic farms, the larger number of workers per farm might also yield social benefits by helping to break down the social isolation felt by sole farmers and sole employees.[945] And farmers' markets have community-building value as well. One study estimated that people have 10 times as many conversations at farmers' markets than at supermarkets—to the benefit, presumably, of both workers and consumers alike.[946] A pilot survey by the California Institute of Rural Studies on job benefits and conditions most appreciated by workers on small-scale farms found that "respectful treatment" was the most important feature, and year-round employment also ranked highly.[947]

While these findings suggest employment and other social gains generated by organic farming, sometimes the differences between organic and conventional farms are harder to detect. A 2005 survey of organic farmers in California attempted to establish whether or not "certified organic" incorporated a conception or practice of sustainability that extended to hired farm labor. The survey found that organic farmers operate on razor-thin margins and often pay as poorly as conventional farmers. These organic producers felt so squeezed by cheap imports on the one hand and large wholesale operations on the other, that they complained that their own wages and benefits were also extremely low. Fully two-thirds of these farmers opposed guaranteed collective bargaining rights for waged employees.[948]

U.S. organic soybean producers have been subjected to the same downward pressures on prices as have the producers of non-organic produce. In 2000, however, several organic farmers formed an organization (OFARM) that, among other things, substitutes collective actions for one-on-one negotiations with large buyers. Organic milk producers in the United States have organized themselves along similar lines. Organic certification remains critical to these producers, and without it they are subject to the pressures leading to consolidation and lower prices faced by conventional producers.

If the social benefits of organic production are not always clearcut, the same is sometimes true of the environmental benefits. Organic produce, for example, is not necessarily synonymous with local food production and a reduction of food miles. The global trade in organics is on the increase, with Chinese exports reaching $350 million in 2005. Mexico produces organic cherry tomatoes for the U.S. market. However, China also produces organic food for its own consumption, as Chinese urban dwellers become more interested in healthier and safer food options.[949] The growing market for organic produce provides an incentive for Chinese farmers to convert their farmland from chemical-dependent techniques back to traditional, pesticide-free, sustainable farming methods. If the consumption of organic produce continues to grow worldwide, then employment growth in this area could become a more generalized and global phenomenon.[950] The United Kingdom, for example, imports 70 percent of its organic produce—along with 50 percent of its conventionally-grown vegetables, 90 percent of its fruit, and 70 percent of its meat.[951]

Organic Production and Developing Countries

While the demand for organic produce is growing in industrial countries, organic methods of farming are also visible in the developing world. At the 2007 "International Conference on Organic Agriculture and Food Security," organized by the FAO, a number of submissions made note of the social benefits of organic production.[952] One study described how, in the Dominican Republic, the establishment and maintenance of organic crops such as cocoa, coffee, and bananas requires intense use of hand labor, as mechanization is still not available for the majority of farm operations. As a result, "the movement from rural to metropolitan areas is reduced by the availability of local employment opportunities."[953] Another study noted that, since 1990, employment in the agricultural sector of northeastern Germany, in the former East Germany, has been reduced by 80 percent; however, larger organic farms developing there are generating employment and other social benefits.[954] And in India, "organic farming is spreading fast to many agro-ecological zones.... Small farmers are showing preference for organic farming practices because it reduces their cost of cultivation, in several cases bringing down to little cash input costs, [and it] provides more employment to members of the farming families"[955]

The growth in organics is to some extent contingent on labeling. As government regulation in agriculture has retreated, the large retailers have filled the vacuum with their own systems of certification, standards, and labeling—usually in partnership with food services companies, manufacturers, and other agrifood interests. Organic producers are organizing in ways that not only challenge this kind of private certification system, but they are also redefining the product being certified as something representative of community, diversity, and local power.

In Mexico, for example, *Coyote Rojo* ("Red Coyote") is an organic bioregional label that began certifying producers in August 2007. Its purposes are to safeguard and promote biodiversity, uphold cultural practices of seed saving, protect methods of crop production and typical foods, and conserve natural resources and sustainable means of harvesting them. According to one study, *Coyote Rojo's* "bioregionalism" focuses on satisfying basic needs in the local area, taking advantage of renewable energy sources, promoting and preserving organic agriculture, and developing local businesses based in local skill, knowledge, and capacity. As the quality of the product is the result of the entire production process, evaluation must encompass the entire process in order to guarantee specified qualities.

The politics behind the *Coyote Rojo* has a bearing on the green jobs discussion. According to one study, the label "is one way of confronting many of the challenges facing this region. It capitalizes on the niche value of maize varieties specific to localities within the bioregion, thus confronting the looming threats to Mexico's single greatest cultural symbol." The hope is that people will be less forced to migrate, taking with them precious knowledge of how to work the traditional and labor-intensive crop growing system known as *milpas*. It is anticipated that the commercialization of local varieties can sustain rural livelihoods and contribute to agronomic diversity at the same time. Bioregionalism and the *Coyote Rojo* project thus offer an alternative to nearby farmers embracing standard production systems defined by transnational supply chains.

These studies suggest that the organic sector may offer a development path that is sustainable at the global level and that organics provide what FAO describes as "alternative employment opportunities for educated young people in rural areas with decreasing chances to make a living in the cities. Rural community development is also a highly valued advantage achieved through collective learning processes fostered by organic agriculture's principles and practices."[956]

Fair Trade Coffee

The demand for "fair-trade" products—particularly tea, coffee, cocoa, and bananas—has grown dramatically in recent years. Fair Trade Organizations promote sustainable methods and also work to ensure that small producers in developing countries receive a fair price for their goods. In 2003, 8,400 tons of green coffee was "Fair Trade" certified, with a retail value of $208 million. It comprised roughly 15 percent of the $1.7 billion specialty coffee market in the United States.

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Fair trade cof ee stand.
www.flickr.com/photo/i_y_e_r_s/500869859

As a result of this certification, workers and farmers in fair-trade production systems generally have better rights and protections than is the case in conventional industries, and the production methods are usually also environmentally sustainable. Typically, fair-trade farmers each cultivate less than 3 hectares of coffee and harvest 1,000–3,000 pounds of unroasted coffee a year. Small farmers are perhaps more aptly defined as those farmers who rely principally on their own families' labor. This makes fair trade potentially representative of an estimated 75 percent of all coffee farmers.

A look at one large company involved in fair trade, Equal Exchange, shows an average annual growth of 32.5 percent between 1986 and 2006. In 2006, the company's sales were approximately $23.6 million, and it employed 94 full-time employees.[957] The combined efforts of the fair trade movement have generated significant numbers of green jobs. While the numbers of such jobs may typically be only a few dozen in each cooperative, they add up. The National Cooperative Business Association reports that in Indonesia, 12,000 jobs have been created as a result of fair-trade exports to the United States.[958]

Proponents of fair trade often view it as a way of challenging the dominant economic concept underlying today's globalization, which touts competitiveness and efficiency above social and environmental concerns.[959] Recently, proposals have been developed to expand fair-trade initiatives to include hard-pressed farmers in the global North. If fair trade coffee is a good thing for farmers in Central America, why not market "fair trade carrots" as a means to help farmers in central England? While considerable economic differences exist between farmers in the North and South, many of the economic dynamics are nonetheless very similar.[960]

Meanwhile, agricultural certification of varying types is well established in Europe and the United States and is expanding rapidly in terms of sales volume and market share. In theory, certification should enable consumers to use their purchasing power to support sustainable products, and so drive social and environmental improvements along the value chain. However, certification faces several problems. It is typically associated with niche markets and, at least in some sectors, may face limited prospects for market expansion. Certification may also become another requirement for market access and a barrier for small producers rather than an opportunity.

Green Employment in Food and Agriculture: Challenges and Opportunities

From the above overview, it is possible to identify several key challenges to the development of green jobs in agriculture. These include:

- In the developing world in particular, the shrinking proportion of smallholders amounts to a decline in small farming that is green or relatively green, to the extent that smaller farms generally use less energy and chemical inputs than larger scale livestock-intensive or plantation systems.
- Some smallholders and entrepreneurs are moving into higher-value, "new agriculture" products, such as cut flowers, that generally require more environmentally damaging inputs and often create low-quality and precarious employment.

- Poverty contributes to land degradation as the poor, due to lack of alternative employment, are forced onto marginal lands with fragile ecosystems and into areas where land is increasingly exploited to meet food needs. They typically lack adequate economic and political support to adopt appropriate agricultural practices.[961]

- Rising income in some parts of the developing world is raising the demand for meat and therefore for intensive livestock production and feed for the animals. This trend is driving up GHG emissions and broadening the environmental footprint of agriculture considerably.

- The globalization of food is increasing the distance from farm to fork, making food more carbon-intensive and lowering air quality as it helps generate "non-green" employment in transportation and other logistics.

- The vertical and horizontal integration of the food industry has raised productivity and lowered employment levels in some sectors of the global food system. Any growth in green employment must therefore confront or adapt to powerful trends to reduce labor inputs in the name of efficiency, productivity, and profitability.

- The spread of superstores and supermarkets is generating employment in facilities that consume large amounts of energy. Serious efforts to make food retail more environmentally sustainable will therefore have employment implications.

- Organic agriculture is growing, is more labor intensive, and brings environmental benefits. For these reasons, policies must be put in place that can help organics scale up dramatically.

Presently much of the employment in the existing global food system cannot be categorized as green. On the contrary, much of this employment is environmentally damaging, and the trends are moving away from green jobs rather than toward them. It is also very difficult for producers, both small and large, to disentangle themselves from these trends and build sustainable alternatives. However, opportunities for green employment have been identified both within the context of the existing global food system and also by way of small farming systems, local food, and organic produce. These opportunities exist in both industrialized and developing countries.

It would appear that the challenges to green employment are more formidable than the opportunities are promising. But much will depend on the policy and institutional frameworks established in the years ahead, from the international down to the local levels. If present trends, driven by market forces, continue, then any growth in green jobs will probably run counter to much stronger trends in the other direction. Only a decisive policy shift, driven by mass political pressure from civil society, and perhaps aided here and there by shifting consumer preferences for healthier and/or local food, has the power to intercept and reverse the trend toward more unsustainable practices.

Postscript: The Rising Cost of Food

It is necessary to note that, as this report was being prepared, the cost of food has risen sharply on world markets. According to the World Bank, global wheat prices increased 181 percent over the 36 months leading up to February 2008, and overall global food prices jumped 83 percent. The FAO's food price index rose by 40 percent in 2007, and the poorest countries spent 25 percent more on imported food. The soaring prices for staple crops, including wheat, rice, corn, and soybeans, have pushed up prices for grain-fed meat, eggs, and dairy products, spurring inflation throughout the consumer food market.

According to the FAO, these changes represent an "unforeseen and unprecedented" shift in the global food system, threatening billions of people with hunger and decreased access to food.[962] In 2008, rising food costs have lead to violent protests in Cameroon, Egypt, Ethiopia, Indonesia, Ivory Coast, Madagascar, Mauritania, the Philippines, and other countries. Responding to the price increases, in April 2008 the World Bank called for a "New Deal for Global Food Policy" and emphasized the recommendations of its 2008 *World Development Report*, discussed above. The new policy would "contribute to inclusive and sustainable development" that would benefit all countries—poor, middle-income, and developed.[963]

The present crisis will give further impetus to demands for a more sustainable, stable, and just global food system. This will open the door to further opportunities for green employment and decent work. However, the situation requires action that goes beyond emergency aid and temporary support.

Forests are major carbon sinks and providers of environmental services which are currently not paid for. Payment of such services can make many forms of forest conservation and sustainable forest management viable and provide stable employment and income for local populations.

6. Forestry

In 2006, the U.N. Food and Agriculture Organization (FAO) reported that forests cover nearly 4 billion hectares (about 30 percent of the world's land area), half of which is located in just five countries: Brazil, Canada, the United States, China, and Russia.[964] Forests serve as carbon sinks, absorbing carbon from the atmosphere and storing it in the wood, soil, and other organic material. Reducing the world's forested area permanently decreases the Earth's capacity to store future carbon emissions.

According to the IPCC, deforestation and forest degradation already contribute more than 18 percent of all greenhouse gas emissions, an amount larger than both the agriculture and transportation sector.[965] Perhaps more significantly, the world's forests store an estimated 4,500 gigatons of carbon dioxide in their ecosystems, an amount larger than all carbon currently found in the atmosphere.[966] A release of this stored carbon into the atmosphere, even over a long period of time, would have catastrophic effects on the planet.

Despite the increasing awareness in recent years of the unique and crucial role that forests play in climate stabilization, not to mention their capacity to protect water, soil, and biodiversity, deforestation continues at an alarming rate. Between 2000 and 2005, an average of 12.9 million hectares of forests were destroyed each year, of which 6 million hectares were primary forest, biologically diverse forests that remain relatively unharmed by human activities.[967] This rate was down only slightly from 13.1 million hectares per year in the 1990s.[968] The greatest losses have occurred in tropical forest regions of Africa, Southeast Asia, and South America. At the current rates, most of the top 10 deforesting countries are likely to have completely diminished their forest cover by 2100.[969]

Deforestation rates are somewhat offset by new forest growth and the replanting of trees (afforestation and reforestation), natural expansion of existing forests, and landscape restoration—bringing the most recent estimate of net forest loss to 7.3 million hectares per year.[970] Temperate countries have seen an expansion of both natural forests and new plantations, while the new growth in tropical countries is mainly a result of new plantations. This new forest growth is extremely important for carbon mitigation scenarios, but it does not compensate for the profoundly negative effects brought about by the destruction of primary forests.

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Workers carrying logs to stack. Overexploitation and lack of proper management have left 23 tropical nations in a position where they now have to import manufactured forest products, paying out in excess of $50 million a year. Malaysia.

Future projections show a slight increase in forest cover of 60 to 230 million hectares of land, primarily in the industrialized countries, and a decrease of 200 to 490 million hectares in developing countries.[971] The increase in forest areas in developed countries is therefore not enough to offset the decline in developing countries. The picture that emerges is a continued decrease in forest area, especially in the tropical forests, where rapid deforestation is occurring. Without drastically slowing the rates of deforestation while promoting smart land-use practices, it becomes nearly impossible to stop global climate change. The IPCC has identified several key land-use changes for carbon mitigation in the forestry sector, including: reduced deforestation and forest degradation, conservation, afforestation/reforestation, and sustainable forest management.[972]

Land-use changes in the forestry sector will likely result in economic implications for the people who depend on forests for employment, income, and subsistence.[973] Although the data on employment in the forestry sector are sparse, the forestry sector likely employs tens of millions of people and provides subsistence and income for hundreds of millions of others. This section of the report will discuss the current levels of employment in the forest sector and analyze possible economic and employment implications associated with a shift toward sustainable practices.

Employment Estimates

The forestry sector is considered to be a significant source of wealth and employment, especially in developing countries. Overall, the sector provides 1.2 percent of global GDP, with more than 10 percent of GDP in the poorest countries and about 5 percent in many developing countries.[974] Exact employment numbers in the forestry sector are, however, difficult to ascertain.

Forestry-sector employment should include all of the work required to plant, harvest, sustainably manage, renew, and protect forests as well as to process both wood and non-timber forest products (NTFP)—but it rarely encompasses all of these areas. Instead, forestry related employment often includes only the forestry workforce (roundwood production, reforestation, harvesting, fuelwood production) and wood-related industries (wood processing, pulp and paper) and often excludes NTFP such as building materials, medicine, food, and crafts. These latter products also generate employment, increase income, and improve health, and should be considered part of the forestry sector's employment zone.

Formal Employment

The most reliable data on formal employment in the forestry sector was collected between 1990 and 2000 and includes employment data for roundwood production, wood processing, and the pulp and paper industry. This information was recently re-published in the FAO's 2007 *State of the World's Forests* report. According to the report, total global employment in forestry in 2000 was 12.9 million, a 4 percent increase from 1990.[975] This employment was more or less divided equally among the three subcategories; however, the proportions differed by region.[976] (See Table II.6-1.) Developing countries tended to have a larger fraction of jobs in roundwood production, while developed countries dominated in wood-processing industries and the pulp and paper industry.

