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Green Jobs: Towards Sustainable Work in a Low-Carbon World

Worldwatch Institute

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Abstract

[Excerpt] The latest assessment report by the Intergovernmental Panel on Climate Change and the widely noted Stern report 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. The present report assembles evidence—quantitative and conceptual—for currently existing green jobs in sectors such as renewable energy, energy efficiency in buildings and vehicles, sustainable transportation, and organic agriculture, and presents various estimates for future green employment. (A future version will provide expanded coverage in additional parts of the economy.)

Keywords

Climate change, environment, green practices, green jobs, renewable energy, sustainable transportation, energy efficiency, green employment

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GREEN JOBS INITIATIVE

GREEN JOBS:

TOWARDS SUSTAINABLE WORK IN A LOW-CARBON WORLD

— PRELIMINARY REPORT —

December 21, 2007

A joint

United Nations Environment Programme

International Labour Ogranisation

International Trade Union Confederation

GREEN JOBS INITIATIVE

Report Prepared by the

Worldwatch Institute

With Technical Assistance by the

Cornell University Global Labor Institute

Cornell University
School of Industrial and Labor Relations

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— EXECUTIVE SUMMARY —

DEFINING GREEN JOBS

The latest assessment report by the Intergovernmental Panel on Climate Change and the widely-noted Stern report 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.

The present report assembles evidence—quantitative and conceptual—for currently existing green jobs in sectors such as renewable energy, energy efficiency in buildings and vehicles, sustainable transportation, and organic agriculture, and presents various estimates for future green employment. (A future version will provide expanded coverage in additional parts of the economy.)

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.

In this report, we define green jobs as positions in agricultural, manufacturing, R&D, administrative, and service activities aimed at alleviating the myriad environmental threats faced by humanity. 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.

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.

Technological and systemic choices offer varying degrees of environmental benefit and different types of 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. It is of course preferable that the most efficient, least-polluting options receive priority. But these are not either-or choices, as all of these options are needed to bring about a more sustainable, low-carbon economy. But they do suggest "shades of green" in employment.

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 should be seen as the most appropriate thresholds. And, given technological progress and the urgent need for improvement, the dividing line between efficient and inefficient must rise over time. Hence, "green jobs" is a relative and highly dynamic concept.

DRIVERS

What are the key drivers of green employment? Although environmental policies are sometimes seen as a potential job killer, employment losses from not addressing the environmental crisis are likely to be far more 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. A carbon tax (or similar measures to internalize environmental costs of production and consumption) could become a key driver of making the economy more sustainable.

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 forward are of small and medium size that are highly innovative and dynamic; they prize employees who are skilled, take individual initiative, and are oriented toward problem-solving. More established companies are playing a role as well. In solar PV development, the leading companies include both start-ups and well-known consumer electronics firms. 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.

Forward-thinking government policies remain indispensable. This has been the case especially 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. In other areas, such as energy, water, and material efficiency, standards and norms are also critical, but policy has been highly uneven and insufficiently ambitious to date. By purchasing goods and services that are more sustainable, consumers, too, are beginning to play their part, assisted by a growing eco-literacy and a bevy of eco-labeling programs.

A point that is not always recognized is that each green job contributes to the greening of jobs in other parts of the economy. Put differently, the creation of green employment in key parts of the economy has the potential to "radiate" across large sections of the economy, thus greening commensurately 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. But clean energy means that any business has 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 (the number of which surpasses vehicle manufacturing jobs by several multiples) are by implication also greener. According to the UN Framework Convention on Climate Change, 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 industry, agriculture, and forestry, but underlines the strategic character of energy and transportation.

REAL POTENTIAL, FORMIDABLE OBSTACLES

Still, the encouraging growth of green jobs needs to be viewed against the sheer enormity of the tasks facing human society in terms of achieving a truly sustainable, low carbon, and more equitable world. A number of inescapable realities need to be addressed:

1. Green jobs are simply not growing rapidly enough. As the Stern Review points out, overall investment in green technologies remains inadequate, notwithstanding the very strong growth in renewable energy. Carbon markets (along with the necessary institutions and networks of climate cooperation) may eventually make an important contribution to financing green development, but for now are still on a distant horizon.

2. 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.

3. We see the emergence of green jobs inside a global labor market still largely driven by conventional job creation. 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.

4. Unsustainable business practices are still quite 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 that can command consumer loyalty through low prices (on the back of "externalized" costs). And surprisingly often, market failures, coupled with lack of green knowledge, impede action.

These do not have to be insurmountable obstacles. Innovative policies can move the transition to sustainability forward at a much faster pace. Governments must 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. This means a decisive and urgent shift in government policy at the global as well as national and local levels with regard to subsidy and tax policy, adequate financing flows and mechanisms, scaling up of promising projects and ventures, sharing of green technologies and relevant information, and replicating both successful regulations and incentives and best industry practices. With progress on these fronts, millions of new green jobs can indeed be generated in coming years.

GREEN JOBS: NOW, AND IN THE FUTURE

The report presents a series of quantifications, estimates, and projections of green jobs around the world. 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. 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 in the field of renewable energy, buildings, transportation, and agriculture. A later version of this report will investigate green employment in additional parts of the economy.

Renewables and energy efficiency are key ingredients in efforts to create a low-carbon economy and help stabilize the global climate system. However, the climate crisis has already crossed the threshold where mitigation alone would suffice. Adaptation to climate change has become an equally pressing need. Adaptive efforts could in coming years and decades become a major source of employment. Projects to protect against rising sea levels and storm surges, flood shelter construction, reforestation initiatives, measures to enhance the resilience of infrastructure and industries, and research into more hardy, drought-resistant and saline-tolerant crops are among the many important tasks. With adequate funding, they can become a source of millions of jobs—most of them in the developing world.

Reducing waste streams and reusing valuable materials through recycling is another important objective. Already, recycling has become a substantial industry. The Bureau of International Recycling estimates that its members in 60 countries worldwide employ more than 1.5 million people. However, this figure does not include jobs in community recycling and composting programs. Nor does it reflect the many jobs in breaking apart discarded products and equipment. Often, however, this is done in very crude ways that are hazardous to the workers involved. 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. Altogether, as many as 10 million people are believed to be involved in all forms of recycling in China—most of it taking place at small workshops where safety and environmental rules are observed mostly in the breach. While these are "potentially" green jobs, major efforts are needed to ensure that they are carried out in a manner that respects international environmental and social standards.

- **Energy Supply Alternatives**

Employment in renewable energy is growing at a very fast pace, and the growth seems likely to accelerate in the years ahead. Moreover, compared to fossil fuel power plants, renewable energy generates more jobs both per unit of capacity and per dollar invested.