Table II.6-1. Formal Forest Sector Employment by Region, 2000

Region	Employment (million workers)	Employment Trends (1990–2000)
Asia and the Pacific	5.6	Overall, employment levels increased. The highest year was 1997 with an estimated 6.4 million workers.
Europe	3.5	Employment levels have been declining. Labor productivity is rising faster than production.
North America	1.5	Employment levels rose slightly at the beginning of the 1990s and have leveled off.
Latin America and the Caribbean	1.2	Total employment increased.
Africa	0.55	Employment levels increased by 30,000, from 520,000 persons in 1990 to 550,000 in 2000. This rise is attributed to an increase in wood processing.
Near East (Northern Africa, Central Asia, Western Asia)	0.4	Employment levels have been fairly stable.
World	12.9 million	

Source: See Endnote 976 for this section.

These data on formal-sector employment in the forestry sector are limited to the three subsectors and may not account for all formal-sector employment. An often-quoted estimate by Peter Poschen of the International Labor Organization puts the number of forest-sector workers in the formal sector at 17 million.[977]

Informal Sector and Subsistence Work

Jobs in the forestry sector are generally considered to be underreported. This is mainly due to the nature of the work, which is seasonal, often part time, and does not translate well into full-time employment. Countries with strong forestry industries, such as Canada and Indonesia, do report employment figures, but most other countries lump their forestry employment data together with agriculture, hunting, and fishing. Because of this, a large number of self-employed workers or farmers do not get counted by national statistics, or they get subsumed under larger catch-all categories. This is especially true of agroforestry, where global employment estimates soar as high as 1.2 billion people, which is a direct overlap with the number of people who are recorded as agricultural workers.[978]

National statistics of income and employment do not measure jobs in the informal sector. The FAO relies on microlevel studies for information on informal sector employment. These microlevel studies often suggest that the number of jobs in the informal sector far surpasses those reported in the formal sector, particularly in Africa, Asia, and Latin America. Informal employment data in the forestry sector fluctuate widely by source. Poschen's research identifies 30 million workers in the informal sector, for a total of 47 million for formal and informal combined.[979] The World Bank estimates that the forestry sector employs 60 million people both formally and informally.[980] Another estimate is as high as 140 million workers.[981] Despite these dramatic variations in employment estimates for informal sector workers, all three sources underscore the significance of informal workers in the forestry sector, pointing to the need for more research in this area.

Importantly, the vast majority of people whose livelihoods are dependent on forestry are not wage earners or even informal workers, but people who rely on the forest for subsistence. These people use the forest as a source of food, fuelwood, and income and are not considered in official forestry employment numbers. The World Bank estimates that roughly 1.6 billion people depend to varying degrees on the forest for their livelihoods, including 60 million indigenous people who are fully dependent on the forest and another 350 million people who live within or near forests and depend on them to a high extent for income and subsistence.[982] More than a billion of these people are engaged in agroforestry and are most likely counted as agriculture workers and forest-dependent people. These workers depend on the forest for food, income, shelter, and fuel and should be included in any discussion pertaining to the forestry sector.

The Role of Small and Medium Sized Forest Enterprises (SMFEs)

The forestry sector is characterized by both large, vertically integrated multinationals and thousands of small and medium-sized forest enterprises known as SMFEs. Not surprisingly, the data for SMFEs is very rough. These enterprises are thought to contribute more $130 billion to the global economy.[983] Mayers and Macqueen (2006) estimate that 50 percent or more of forest employment in many countries is found is SMFEs, and as high as 80–90 percent in some developing countries.[984] They speculate that at least 20 million people are employed in SMFEs, and estimates soar as high as 140 million when the informal sector is included.[985] These enterprises also employ the majority of people who produce small wood products. SMFEs are especially significant because they tend to be very labor intensive and can be a growing source of employment, especially in developing countries.

Trends in Employment

Despite the slight increase in employment over the past decade, as reported by the FAO, formal employment in the forestry sector has most likely decreased during this time. It is clear that there has been a decline in formal employment in the global North due to increases in productivity, outsourcing, and mechanization—but trends in the informal sector are much less apparent. For the informal sector, there is a shift toward informalization, but also toward mechanization. As the forestry sector becomes more highly mechanized, it is likely to see an overall decrease in both formal and informal employment.

Income in the forestry sector varies greatly by type of job, location, and employer, but there are general trends that exist within each subcategory. It is widely agreed that pulp-and-paper manufacturing jobs are the highest paid in the industry, followed by engineered wood-panel production and then sawmill jobs. Aside from a few developed countries, the logging industry is associated with very low wages. Many forestry jobs provide sporadic, part-time, and seasonal employment. This is especially true for informal-sector workers, who also lack benefits that may accompany formal sector work.

There has been a shift away from vertically integrated forest products companies toward global corporations that compete for capital in the global economy. Because of this, companies in the forest industry are under increasing pressure to generate a competitive rate of return.[986] One response to this market pressure is to reduce costs by reducing the number of workers with who have a formal employment relationship.. Such a response is a significant driver for a growing trend for forest workers to be defined as "independent" contractors rather than wage employees. By shifting this portion of production costs from the company to the contractor, the company is able to increase its return on investment (ROI). Such company business practices also relieve the employer from a number of social costs and can contribute to other governance issues.

Workers are often paid by piece rate, which frequently requires long hours under harsh working conditions to exceed poverty-level wages. This ongoing breakdown of the employment relationship and the growing decent work deficit brings a host of additional safety and health concerns to a sector that is already associated with hazardous working conditions. Jobs in the forestry sector, especially logging jobs, are in the top three most dangerous jobs in almost all countries.[987] According to the Building and Woodworkers International Union (BWI), "tropical loggers stand a one in ten chance of being killed over a working lifetime."[988] Informalization brings unskilled, untrained workers and high turnover rates which increase injuries and fatalities in the industry. Other jobs in forestry, like sawmill jobs, are described by Building and Woodworkers International (BWI) as "increasingly subcontracted and hazardous" and woodworking as constantly depending "on the workers' skills to avoid injuries, rather than on any prevention measures."[989]

Global Employment Estimates

Despite growing informality and mechanization, forestry is still a very significant sector, with roughly 1–2 percent of the global workforce and over a billion people dependent upon forests for their income and livelihoods. The forestry sector is also an important source of income and employment for developing countries and for rural communities where there are few available economic activities.[990]

The majority of workers in the formal forestry sector are men, but certain types of jobs, such as reforestation, fuelwood gathering, and agroforestry include an increasing number of women.

The lack of precise data on employment is reflected by the large variance between estimates, especially in the informal sector. The estimates for indigenous people who rely on forests for income and subsistence are also very rough extrapolations. By comparison, the data that exist for formal-sector employment appear to be much more reliable, although these data are also somewhat inconsistent compared to other sectors outside of forestry. There is a genuine need for better employment data in the forestry section, particularly in the informal sector and for people relying on the sector for their livelihoods. Table II.6-2 briefly summarizes the types of jobs that comprise the forest sector, along with highlighted characteristics and trends in the industry.[991] Table II.6-3 summarizes employment estimates for the sector.[992]

Table II.6-2. Employment Characteristics and Trends within the Forestry Sector

Category	Types of Jobs	Employment Characteristics and Trends
Forestry Workforce	Wood Harvesting Jobs (also called Logging or Forest Harvesting) Includes: chain saw operators, machine operators for tractors, loaders, cranes, harvesters and logging trucks, truck drivers, choker setters, etc.	• Over the past several decades, overall decreasing trends in employment due to increasing mechanization. • Increasingly contract and informal labor. • Considered one of the most hazardous types of work.
	Reforestation and Af orestation jobs (work includes: tree planting, fertilization, nursery jobs, weed and pest control, and pruning	• Mainly seasonal employment. • Women comprise 10–15 percent of the tree-planting workforce.
	Fuelwood Gathering	• Generally informal work for subsistence, but may provide some additional income for households. • 80–85 percent of all wood processing in developing countries is for fuel. • Mostly performed by women.
	Agroforestry	• 60–80 percent of farmers in the developing world are women and could benefit from agroforestry.
Wood Related Industries	Wood Processing: panel production and sawmill jobs and misc. wood products (furniture, crafts, construction materials, etc.)	• Panel production wages are second only to paper and pulp manufacturing, making them relatively high compared to other forestry jobs. • Wood processing comprises about one-third of all formal jobs, but also employs a huge amount of informal sector workers in developing countries.
	Paper and Pulp Manufacturing	• Generally provide the highest wages in the sector
Non-Timber Forest Products (NTFP)	Generally informal, small-scale, and subsistence work that includes gathering and picking of food products, medicine/ chemical products, and non-wood (bamboo, cork, thatching grasses) for construction and structural purposes	• Large numbers of informal and subsistence workers, predominantly in tropical areas and developing countries. • Generally excluded from forestry employment data. • Mostly non-mechanized work. • Work tends to be located in remote forest areas.

Sources: See Endnote 991 for this section.

Table II.6-3. Global Employment in the Forest Sector, by Type

Category	Number of Workers (millions)
Formal Sector Employment	12.9 –20
Informal and formal sector forest-based enterprises	47–140
Indigenous people who primarily depend on natural forests for their livelihoods (hunting, gathering, shifting cultivation)	60
People who live in or near forests and depend on forest for additional income	350
Smallholder farmers who use agroforestry practices	500 million–1.2 billion
Total (Rough Estimate)*	957 million–1.75 billion

**It is extremely dif cult to f nd accurate totals for the stated categories because:*
1) there is a large range of estimates, and,
2) some of the categories are likely to overlap. The 1.75 billion is likely an overestimate.
Sources: See Endnote 992 for this section.

Land-use changes will result in economic and employment implications. There many be new socioeconomic benefits provided by the new use of land, but there may also be lost economic opportunities from previous land uses, especially if the land was currently used for agriculture and provided income and subsistence for the farmers and workers. According to the IPCC, "the net effect of land-use change on employment, income, and equity cannot be determined a *priori*; it must be evaluated on a case-by-case basis. The social systems in each country will strongly influence the socioeconomic impacts associated with any given activity."[993] Even though each country or locality will have differences in how these land-use changes affect employment, there are also commonalities among specific land-use changes.

Avoiding Deforestation

Deforestation leads to increased levels of carbon emissions and continued loss of biodiversity. The IPCC has identified several key land-use changes for carbon mitigation, which will likely have an economic impact on the people who are dependent upon the forestry sector.

Avoiding deforestation remains by and large the biggest challenge in the forestry sector. Deforestation is widely believed to be the result of converting forests to agricultural land, resettlement, fuelwood collection, and unsustainable industrial logging practices. But the key underlying force behind deforestation is poverty and lack of economic alternatives. Low wages, unemployment, and lack of income for farmers and landless people force people to convert forestland for basic income and subsistence needs.

There is a direct link between poverty and deforestation. The poorest countries have the highest deforestation rates, both in terms of the total amount of forest lost and as a percentage of the country's forest cover. The top five countries with the greatest overall loss of forest cover from 2000 to 2005 were Brazil, Indonesia, Russia, Papua New Guinea, and Peru.[994] During the same period, Nigeria, Vietnam, Cambodia, Sri Lanka, and Malawi had the highest percentage of forest loss, with Nigeria and Vietnam destroying over half of their forest cover.[995]

Deforestation is by far the leading contributor to greenhouse gas emissions in developing countries. The third and fourth largest emitters in the world are Indonesia and Brazil, respectively (after China and the United States), with the vast majority of their emissions attributed to deforestation.

Reduced Emissions for Deforestation and Forest Desertification (REDD) Schemes

Most of the "Avoiding Deforestation" discussions at the December 2007 U.N. Climate Change Conference in Bali, Indonesia, revolved around Reduced Emissions from Deforestation and Forest Degradation, also known as REDD schemes. The basic premise behind REDD schemes is that deforestation can only be avoided by creating economic incentives or compensation for conservation. Payments travel via carbon markets or through direct aid money. Under these schemes, highly industrialized countries pay less-developed countries predominately in the Global South an amount commensurate to the emissions that are reduced. In theory, these avoided deforestation or REDD schemes would provide additional income for indigenous forest people and landless farmers as large sums of money are shifted from developed to developing countries.

There is general agreement that developing countries with forest area need financial assistance from the developed nations in order to reduce deforestation. The Stern Review on the Economics of Climate Change estimates that the amount of money needed for deforestation avoidance or prevention would equal roughly $5–10 billion annually.[996] Advocates of REDD believe that this money will directly benefit rural populations by generating increased employment and incomes. If this scenario unfolds, then the programs would be a source of much-needed green jobs for rural and forest economies.

The REDD schemes are not without their critics, however. Concerns have been expressed that the unequal structure of land ownership, as well as corruption, may prevent the economic benefits from actually reaching the intended recipients. These critics also warn that the World Bank, NGOs, and governments will make decisions without consultation with local forest people, who in many cases have historically been stewards of the forest. Some believe that reliance on market-based mechanisms will simply continue the problems that now plague overseas development assistance in general.

At this time, there are very few examples of REDD schemes and little empirical data on whether these programs actually provide additional sources of employment and income for indigenous people in forest communities. For this reason, an analysis of the economic benefits of these schemes is beyond the scope of this report. Assuming that the number of avoided deforestation and REDD schemes are likely to continue during the U.N. climate negotiations process, more information is needed on the economic and employment implications of these and similar programs and how funds would actually be distributed to the intended recipients.

Biofuels Boom

Tackling deforestation is likely to become more challenging as forests come under increasing pressure from the boom in biofuels. Biofuels production has been heralded in the past few years as a way for countries to reduce their carbon emissions, reduce their dependency on oil, and stimulate their local and rural economies. However, biofuels are now under increasing scrutiny from researchers and environmentalists for contributing to rising food prices and the loss of biodiversity, and for failing to reduce overall carbon emissions. Recent studies on biofuels have shown that if forests are cleared to produce biofuels, there is actually an increase in lifecycle emissions.[997] The reason for this is two-fold: first, when forests are cleared to make room for biofuels, carbon is emitted into the atmosphere; second, forests absorb more carbon than agricultural land and thus reduce the carbon absorption of the land.

The growth in palm oil production in Indonesia and Malaysia is particularly alarming. By 2005, global production of palm oil totalled 12 million hectares. Indonesia has the fastest rate of increase in the conversion of forest-covered land into large palm oil plantations. Despite the rising social and scientific opposition to palm oil and other biofuels, production is likely to continue because these fuels remain a highly profitable and relatively inexpensive source of energy.

The status of biofuels as a source of clean and renewable energy is presently a source of some controversy. Those who take a full lifecycle approach to this question often maintain that, when the deforestation and other land-use changes are considered, along with the quality of employment, the impact on emissions levels, and the energy inputs involved, then biofuels are far from green. Others hold a brighter view of biofuels, especially "second-generation" fuels derived from sources like switchgrass. But for now, workers engaged in the production of biofuels cannot yet be categorized as green in any definitive sense, and more work needs to be done in this area.

© TopFoto
Oil palm fruit is loaded into presses and the oil collected in large tanks underneath, at this factory in North Sumatra, Indonesia.

Afforestation and Reforestation

Afforestation and reforestation projects replace non-forest land with new forest cover. Afforestation differs slightly from reforestation in that it uses land that was not formerly forestland. Both projects are effective ways to increase carbon absorption and reverse desertification, which is often caused by deforestation and poor agricultural practices.

The United Nations Environment Programme (UNEP) recently launched a major tree-planting campaign called the Plant for the Planet: Billion Tree Campaign with the goal of planting 1 billion new trees each year. The number of trees already planted exceeds 2.1 billion, while the number of pledged trees is 3.6 billion. Due to the success of the program, UNEP has expanded its goal to plant 7 billion trees by the end of 2009.[998] Participating countries include Ethiopia, Mexico, Turkey, Kenya, Cuba, Rwanda, South Korea, Tunisia, Morocco, Myanmar, and Brazil.[999]

While it may seem obvious that these afforestation and reforestation projects would be considered green employment, it is important to consider what type of work is generated from these activities. Currently, the industry standard is dominated by seasonal, contract work. The planting season is very short, particularly in temperate forests, where workers may be employed for as little as 8–12 weeks. Tree planting is also generally low paid with few-to-no benefits. Payment is commonly determined by piece wages, which often leads to rushed work and long hours on the job. Creating "green" jobs may necessitate more-vigorous project requirements to ensure that decent work is created with above poverty-level incomes.

The amount of new employment generated will also depend largely on the size of the project and whether the work is manual or mechanized. Mechanized tree planting has a much lower labor intensity than manual planting. Machines are able to plant between 400 and 1,500 trees per hour depending on the type of machine, the size and species of the seedling, and the skill level of the crew.[1000] Manual reforestation is physically challenging and is done at a much slower pace. Manual forestry workers literally dig holes and plant tree seedlings in the ground. On the positive side, mechanization generally increases safety and the ability for companies to pay higher wages.

Other afforestation and reforestation work includes cutting down extra trees, removing brush around the trees, slash burning, and pruning the new trees to maximize tree growth. Afforestation and reforestation jobs also include the workers who grow seedlings in nurseries and people who transport trees to the forest.

Afforestation and reforestation projects that remove carbon from the atmosphere have recently been included under the Clean Development Mechanisms (CDM) of the Kyoto Protocol. The first project, officially registered in November 2006, involves restoring 2,000 hectares of eroded land in the Pearl River Basin in China in order to develop a sustainable harvesting industry for local communities.[1001] Over the next several decades as countries and companies try to grapple with how to reduce their carbon emissions, more and more CDM afforestation and reforestation projects are likely. Because decent work standards are not required under the current CDM rules, the work created by these projects is likely to follow the industry standard. This could change over the next several years if governments are willing to discuss minimum work rules required for CDM eligibility. Certainly there is no way of knowing with any degree of certainty whether or not these afforestation and reforestation projects will have positive or negative consequences for communities, but it is more likely to have positive benefits if these jobs provide decent employment for workers.

Agroforestry

Agroforestry, a type of afforestation project, is the process of planting integrated tree systems on agricultural land in order to diversify and increase the productivity of the land. Agroforestry practices include: agrosilvicultural (planting trees with crops), silvopastoral (trees with livestock), and agrosilvopastural (trees with both crops and livestock). There are a multitude of environmental benefits associated with agroforestry, including watershed protection, enhanced biodiversity, and improved soil quality. These practices extend the period of agricultural production on the land, therefore reducing the need to clear additional forestland. For this reason, it is considered a practice that can help slow tropical deforestation.

Agroforestry has a greater potential to sequester and store carbon than most land-use changes. The potential exists not in the level of carbon stored, but in the vast amount of underutilized land that can be enhanced by adopting this practice. Depleted agricultural and recently deforested land can be transformed into high productivity cropland and store an average of 80 tons of carbon per hectare or more.[1002] According to the World Agroforestry Center, there are 600 million hectares of unproductive cropland that could be converted into high-productivity farming with a medium-level carbon sequestration potential. Additionally, 300 million hectares of agricultural land could become more sustainable through agroforestry.[1003] As global climate change leads to rising temperatures accompanied by increased storm intensity and changes in rainfall patterns, the adoption of agroforestry practices will become increasingly important in helping farmers adapt to changes in the environment.

Integrating trees with crops and livestock is not a new concept. Farmers have practiced agroforestry to varying degrees for hundreds of years. Because of the myriad environmental benefits, farmers who effectively adopt or enhance their agroforestry practices could be considered green agricultural workers. In recent times, more and more poor farmers have used agroforestry practices to help sustain their livelihoods. The World Bank estimates that there are nearly 1.2 billion people who already depend on agroforestry to some extent for food, fuelwood, and non-timber forest products (NTFP) for subsistence and additional sources of income.[1004]

Many large agroforestry projects have been developed in Africa, Asia, and Latin America. There is a general consensus that agroforestry has a positive impact upon farmers, but there is limited data on individual projects. The following is a brief snapshot of recent agroforestry projects in Africa, as compiled by the World Agroforestry Centre:

- In East Africa, about 200,000 smallholder dairy farmers use agroforestry to produce fodder as an additional source of food for their livestock. Cost analysis showed that farmers who planted an average of 500 trees increased their farm income by over 25 percent, from \$95 annually to \$120. These funds are generally used for household improvements and school fees for children.[1005]

- In Tanzania, more than 300,000 hectares of degraded soil were renewed through the indigenous 'ngitili' system, a method where native trees are planted on grazing land in order to protect the land during the dry season. This process was shown to increase earnings, provide better nutrition, increase crop production, and reduce time spent collecting fuelwood.[1006]

- In 2003, an estimated 200,000 farmers in Eastern and Southern Africa were using leguminous trees instead of fertilizers on their maize farms.[1007]

Despite the fact that many smallholder farmers already practice agroforestry to some extent, its potential still has not been met. Comprehensive agroforestry programs—which include some combination of fruit trees, medicinal trees, timber, fertilizer trees, and fodder for animals—have the capacity to alleviate poverty, improve health, and help meet the Millennium Development Goals. Agroforestry also contributes to food security and improved health by increasing the amount of food and farm products available for consumption. This helps fulfill the subsistence requirements of agricultural households and has been shown to reduce hunger, improve nutrition, and increase accessibility to medicinal trees.

Agroforestry can also help alleviate fuelwood shortages by growing timber on agricultural land, which is especially significant for women who make up 60–80 percent of small farmers and are often burdened with traveling far distances to collect wood. The increased production and diversification of farm products can also lead to supplementary sources of income as farmers are able to sell additional products in local markets. Agroforestry also has a great potential for employment generation, especially for rural areas.

One study that looked at 200 farms in India showed an income increase from \$56–\$60 an acre per year to \$598– \$786 an acre per year through the integration of multiple types of trees.[1008] The increased income was attributed to selling fruit and timber as well as other activities such as basket weaving and raising livestock. Employment for the farmers also increased from seasonal to year-round work, thereby eliminating the need for farmers to migrate in search of additional work. While it is widely accepted that developing comprehensive agroforestry practices increases income, these projects are limited by the lack of funds available. These projects have large upfront costs and an extremely long payback period, and therefore must rely on external funding sources. Unless there are large, ongoing, sustainable sources of funds designated for agroforestry, they are unlikely to be scaled up in a way that makes a significant impact on deforestation and greenhouse gas emissions.

Sustainable Forest Management (SFM)

Illegal logging remains one of the major barriers toward achieving sustainability in this sector. Illegal logging practices range from avoiding taxation to extracting wood from a protected area. These practices undercut the prices of sustainably managed forests and make it difficult for companies engaged in sustainable forest management (SFM) to compete. While weak governance and corruption in forest countries are often blamed for illegal logging practices, the demand for lower-priced wood products in developed countries is also a main driver behind illegal logging as countries or regions like the United States, European Union, Japan, and China have done little to stop the purchase and import of illegal logs.

Table II.6-4 shows some of the highest estimates of illegal logging in selected countries.[1009] The practice is pervasive throughout developing countries, but it also exists in the European Union, Canada and the United States to a somewhat lesser extent. The World Bank estimates the total market value of timber lost to illegal logging to be more than $10 billion per year. It also estimates that an additional $5 billion in uncollected taxes and royalties is lost due to corruption.[1010]

Table II.6-4. Estimates for Illegal Logging, Selected Countries

Country	Share of Logging that is Illegal (percent)
Cambodia	90–94
Bolivia	80
Brazil	20–47, as high as 80 percent in some regions
Indonesia	60–70
Peru	80
Ecuador	70
Gabon	70
Papua New Guinea	70
Ghana	60
Cameroon	50
Myanmar	50
Russia	50 in Russian Far East 10–15 in North-West Russia

Sources: See Endnote 1009 for this section.

From an employment and income perspective, illegal logging relies on cheap labor and would not be considered decent work. In addition, local communities and governments are further hurt by the loss of large sums of tax revenue that could be used to improve basic infrastructural needs (schools, hospitals, roads, water, energy, etc.).

Roundwood Production

Roundwood production, which includes industrial wood products such as pulp for paper, lumber and wood panels, as well as wood for fuel, is on the rise. From 1961 to 2005, roundwood production has increased steadily from 2,342 million cubic meters to 3,503 cubic meters per year.[1011]

Industrial wood and fuelwood each share about half of total roundwood production, but these wood products vary widely between developed and developing countries, with industrial products used mainly in the developed countries and fuelwood used predominantly in the developing countries.

In 2005, the United States, India, China, Brazil, Canada, and Russia produced about half of the total global roundwood production.[1012] Even though China is one of the top producers, it is also the largest importer of roundwood.[1013] China's overall imports of roundwood have tripled and its trade with Russia has increased 21-fold over the past decade.[1014] Rising fuel prices have contributed to the growing demand for wood as a cheaper alternative to fossil fuels.

Roundwood production is expected to continue on this growth pattern as the global population increases and as the growing demand for paper, building materials, and cheap sources of fuel continues. Approximately one-third of the world's forests are already used mainly for wood production, fiber, and non-timber wood products.[1015] This increased demand for wood and other non-timber forestry products (NTFP) puts additional pressure on a system that is already compromised by deforestation and illegal logging—underscoring the need for a sustainable forestry sector.

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Land desecration in the Amazon in the name of progress. Venezuela

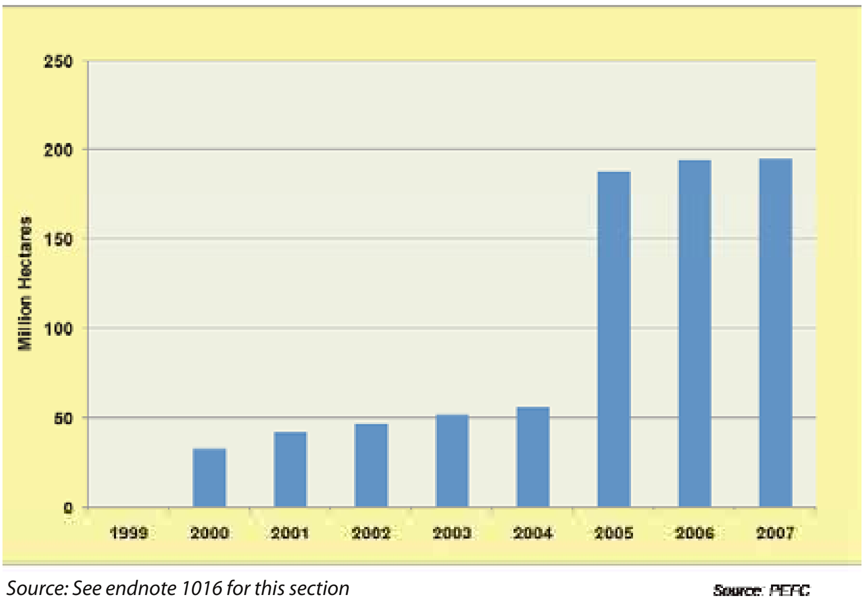
Sustainable Forest Management and Certification Schemes

Following a series of failed intergovernmental agreements in the 1970s and 1980s, sustainable forest management (SFM) emerged in the early 1990s as a method to combat deforestation and illegal logging. The basic premise behind SFM is that the production of forest products must be balanced with maintaining forest ecosystems in order to ensure that forests are available for future generations. It is based on three pillars of sustainable development: economic, environmental, and social. Although there are no universal standards, there are several key elements for SFM focusing on biological diversity, conservation and the health of forests, soil and water resources, carbon mitigation, socio-economic benefits, and the productive capacity of forests.

Certification standards have been developed in many countries and regions of the world to enhance sustainable forest management at the forest level. There are currently over 50 different certification schemes, but the most commonly used ones are the Forest Stewardship Council (FSC) and Programme for Endorsement of Forest Certification (PEFC) schemes. Certification schemes work by providing labels on wood and wood products that guarantee to purchasers and customers that the products were produced in a sustainable manner.

Certification represents only a fraction of the total global wood market and forestry sector, but has been growing especially rapidly in the last few years.[1016] (See Figure II.6-1.) These schemes are being driven by governments like the European Union and by major retailers like IKEA and Home Depot, who are increasingly requiring certification as a cost of doing business. Certification schemes are currently limited by consumer demand and by the willingness among corporations and countries to demand certified projects. The cost of certification can also be a major barrier for small landowners and those in developing countries. Despite these limitations, certification represents a substantial portion of internationally traded timber. Even though certification is a voluntary system, it appears that it may become a prerequisite for the international timber trade.

Figure II.6-1. Growth of PEFC-Certified Forests, 1999–2007



Source: See endnote 1016 for this section

Certification schemes are still largely concentrated in the Global North. Table II.6-5 shows the global distribution of Forest Stewardship Council certificates.[1017] Although there are 79 countries that participate in FSC certification, more than 80 percent of the certified forest cover is concentrated in North America and the European Union.[1018] PEFC's certificates are similarly concentrated in the Global North, with Canada at 76 million certified hectares out of PEFC's total 194 million hectares while Brazil has less than 1.0 million certified hectares.[1019] (See Table II.6-6.) In 2005, the International Timber Trade Organization reported that less than 5 percent of tropical forests (2.4 percent of protected forests, 7.1 percent of productive forests) were sustainably managed.[1020]

Table II.6-5. Forest Stewardship Council Participation by Region, 2008

Region	FSC-Certified Area (hectares)	Number of Certificates	Share of Total FSC Certification (percent)
Europe	51,738,120	409	50.01
North America	33,568,390	143	32.45
South America and Caribbean	11,541,973	251	11.16
Africa	3,011,293	40	2.91
Asia	1,974,650	59	1.91
Oceana	1,621,973	31	1.57
Total	103,456,399	933	100

Source: See Endnote 1017 for this section.

Table II.6-6. PEFC-Certified Forests, 2007

Country	Endorsed Certified Forest Area (hectares)	Chain of Custody Certificates (number)
Canada	76,022,900	90
United States & Canada (SFI*)	54,565,945	23
Finland	20,719,735	113
Australia	8,674,169	15
Norway	7,537,102	10
Germany	7,272,106	601
Sweden	4,289,287	72
Austria	3,960,200	239
France	3,318,556	957
Czech Republic	1,849,754	221
Chile	1,681,578	15
Spain	1,047,989	108
Brazil	973,830	2
Slovak Republic	862,067	6
Italy	641,774	71
Switzerland	403,916	228
Belgium	255,122	105
Denmark	206,395	18
Latvia	80,761	3
Luxemburg	25,469	6
United Kingdom	0	523
Netherlands**	0	53
Japan**	0	42
China**	0	8
Portugal	0	7
Hungary**	0	3
India**	0	1
Ireland**	0	1
Malaysia**	0	1
Morocco**	0	1
New Zealand**	0	1
Philippines**	0	1
Total	194,388,657	3,545

**SFI = Sustainable Forestry Initiative. **A number of timber and paper processing or trading companies in the country hold the international PEFC Chain of Custody certif cation where there is no national PEFC-endorsed certif cation scheme. Source: See Endnote 1019 for this section.*

Employment Consequences of Sustainable Forestry Management

There are several key employment benefits provided by sustainable forestry management and certification schemes. Practicing sustainable forest management means that the forests will be maintained for as long a period of time as there is a market value or legal protections, which provides long-term employment opportunities for rural economies. Certain certification schemes also have very specific standards for employment. For example, the PEFC, FSC, and the Malaysian Timber Certification Council (MTCC) require that in order to be certified, certain employment standards must be met including compliance with national labor laws and international agreements, minimum health and safety rules and protective equipment for workers, guaranteeing the right to join a union, training and education programs, and no child labor.[1021]

A major study by Yale University looked at certification schemes in several developing countries and found that the overall economic and employment consequences of certification were mixed. The outcomes differed by country, but in general the positive outcomes were additional tax revenue, increased wages, improved working conditions, and market transparency, which led to compliance with contracts and less illegal logging. There were varied results with regard to how certification affected the number of jobs. In most cases, certification led to increased levels of employment, but for at least one case, there was an overall decline in the number of jobs. Certification puts limitations on the production of timber, which led to a decrease in the number of hectares harvested, and decreased volume can, at least in the short term, reduce the number of jobs.[1022]

Conclusion

Jobs in the forestry sector should be more broadly defined to include all work that provides income and helps alleviate poverty. These jobs include the formal sector, informal sector, and subsistence workers. Currently, it is unknown how many people are employed in the forestry sector, but a rough estimate of those who are dependent upon forests to some extent for income and subsistence is likely to be between 1 and 1.75 billion.

It is widely accepted that land-use changes in the forestry sector are desperately needed and that these land-use changes will result in economic changes. Due to the lack of information about employment in this sector, it is impossible to give a global quantification of green jobs that might be created through agroforestry, afforestation and reforestation, sustainable forest management (SFM), and avoided deforestation projects. These sustainable land-use changes are likely to have positive long-term impacts on employment measured both in the quality and quantity of jobs. These sustainable land-use changes may, however, have some immediate negative consequences, but sustaining this sector is likely to have a long-term positive effect on employment as jobs are extended over a much longer period of time.