Globally around 300,000 workers are employed in wind power and more than 100,000 in solar photovoltaics. In China, the U.S. and Europe more than 600,000 are employed in solar thermal—by far most of them in China. Almost 1.2 million workers are estimated to be employed in biomass in just four leading countries, namely Brazil, the U.S., Germany and China. Overall, in countries where data are available, the number of people employed in renewables is presently around 2.3 million. (See Table ES-1) Given the gaps in employment information, this is no doubt a conservative figure.

Half of these jobs are in biofuels—mostly in agriculture (growing and collecting of feedstock), but also in (better paying) processing industries. There is vigorous and contentious debate over their economic and environmental cost and merits, their energy content and energy net balance, and the question whether biofuels used to power inefficient cars directly compete with food production. (*The Economist* comments in its December 6, 2007 edition: "Fill up an SUV's fuel tank with ethanol and you have used enough maize to feed a person for a year.") The answers vary strongly, depending on the feedstocks and production methods used, although corn-based ethanol is increasingly recognized to be a particularly poor choice.

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

Renewable Energy Source	World / Selected Countries[1]	Employment
Wind	World	300,000
Solar PV	World	115,000
Solar Thermal	China, Europe, USA	624,000 +
Biomass/Biofuels	Brazil, USA, China, Germany	1,174,000
Hydropower	Europe, USA	39,000
Geothermal	USA, Germany	25,000
Renewables, Combined		**2,277,000**

[1] Countries for which information is available.

Social issues weigh in heavily as well. Much of the employment on sugar cane 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 (including in countries that are not represented in the table above). Particularly in Malaysia and Indonesia, which are set to dramatically step up their involvement in palm oil for biofuels, these issues remain controversial.

The spurt in employment in renewables is driven by a more than six-fold increase in investment from 1998-2007, growing from $10 billion to $66 billion. By 2003, renewables accounted for about one-sixth of world investment in power generation facilities and equipment. Some estimate that investment could quadruple to $210 billion in 2016.

To date, a small group of countries accounts for the bulk of renewables investments, technology development, production, and installations. 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. China's employment numbers are particularly high because the country continues to rely on large numbers of cheap labor, in contrast with the higher labor productivities found in Western industrialized countries.

In Germany, a leader in wind and solar technology, direct and indirect employment in renewables was estimated at 260,000 in 2006 and could reach 400,000 to 500,000 by 2020 and 710,000 by 2030. In the United States, there are about 446,000 direct and indirect jobs in renewables. (Some 390,000 if jobs involved in ethanol production of questionable environmental and social merit are subtracted.) Rough estimates for China indicate that there may be close to 1 million renewables jobs, close to two thirds of which are in the solar thermal industry. Brazil's sugar cane-based ethanol industry is said to employ about half a million people, and it is hoped that its biodiesel program, launched in 2006, may eventually generate an additional 400,000 jobs.

There is broad job potential for many other countries (especially developing countries) as well—if not in manufacturing wind turbines or solar panels, then in installing and maintaining them or in gathering and processing feedstock for biofuels. There is a need for mechanisms to ensure timely diffusion of renewables technologies and related job skills around the world. But national policies are important as well. Germany's experience in particular can serve as a model for many other countries: the government enacted legislation to ensure that electricity generated from renewables has equal access to the national grid at guaranteed minimal rates.

Given strong and 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 incoming 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. "rustbelt"), 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. A country like Germany views its investment in wind and solar PVs as a crucial aspect of its export strategy. Success will mean that many, if not most, German jobs in these industries will depend on the bulk of wind turbines and solar panels being sold abroad rather than at home. Although this does not have to be a zero-sum game, a stellar export performance by a handful of other countries does imply more limited opportunities elsewhere on the planet. Chinese companies may eventually come to dominate international sales in the solar thermal sector, for example. Competing on the basis of cheaply produced systems, they may outcompete European producers and possibly cause job loss there. As renewables industries mature, they will be increasingly marked by difficult issues of competitiveness, trade rules, and wage differentials that are already familiar topics in other industries.

In addition to renewables, much attention has been directed towards the mitigation potential of carbon capture and storage (CCS). Even though coal-fired power plants are not a sustainable energy option, a pragmatic strategy has to find ways to limit the carbon emissions associated with the coal plants that already exist, not to mention the larger number in the pipeline. However, the employment implications of CCS have received scant consideration. CCS is not yet capable of large scale deployment and "CCS jobs" are themselves 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, CCS will be capital intensive,

analogous to the oil and gas industry. Therefore the jobs created per million dollars of investment can be expected to be low. Some projections suggest that ultimately, the CCS industry could be on the same scale as the petroleum industry.

- **Energy Efficient Buildings**

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% by 2020. Efficiency measures in the building sector includes 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 US and Europe, show that energy efficiency measures lead to an overall net increase in jobs. The positive result of both environmental improvements and employment increases from energy efficiency measures is known as the 'double dividend'.

The IPCC 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." Several general energy efficiency studies were conducted in North America and Europe during the 1990s and concluded that for every petajoule of energy saved between 40 and 100 jobs were created. A 2000 study conducted by the British Association for the Conservation of Energy which looked at nine European Union countries found that for every 1 million Euros invested in energy efficiency in the residential building sector, 11.3 to 13.5 jobs were created.

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 study commissioned the American Solar Energy Society 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 green job figures may need downward revision.

Types of jobs that are likely to be directly created in green building and the retrofitting process are green designers and architects, auditors, engineers, estimators, project managers and various jobs in the constructions trades including: pipe fitters, sheet metal workers, HVAC (heating, ventilation and cooling) technicians, engineers, electricians, and general construction workers. Most of these jobs are created during the initial construction or investment period and are likely to be local jobs, which is especially beneficial for developing regions as well as areas of high

unemployment. Jobs are not only created in the building design, operations and construction, but also in administration and consulting for these green building and energy efficiency projects.

Jobs in the green building sector are likely to stimulate jobs in the manufacturing of green building components and systems including efficient waste, lighting, HVAC, water filtration, insulation systems and energy efficient appliances. Photovoltaic 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. Energy efficient appliances and building components use more skilled labor than manufacturing inefficient ones, which not only leads to larger number of jobs but also higher paying, higher skilled employment.

Induced jobs are created as money that would have previously been spent on energy services is freed up and re-spent back into the community. Money is shifted away from energy intensive sectors, which are generally low in labor intensity. 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 industries are likely to see a reduction of jobs in these sectors. This shift from energy intensive and producing fields to other sectors requires a just transition for workers.

Some data on current levels of 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. A recent analysis of the German building retrofitting project showed that 140,000 jobs were either saved or created in the building sector to retrofit approximately 200,000 homes. The US Green Building Council reports there are currently over 40,000 LEED Accredited Professionals trained in green building design and construction or operations and maintenance. ESCOs (Energy Service Companies) have provided funding for $20 billion worth of energy efficiency projects worldwide since the 1970s and report that approximately $7 billion has gone for labor employment.