Much of this uncertainty around green employment in the forest sector is due to a lack of information about general employment in the forestry sector. The next Global Forest Resource Assessment (GFRA), published by the FAO, will be released in 2010. This report presents an opportunity to compile a clearer and more consistent picture of forestry employment data. According to the 2005 GFRA report, "a focused effort should be made to improve the quality of employment statistics in a few key countries in which the reported statistics are missing, or are very high but may be based on minimal survey data or very simple estimation techniques."[1023] The 2005 report included information from 138 countries; the 2010 report hopes to include 235 countries and territories. The 2010 survey will also "generate unprecedented information on deforestation, afforestation, and natural forest expansion."[1024] In order to understand green employment in the forestry sector, it is imperative that the 2010 GRFA and similar studies analyze the employment and other socioeconomic impacts of these land-use changes.

Part III
Outlook and Conclusions

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Adults receiving vocational training at Kiatec, a Private Sector electronics manufacturer. Kampala, Uganda.

1. A Fair and Just Transition

This section of the report considers the social dimension of the transition to a sustainable, low-carbon economy. The transition itself will be a social process. It involves technological innovations, shifts in business and investment strategies, as well as a new set of policies—all of which are products of social interactions and negotiations.

The transition will also involve businesses, workers, communities, and movements. It will produce new green jobs and the greening of some existing jobs. However, it will also result in job losses and jeopardized livelihoods in certain regions, communities, industries, and economic sectors. In particular, energy-intensive industries, extractive industries, and road transport could witness serious job declines.[1025] Faced with this scenario, calls are emerging for a "fair and just transition," whereby those harmed by the changes are adequately assisted, and the new opportunities created are shared by specific groups of workers, social constituencies, and communities. For convenience, we will refer to this as a "Just Transition."

There appears to be an emerging framework that allows for a Just Transition to operate on several levels, ranging from the global-societal level down to workplaces and local communities. This framework is grounded in some well-established social practices in the face of job challenges, and is reflected in the ongoing work of the ILO, the trade unions, national and local governments, business and industry, and community-based organizations. However, it is a framework that has been structured around a principle and a goal. The principle holds that the costs and benefits of a transition to sustainability should be shared widely across society. The goal is to generalize this principle at the level of policy. Steps are being taken here and there to turn the Just Transition approach into reality, but there is still a long way to go before it becomes a policy norm.[1026]

Historical Experience

While major economic transitions in the past have led to significant social and economic progress for society, it is also necessary to note that fair and just transitions have not happened often in history. In fact, the story of the social impacts of economic change throughout history is replete with countless examples of often serious hardships. In recent decades, deindustrialization in the developed world and the impact of structural adjustment programs and excessive liberalization in some developing countries are examples of these poorly managed transitions. Overall, modern society often has struggled to deal effectively with the social negatives triggered by major economic turbulence and change. This history weighs heavily on the shoulders of those who hope to ensure that the next great economic transition—the transition to a green and sustainable economy—will depart from this often discouraging script.

The story of economic change is, however, also a story about political choices. More often than not, these choices have put the accumulation of wealth before the needs of the majority. Policymakers have also shown a propensity to let accommodations to economic change be left to market forces, especially given the fact that economic transitions are occurring all the time and such changes are often socially and economically beneficial. However, the transition to a sustainable economy and the qualitative expansion of green employment is likely to resemble no other transition in human history. It is a transition that will be assisted by market forces to some extent, but other market forces will push against the needed changes. The scope of the transition will be global and it will need to proceed at a pace that's more or less unprecedented in economic and social history. In just two or three decades, the entire global economy will need to be well on the road to a low-carbon and sustainable future. Markets cannot drive the transition, and neither can they be relied upon to deal with the problems that the transition will inevitably create.

Thus, the effort to expedite a Just Transition to a green and sustainable economy will also involve a new set of approaches and policy options. The need to green our economy presents an opportunity to make the right policy decisions, but there is nothing intrinsically fair or just about either the process of becoming green or the end result—this must be pursued politically within the overall paradigm of sustainable development whereby the social dimension is fully and equitably integrated into the economic and environmental dimensions.

Fortunately, the effort to create a Just Transition can draw encouragement from the long tradition of social and labor legislation put in place to protect the poor and disadvantaged, to facilitate and enable the creation of socially necessary work, and to embed social solidarity in the fabric of economic life. But perhaps the key to understanding the potential of a Just Transition is not to view it simply as some kind of safety net, but as a means to bring economic life into a democratic and sustainable framework, one grounded in meaningful social dialogue and driven by broadly shared economic and social priorities. The issue, then, is not simply about the transition itself, but what follows the transition—the goal being a new mode of production and consumption that allows for greater social inclusion, equity, and opportunity.

The ILO Framework

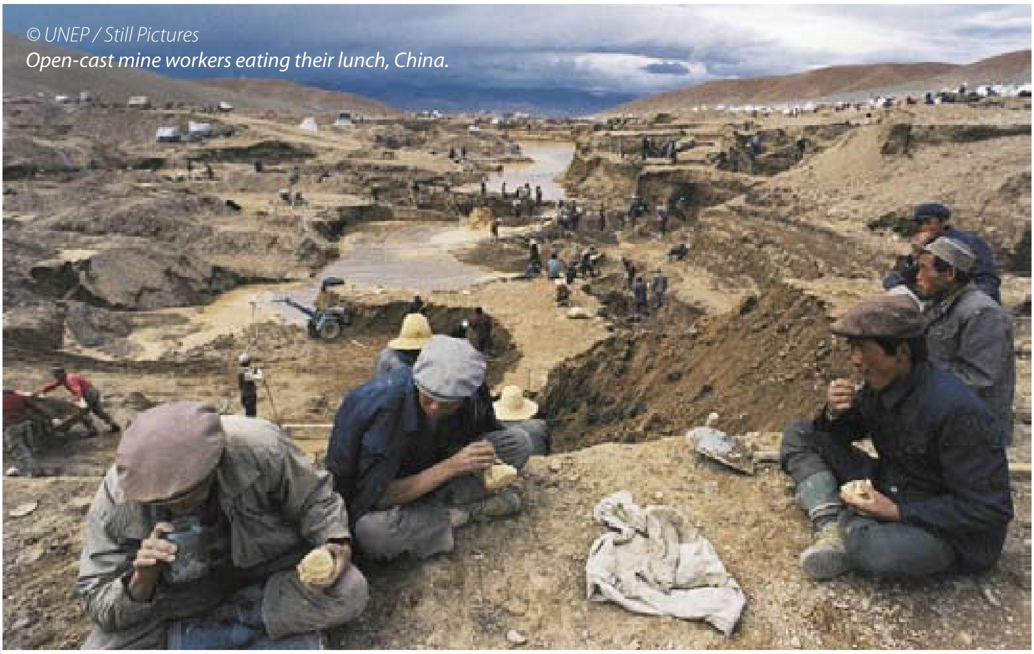
The framework for a Just Transition will need to be erected on five broad and interlinked foundation stones, as identified by the ILO. Although only briefly summarized here, these foundation stones are central to the issue of managing economic transitions and shaping economic futures in global terms.

1. ***Workers Rights.*** The expansion and enforcement of workers rights allows for workers to associate freely with other workers and organize if they so wish. The capacity for workers to do this will help ensure that a Just Transition will actually take place. Basic workers rights were embodied in the ILO's Declaration of Philadelphia in 1944. Moreover, the 1998 ILO Declaration on Fundamental Principles and Rights at Work is an expression of commitment by governments, employers' and workers' organizations to uphold basic human values. The main mechanism through which the ILO Conventions are implemented is national government legislation and enforcement of labor market legislation.

2. ***Decent Work.*** Rights must be accompanied by opportunities for decent work, as defined by the ILO's Decent Work Agenda. Decent work is work that takes place 'under conditions of freedom, equity, security and dignity, in which rights are protected and adequate remuneration and social coverage is provided.'[1027] Decent work has four pillars: Employment, Social Protection, Rights, and

Social Dialogue. Gender equality is an integral cross-cutting theme in the decent work agenda, with particular focus on the process of creating equal opportunities for women, enhancing their social protection, ensuring that the human rights of women are addressed, and enabling them to participate in social dialogue. The ILO regards decent work as central to efforts to reduce poverty, and as a means for achieving equitable, inclusive, and sustainable development.

The ILO established the Decent Work Agenda as a response to the fact that many millions of people face deficits, gaps, and exclusions in the form of: unemployment and underemployment; poor-quality and unproductive jobs; unsafe work and insecure income; rights that are denied; gender inequality; migrant workers who are exploited; lack of representation and voice; and inadequate protection and solidarity in the face of disease, disability, and old age.



© UNEP / Still Pictures
Open-cast mine workers eating their lunch, China.

3. ***Social Protections.*** The ILO and others advocate for a "social floor" and rights-based approach to protections. The ILO's Declaration of Philadelphia of 1944 stated that, "poverty anywhere is a threat to prosperity everywhere," thus establishing the principle that "all human beings have the right to pursue both their material well-being and their spiritual development in conditions of freedom and dignity, of economic security and equal opportunity."[1028] The presence of a solid social floor is conducive to a Just Transition in that, in principle, it allows workers and communities to shift into new forms of sustainable economic activity without the fear of falling into extreme poverty. It also encourages risk-taking and entrepreneurial activity in the new green economy. The absence of such basic protections, however, will compel workers to resist change in some instances and engage in environmentally damaging economic activities in others.

4. ***Social Dialogue.*** A Just Transition will only be true to its name if transition policies are designed and implemented with the active participation of those whose lives they affect: employers, workers, and farmers, ranging from the national level to the local level, on farms, in offices, and on factory floors. In order to move from unsustainable industries to more sustainable ones, workers, employers, and

governments need to cooperate. Social dialogue at the national level through planning, education, and preparation of changes will make such transition more fair and efficient. The main goal of social dialogue is to promote the building of a consensus and the democratic involvement of the main stakeholders in the world of work. Successful social dialogue structures and processes have the potential to resolve important economic and social issues, encourage good governance, advance social and industrial peace and stability, and boost economic progress.[1029] Social dialogue has occurred at the national level through various tripartite mechanisms involving employers, trade unions, and government bodies. Today, social dialogue happens at the community level and in the workplace, and in companies that are seeking to reposition themselves to take advantage of green business opportunities.

5. ***Sustainable Businesses.*** The International Labor Conference convened by the ILO in June 2007 discussed the promotion of sustainable enterprises. The conclusions of that discussion provide an important contribution agreed to by the ILO's tripartite constituency of governments and employers' and workers' organizations on how to promote enterprise development in a manner that aligns enterprise growth with sustainable development objectives and the creation of productive employment and decent work. The conclusions identify and elaborate on 17 pillars of an environment that is conducive for sustainable enterprises; outlines six enterprise-level principles; and provides guidance to governments, the social partners, and the ILO in promoting sustainable enterprises. Another important tool related to sustainable enterprises within the UN system is the Global Compact, which asks companies to embrace, support, and enact a set of 10 principles in the areas of human rights, labor standards, the environment, and anti-corruption. The Global Compact provides a platform for responsible corporate behavior and a framework within which an employers' policy on climate change can be developed and help contribute to a Just Transition. The OECD Guidelines for Multinational Enterprises and the ILO Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy both provide useful frameworks for the development of sustainable enterprises.

Business Approaches to Just Transition[3]

Many leaders of the business community recognize the need for more sustainable forms of production and consumption. Business also largely accepts that climate change is a shared problem and that climate stabilization is a shared responsibility. But just as there are risks and opportunities for workers, the same is true of employers. Business therefore sees a compelling need to ensure that the burdens of responsibility for achieving sustainability and climate protection are distributed equitably. Government support and assistance for business should be provided where needed.

In general, the sustainability of enterprises will be contingent on their capacity to honor their social obligations while at the same time remaining commercially viable producers of goods and services. Failure to achieve the latter will make the former more or less irrelevant, because only commercially successful businesses can continue to employ people and thus serve communities. Indeed, the ILO recognizes "sustainable enterprises are a principal source of growth, wealth

3 The views and perspectives of the International Organization of Employers (IOE) shared with the authors have been particularly helpful in the preparation of this section.

creation, employment and decent work."[1030] It is therefore in the public interest to ensure that businesses remain viable in the traditional commercial sense in order to be sustainable.

The transition-related obligations of businesses can therefore extend only so far. Just as workers, especially those not protected by collective agreements or with the means to access entitlements, must be able to call on their government to act on their behalf and to provide direct assistance, then the same rights must be extended to business who are similarly vulnerable and in need of financial and technical aid. However, governments' capacity (and willingness) to accept responsibilities for both workers and businesses will also vary considerably. Governments, in protecting the interests of entire societies and as overseers of economic development, should promote the viability of private and public enterprises and help to preserve their capacity to employ, reward, and protect workers. In this view, helping companies therefore almost invariably helps workers and communities.

Moreover, governments must also concern themselves with the "micro" economic issues that affect the sustainability of enterprises. These include the need to provide the working capital to meet extraordinary commitments for redundancies or relocations as well as the infrastructure to provide education, training, retraining, and even influencing of consumer attitudes and trends. Governments therefore have a responsibility as part of their economic and social management programs to ensure that all the links in the supply chain can withstand the challenges of transition, and to ensure the economy as a whole remains viable and sustainable.

Regarding the environment, the Global Compact articulates three principles for business to follow. Firstly, businesses should support a precautionary approach to environmental challenges; secondly, businesses should undertake initiatives to promote greater environmental responsibility; and thirdly, businesses should encourage the development and diffusion of environmentally friendly technologies. These principles serve as important points of reference for businesses as they attempt to address the key environmental challenges. They are intended to direct activity to areas such as research, innovation, cooperation, education, and self-regulation that can positively address the significant environmental degradation, and damage to the planet's life-support systems, brought by human activity.[1031]

The capacity of individual businesses or the business community as a whole to apply these principles on a day-to-day basis remains, however, both an unanswered question and a formidable challenge. There are differences of philosophy and approach between businesses and civil society actors (especially trade unions) around who should shoulder what responsibilities. Businesses frequently have a broad range of obligations to consider. They have obligations to governments as taxpayers, to consumers, suppliers, and investors, as well as to employees and communities. They usually operate in a competitive marketplace and can sometimes ill-afford to make commitments to workers who they no longer require.

As discussed elsewhere in this report, many investors today routinely expect returns that would have been regarded as exceptional just two or three decades ago, and within shorter time frames. Still to be explored is the impact that climate change in particular will have on the terms and conditions of employment. New issues will surely arise that will have as-yet unknown effects on the workplace, labor markets, and the social negotiations that will determine the shape and character of the transition to a sustainable future. Traditional labor-management tools and mechanisms for negotiation are likely to be particularly useful. These tools and mechanisms may constitute the first line of defense and a platform for action in shared efforts to deal with the employment and societal challenges that lie ahead.

Meaningful social dialogue is therefore critically important both to ease some of the tensions between business, trade unions, and civil society around the coming transition, and to frame the issues in ways that can help realize the many mutually beneficial features of a green and sustainable future. The alternative is a protracted and potentially destructive battle over social and material resources that will be to the detriment of all involved.

Trade Union Approaches

The trade unions have paid considerable attention to the idea of a Just Transition, and thus their contribution deserves particular consideration. The trade union understanding of the concept of Just Transition often combines elements of strategy (as a component of education, mobilization, and bargaining); a policy or collective bargaining "mechanism" to aid certain groups of workers affected by employment changes; or an overarching principle like that of social solidarity.

The term Just Transition has roots in the U.S. labor movement. Its origins can be traced back to efforts of the Oil Chemical and Atomic Workers (OCAW, now part of the United Steelworkers) to negotiate a "Superfund for Workers" when the 14,000 acre (5,670 hectare) Ciba-Geigy chemical facility in New Jersey was closed down in the mid-1980s because its toxic footprint had attracted opposition from environmental groups and government officials. More than just a demand for income protection for the plant's 650 workers, the union also sought a program of government-funded retraining for the displaced employees.

The trade unions' approach to Just Transition is entirely consistent with the ILO's efforts to win broad and meaningful commitments to workers rights, basic protections, decent work, and social dialogue. Like the ILO, unions have been pressuring governments and employers to make these commitments long before the present challenge to building a green economy moved to center stage. Unions understand that Just Transition cannot occur without an employment-focused macroeconomic policy. It also means that businesses need to make efforts to ensure that the concerns of communities where their operations are taken into account are adequately addressed.

But the starting point for the trade unions is the realization that the transition to a green economy will create both risks and opportunities for workers. Therefore, the trade unions have made Just Transition a top priority. While enthusiastic regarding the prospects of green employment growth, trade unions wish to ensure that workers who lose their jobs as a result of moves toward sustainability should be adequately protected and assisted. This is not just an issue of equity, but it is also means to reduce resistance to change among groups of workers who would stand to lose as a result of environmental or climate protection policies.

The International Trade Union Confederation (ITUC) and the Trade Union Advisory Committee to the OECD (TUAC) have highlighted the need for worker retraining and protections for those who are driven out of the labor market either permanently or temporarily. Unions are also concerned that communities harmed by the closure of workplaces are targeted for fresh investment as part of a Just Transition, and that new jobs created (like green jobs in general) are of good quality and pay enough to sustain workers and their families. At the UN's climate change negotiations, the ITUC and TUAC have also promoted the need for further research on the short and long-term employment effects through sector-by-sector and regional employment analyses.[1032]

Just Transition is, however, more than just about the protection of those who might be negatively impacted by climate protection and other environmental policies. Unions have also highlighted the need to involve workers in all levels of decision making, but especially in the workplace where the worker/union voice is needed in determining the design of new sustainable production systems and work practices.

According the Canadian Labour Congress

This (Just Transition) requires workers' participation and control over our own future. Otherwise, any environmental change will be incomplete and one-sided; it will benefit only the rich and privileged. Just Transition is essential to the process of environmental change. Many of our members work in jobs that will become obsolete if unsustainable production, environmental degradation and resource exhaustion are allowed to continue along their current path. But if workers' health and livelihoods in high-paying quality jobs are to be secured, there will have to be safeguards so that workers are not simply thrown on the scrap heap as a sustainable economy, in both the manufacturing and service sectors, takes the place of unsustainable modes of production. The labour movement has a vital role, not only in working for Just Transition, but in following up the moves to sustainability, so that displaced workers continue to work in a union environment, with all the benefits and protections that unions have offered in the past.[1033]

Just Transition is therefore a building block for a sustainable economy. Accordingly, unions have sought to establish the idea of a Just Transition in the ongoing debates on sustainable development. The ITUC and TUAC have participated in the negotiations dealing with the implementation of the Kyoto Protocol. They have highlighted the need to obtain workers' support in order to reach a global consensus on prevention of climate change.[1034]

Trade & Technology Transfer

Many businesses, trade unions, and communities in both the developed and developing world are concerned that a Just Transition be based on equitable trade relationships. Regarding climate protection, policies aimed at reducing emissions require strong regulatory measures and constraints to achieve compliance. Countries with emission reduction commitments (such as EU countries) have implemented various mechanisms in order to reduce the greenhouse gas intensity of their economies, the main one being the carbon market. As regulations become tighter, many anticipate that the competitiveness of these industries is likely to be affected as direct competitors in countries with no emissions-reduction targets would not be required to pay this extra 'carbon cost.'[1035]

Energy-intensive companies operating in internationally traded sectors and covered by the EU's Emission Trading Scheme (EU-ETS), especially those involved in iron and steel, or cement, are faced with a carbon price that does not apply to their competitors operating outside the EU. As the Confederation of British Industry (CBI) notes, it is difficult to estimate the precise impact this will have on different sectors, but it could be enough to make some industrial processes in the EU uncompetitive particularly if, as will be necessary, the overall cap is tightened. This could potentially encourage production to relocate elsewhere, which would not help to reduce global emissions but which would cause considerable damage to the European economy.[1036]

The ETUC, while supporting the European Commission's "Energy and Climate Change" package released in early 2008, has called for the introduction of a carbon tax (or a "border adjustment mechanism") from heavy industry imports entering the EU from countries that have not made similar commitments.[1037] However, unions recognize that these mechanisms may negatively affect developing countries, and thus provisions are needed for resultant proceeds of the tax or mechanism to expedite the adoption of green technologies or adaptation measures. A differentiated adjustment mechanism is needed to help ensure that developing countries do not face an additional burden on top of the effects of climate change itself.[1038]

There remains a pressing need to increase technology transfer to the developing world for the purpose of facilitating cleaner economic growth on the basis of the lowest possible cost within the shortest possible time frame. Any transfers of climate-friendly technologies to developing countries should occur under preferential rather than full market-based commercial conditions. This will allow business and governments in the developing world to use clean technologies and thus take important steps toward sustainable development. This will require developed countries to fully implement their commitments in this area under the Kyoto Protocol. Article 11 of the Protocol calls for developed country parties to "provide such financial resources, including for the transfer of technology, needed by developing country parties to meet the agreed full incremental costs of advancing the implementation of existing commitments."[1039]

However, the problem of reconciling WTO rules on trade-related intellectual property rights (TRIPs) with access to clean technologies for developing countries will need to be resolved. IPRs confer monopoly rights and can curb affordable access through higher prices that usually include monopoly profits. They can also be a barrier to the introduction or upgrading of technology by private industry or public-sector agencies in developing countries. The insistence on the full protection of intellectual property in relation to climate-friendly technology risks erecting a major barrier to technology transfer.

As noted elsewhere in this report, adequate support for programs for adaptation to climate change is critically important. Governments must act to enhance poverty reduction and climate change adaptation through the creation of green and decent jobs, as these forms of employment contribute to sustainable economic growth and lift people out of poverty. These actions can lay down important pathways to overcoming vulnerability to climate change.

Just Transition in National Contexts

National governments, employers' organizations, and union bodies are in a number of instances presently working towards the goal of a Just Transition. There has been considerable discussion around the need to rethink national energy policy, and to set social dialogue at the national and sectoral levels.

In Spain, government agencies, employers, and unions have worked hard to establish mechanisms for social dialogue on climate protection in several sectors, namely energy, oil refining, iron and steel manufacturing, glass and ceramics, cement production, pulp and paper production, and (most recently) transportation and construction. Among other things, these "social dialogue roundtables" are empowered to monitor progress toward reaching emissions targets, and developing criteria to allocate emissions for each installation (based on the sectoral allocations approved by the European Commission.) However, the roundtables are also concerned with identifying and reducing adverse social effects, in particular those related to competitiveness and employment as the result of Spain's efforts to comply with the Kyoto Protocol.[1040]

In Germany, a broad coalition of government, industry, unions, and environmental NGOs have collaborated around initiatives to renovate buildings for climate protection purposes, while at the same time creating sustainable jobs and improving social conditions. The job creation aspect of a Just Transition has been demonstrated through the Alliance for Work and Environment, which aims to renovate 300,000 apartments, create 200,000 jobs, reduce 2 million tons of CO2 emissions annually, and lower heating bills for tenants, landlords, and the state by about $4 billion, through reduction of unemployment costs, increased income taxes, etc.

In the Netherlands, the national "Green4Sure" project aims to develop a comprehensive energy plan to halve the country's greenhouse gas emissions by 2030, based on 1990 levels. The effort has been spearheaded by unions (ABVAKABO FNV and FNV Vakcentrale), in partnership with environmental organizations. The main focus of the study was the policy instruments used by the government to reach the emissions target. The policies in question concerned the development and deployment of new technologies, greater use of climate-neutral energy sources, and inducing behavioral change. One of the goals of the plan is to create a pathway for these emissions reductions that does not seriously impact incomes and leads to no net loss of jobs.

In the United States, the idea of a Just Transition has been captured in proposed Congressional legislation on climate protection. As of early 2008, legislation developed by Senators Lieberman and Warner (the Lieberman-Warner bill) contained several pathbreaking provisions to help workers displaced by the effects of emissions-reduction measures. These provisions include quality job training to any workers displaced, temporary wage assistance, health care benefits to workers in training programs, and other measures. The draft legislation also puts in place mechanisms to transition workers into new jobs created by the legislation and "to provide skilled workers to enterprises developing and marketing advanced technologies and practices that reduce greenhouse gas emissions." The assistance to workers also includes "travel costs incidental to participation in a training program" and "a portion of the cost of relocating to a new job."[1041]

In Argentina, the General Confederation of Labour (Confederación General de Trabajo—CGT) has a 'Framework Environmental Agreement' with the government that expounds the incorporation of environmental clauses in collective agreements and the participation of workers in policy processes to achieve sustainable development. Plans have been proposed to offer training for trade union "environmental delegates" and to promoted good quality green jobs in different economic sectors.[1042]

© Jenny Star: ***Demonstration.***

Greening the Workplace

Another critically important dimension of a Just Transition concerns efforts to green the modern workplace. Here, employers and unions are beginning to work together in the greening process, building on a long tradition of collaborating on occupational safety and health.

Companies and trade unions have worked together to establish and implement workplace targets for efficiency and waste minimization. Together, they hope to contribute to the creation of a new workplace culture that will ensure reduction of greenhouse gases in production and the life cycle of products as well as make substantial changes to personal and community consumption patterns of workers.

Within the international trade union community, unions in the United Kingdom are perhaps furthest along in developing this work. The TUC's GreenWorkplace project is particularly noteworthy in that it involved support for unions to make six demonstration workplaces "greener."[4] Focusing on energy saving as a key priority, the greening process began in 2006 with employee opinion surveys, open days or open "events" with outside speakers from environmental organizations, training for "green reps," and building member support for negotiations with management. The efforts often led to

4 The six workplaces are Corus, Friends Provident, DEFRA, TUC, Scottish Power, and British Museum.

new bargaining structures such as joint environment committees being established or worked toward, facilities time granted, new reps coming forward, and formal agreements on facilities time being worked toward.[1043]

According to the TUC

The project involved union "green reps" being able to conduct their own workplace energy audits and to get management to measure and report information on energy costs for the first time. Actual or potential energy/carbon savings were identified in all projects. There were widespread benefits in terms of raised awareness in the movement and increased demand for (TUC) training courses, speakers at conferences, and a high number of affiliate conference policies being passed, particularly the demand for statutory bargaining rights on the environment.

In the United States, the 1.9 million member Service Employees International Union (SEIU) has launched several green workplace initiatives. "Conservation in California" involved an SEIU janitors' local (branch) forging an innovative partnership with building owners to cut the use of electricity by 10 percent in major office buildings statewide. Work schedules were modified to limit the amount of cleaning at night, and janitors were trained to turn off lights, machinery, and computers and implement other conservation programs. In New York, the 80,000 member SEIU Local 32BJ has been providing green building training to building and maintenance members in New York City. Funded through a state agency, it started as a six-session class and has now expanded to 11 sessions. It includes detailed training on energy and water conservation, green chemicals, ventilation and heating systems, energy audits, and more. A "carbon footprint class" is the most recently added segment. SEIU is also aiming to reduce the fuel and electricity consumption of SEIU Members to reduce their bills and their carbon footprints.[1044] The Canadian Union of Public Employees is pursuing a number of initiatives of a similar nature.[1045]

The workplace-level approach to a Just Transition also poses the need for governments to legislate in favor of improved labor rights, such as right to participate, "right-to-know" (about workplace emissions, technological choices, plans for energy saving, use and efficiency), whistleblower protection, and the right to refuse unsafe or environmentally harmful work. However, it also underscores the potential for collaborative action in the workplace and an important role for joint labor-management committees and similar bodies. Among other things, these committees could work to identify ways to improve energy efficiency, more efficient use of water and other natural resources and raw materials, and low-carbon work schedules.

Traveling to Work

A Just Transition must also address the issues of mobility and gaining access to work. In the global South, millions of workers live on the streets or on rooftops in order to be close to sources of employment in high-rent inner-city areas.[1046] Countless others, due to lack of adequate public transportation, spend hours every day traveling to and from work. In the developed countries, traveling to work also consumes an enormous amount of time and energy.[1047] More and more unions around the world are therefore including mobility plans in their collective agreements, and more and more unions are demanding an urban planning and public transportation systems that respect workers and the environment.

In South Africa, the main union federation, COSATU, has launched a "Red October Campaign." This campaign seeks to draw attention to the problems resulting from the apartheid policy of forcing Africans to live far from their place of work. According to COSATU, "The situation has been aggravated by the decision to shut down rural rail lines and by the deterioration in many rural roads. This has undermined farm and rural processing industries, aggravating the already high joblessness of the rural areas." The campaign fights for an efficient municipal bus system and a substantial increase in investment in commuter rail. These demands have spilled over to calls for: "(a) concerted effort to build more working-class housing near the cities. We need to see a vast expansion in the effort to renovate high rises in city centres. We need more medium and high-density settlements. And we need improved provision of government services and retail sites in black townships that are distant from the cities."[1048]

Job Losses and Retraining

Unions are understandably concerned about the loss of jobs, especially in energy-intensive industries. However, employment numbers in extractive industries and related sectors such as oil refining are limited—and falling. This is particularly true for coal mining, despite the fact that coal production continues to grow. (In the United States, for example, coal production rose by close to one-third during the past two decades, but mining employment fell by 50 percent.) In most instances, the decline in fossil fuel-based employment is being driven primarily by increased mechanization and labor productivity increases, and not by a policy shift away from fossil fuels. These declines are expected to continue irrespective of any significant shift in energy policy toward renewable sources of energy. But they can be expected to accelerate under a climate stabilization policy.

Especially where industries are highly concentrated in one or a handful of regions, these impacts can have serious consequences for the local economy and the viability of communities. These regions will need proactive assistance in creating alternative jobs and livelihoods, acquiring new skills, and weathering the transition to new industries.

Training "Green Collar" Workers

Both employers' organizations and trade unions have drawn attention to the fact that a transition to a green economy will create demand for workers, many of them in skilled trades or professions, and that filling these positions will require adequate training programs. The British CBI has expressed concern that sectors going green are experiencing a "skills gap" affecting the supply of technical specialists, designers, engineers, and electricians, "as well as appropriately trained sales staff in the retail sector, and project managers specialising in delivering a range of mitigation and adaptation solutions." [1049] The U.S.-based National Association of Manufacturers has for some years insisted that U.S. workers lack the skills required to serve modern manufacturing, green or otherwise.[1050]

The capacity of business and industry to adapt their enterprises to climate change will be a vital component to a Just Transition. Along with the skills gap can be placed the "management challenge," which will consist in the development of new perspectives, awareness, and managerial capacities. According to Susan Helper, these new capacities will also require new styles of management. Developing new production systems "is not just a matter of sending some blue-collar workers to be trained. Managers must be willing and able to learn new skills as well, and to make use of the skills their subordinates have obtained. Supervisors must be retrained from being disciplinarians to being coaches."[1051]

Employers' organizations and other business groups can facilitate the transition process by encouraging their affiliates and partners to engage in social dialogue and to take practical action within the workplace on these issues. In some developed countries, the level of deindustrialization has become so advanced that efforts will need to be made to ensure that the green manufacturing sector is capable of functioning without crippling bottlenecks and skills gaps in the workforce. Investment in workforce development is therefore critical.[1052] At the global level, the ITUC has linked the skills gap issue to the need for a full package of programs providing "compensation, retraining, re-employment and re-location, with special emphasis on the most vulnerable workers including women."[1053]

Community-based organizations have also become involved in the Just Transition discussion. While seldom using the term Just Transition itself, organizations representing low-income populations have promoted the idea that green-collar employment provides a "pathway out of poverty" for individuals and communities in economically depressed or marginalized areas. In the United States, many of these community organizations are linked to the "environmental justice" movement. This movement draws attention to the fact that working-class communities of color are far more likely to be situated next to toxic dumps and waste management facilities, and also suffer poor air quality as a result of heavy vehicles driving through their neighborhoods.

U.S.-based groups are also eager to address the fact that young people of color often have difficulty gaining access to apprenticeship programs for skilled trades—at a time when skilled workers are ageing and shortages of skilled workers are becoming a major concern for employers. Women workers, too, have only just begun to make inroads into trades that were for generations the exclusive domain of male workers. According to the U.S. Department of Labor, in the coming decade the construction industry alone will have to recruit and train nearly 250,000 new workers each year—not factoring in additional jobs due to the scaling up of green work such as retrofitting and installation of solar power. In a 2005 survey by the National Association of Manufacturers, 90 percent of respondents indicated a moderate to severe shortage of qualified, skilled production employees like machinists and technicians. Similarly, the National Renewable Energy Laboratory has identified a shortage of skills and training as a leading barrier to renewable energy and energy efficiency growth.[1054] A truly Just Transition will therefore require that the doors to the new green economy be fully opened to those who had difficulty finding their place in the "old" economy for reasons related to discrimination or lack of skills, resources, or opportunities.[1055] (See Box III.1-1.)