Future employment projections from energy efficiency programs in green buildings, retrofitting and energy efficient building components have also been generated. Future green job projections include:

- 5,600 to 7,840 person years of employment in Canada to retrofit municipal buildings on a national scale.
- The Apollo Alliance projects 827,260 jobs in the US through investment in high performance buildings, both retrofitting and new green construction. The plan requires an US$89.9 billion dollar investment to improve financing for green buildings, providing tax incentives, investing in research and development and promoting new building codes and standards.
- The Apollo Alliance report also estimates that an investment of 3.5 billion to modernize appliance standards would result in 29,876 jobs.

- In 2005, the European Commission estimated a 20 percent reduction in EU energy consumption had the potential to create up to 1 million jobs in the EU, many of which are in the building trades.
- The US Department of Energy predicts that standards on clothes washers, water heaters and florescent lamp ballasts would create 120,000 jobs in the US through 2020.
- The European Trade Union Confederation reports a 75 percent reduction in the EU in the building sector would create 1,377,000 full-time equivalent (FTE) jobs in the 2030 scenario, and 2,585,000 FTE jobs in the 2050 scenario.
- 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 collection and biomass plantations.)

These energy efficiency programs in the building sector are possible but will require enormous amounts of investment and major efforts to ensure available natural, technical and human resources. Fortunately, most of the changes required to shift from to greening the building sector can primarily be done with existing technology with little or no net cost. They also have an enormous potential to create millions of jobs in the building, manufacturing and other sectors. The results of investing in energy efficient buildings are positive economic and employment growth as well as the reduction of emissions, waste, energy and water use. Greening the building sector is critical for sustainable development and climate change mitigation and adaptation.

- **Transportation**

Leadership in pursuing fuel economy and cleaner cars is essential to the future viability and employment in the automobile 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.

The global employment implications of greener cars—fuel efficiency determines how much carbon a vehicle emits but does not necessarily have a direct influence on other air pollutants—are difficult to estimate. This is due to limited availability of relevant data and incompatible standards and reporting categories among different nations, but also because fuel efficiency is far from a static concept, and there are no unambiguous thresholds that separate gas sippers from gas guzzlers.

An assessment of the most efficient cars available globally today suggests that relatively green auto industry jobs may number about a quarter million. Using somewhat more lenient definitions, the number rises to about 800,000. This estimate is based on data from Europe, Japan, South Korea, and the United States, which together account for more than 4 million car manufacturing jobs, or half the global total.

Using carbon emission thresholds of 120 and 140 grams of CO_2 per kilometer to determine what share of vehicle production can be considered efficient and clean, the job numbers total 150,000 and 526,000, respectively, in the European Union. The same approach suggests that Japan may have between 62,000 and 204,000 green jobs, and South Korea between 10,000 and 72,000. In the United States, where cars are much heavier and fuel efficiency has not been seriously pursued, the figure for workers producing efficient vehicles is an estimated 13,000. (These numbers are for direct employment in the auto industry only.)

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 thus to be on track to green a good portion of its 182,000-strong vehicle manufacturing workforce.

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.

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).

There are broader employment benefits: Studies show that fuel efficiency adds to employment both in the automotive industry itself and more broadly throughout the economy when consumers, purchasing less fuel, are able to purchase other goods and services from more labor-intensive industries.

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 and thus reduced transportation needs and less driving. 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 thoroughgoing modal shift away from private vehicles towards rail and other public transport can generate considerable net employment gains, reducing emissions, and improving air quality.

Railways are more 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. A sustainable transport policy needs to reverse this trend. High-speed rail can compete well with both automobiles and

trucks and, over certain distances, with aviation. But it is important to build or rebuild rail networks that integrate high-speed lines connecting major cities with regional and local lines.

Buses, trams, and railways use far less energy per passenger- or freight-kilometer. Jobs in manufacturing the requisite vehicles and equipment and in operating these systems are, in principle, green jobs. 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 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.

Similar retrofits are needed for the highly-polluting two-stroke engines that are ubiquitous in two- and three-wheelers 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 will 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.

- ## Agriculture and the Global Food System

The future of green jobs in agriculture and the food system 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. These obstacles to green employment can be located at all points of the global food system, from the threatened livelihoods of small farmers; the energy and chemical inputs used in intensive farming; the expansion of certain plantation crops; the growth of intensive livestock systems as a result of rising meat consumption; the globalization of food and "food miles"; the rising market power of large retailers; and the problem of vast amounts of GHG-producing food waste in the developed world.

Perhaps more than in any other economic sector, the future of green jobs in agriculture and the global food industry is inseparable from the question of the system's overall sustainability. However, sharp disagreements exist as to what actually constitutes sustainability. Can the existing system be made more sustainable over time by, as the World Bank has proposed, changes here and there? Or is the present agro industrial model fundamentally unsustainable and in need of a radical overhaul, as small farmers and workers organizations frequently claim?

One thing is clear: 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 is being squeezed on all sides, a process that is accelerating urbanization, informality, and thus social and environmental stress all across the developing world in particular. The drivers of this squeeze include trade liberalization supported by the WTO and rich-country subsidies to agribusiness and the rising market power of large producers and retailers.

Another factor squeezing smallholders is the rise of plantation crops like soy and palm oil. The expansion of plantations both displaces farmers as it advances deforestation, sometimes pushing the displaced into illegal logging which makes the problem worse. Then there is the rise of the higher value "New Agriculture" where export-oriented production of tropical fruits, vegetables, wine and cut flowers is rising dramatically, as are the levels of energy and chemical inputs required for their production and transportation. For those fortunate enough to become integrated into these new global supply chains the rewards are considerable, although the working conditions in these industries are often extremely poor and disproportionately affect women. For those producers who fail to become integrated there is often nowhere else to go except away from farming and rural life altogether.

Farmers are basically being expunged from the global food system. 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 to 1.3 billion people, made their living from growing food and raising livestock. In 1995, however, a quite higher proportion—44.4 percent—had worked in agriculture.

Another important factor is the levels of consolidation taking place. In recent years the horizontal and vertical integration of the global food industry has seen the emergence of a group of large retailers and producers. The dynamic of the industry is towards more and more efficiencies that in turn drive workers and farmers from large parts of the global food system. The market power of the large companies allows them to dictate "take it or leave it" terms on those who actually grow the food.

Given these circumstances, a green jobs agenda for agriculture will require bold policy interventions that will need to both confront market trends, rich-country consumption patterns, and powerful business interests.

First and foremost, and as a core component of an overall strategy to achieve sustainability, there needs to be a long term commitment made to the preservation of the green, or relatively green, livelihoods that *already exist* by ensuring the long term viability of small farming systems. Acting on this commitment over a two or three decade time frame could preserve existing green livelihoods and improve their quality and their level of greenness over time. It would also make a major contribution to preserving and repairing the world's natural resources and reducing the enormous amount of GHGs generated by agriculture (roughly 15 percent) and deforestation (around 14 percent).