Box III.1-1. The Oakland Green Jobs Corp: Opening Doors to the Green Economy

The Oakland Green Jobs Corps is a job-training program that provides a pathway into green careers for Oakland, California, residents with barriers to employment. Beginning in the fall of 2008, it will provide young adults with job training, support, and hands-on work experience so they can independently pursue opportunities in the new energy economy. The Oakland Green Jobs Corps is a central achievement of the Oakland Apollo Alliance, co-convened by the Ella Baker Center for Human Rights and the International Brotherhood of Electrical Workers Local 595.

The Oakland City Council recently approved $250,000 to fund the Corps, providing a vital pool of seed funding for attracting matching funds over the long term. The first three months of the program will provide wrap-around services including basic literacy, life skills, and job readiness training; financial management; environmental awareness; and other specialized support services. Trainees will also go through several rotations learning vocational hard skills related to green-collar work in key sectors. Participants will finish the program with six-month paid internships in renewable energy, energy efficiency, and green construction projects.

Local firms have joined an Oakland Green Employer Council and are playing a critical role by shedding light on their workforce needs and providing internship placement opportunities for Corps trainees. The Ella Baker Center and the Oakland Apollo Alliance have been champions of the program, but they will not run or house the Oakland Green Jobs Corps program. The $250,000 seed funding from the City will be awarded competitively through an RFP (Request for Proposals), thus identifying the best-qualified people in Oakland to run the program. Ideally, this will result in a partnership of organizations that includes a job-training program, a community college, employers, labor unions, and other institutions that together can provide the complete Oakland Green Jobs Corps curriculum and pathway. For more information, see www.ellabakercenter.org/gcjc.

Source: See Endnote 1055 for this section.

The issue of workers' training and skills will be taken up at the ILO's 97th Session of the International Labour Conference (ILC) in June 2008, under the title "Skills for improved productivity, employment and development." The report prepared for the general discussion provides a comprehensive review of these issues and highlights two objectives of special relevance to the green jobs discussion here. The first objective is to "demonstrate how lifelong learning minimizes the displacement costs of technological change by preparing workers for alternative employment." The second objective is to "increase recognition of the importance of synchronizing national skills development policies with policies on technology, trade and environment." The ILC report includes a separate chapter on anticipating and managing the impact of three key global drivers, including climate change, and highlights all three elements of skill development policy, namely: "taking advantage of emerging opportunities by matching the demand for and supply of new skills; facilitating adjustment and mitigating its costs for workers and enterprises adversely affected by global changes, and sustaining a dynamic development process."[1056]

The Flexicurity Option

In recent years, there has been an attempt to reconcile a solid "social floor" with the needs of a modern competitive economy for labor market flexibility. This effort has given birth to the concept of "flexicurity"—a term reflecting the embrace of flexible working arrangements while at the same time preserving a high level of social security. The political impetus behind this concept comes from the EU-15 countries and their concerns to reposition their economies in the face of competitive pressures from emerging economies, and for the real or perceived need to raise productivity, innovation, and labor market participation. According to the EU Commission, this framework allows for "more and better jobs through flexibility and security."[1057] Central to the flexicurity model is a shift "from job security towards employment security."[1058] The core elements of the flexicurity model are:

- Flexible and secure contractual arrangements and work organizations, both from the perspective of the employer and the employee, through modern labor laws and modern work organizations.
- Active Labor Market Policies (ALMP), which effectively helps people to cope with rapid change, unemployment spells, reintegration and, importantly, transitions to new jobs—i.e., the element of transition security.
- Reliable and responsive lifelong learning (LLL) systems, to ensure the continuous adaptability and employability of all workers, and to enable firms to keep up productivity levels.
- Modern Social Security systems, which provide adequate income support and facilitate labor market mobility. This includes provisions that help people combine work with private and family responsibilities, such as childcare.

As a process variable this definition includes: "Supportive and productive social dialogue, mutual trust, and highly developed industrial relations are crucial for introducing comprehensive flexicurity policies covering these components."[1059]

The flexicurity approach may facilitate the effort to develop a Just Transition, and clearly overlaps with the central principle that workers need income, employment, and labor market security rather than a particular job in a particular industry with a particular employer. However, while flexicurity today appears to be working reasonably well in a few advanced European economies (such as Denmark), many will question whether it is even plausible to imagine such a system being put in place in many countries of the developing world (or, for that matter, some developed countries).

Presently, Denmark commits roughly 4.5 percent of annual GDP to the social programs that sustain the flexicurity model. According to economic analyst Robert Kuttner, a similar commitment on the part of the United States would require an investment of $600 billion annually.[1060] Presently, "current U.S. spending on all forms of government labor-market subsidies—of which meager and strictly time-limited unemployment compensation makes up the most part—is about 0.3 percent of GDP, less than $50 billion."[1061] Also, by way of comparison, India presently spends 4.8 percent of GDP on health care.[1062] For many, the flexicurity model is compelling, but the political and social will to dedicate the resources necessary for it to function will prove critical to its prospects of becoming applied beyond a few wealthy countries.

Challenges to Just Transition

This section has sketched out a framework for a Just Transition that extends from the level of the workplace to the broader global-societal dimension. Within its scope fall issues of protection, retraining, and relocation of workers displaced from declining industries; the generation of good-quality green jobs that are available to all communities; and the question of fair trade, technology transfer, and ensuring sufficient funds for adaptation to climate change. Meaningful worker and community participation is seen as an essential feature of the transition, as is social dialogue at all levels of decision making.

The real-world challenges to this kind of Just Transition framework are, however, formidable. At the global-societal level, the foundation stones of enforceable workers' rights and decent work are a long way from being installed. These decent work and rights deficits often transmit down to the local level. Establishing a moral economy based on social solidarity in an environment of intense competition is therefore a major challenge. As suggested above, the notion of "flexicurity" has been offered as a way to reconcile these tensions, but what might be relatively successful in the rich Nordic countries may have more difficulty becoming established in the economically stressed regions of the world where resources are often scarce.

Aside from the "resources challenge," however, Just Transition faces five additional challenges:

1. ***The Employment Challenge.*** There is simply not enough decent work being created in today's global economy to absorb the growing number of people entering the labor market, and the trend is generally toward more informality and precariousness, not less. Moreover, the work generated by the new global production systems often falls short of the standards set by the Decent Work Agenda, and in many countries employers and political leaders are seeking more labor-market flexibility as a way to advance growth and competitiveness. Today, approximately 1.5 billion people, or one-third of the working-age population worldwide, are either unemployed or underemployed. Roughly, 1.3 billion workers are "working poor" who are unable to earn enough to lift themselves and their family members from serious poverty. Globally, this constitutes a massive challenge to the green-jobs future based on a Just Transition.[1063]

2. ***The Rights Challenge.*** Rights lie at the core of the Decent Work Agenda. However, the implementation of the ILO's core labor standards is often weak. The emphasis on flexibility and competitiveness has in many instances made it difficult for workers to either gain access to their rights and to use them effectively (by organizing unions, for example).

3. ***The Social Protection Challenge.*** Some of the problems connected to insufficient levels of decent work and the weak enforcement of rights could be ameliorated by high levels of social protection. But the idea of building a solid "social floor" has been under attack in recent decades, and reinstating it as a priority will require a major policy shift in the direction of social solidarity and some degree

of wealth redistribution. Health care and education are just two examples where there has been an international trend away from universal coverage toward marketization and fee-for-service approaches. Whatever the benefits this approach has produced for some, it has also meant less protections for others and brought with it higher levels of social inequality.

4. ***The Social Dialogue Challenge.*** Employers and governments routinely engage in social dialogue—but it is a dialogue that often excludes civil society organizations like trade unions and NGOs. Establishing a full commitment to social dialogue is therefore a challenge to a Just Transition. However, there is also the issue of putting in place the capacity for dialogue in the form of opening pathways for information sharing, training, and awareness building. Both employers and trade unions need to develop their capacity to have a meaningful say in policy negotiations at the local, regional, state/provincial, national, and international levels. Training programs in specific economic and social and environmental matters are therefore needed. Skills development and training of workers and management staff in the principles of productive social dialogue is therefore essential.

5. ***The Equity Challenge.*** In the absence of a decisive turn toward broad global-societal commitments to workers rights, decent work, social protections, and social dialogue, it remains necessary to at least ensure that specific features of the transition are relatively fair and just. The two obvious features are, firstly, the protection of workers whose jobs have been lost and livelihoods compromised as a result of the transition to a green and sustainable economy, and, secondly, ensuring that green jobs and related opportunities are spread equitably among all groups and populations. The problem of racial exclusion from the "old economy" was referred to above, but gender exclusion from certain trades and professions as well as "glass-ceiling" type obstacles to women's attempts to negotiate traditional career ladders remains a serious problem and one that must be tackled effectively in any transition process that aims to be truly equitable.

At first glance, these challenges seem more manageable. But why should a coal miner who loses his or her job as a result of climate protection policies be protected when a coal miner who loses his or her job as a result of mechanization (or some other reason) is more or less without comparable support? This is one of many problems of a more targeted approach to a Just Transition. Against a general background of turbulence and change where workers are expunged from their places of work with alarming frequency, any provisions put in place to protect one group of workers from the associated hardships will be regarded as inequitable by those for whom no provisions have been extended.

A Just Transition can be advanced through precise and targeted policies aimed at specific workers, social constituencies, and communities. A compensation package here, or a green jobs training program there, may in their own way make the transition to a sustainable economy more fair and just. But a Just Transition may in the end require a fairly seismic policy shift toward more or less universal rights, social solidarity, and protections, and the creation of decent work is clearly overdue. This shift was necessary before the issue of green jobs became fashionable. It is even more necessary now

2. Conclusions and Recommendations

This report is being published at a time when interest in green jobs has reached extraordinary levels. With this interest has come an infectious optimism regarding the potential of green employment. In a sense, the green job has become something of an emblem for both a new and sustainable economy and a more just society.

Much of the present optimism around green jobs is justified. The growth of green employment in many countries is already very significant. This report presents a series of quantifications, estimates, and projections of green jobs around the world, in addition to anecdotal and circumstantial evidence of green jobs growth and potential.

There are, of course, many remaining data gaps. Governments must establish statistical reporting categories that recognize and help capture relevant employment in both newly emerging industries and green employment in established sectors. As the German government has done, governments should also commission in-depth modeling and econometric efforts to analyze not just direct green jobs but also those that are related in a more indirect manner. Business associations and trade unions can play a useful part as well. Some have begun to do job surveys and profiles, but far more of these kinds of efforts are needed. Attention also needs to be given to disaggregating data on the basis of gender in order to ensure that there is equality of opportunity for women and men for green jobs. And greater scrutiny of supply chains is warranted, to better understand just how much many traditional businesses and occupations are positively affected and reinvigorated by the greening of the economy.

Key Job Findings

Energy Supply

- ***Renewables.*** Renewable energy sources are expanding rapidly. We estimate current employment at about 2.3 million jobs worldwide. Given incomplete data, this is in all likelihood a conservative figure. The wind power industry employs some 300,000 people, the solar PV sector an estimated 170,000, and the solar thermal industry more than 600,000, many of the latter in China.

- ***Biofuels.*** About half of all present renewables jobs are found in the biofuels industry. However, there are rising doubts about the environmental benefits and economic impacts of at least some types of biofuels. In addition, the bulk of biofuels jobs are found at sugarcane and palm oil plantations, where wages are low, working conditions often extremely poor, and worker rights at least in some cases suppressed. Many of these jobs can hardly be described as good or decent employment.

- ***Fossil Fuel Industry.*** A greening of the economy implies a much-reduced role for fossil fuels. But the oil, natural gas, and coal industries are not major employers, and with each passing year, growing automation and mechanization translates into fewer jobs—sometimes even in the face of expanding production. The coal industry epitomizes these trends. Countries like China, the United States, Germany, Britain, and South Africa have all shed many hundreds of thousands of jobs. In the United States, coal output rose by almost one-third during the past two decades, yet employment has been cut in half.

- ***CCS***. Carbon capture and sequestration has been offered by the coal industry and a number of trade unions as a way to reduce coal's carbon footprint. There are many remaining questions regarding how much carbon emissions could be reduced in this manner, whether the technology actually works, and whether carbon can reliably remain sequestered for long periods of time. Being capital intense, it appears unlikely that CCS could become a significant source of employment. And there is a danger that CCS will absorb scarce investment resources that otherwise might be devoted to renewables and energy efficiency.

Buildings

- ***Energy Efficiency.*** Nearly all efficiency measures, especially in the building sector, show positive employment and economic effects. A 2000 study by the U.K. government concluded that for every $1.4 million (€1 million) invested in residential energy efficiency, 11.3 to 13.5 FTE (full-time equivalent) jobs were created.

- ***Green Buildings.*** Using current technology, high-performance buildings have the potential to save energy by at least 80 percent compared with traditional building construction. Jobs in this sector are likely to be performed by people who already work in the building sector, but redefined in terms of new skills, training, and certification requirements. Currently there are over 40,000 LEED-Accredited Professionals in the United States.

- ***Retrofitting.*** In the building sector, retrofitting has the largest potential to reduce greenhouse gas emissions by 2030, creating jobs in construction, building operations, auditing, architecture, engineering, manufacturing, and administration, among others. Most of the jobs are performed directly at the work site, which is significant for rural and developing economies. From 2001–2006, through $5.2 billion (€3.8 billion) in public investment and $20.9 (€ 15.2 billion) in private investment, Germany's retrofitting program resulted in 342,000 apartment retrofits and the creation of 145,000 additional FTE jobs in 2006.

- ***Efficient Building Components.*** According to the McKinsey Global Institute, the building sector has four out of the five most cost-effective ways to reduce emissions: lighting, insulation, air conditioning and water heating. The U.S. Department of Labor estimates that higher standards for clothes washers, water heaters, and fluorescent lamp ballasts would create 120,000 jobs in the United States through 2020.

Transportation

- ***Railways.*** By dint of their high degree of energy efficiency, railways can generally be regarded as sources of green employment. Unfortunately, the trend over the last few decades has been away from railways in many countries, and toward cars, trucks, and planes. Employment—both in operating rail lines and in manufacturing locomotives and rolling stock—has fallen accordingly. Railway jobs in China and India fell from 5.1 million to 3.3 million during 1992–2002. In Europe, railway employment is down to about 900,000 jobs; the number of workers in manufacturing rail and tram locomotives and rolling stock there has declined to 140,000.

- ***Urban Mass Transit.*** Employment statistics for urban transit are incomplete and trends vary considerably by city and country. But some 1.3 million people work in public transit in the European Union and the United States alone. Bus Rapid Transit systems are being put in place in growing numbers of cities around the world, providing affordable and reliable transit options. There are also substantial green employment opportunities in retrofitting diesel buses to reduce air pollutants, and in substituting cleaner CNG or hybrid-electric buses. In New Delhi, the introduction of 6,100 CNG buses by 2009 is expected to lead to the creation of 18,000 new jobs.

- ***Automobiles.*** An assessment of the most efficient cars available today suggests that relatively green auto-manufacturing jobs may number about a quarter million out of roughly 8 million direct jobs worldwide. The bulk of these are in Europe and Japan. The number of green jobs elsewhere, including the United States, China, and India, is still very limited. But Thailand has launched a promising initiative to produce more fuel-efficient cars and thus to green a good portion of its 182,000-strong vehicle manufacturing workforce.

- ***Two- and Three-Wheelers.*** Highly polluting two-stroke engines are ubiquitous in developing countries, and particularly in Asia. Pilot projects in the Philippines suggest that retrofits cut fuel consumption by 35–50 percent and emissions of air pollutants by as much as 90 percent. Many jobs can be created through installing and servicing retrofit kits.

Basic Industry

- ***Steel.*** Secondary steel production, based on recycled scrap, requires 40–75 percent less energy than primary production and can therefore be seen as a proxy for greener production. Worldwide, 42 percent of output was based on scrap in 2006. Possibly more than 200,000 jobs are involved in secondary steel production worldwide. Scrap use is particularly pronounced in Turkey, Spain, the United States, South Korea, Germany, and Japan. Reusing byproducts such as steel slag is another way of greening parts of the industry; in the United States alone, close to 3,000 people are employed in slag recovery.