Farmers and agricultural workers' unions, along with many in the 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 biofuels. Soy and palm oil production creates fewer jobs per hectare of cultivated land than small farms and the effects on biodiversity are very serious. There is a pressing need to reduce the decent work deficits found in agriculture by improving the pay and working conditions of the 500 million agricultural waged workers, many of whom are women and a relatively high proportion are children. Pesticide exposure claims the lives of 40,000 workers every year on farms and plantations, therefore the reduction of pesticides will both help make existing jobs greener and save lives.

The evidence suggests that considerable green employment benefits are embedded within this vision of sustainability. Small farming systems can be as productive (and sometimes more productive) than intensive farming systems that rely on high energy and chemical inputs. Indeed, 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 the ecological literacy still further, yields can rise within a sustainable framework.

Small farming systems certainly employ more people than mechanized farms and/or plantations. The most recent agricultural census in Brazil showed that one rural job is created for every 8 hectares cultivated by small farmers, whereas large-scale mechanized farms require an average 67 hectares for each unit or rural employment. In Banana production, an IUF study shows that 2,000 workers are employed for every 1,000 hectares dedicated to bananas. However in Colombia, where palm oil production has grown dramatically and displaced banana plantations, 1,000 hectares employs just 100 workers. High-yield sustainable farming is knowledge intensive and requires research and extension systems that can generate and transfer knowledge and decision-making skills to and between farmers. Developing the ecological literacy of farmers could, therefore, create significant employment.

Policies supporting the expansion of urban agriculture are also needed. 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, particularly in areas with high levels of underemployment and informality.

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.

A study for the Food and Agriculture Organization confirms that organic farming requires additional manpower compared with high-input conventional systems, although the precise outcome depends on climate, crops, and farm size. A large study of 1,144 organic farms in the

U.K. and the Republic of Ireland showed that organic farms employed 135 percent more full time workers per farm than conventional farms. In these two countries, organic agricultural land amounts to 4.3 percent and 1 percent of the total farm area, respectively. If 20 percent of farm land became organic in both countries, there would be an increase of 73,200 jobs in the UK and 9,200 in the RI.

Studies conducted in developing countries (such as India and Turkey) are consistent with these findings. 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 preserve jobs in smaller food retail establishments. In many cities across the U.S. citizens groups and unions have successfully mobilized to halt Wal Mart moving in to their communities, thus protecting small high street businesses. There is evidence that food superstores lead to serious net job losses in the food retail sector. The UK-based National Retail Planning Forum reports that many of the new superstore jobs are also part-time, lower paying and generally of poorer quality. Another report from the UK notes that 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, Sainsburys - £85,986, and Safeway, £94, 897. Large retail is also extremely energy intensive, so in this respect jobs in smaller stores are probably greener than those in large supermarkets and superstores. Today's large retail establishments consume an estimated six times as much electricity as factories as a result of lighting and refrigeration.

Other policies to advance sustainability have shown to create green jobs, such as payment for environmental services (PES). In the UK, the English Countryside Stewardship Scheme has created jobs for farmers, contractors and other small rural businesses. The Tir Cymen scheme in Wales was created to promote sustainable farming in 3 rural areas. 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. 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 employment-creating potential. For example, activities like terracing or contouring of land, building irrigation structures, etc., are labor intensive and are urgently needed to prevent further depletion and degradation. Additional investments will be required to store and save water, thus creating

employment in producing, installing and maintaining the necessary equipment. The move towards integrated water management, which involves canal lining and microirrigation, also involves labor inputs. Other sources of work include rehabilitating dams, barrages and embankments which improve the flow of rivers. Employment could also be generated as part of the broad effort to raise water productivity. The World Bank notes that substantial public investments in off-farm infrastructure are also required, supported by water management institutions staffed by people with the necessary background in hydrology. There also appears to be employment potential in combating soil erosion involving tree planting and straightforward stone bunding.

Proposed policies regarding climate change adaptation and mitigation can also create green employment and contribute to sustainable development, although the numbers involved are again difficult to estimate. The IPCC has developed a list of mitigation measures, many if not all of which require labor inputs. For example, soil conservation efforts such as conservation tillage, agroforestry, rehabilitation of degraded crop and pasture land promise to create employment and sustain rural livelihoods. Conservation tillage also requires specialized equipment, which also means jobs for those making it. 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.

The main policy challenge here concerns the lack of finance made available to support adaptation in the developing world thus far, as the UNDP's *Human Development Report* for 2008 notes. 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 also observes that little progress in implementation has been made because of the costs involved. In its Fourth Assessment Report, the IPCC states that 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 technology transfer.
The potential for green jobs and green livelihoods in a system of sustainable agriculture are difficult to estimate. However, given the fact that 1.3 billion people are presently involved in agriculture, a truly global transition towards more labor intensive sustainable methods could create many millions of new jobs and preserve those green or relatively green livelihoods that already exist. The political and cultural obstacles to such a transition to sustainability are presently enormous, but this opposition may itself be unsustainable over the medium to long term as the environmental crisis deepens and farmers, workers and consumers organize for a sustainable future.

POLICIES FOR A GREEN JOBS STRATEGY

The obstacles to a sustainable world are primarily political and financial and have little to do with the lack of technology or knowledge. And while these obstacles have been identified and

discussed by others, the main ones bear repeating if only to underscore the fact that the barriers to sustainability are, in the final analysis, also barriers to a qualitative growth in green employment at the global level.

• A Green Investment Agenda

Investment creates employment. Without adequate investment the number of new green jobs, or the greening of existing ones, will be impaired. Investment in renewables has grown exponentially in recent years to an estimated $66-85 billion in 2007. This represents about 18 percent of all investment in power generation facilities and equipment and is a major accomplishment. Yet huge sums continue to be directed towards further fossil fuel extraction and towards conventional utility projects. Meanwhile, the Stern review notes that investment levels in energy-saving technology have actually declined by as much as 50 percent over the last two decades in real terms.

The level of investment is also highly inadequate with regard to fuel efficient vehicles and energy retrofits of homes and buildings. Meanwhile, funds for climate change adaptation in the countries and regions of the developing world that will suffer the most from its consequences are abysmally small.

Yet, adequate public and private funding in a number of priority areas could create innumerable jobs. These include continued, accelerated development of wind, solar, and other renewable energy technologies; fuel economy technologies, including second-generation hybrids, plug-in electrics, and fuel cell vehicles; sustainable urban transportation (including BRT systems, alternative fuel buses, etc.), closely linked to urban revitalization; advanced building materials and technologies; increased appliance efficiency; organic and drought-resistant (water-efficient) farming methods; land conservation; and flood prevention and climate protection infrastructure.

• The Need for Government Action

At present, the global market volume for environmental products and services, including energy efficiency, recycling, water sanitation and efficiency, and sustainable transport, runs to about €1,000 billion and may reach €2,200 billion by 2020. This is an encouraging beginning and it has led to growth in green employment. But much more needs to happen to address the environmental crisis and especially climate change. Timely action on the scale needed will occur only with a strong set of targets and mandates, and policy changes that will put an end to today's unsustainable business practices. As current experience in various areas—from vehicle fuel economy to carbon trading—demonstrates, a purely voluntary, market-driven process alone will not deliver. An ambitious mix of regulations, business incentives, and genuine public-private partnerships is required.

While private companies have an important role to play in terms of investments and green job creation, their risk and profit appraisal and their time horizon does not necessarily match with the scale, urgency, and long-term perspective of the public agenda emerging in response to the climate challenge. In assessing such factors as risk and return on investment, private companies will tend to focus on certain countries but disregard other parts of the world, perhaps especially those most affected by climate change and in need of job creation.

Recent business, governmental, and UN 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." The Stern Report on the Economics of Climate Change argues in favor of "a strong technology policy framework that drives action by the private sector." And UNDP's *Human Development Report 2007/2008* concludes that a range of barriers to a breakthrough in climate change mitigation "can only be removed through government action. Public policies on regulation, energy subsidies and information have a central role to play."

The governmental toolbox offers many appropriate instruments, but in most cases these have not been applied at the scale and intensity needed to end unsustainable practices and to promote green employment. Key measures are public investment, subsidy shifts, new R&D priorities, and ecological tax reform. Among non-financial or –fiscal measures, extended producer responsibility laws, eco-labeling, and specific sets of targets, mandates, and promotion of green alternatives—especially in the energy field—play an important role. The tools are available, but they need to be applied with much greater urgency if large-scale green employment is to become a reality.

- ## Green R&D and Technology Transfer

The continued development and diffusion of green technologies is critical to a green jobs future. Some real or potential technological options—like those involved in carbon capture and storage—may produce few employment gains but the environmental gains could be immense. Other technologies such as those involved in water or land conservation in farming, further developing renewable sources of energy, as well as improving energy efficiencies in buildings and vehicles, promise to create plentiful work while making an important contribution to a sustainable future.

Serious challenges remain. As the Stern Review notes, real levels of R&D in low-carbon technologies have actually fallen sharply in recent decades. Carbon taxation is expected to create incentives for the emergence of these technologies, but the charged politics may not permit timely and adequate action, and as a consequence, market responses will either not happen or not fast enough. Governments must put in place other business incentives (such as tax breaks) to maximize private sector investment in green technologies. Public procurement can also help in this process.

The situation with coal illustrates the problem perfectly. The early deployment of Integrated Gasification Combined Cycle (IGCC) and CCS technology in major coal-using countries like China, India, and South Africa would constitute a major breakthrough in the battle to control emissions. However, while projects aimed at cooperation have occurred, such as between the EU and China, and between the US and China, these have proceeded at a pace that's alarmingly slow given the urgency of the emissions situation globally. As the UNDP notes, "At this rate the key technologies will arrive on the battlefield far too late to help the world avoid dangerous climate change."

The competitive calculus of private companies may be at odds with the need to share cutting-edge green technologies as rapidly as possible. In the case of China, for instance, 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. Countries that are in the lead in green technologies, such as Germany, may similarly be averse to such technology sharing, preferring to maintain their export edge.

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 emissions will be unsuccessful, and the promise of a massive increase in green jobs will be unfulfilled—with tragic consequences.

- ## International Cooperation and Aid

The development of green employment across the developing world is being seriously hindered by the abysmally low levels of financial assistance being made available by the developed countries, and the continued bias of multilateral development agencies and national export credit agencies in favor of fossil fuels and large-scale hydropower. Regarding adaptation to climate change, the commitments made by rich-country governments as signatories to the UNFCCC back in 1992 have not been met. The 2007/2008 edition of the *Human Development Report* laments rightly 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."

The contrast between the money being spent on climate change adaptation efforts in rich countries and the amounts spent in poor countries could not be more stark. The UK, 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, currently only $26 million has been spent multilaterally for adaptation measures—a figure that, notes UNDP, is the equivalent of one week's worth of spending on flood defenses in the UK. 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 disaster events.

An effective global adaptation financing strategy is clearly needed. 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.

A reorientation toward renewables could make a huge difference with regard to poverty eradication and job creation, particularly if it were directed toward micro-lending 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.

- **The Clean Development Mechanism and Carbon Trading**

The Clean Development Mechanism (CDM) and Joint Implementation (JI) instruments included in the Kyoto Protocol—under which companies and governments can acquire carbon credits by supporting specific emissions reduction projects—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 (out of about $30 billion worth of global carbon transactions). According to UNFCC estimates, international carbon finance flows to developing countries could eventually climb as high as $100 billion a year in coming decades.

It is tempting to regard CDM-related flows as a way to overcome international financing strictures. But some major problems need to be addressed. First is the highly slanted distribution of CDM projects. Among projects slated for 2002-2012, China alone garners more than half of all associated funds. Most of Latin America is largely losing out, and Sub-Saharan Africa weighs in with an abysmal 2 percent. Second, the costs of certifying a project under CDM have so far been exorbitant (amounting on average to 14-22 percent of projected revenue from selling project carbon credits), and thus are a major barrier for poorer countries and smaller projects. Third, the CDM approach has been piecemeal, 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. Green employment generation does not appear to be an express objective of current CDM projects.

Beyond CDM, if carbon trading is to become a major funding source for climate mitigation and adaptation, then it is important that emissions rights be sold. But in the first phase of the European Union's Emissions Trading Scheme (EU-ETS)—which currently accounts for the bulk of all carbon trading—95 percent of the permits were distributed for free to large emitters. Corporate lobbying led to a situation where allocated carbon permits surpassed actual emissions,

causing carbon prices to fall to nearly zero before recovering somewhat. The cap set for 2008 to 2012 is just 2 percent below actual emissions for 2005, and at most 10 percent of permits can be distributed via auction. Revenue generation will thus remain extremely limited.

JOB TRAINING

Investment to create green jobs is one side of the jobs coin; training and skill building is the other. Both are necessary to bring green employment to its full potential. 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.

JUST TRANSITION

Green employment gains need to be balanced against significant and unavoidable job losses incurred as a result of the movement towards a low-carbon and sustainable society. Overall, far more green jobs will be created in the move toward a sustainable economy than jobs lost. But for affected workers, as well as their families and communities, transition assistance is needed.

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 primarily being driven 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 towards renewables. But they can be expected to accelerate under a climate stabilization policy.

Employment in other industries, too, may suffer from substantial efforts to move toward a low-carbon, high-efficiency economy. For example, while greater vehicle fuel efficiency does not necessarily harm auto industry jobs, a far-reaching modal shift would.

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 pro-active assistance in creating alternative jobs and livelihoods, acquiring new skills, and weathering the transition to new industries.

The transition to new and sustainable patterns of production and consumption and a low carbon future will entail major shifts in employments patterns and skill profiles. 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 still more principle than reality.