- ***Aluminum.*** Recycling aluminum scrap uses only 5–10 percent the amount of energy it takes to make aluminum from scratch. About one-quarter of global production is scrap-based. No global employment numbers exist for such secondary production. But the United States reports about 6,000 employees in secondary production, and Japan has about 12,000. Europe has an estimated 10,000 direct and indirect jobs in aluminum recycling. China's numbers are unknown, but given the country's large production and low labor productivity, they must be substantial.

- ***Cement.*** The cement industry can become greener through energy-efficiency improvements and by using alternative and recycled content. Although these measures may make existing jobs a pale shade of green, it is not expected to be a major source of new green employment.

- ***Pulp and Paper.*** Recycling paper is the fastest-growing source of new green employment in the pulp and paper industry. The World Bank estimates that in 2002, Brazil had over 28,000 formal jobs in paper recycling. In developing countries, paper recycling is often performed by an informal network of scrap collectors. In countries like Brazil and Colombia, scrap collectors have begun to form cooperatives in order to increase working conditions and pay.

- ***Recycling.*** The Bureau of International Recycling in Belgium estimates that its members in 60 countries employ more than 1.5 million people. But this is a serious undercount. Recent reports put the number of recycling and remanufacturing jobs in the United States alone at more than 1 million. Jobs in this sector in Western Europe and Japan can be assumed to be even more numerous, as these regions have achieved higher rates of recycling than the United States. In China, an estimated 10 million people are employed in all forms of recycling, with 700,000 alone in electronics recycling. Brazil is thought to have some 500,000 recycling jobs. Communal recycling and composting efforts in all likelihood add many additional jobs.

Food and Agriculture

- ***Organic Farming.*** With sales reaching $100 billion in 2006, organic farming is beginning to register an impact. Greener and somewhat more labor intensive than industrialized agriculture, the conversion of more farmland for organic production could provide a good source of green employment in the future. A study of 1,144 organic farms in the United Kingdom and the Republic of Ireland showed that they employed one-third more full-time equivalent workers per farm than conventional farms. Organic agricultural land amounts to 4.3 percent and 1 percent of the total farm area in these two countries, respectively. If 20 percent of farmland became organic in both countries, there would be an increase of 73,200 jobs in the United Kingdom and 9,200 in Ireland.

- ***Urban Agriculture.*** An estimated 800 million people already grow their own food in urban areas. This may generate few jobs in the conventional sense, but individual families and groups organized in cooperatives working to grow their own food are sustaining themselves and helping the environment.

- ***Sustainable Small Farming.*** Small farms are more labor and knowledge intensive than agro-industrial farms and use fewer energy and chemical inputs. But today, hundreds of millions of smallholders are being squeezed by excessive liberalization and the power of big retail. Poverty and exploitation are rampant. However, with adequate technical and infrastructural support, yields from small farms using crop rotation, manuring, natural pesticides, and other sustainable methods can match the larger (but more environmentally damaging) facilities. A policy-driven conversion to this type of farming will perhaps take decades, but the potential for green and decent work is considerable and the environmental benefits could be enormous.

- ***Payment for Environmental Services, Improved Natural Resource Management.*** Paying rural dwellers for repairing and protecting the natural environment could generate very large numbers of jobs. In South Africa, a public "Working for Water" program has provided work for 25,000 previously unemployed people. Terracing or contouring of land, building irrigation structures, water conservation, and other such activities are labor intensive and will also provide employment, as will the rehabilitating of dams, barrages, and embankments.

- ***Climate Change Adaptation.*** Climate change adaptation and mitigation can create green employment as well, although the numbers involved are difficult to estimate. Soil conservation efforts such as conservation tillage and the rehabilitation of degraded crop and pasture land promise to create employment and sustain rural livelihoods.

Forestry

- ***Afforestation/Deforestation.*** Planting trees creates large numbers of jobs, but these jobs are often part-time, seasonal, and low paid. Greening these jobs will require more rigorous project requirements for labor standards.

- ***Agroforestry.*** Concentrated mainly in Africa, Asia, and Latin America, agroforestry, which combines tree planting with traditional farming, has been shown to create employment, food, and fuel security and provide supplementary income for small farmers. Agroforestry projects rely on external funding to pay for upfront costs and are therefore limited by the lack of funding sources available.

- ***Sustainable Forestry Management (SFM).*** Certification schemes like FSC and PEFC represent a fraction of the global wood market, but are rapidly increasing their shares. While the economic and employment consequences of certification standards are generally positive, at least in one case, there was evidence to suggest that certification decreased the amount of land that could be harvested and in turn reduced the number of jobs. However, in the long run, such schemes provide more stable employment over a greater period of time and opportunities to increase labor standards.

Main concepts

Two concepts are important. First, not all green jobs are equally green. We employ the term "shades of green" to indicate that some policies will yield greater environmental benefits than others. Pollution avoidance is better than pollution control. Mass transit is preferable to automobiles, even if they are reasonably fuel-efficient. Still, lighter shades of green can play an important role in the overall process of putting the economy on a more sustainable footing, particularly to the extent that they provide the time and flexibility needed to pursue the deeper shades of green for long-term sustainability.

A similar picture unfolds with regard to the question of whether green jobs are decent jobs. There is an enormous range in terms of skill requirements, occupational profiles, career prospects, and wages among green jobs. And there is a panoply of working conditions and worker rights. Green jobs can be good jobs, but this depends to some extent on technical aspects (that is, the extent to which certain types of work expose workers to hazards), and on the degree to which union organizing and collective bargaining are permitted.

As previously noted, many biofuel plantation jobs are unlikely to meet decent work standards. Recycling can entail dirty, undesirable, and hazardous work—as is the case in the electronic scrap industry and for the many thousands in ship dismantling in South Asia. Much of this work is also informal and, by definition, irregular. Here, the North-South divide is stark. In the richer countries, recycling is regulated and linked to environmental protection, and the jobs involved are relatively decent. But in middle-income and poor countries, millions engage in informal and poorly regulated forms of recycling as a means to earn a meager living. The sight of children wading through piles of garbage to find something of value presents an enduring image, one that says as much about the global world of recycling than any other.

Second, the creation of green employment in key parts of the economy has the potential to "radiate" across large swaths of the economy, thus greening commensurately large sections of the total workforce. For instance, providing clean energy supplies means that any economic activity has far less environmental impact than today, when fuels and electricity are still produced largely from dirty sources. Likewise, greening vehicles (that is, producing cars, trucks, and buses that run on cleaner fuels and are more efficient) means that the many millions of jobs in transportation services are by implication also greener. Green buildings to an extent help green the jobs of those who work in them. Nonetheless, such effects do not obviate the need for additional environmental measures, such as phasing out the use of toxic materials, reducing waste, and so on. But it does imply that beyond the numbers of green jobs that can be quantified in specific sectors, such as renewables, there is a far greater realm of sustainable employment.

Real Potential, Formidable Challenges

The potential for further green job growth is tremendous. Renewable energy is poised for continued expansion, and may generate more than 8 million jobs in wind and solar alone over the next two decades. If most or all new buildings were constructed according to higher efficiency standards, it would revolutionize the construction industry. Many additional green jobs can be created through extensive weatherization and retrofitting of existing buildings. Similar change is possible in agriculture—switching the bulk of the world's farming to organic and sustainable methods.

Manufacturing the world's motor vehicles by incorporating the very best in fuel-efficient technology would dramatically lessen their environmental footprint and create green jobs in this key industry. Modern efficient public transportation systems could be established where today poor-quality and inefficient ones operate or, as in many cities of the global South, do not yet exist at all. Industrial operations have enormous greening potential by boosting the efficiency with which they use energy and materials and minimizing the waste streams they leave behind. Some basic industries can also further improve the rate at which they rely on recycled scrap rather than mining and smelting virgin materials. The expansion of a broad range of recycling and remanufacturing activities could generate huge numbers of jobs.

Imagine if economic stimulus packages and other government and business programs around the world were truly aimed at spawning a revolution in innovative green technologies—that is, they provided funds to retrofit buildings so they no longer require heavy air conditioning in the summer and expensive heating in the winter, or they boosted public mass transit and encouraged or even required developers to build communities that are less sprawling and more walkable.

The numbers of additional green jobs that could be generated through such pathbreaking measures is unknown, but obviously enormous. Table III.2-1 offers a broad look at the greening potential of different sectors of the economy—that is, the extent to which their environmental impacts can be reduced. It also characterizes green job growth in these areas to-date and offers orders-of-magnitude estimates of future green job growth. In doing so, it demonstrates the wide variety of greening potential, and the diverging degree to which this potential has so far been translated into reality.

Table III.2-1. Green Job Progress To-Date and Future Potential

		GREENING POTENTIAL	GREEN JOB PROGRESS TO-DATE	LONG-TERM GREEN JOB POTENTIAL
ENERGY	Renewables	Excellent	Good	Excellent
	CCS	Fair	None	Unknown
INDUSTRY	Steel	Good	Fair	Fair
	Aluminum	Good	Fair	Fair
	Cement	Fair	Fair	Fair
	Pulp and Paper	Good	Fair	Good
	Recycling	Excellent	Good	Excellent
TRANSPORTATION	Fuel-Efficient Cars	Fair to Good	Limited	Good
	Mass Transit	Excellent	Limited	Excellent
	Rail	Excellent	Negative	Excellent
	Aviation	Limited	Limited	Limited
BUILDINGS	Green Buildings	Excellent	Limited	Excellent
	Retrofitting	Excellent	Limited	Excellent
	Lighting	Excellent	Good	Excellent
	Efficient Equipment and Appliances	Excellent	Fair	Excellent
AGRICULTURE	Small-Scale Sustainable Farming	Excellent	Negative	Excellent
	Organic Farming	Excellent	Limited	Good to Excellent
	Environmental Services	Good	Limited	Unknown
FORESTRY	Reforestation/ Afforestation	Good	Limited	Good
	Agroforestry	Good to Excellent	Limited	Good to Excellent
	Sustainable Forestry Management	Excellent	Good	Excellent

A bright green future is possible. There is additional job potential with regard to reactive measures—dealing with the accumulated environmental ills of the past. The building of much-needed adaptation infrastructure to protect communities from extreme weather events has barely started, but presumably would employ large numbers of people, even if only temporarily. Sustainable management of the world's forests, which could involve replanting and cultivation of billions of trees, barely exists today in countries with rampant deforestation, but could form the basis of reinvigorated livelihoods for many communities. Afforestation and reforestation efforts, too, would provide work for many people.

The evidence presented in this report suggests that moving forward on these and other fronts simultaneously will result in green jobs being created in quantities that will make today's numbers seem insignificant by comparison.

This optimistic assessment of the potential for future green job growth—and the policies discussed in the remainder of this section—must, however, be seen against the backdrop of some pressing and unavoidable realities. These include:

- ***Green jobs are expanding, but are not yet growing rapidly enough***—especially when one considers the fact that the global labor market is expanding by some tens of millions every year. Moreover, employment levels are generally lagging behind the supply of new workers. In 2006, the ILO reported that the number of unemployed people is at record levels—195.2 million. Together, the unemployed and underemployed (working hard without earning sufficient incomes) amount to 1 in 3 of the world's workers. Unemployment has hit young people (aged 15 to 24) the hardest, with 86.3 million young people representing 44 percent of the world's total unemployed in 2006.

- ***Green employment has gained an important foothold in the developed world; however, it is still quite exceptional in most developing countries.*** Yet these same countries account for some 80 percent of the world's workforce. China and Brazil appear to be making progress in this regard, but much more needs to be done to ensure that green employment becomes a truly global phenomenon.

- ***The rising level of informality in the global economy constitutes a major challenge to green job growth.*** Moreover, the chronic and worsening levels of inequality both within and between countries are a major impediment. The effort to advance decent work and pro-poor sustainable development is critical to building green jobs across the developing world in particular.

- ***Unsustainable business practices are still prevalent—and often remain more profitable than green ways of doing business.*** Short–term pressures of shareholders and financial markets are not easily overcome. The early adopters of green business practices have to contend with companies—manufacturers and retailers—that command consumer loyalty through low prices achieved on the back of "externalized" costs. And surprisingly often, market failures, coupled with lack of green knowledge, impede action.

Pathways to a Sustainable Future

As daunting as these challenges are, there are a number of concrete steps that should be considered by governments, businesses, and civil society that can further expand green employment and the green economy. These are discussed below.

Business and Government Action

It is now widely accepted that employment losses from *not* addressing the environmental crisis are likely to be very serious. Resource depletion, loss of biodiversity, and storms, floods, and droughts induced by climate change will exact ever-growing costs, and increasingly undermine the viability of many businesses and of livelihoods in agriculture. Green innovation helps businesses stay at the cutting edge and hold down costs by reducing wasteful practices. This is essential for retaining existing jobs and creating new ones. Late adopters, by contrast, run the risk of falling fatally behind on innovation.

In some instances, green employment creation is due to the conscious decisions of companies to adopt more-sustainable business practices—and the recognition by venture capital firms that clean technology development offers significant business opportunities. Many of the companies driving renewable energy solutions prize employees who are skilled, take individual initiative, and are oriented toward problem solving. While many of them are small and medium-sized companies, larger, more established companies are also playing a role. In solar PV development, the leading companies include both start-ups and well-known consumer electronics firms—even large oil companies like BP and Shell. Large firms such as auto manufacturers are by nature less nimble and fast-moving, but they too will need to embrace sustainability concepts far more quickly and comprehensively. Toyota has demonstrated the possibilities with its Prius hybrid.

Major companies are talking about investing in climate solutions. For example, in February 2008, nearly 50 leading U.S. and European investors representing more than $8 trillion of assets met at the U.N. to lay out a timetable for their commitments to global climate change and to call on governments and other investors to act with their money as well.[1064] These investors collectively pledged to commit $10 billion to green investments from 2008–2010.[1065]

Private companies have an important role to play in terms of investments and green job creation. However, the risk and profit appraisals typical of modern business behavior, the seemingly ever-rising expectations of shareholders, as well as concerns about protecting intellectual property, may together impede the flow of capital into the green economy. Current experience in various areas—from vehicle fuel economy to carbon trading—suggests that a purely market-driven process will not be able to deliver the changes needed at the scale and speed demanded by the climate crisis. Truly sustainable development requires a long-term approach, whereas today's business practices are too often driven by short-term considerations.

Governments must therefore establish an ambitious and clear policy framework to reward, support, and drive sustainable economic and social activity, and be prepared to confront those whose business practices continue to pose a serious threat to a sustainable future. Recent business, governmental, and U.N. reports underline this point. McKinsey & Company does not mince words in stating that, "Without a forceful and coordinated set of actions, it is unlikely that even the most economically beneficial options would materialize at the magnitudes and costs estimated here." And the UNDP's *Human Development Report 2007/2008* concludes that a range of barriers to a breakthrough in climate protection "can only be removed through government action. Public policies on regulation, energy subsidies and information have a central role to play."[1066] Timely action on the scale needed will occur only with a clear set of targets and mandates, business incentives, public investment, ecological tax reform, and genuine public-private partnerships.

Private and public policies must pursue "low-hanging fruit" even as they lay the groundwork for the more challenging technical and structural transformations needed to move toward a greener, low-carbon economy. There are many ways in which immediate energy savings or other environmental benefits can be realized at little or no cost. In the building sector, efficient lighting and appliances are widely available at increasingly low cost. A global switch to replace one in five light bulbs by 2030 would save 400 million tons of CO_2 emissions.[1067] Accelerating tree planting and forestry maintenance efforts would advance climate stabilization goals and create large numbers of jobs in a relatively short time frame.

Beyond short-term measures, the Stern Review calls for "a strong technology policy framework that drives action by the private sector." Such a policy "is vital to bring forward the range of low-carbon and high-efficiency technologies that will be needed to make deep emissions cuts."[1068] The possibilities of farther-reaching technological change are evident in the field of renewable energy, where innovative feed-in laws (securing access to the electrical grid at guaranteed prices) and production targets have been a major driver. Markets with strong consistent political support (such as Germany) have clearly thrived, while those with stop-start mechanisms (such as the United States with its unsteady Production Tax Credit) have developed unevenly.[1069] In the auto industry, a concerted international fuel-efficiency and low-emission strategy is needed. That, along with the pursuit of alternative fuels, hybrid and plug-in electric vehicles, and hydrogen/fuel cell-powered cars, could portend many job opportunities in the future. Other technological options—like those involved in carbon capture and storage (CCS)—may ultimately produce few employment gains but the environmental benefits could be considerable.