Today's turbulent labor markets are characterized by growing informality, precariousness, and a tendency to replace stable terms of employment with fixed-term contracts and casual

arrangements. As already noted, employment in extractive industries, chemical and allied products, shipping, food, and elsewhere in manufacturing is trending downwards as a result of technological change, efficiencies, and also offshoring. A green jobs strategy must therefore be situated within a just transition framework, but this framework must extend far beyond the needs of specific groups of directly impacted workers to include all workers. This underscores the importance of the Decent Work Agenda and for a global approach to social protection where every society establishes a social floor.

The role of the trade unions is critical to the success of the green jobs strategy, and an implacable commitment to just transition on the part of policymakers will ensure maximum trade union cooperation within a framework of social dialogue and freedom of association. Unions internationally have immense experience in worker training and education, and can both expedite change and enhance the quality of new and reconfigured jobs. Meaningful trade union input into the many policy and workplace decisions, both large and small, is also essential. However, the green jobs strategy must be pursued with the view to providing decent work to those who have until now been excluded from better quality jobs as a result of inadequate skills and education or because of race, gender, ethnic, and other forms of discrimination.

PART I

DEFINITIONS AND POLICIES

SECTION 1. DEFINITIONS, SCOPE AND CONCEPTS

In October 2007, the online global career and recruitment service MonsterTRAK launched "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."[1] 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.

There is growing recognition that humanity faces a severe environmental crisis. Air and water pollution, deforestation, desertification, and overfishing are among the key challenges. These problems are compounded by the specter of climate change. 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 waste, and undermine critical eco-systems and eco-services.

To address this challenge will require the development of more benign technologies, a boost in the efficiency with which energy and raw materials are being used, a critical assessment of lifestyle and consumption choices, restoration efforts, but also adaptation to those environmental changes that now seem inevitable and perhaps irreversible. These changes amount to a fundamental ecological transformation of the economy. The move toward a more sustainable economy at once poses a profound challenge for governments, companies, communities, and individuals, and offers vast business and employment opportunities.

But without initiative and impulse from both governmental policy and private investment, these changes will not happen automatically or sufficiently fast. Subsidies, tax structures, and accounting methods that permit the "externalization" of severe environmental costs and therefore make unsustainable practices appear to be sustainable and profitable remain big barriers to more rapid change. So are the deeply-ingrained corporate cultures and patterns of thinking that permeate much decision-making.

Defining Green Jobs

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

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 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 eco-systems. This includes activities, cleaner technologies, products and services that reduce environmental risk and minimize pollution and resource use."[2]

Seen from an ideal point of view, a green economy is one that does not generate any waste and is hyper-efficient in its use of energy, water, and materials. Using this green utopia as a yardstick would mean that

there are few, if any, green jobs. But from a practical perspective, there are many technologies, work processes, and products and services that reduce humanity's environmental footprint, making the economy become more sustainable and thus bridging the enormous gap between today's reality and any kind of green utopia. Given the urgent nature of the environmental crisis, these improvements must be very substantial; marginal changes will simply be overwhelmed by a combination of growing consumption and growing human numbers.

Efficiency is at the core of the environmental challenge—doing more (or the same) with far less material input. But efficiency is a relative and highly dynamic concept. Where is the dividing line between efficient and inefficient? How much more efficient is sufficient? And, given technological progress, can yesterday's level of efficiency still be regarded as efficient tomorrow? Thus, the definition of a green job is ever-changing over time.

The concept of green jobs joins environmental and employment concerns. For a sustainable economy to work for the great majority of the world's workforce, green jobs will need to encompass a range of skills, educational backgrounds, and occupational profiles. And the International Labour Organization emphasizes that green jobs also need to be decent jobs—pairing concerns like efficiency and low emissions with reasonably high labor standards and working conditions. Of course, the precise nature and circumstances of jobs across the planet varies widely, not least with regard to how well remunerated these jobs are. In this regard, for the foreseeable future there can be no single global standard. But even accepting the inevitability of pay differentials, a green job cannot be exploitative or harmful; it needs to provide equal hope for the environment and the job-holder. For example, a recycling job is not a green job if it exposes workers to dangerous materials.

In summary, we define green jobs as non-exploitative and safe positions in agricultural, manufacturing, scientific and technical, administrative, and service-related activities that alleviate the myriad environmental threats faced by humanity. 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.

Counting Green Jobs

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—certain industries or countries. Even where such data are available, they tend to be snapshots rather than time series, and estimates and projections rather 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. Also, efficiency is a relative concept, and there is no easily agreed threshold or cutoff point that separates non-efficient from efficient methods of production. And as time evolves and new technologies become available, what was once considered efficient may no longer meet that description. The same is true for "waste."

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.

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? How well do companies adapt, and to what extent do they attempt to green their operations in pro-active fashion or resist such change? The nature of the 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. (For instance, in November 2007, Charles River Associates published a study financed by the American Petroleum Institute that predicted a net loss of almost 5 million jobs by 2030 as a consequence of energy and climate change legislation proposed in the U.S. Congress. Most studies agree, however, that the likely impact is a small positive change in total employment.[3])

SHADES OF GREEN

"Clean tech" is a broad term that 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.[4]

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 lump together pollution control and waste management 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

is related to pollution control measures. The sector was expected to grow to close to $800 billion by 2015.[5]

Pollution control responses were central to the initial response to signs of environmental degradation from the 1960s and 1970s on. Environmental regulations led to the creation of a sizable industry that, by the turn of the century, employed a conservatively estimated 11 million people worldwide, many of them in traditional manufacturing and construction jobs.[6]

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

Energy Supply	
	Integrated gasification / Carbon sequestration
	Renewables (wind, solar, biofuels); 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 (reducing distance and dependence on motorized transport)
Manufacturing	
	Pollution control (scrubbers and other tailpipe technologies)
	Clean production techniques (toxics avoidance)
	Cradle-to-cradle (closed-loop systems)
Buildings	
	Solar heating/cooling, solar roofs
	Weatherization / retrofitting
	Green Buildings (efficient windows and lighting; insulation; building materials)
Materials Management	
	Recycling
	Reuse
	Extended Producer Responsibility / Product Take-back
	De-materialization
	Durability and repairability of products
Retail	
	Promote efficient products / eco-labels
	New service economy (selling services, not products)
	Locate stores closer to residential areas
	Minimize shipping distance from origin of products to store location
Agriculture	
	Soil conservation
	Water efficiency
	Organic growing methods
	Reducing farms-to-market distance

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 ecological-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 the 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, the diversification of transportation modes, and the development of "clean production" 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 one hand to proactive measures on the other. Table I.1-1 gives an indication of this graduation from more limited to more transformative approaches for major parts of the human economy and society.

Developing renewable, efficient, and waste-avoiding technologies, production processes, and 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 definition of what constitutes a green job—or more specifically, a consistent definition of 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 a more of an impressionistic picture than a precise set of job figures.

CONCEPTUAL ASPECTS

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, or if, as the Australian government decided, inefficient light bulbs are phased out.
- Fourth, it would appear that many jobs will simply be **redefined** in terms of the day-to-day skill sets, work methods and profiles. It goes without saying that this last aspect is by far the hardest to document and analyze, and to foresee the full implications.

Some of the new green jobs will be in high-skilled, high-tech positions. Green awareness and applied literacy will become increasingly important in many professions. But not all green jobs will be new, 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.[7] 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 (R&D), professional associations, and civil society organizations (advocacy and watchdog groups, community organizations).

Table I.1-2. Greening the Economy: Types of Employment Effects

Type of Effect	Observation
Positive and negative employment effects	• Green policies and business practices can create new or preserve existing jobs. • 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 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 directly created through increased demand and output induced by environment-related expenditures. • Indirect employment effects are due to higher demand for intermediate goods and services, and due to multiplier effects (increased wage incomes that generate further demand and employment).
Temporary and sustainable 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 (reflecting the aggregate amount of employment generated)

Source: Adapted from Organisation for Economic Co-operation and Development (OECD), *Environment and Employment: An Assessment*, Working Party on National Environmental Policy, ENV/EPOC/WPNEP(2003)11/FINAL (Paris, 17 May 2004), pp. 9-10. Available at http://www.oecd.org/dataoecd/13/44/31951962.pdf.

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. And in conceptual terms, too, there are important distinctions. (See Table I.1-2)

There is also the question to what extent specific communities, regions, or countries benefit from green employment. In part, this is linked to the question 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 accrues to a relatively small group of countries, at least until other countries catch up. (This goes for R&D and manufacturing operations; 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.)

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 every-day 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 thus at all be considered. 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 is where purchases of food, clothing, etc. are made; in other words, to what extent money spent circulates in the local or regional 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 necessarily 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 for each unit of spending than expenditures in more polluting and waste-generating industries. In other words, are they more or less labor-intensive?

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 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 has to 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 for the same cost. An in-depth literature review prepared by the U.S. Department of Energy on behalf of the International Energy Agency 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 (<10-40 percent) for residential space heating, water heating and automotive transport; and anywhere from 0 to 50 percent for residential space cooling.[8] 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.[9] 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 (that would have been necessary to construct and open additional coal or bauxite mines, refineries, metals-processing plants, power stations, dams, or irrigation systems). 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. (In the electricity-generating sector, for instance, an estimated $170–$200 billion were invested annually during the 1990s.[10]) The authors of a 1999 study, *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."[11]

Shifting from fossil fuels to 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 or up front it may well entail higher costs. First, with regard to alternative sources of energy, it took a number of years for wind-

generated electricity to become cost-competitive with gas and coal-fired power plants. Solar PVs remain far more expensive for the foreseeable future. To the extent that governments mandate that such alternatives are 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. Second, for energy efficiency projects, the up front 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.

WINNERS AND LOSERS

As the move toward a low-carbon and more sustainable economy gathers steam, growing numbers of green jobs will be created. Not everyone will be a winner, however. There will also be losers—at least temporarily: 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 and waste disposal expenses. Such advantages will loom larger as governments move to counter climate change and to direct economies toward greater sustainability through full cost accounting and other measures, so that energy and materials inputs are properly priced.

Jobs and attendant incomes will occur primarily in those countries, companies, and locations that lead the development of green technologies and manufacturing of equipment like solar panels and wind turbines. Unlike the conventional energy industries of coal, oil, and natural gas, the winners in the development of renewables 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. carmakers have long been reluctant to pursue this technology (and fuel efficiency more generally) and have announced heavy layoffs in recent years.

As with any type of economic change, there will be winners and losers, although public policy (through technology diffusion and other measures) can and should seek to minimize disparities. Although the losers, with regard to employment, are likely to be far outnumbered by the winners (as many studies suggest), 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, or the new jobs may primarily arise in other locations. Regions and countries that depend heavily on extractive and polluting industries will confront a substantial challenge to diversify their economies. Thus, overly aggregated job numbers may hide important distinctions and disparities.

There are examples of cities and regions that have begun to successfully reinvent themselves. Toledo, 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 solar panels.[12]

Resource extraction and heavy, 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.

QUALITATIVE ASPECTS

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. Unfortunately, many of the existing studies pay only cursory or no attention to these dimensions.

Green jobs span a wide array of skills and occupational profiles. They will occur in research and development; professional fields such as engineering and architecture; project planning and management; administration, marketing, retail, and customer services; auditing (diagnostics, monitoring); and in many traditional blue collar areas such as plumbing or electrical wiring.

Wind power development, for example, 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.[13] 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.

In principle, environmental policies may be expected to contribute to the demand for more educated and skilled workers, as green production in general equals more intelligent production methods. This is a general hypothesis, however, that needs testing in specific circumstances.

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 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. Materials productivity, too, is barely higher now than it was in 1950. [14]

European and Japanese economies have been more attentive to efficiency goals (and consume far less in per capita terms). For example, driving one mile in the United States requires an estimated 37 percent more fuel than 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.[15]

Nonetheless, similar trends are observable: in Germany, for instance, 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.[16] German industry could save about 20 percent of its current raw materials use by 2016 through higher materials efficiency—avoiding annual inputs worth about €27 billion.[17] 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.[18]

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. (See Table I.1-3.) 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.1-3. 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: McKinsey Global Institute, *Leapfrogging to Higher Energy Productivity in China* (July 2007), p. 10. Available at http://www.mckinsey.com/mgi/reports/pdfs/leap_frog/MGI_china_perspective.pdf.

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.[19]

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.[20]

There are many opportunities for business innovations, including better design, new materials, improved fabrication technologies, and use of innovative software.[21] 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.

SECTION 2. SETTING THE CONTEXT: A DUAL CHALLENGE

Note: This section will be completed during the final phase of the project and is expected to help place this report within the context of today's rapidly evolving economic and environmental challenges and opportunities.

SECTION 3. GREEN POLICIES AND BUSINESS PRACTICES

GREEN BUSINESS 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 offers the following pragmatic reasons why business should consider investing in sustainable ecosystems: [22]

- Create new revenue streams by introducing innovative products and services such as, for example, substitutes for ecosystem products
- 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.[23] The same year, Siemens, one of Germany's corporate giants, decided to devote half its research budget of €5.7 billion to climate-protection programs.[24] 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 €1,000 billion, according to German-based Roland Berger Strategy Consultants, with a projected €2,200 billion by 2020. The firm offers the following estimates for individual market segments: [25]

- energy efficiency technologies (appliances, industrial processes, electrical motors, insulation, etc.): €450 billion at present (€900 billion by 2020)
- waste management/recycling: €30 billion (€46 billion by 2020)
- water supply/sanitation/water efficiency: €185 billion (€480 billion by 2020)
- sustainable transport (more efficient engines, hybrids, fuel cells, alternative fuels, etc.): €180 billion (€360 billion by 2020).