Competition or Cooperation?

The expedited development and diffusion of green technologies is critical to a global green jobs future. But what is good for the environment may not always intersect with what is good for companies from a commercial standpoint or countries from the standpoint of economic competitiveness. The competitive calculus of private companies often appears to be at odds with the need to share cutting-edge green technologies as rapidly as possible. In the case of China, wind power companies have been eager to invest there, but have not deployed the latest designs—for fear that domestic companies will reverse-engineer and copy them. Another obstacle to firms making large investments in technology innovation is that energy companies cannot easily capture all of the future returns on these investments.[1070] Engineering patents are harder to define than, say, pharmaceutical patents, and can be more easily circumvented.[1071] R&D-related skills and knowledge "spills over" to benefit other companies, discouraging investment.[1072]

Nations leading in green technologies are understandably averse to freewheeling technology sharing. These countries will want to press their advantage and capture or maintain export markets in addition to serving their own domestic markets. Indeed, countries like Germany and Japan see the environment as a key dimension of their future economic strategy. Even as they develop wind and solar technologies, China and the United States increasingly adopt a similar outlook. Meanwhile, countries may seek to privilege domestic producers that are technologically several steps behind the market leaders. This may make sense from an industrial policy perspective, but it constitutes a drag on the global effort to address climate change and green the world economy.

The fact that some countries are further ahead than others with regard to clean technologies does not, however, alter the fact that greenhouse gas emissions do not respect national borders and that the world must face the problem of global warming collectively. This can and must be done in a way that shares knowledge, skills, and expertise. Developed countries have a particular role and responsibility in this regard, but larger developing-country economies like China, India, and Brazil can make a big contribution to an international cooperative RD&D effort aimed at expediting technology sharing and transfer. China, for instance, has invested $930 million in climate change technology innovations since 2001, and the Chinese Ministry of Science and Technology recently launched a Scientific and Technological Actions on Climate Change initiative with the aim of "enhancing the role of science and technology in responding to climate change."[1073]

New mechanisms need to be developed that overcome obstacles to expedited technology diffusion. Innovative public-private partnerships can be part of the solution. Cooperative R&D centers that anchor green technology development in the public realm are another. And an adequately endowed global fund to expedite the spread of green technologies and climate adaptation measures, as proposed by China and others, also deserves urgent consideration. Without an integrated international framework the fight to reduce carbon emissions will be unsuccessful, and the promise of a massive increase in green jobs will be unfulfilled—with tragic consequences.

Financing a Green Jobs Agenda

Investment creates employment. The good news is that global investments in "clean tech" (mostly renewable energy)—including venture capital, project finance, public markets, and R&D—expanded by 60 percent from $92.6 billion in 2006 to $148.4 billion in 2007.[1074] A report by UNEP's Sustainable Energy Finance Initiative, involving some 170 financial institutions, estimates that the market providing finance for clean and renewable energies could reach $1.9 trillion by 2020.[1075]

But other areas offer less reason for celebration. The Stern Review notes that investment levels in energy-saving technology in power generation have actually declined by as much as 50 percent over the last two decades in real terms.[1076] For energy conservation, investments stood at a paltry $1.1 billion in 2006.[1077] The IEA also concludes that, "R&D investment is not adequate given the magnitude of the climate challenge. Government spending on energy R&D has fallen, while the private sector is focused on projects with short-term payoffs."[1078]

No one knows how much a full-fledged green transition will cost, but needed investments will likely be in the hundreds of billions, and possibly trillions, of dollars. It is still not clear at this point where such high volumes of investment capital will come from, or how it can be generated in a relatively short period of time. This challenge, formidable though it is, needs to be viewed in proper context. In the first place, inaction will be far more costly. The Stern Review estimates that climate change could reduce global GDP by at least 5 percent, and perhaps as much as 20 percent, by 2050.[1079] Secondly, huge sums continue to flow into fossil fuel extraction and conventional utility projects. Capital spending for just one project—tar sands extraction in Alberta, Canada—totaled \$55.3 billion from 1999–2006, and a further \$100 billion might be invested from 2006 to 2015.[1080] The oil industry recorded revenues of \$1.6 trillion dollars and profits of more than \$140 billion in 2005.[1081] The problem is therefore not simply a shortage of capital, but more a matter of where capital is being invested and for what reasons.

Thirdly, conventional fossil fuels are also subsidized. Significantly, the annual investment in clean energy technologies is, according to the Stern Review, "dwarfed by the existing subsidies for fossil fuels worldwide that are estimated at \$150 billion to \$250 billion each year."[1082] Phasing out subsidies for fossil fuels, taxing "windfall" oil profits, and adopting carbon taxes are among possible sources of revenue for the employment-creating transition to a sustainable and low-carbon economy.[1083] Fourthly, the auctioning of pollution allowances could generate many billions of dollars. Climate protection legislation being developed in the United States could generate anywhere between \$30 billion and \$250 billion annually.[1084] In 2006, carbon trading under the EU's Emission Trading Scheme was valued at \$24 billion.[1085] However, the levels of revenue generated are contingent upon the portion of permits that are auctioned under the respective schemes.[1086] Fifthly, the issue of investment often boils down to priorities and policy choices. One obvious example is military expenditures. A reduction in these expenditures would also free up large quantities of public money for green investments. In 2006, global military spending topped \$1.2 trillion.[1087] In fiscal year 2008, the United States planned to spend \$647.2 billion on its military, more than the rest of the world combined. In contrast, federal government budget requests for fiscal year 2008 would provide a mere \$7.4 billion for climate change-related programs.[1088]

The development of green employment across large swaths of the developing world is being seriously hindered by the abysmally low levels of financial assistance from developed countries. A large portion of multilateral aid continues to favor fossil fuels and large-scale hydropower.[1089] Meanwhile, the money that was supposed to be set aside for adaptation to climate change has not thus far materialized. The 2007/2008 edition of the *Human Development Report* notes that, "To date, international cooperation on adaptation has been characterized by chronic under-financing, weak coordination, and a failure to look beyond project-based responses."[1090] While countries like the United Kingdom, Germany, the Netherlands, Italy, and the United States have spent billions of dollars on flood defenses and other protection measures, only \$26 million has been spent multilaterally for adaptation measures in developing countries—a figure equivalent to one week's worth of spending on flood defenses in the United Kingdom.[1091]

An effective global adaptation financing strategy is clearly needed. The UNFCCC estimates that by 2030, developing countries will require $28 to $67 billion in funds to enable adaptation to climate change.[1092] UNDP has estimated that to adequately finance "climate-proofing" development investments and infrastructure will require $44 billion per annum by 2015; a further $40 billion per year will be needed to adapt poverty reduction programs to climate change, and thus strengthen human resilience. Climate-related disaster response could add another $2 billion. This total of $86 billion would require developed countries to mobilize around 0.2 percent of GDP in 2015—or roughly one-tenth of what they currently spend on defense.[1093]

Another way of financing green employment is through micro-lending programs that poorer families and communities can access and afford. Countries like China, Nepal, and Bangladesh have successfully used low-interest (subsidized) loans and micro-lending to introduce biogas, solar energy, small hydro, and wind projects. This reorientation toward renewables could make a huge difference with regard to poverty eradication and job creation.

The Clean Development Mechanism (CDM) and Joint Implementation (JI) instruments included in the Kyoto Protocol have been cited as potential funding mechanisms for green projects. In 2006, the combined value of CDM and JI projects amounted to about $4.4 billion.[1094] But some major problems need to be overcome. There is the fundamental question of whether these mechanisms can even achieve their stated goals.[1095] And there are more pragmatic issues such as the highly slanted distribution of projects (many being undertaken in China, but very few in Africa), the high costs of certification, and the piecemeal character of these projects, which have been driven more by the needs of private companies looking for cheap carbon credits than by a strategic assessment of the investment needed in moving toward sustainability.[1096]

Equity Concerns, Just Transition, and the Workforce of the Future

The creation of a sustainable economy will require a new policy framework grounded in social solidarity and equity. Progress will require addressing disparities both between countries and within countries. It will require farmers being paid a fair price for their produce, and workers being treated equitably in terms of their pay, conditions, and basic rights. It will also require governments to be proactive in their efforts to ensure that all citizens have access to a decent standard of health care, education, and habitation. A sustainable economy cannot be built on "green for a few"—a few countries, a relatively limited number of workers, and with regrettably few positive outcomes overall. It must mean "green for all"—creating decent work and stable communities and allowing for a fairer distribution of wealth.[1097]

Green investment (and thus most of the green jobs in the foreseeable future) is currently found primarily in a relatively small number of countries. Those nations that lead technological development with regard to renewable energy, energy and materials efficiency, etc., are likely to reap the bulk of the associated R&D and manufacturing jobs—among them Japan, Germany, and other OECD countries, but also China, Brazil, and others. Employment in installing, operating, and maintaining green technologies and equipment, by contrast, will be more widely spread.

And yet the vast majority of the world's working population lives in poorer countries where not just green, but also decent work is scarce, jobs are often precarious, and levels of informality, unemployment, and underemployment are alarmingly high. A green jobs strategy needs to address these tremendous challenges. In essence, this is not so much a question of technology, but rather of broad social and working conditions, rights, and empowerment. As such, there is no quick fix. But a green jobs strategy would be remiss to ignore this dimension.

Moreover, much of the world's urban growth is measured in the rise of slum conditions. Today 1 billion people inhabit the Earth's 200,000 slums.[1098] In principle, greening these teeming urban agglomerations presents an unparalleled economic opportunity—providing decent and efficient housing; replacing inefficient and hazardous wood and coal stoves in people's homes with alternatives that do not endanger their health; developing affordable and non-polluting transportation networks; establishing waste management and recycling operations that raise sanitary standards; and providing clean drinking water, among other measures. The green employment that would result is many magnitudes larger than anything currently on the drawing board. But it will happen only if governments and businesses alike adopt radically different philosophies and operating principles.

Equity concerns are intertwined with the issue of Just Transition and the need to train and educate a green workforce ready to both build and drive the green economy. Just Transition was discussed in some detail in the previous section of this report. At its core, Just Transition recognizes that green employment gains need to be balanced against significant and unavoidable job losses incurred as a result of the movement toward a low-carbon and sustainable society. Overall, far more green jobs will be created in the move toward a sustainable economy than jobs lost. Skills profiles will also change, and there is clear evidence that much of the green employment of the future will be high skilled and thus might be expected to be better paid. But for workers who lose their jobs, as well as their families and communities, transition assistance is needed. Where industries are highly concentrated in one or a handful of regions, job losses can have serious consequences for the local economy and the viability of communities. These regions will need proactive assistance in creating alternative jobs and livelihoods, acquiring new skills, and weathering the transition to new industries.

Active labor market policies and broad social protections are therefore essential to ensure a fair and just transition for workers and their communities. This must involve income protection as well as adequate retraining and educational opportunities and, where necessary, resources for relocation. However, Just Transition is today still more principle than reality.

Policymakers and public officials must also pay more attention to the fact that, when it comes to supplying the green economy with the kind of workers it needs, a "skills gap" already exists. In many OECD countries, deindustrialization and offshoring of manufacturing have created a situation where companies in the fledgling green economy are struggling to find workers with the skills needed to perform the work that needs to be done. Indeed, there are signs that shortages of skilled labor could put the brakes on green expansion. A 2007 survey of Germany's renewables industry, for instance, concludes that companies in this field are already suffering from a shortage of qualified employees, and especially those needed in knowledge-intensive positions. There is thus a need to put appropriate education and training arrangements in place. The best approach—whether to focus on trade schools, universities, on-the-job training in the workplace, or some other arrangement—will vary from country to country, given different educational systems.

Solid R&D, engineering, and manufacturing capacities are a critical aspect of building green industries and jobs. Indeed, some occupations in the renewables sector or in energy efficiency require highly educated and even quite specialized personnel, including a variety of technicians, engineers, and skilled trades. At the cutting edge of technology development for wind turbine or solar PV design, for instance, specialization has progressed to the point where universities need to consider offering entirely new study fields and majors. Still, green employment is not limited to high-end skills. There are many positions that demand a broad array of skill and experience levels, especially in installation, operations, and maintenance.

In both developing and industrialized countries, there is increasing need for what some have termed "green collar" training in a broad range of occupations besides the most highly educated positions. This is important both to prepare the workforce at large for the skill requirements inherent in green jobs and to ensure that green industries and workplaces do not face a shortage of adequately trained workers. It is also important as a commitment to people in poorer and disadvantaged communities—providing a ladder out of poverty and connecting green jobs with social equity. For example, proposed U.S. legislation would provide funding of up to $125 million to establish job training programs, curricula, and job standards on the federal and state levels, and the "Green for All" campaign is working to secure $1 billion by 2012 to "create green pathways out of poverty" for 250,000 people in the United States.

Promoting such job training is equally important in developing countries. A variety of U.N. and other international agencies such as UNEP, ILO, UNIDO, and CGIAR, working in conjunction with business, trade unions, and community organizations, could play a critical role in setting up green training and expertise centers in developing countries.

In all countries, it is important to link green subsidies, tax breaks, and other incentives provided to companies with job quality and training standards, to ensure the creation of what the Apollo Alliance and Urban Habitat have called "high-road jobs"—decent pay and benefits and safe working conditions. Training and education for green jobs will also need to emphasize gender equality. The German experience suggests that women are strongly under-represented in the renewables sector, and especially in science and technology-intensive jobs.

The Next Great Transformation

In his epic work *The Great Transformation*, Karl Polanyi described how in the century or more leading to World War II, governments provided the structures and policies to support and shape a modern market economy.[1099] At the same time, those governments needed to mitigate the harsh social effects of unregulated and uncontrolled economic practices. The next transformation will actually be greater still in the sense that it will need to be much faster, more global, and altogether more equitable than anything yet seen in human history. Such a rapid and thoroughgoing change will require government, business, and civil society to rethink their traditional roles. A new balance between competing interests needs to be struck so that commonly established targets and objectives can be pursued.

A central feature of the next transformation will be green jobs. This report has documented and discussed how green jobs are already emerging in certain industries, sectors, and regions and their growth will surely accelerate in the coming years. On the evidence presented here, the potential for a qualitative increase in the numbers of green jobs is almost unlimited. However, it is also clear that only a very tiny portion of the work being performed in the world today can be described as green.

Under different historical circumstances, the pace of green job growth might be considered satisfactory, even in some respects impressive. However, in just two or three decades the entire global economy will need to be well on the way to being low-carbon and sustainable. The historical circumstances therefore demand that bold measures be taken to both expand the green economy and grow green jobs at a much faster pace in the developed world, and to ensure that the same process begins in earnest in the developing countries.

The international community must also approach this challenge in new ways. Almost 15 years after the world began negotiating the Kyoto Protocol, the levels of greenhouse gases are not only increasing, they are accelerating. A full 20 years after the Brundtland Report alerted the world to the urgency of moving toward sustainable development, the planet's stock of natural resources continues to be depleted and degraded at an alarmingly rapid rate. Many of the targets established in the year 2000 around the Millennium Development Goals will not be met by 2015. In the words of Mary Robinson, the former president of Ireland and former U.N. High Commissioner for Human Rights, "This is tragic and unacceptable because we know what works and what kinds of actions are needed to make faster and more equitable progress."[1100]

The same is true of green jobs. We know what works and what types of action are needed. Green jobs are emblematic of a low-carbon and sustainable future, and it is imperative that decisive action be taken now to advance their growth and to remove all obstacles in their path—whether those obstacles take the form of insufficient investments, irresponsible consumption, or the blind imperatives of competition and profit. It is encouraging that the recent global deliberations on climate protection and sustainability reveal higher levels of urgency and determination. The stage is set for action to commence.

Today, sustainability should be non negotiable, as should the notion of an equitable transition. If these were to become the main principles guiding policy, business practices, and—over time—the behavior of individuals, then green jobs and decent work can be expected to grow both exponentially and hand in hand.

Endnotes

Section 1. Definitions, Scope, And Concepts

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l/100km	***km/l***	***mpg***
35	2.9	6.7
30	3.3	7.8
25	4.0	9.4
20	5.0	11.8
15	6.7	15.7
10	10.0	23.5
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Part III. Outlook and Conclusions

Section 1. A Fair and Just Transition

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