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; 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 are 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).[26] The choices made today—whether to invest predominantly in conventional energy or in alternatives—will be a major determinant how the world fares in its efforts to address environmental degradation and climate change.[27] 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 four-fold increase over 2005. Green business is becoming an engine of German economic development.[28] 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.[29]

Financial Flows in the Energy Sector

The United Nations Framework Convention on Climate Change 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."[30] 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.[31] 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.[32] 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.[33] 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.[34] 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."[35] 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."[36] 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.[37]

- 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."[38]

- UNDP's *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."[39]

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 driving forward a strong framework within which green employment can be promoted far better than is possible today. This section will first discuss a number 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 a variety of 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.[40] There are many examples of small and large-scale efforts. In its drive to accelerate the development of the renewable energy sector, for instance, Chen Deming, vice chairman of China's National Development and Reform Commission (NDRC), announced in September 2007 that the country was planning to invest 2 trillion yuan ($265 billion) in renewables.[41] An effective effort on a much smaller scale is the four-year $7.6 million Indian Solar Loan Program that was launched by UNEP and two Indian banks in 2003 to help accelerate the market for domestic solar systems in the country's south.[42]

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.[43]

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 car use are not charged to motorists, which makes individual automobile travel cheap in comparison with rail and other modes of transportation.[44]

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.[45] 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.

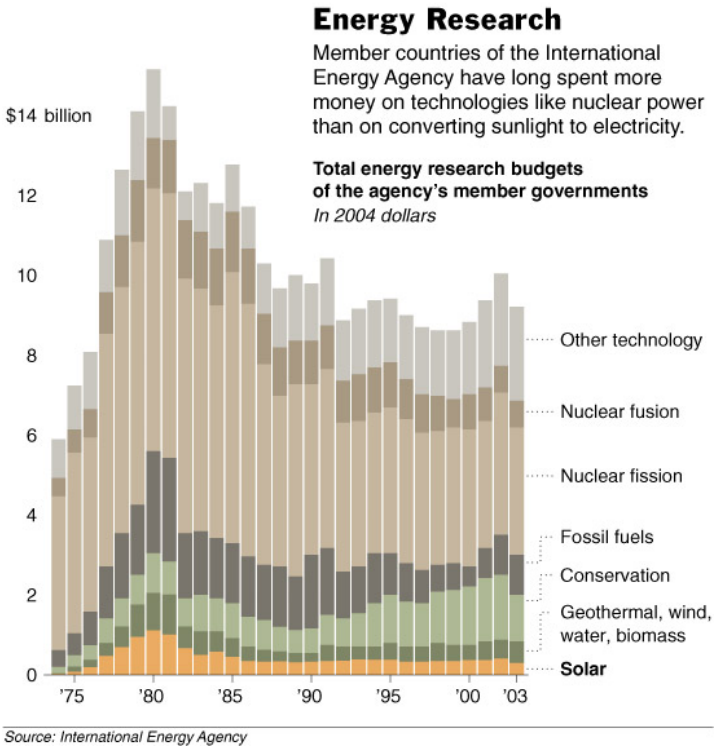
Various types of renewables subsidies have had considerable success in a number of countries. Providing favorable financing through low-interest loans for individuals and businesses can help create a market that otherwise might take a very long time to emerge and to climb to a scale where significant 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.[46]

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. Such support for fossil fuels is now much more limited than it was in the 1980s and 1990s. But nuclear technologies are still receiving massive assistance. Renewable energy is receiving negligible amounts—including solar technologies, which have yet to become cost-competitive with fossil fuels. Support for energy conservation, meanwhile, has increased since the 1990s, but is also still dwarfed by nuclear R&D. (See Figure I.3-1.) The Stern Review recommended doubling the aggregate amount of public funds devoted to energy R&D from the current level to about US$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.[47])

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.[48] Dan Kammen of the University of California notes some facts that are startling at a time when concern over both energy security and environmental degradation is high: the federal government's fiscal year 2008 energy research and development request of $2.7 billion is far less than spending in the late 1970s and early 1980s; the 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.[49]

Figure I.3-1. Energy Research and Development Budgets, IEA Members, 1974-2003



Source: Andrew C. Revkin and Matthew L. Wald, "Solar Power Wins Enthusiasts but Not Money," *New York Times*, July 16, 2007, http://www.nytimes.com/2007/07/16/business/16solar.html.

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.[50] By 2006, the World Bank had increased its support for energy efficiency projects (($447 million) and renewable energy ($412 million).[51]

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. Ex-Im 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.[52]

Meanwhile, overseas development assistance by members of the Organization for Economic Co-operation and Development (OECD) has been heavily focused on hydropower, and the amounts provided have fluctuated heavily. (See Table I.3-1)

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).[53]

Table I.3-1. Overseas Development Assistance for Renewable Energy, 1999-2003

	1999	2000	2001	2002	2003
	(millions of 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, for hydro $420 million/year.
Source: REN21 Renewable Energy Policy Network, *Renewables 2005 Global Status Report* (Washington, DC: Worldwatch Institute, 2005). Note 15, available at http://www.ren21.net/pdf/RE2005_Notes_References.pdf.

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 Emissions 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).[54] According to UNFCC estimates, international carbon finance flows to developing countries could eventually climb as high as $100 billion a year in coming decades, as carbon trading expands.[55] 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.[56]

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.[57]

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 EU-ETS, 95 percent of the permits were distributed for free to large emitters[58]—effectively foregoing substantial revenue that could have been used to promote environmentally benign technologies, either within the EU or abroad. 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 to 2012 is just 2 percent below actual emissions for 2005, and at most 10 percent of permits can be distributed via auction.[59] 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.[60]

Table I.3-2. Environmental Tax Revenue, European Union, Selected Years

Environmental Taxes	1980	1990	2000	2004
	(billion Euros)			
Revenues	54.6	130.4	242.8	266.4
	(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

Data are for EU-15 members.
Source: Ulf Johansson and Claudius Schmidt-Faber, "Environmental Taxes in the European Union 1980–2001," *Eurostat Statistics in Focus*, 9/2003; EUROSTAT online database, available at http://epp.eurostat.ec.europa.eu/portal/page?_pageid=0,1136239,0_45571447&_dad=portal&_schema=PORTAL.

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 European Union (EU) more than quintupled between 1980 and 2004, to 266 billion Euros. (See Table I.3-2.) The bulk of these revenues are derived from taxes on gasoline and diesel, and on motor vehicles.[61]

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."[62]

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 (CO2). 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.[63]

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.[64]

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.[65] (See Table I.3-3.)

Table I.3-3. Extended Producer Responsibility Laws, Selected Industries [as of 2004; update]

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

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 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 1 July 2006. There is growing concern worldwide about these hazardous materials; Japan is the leader in eliminating such substances from electrical and electronic products, and China intended to model its policy on the EU Directive. [66]

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.[67] An eco-label first 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.[68] 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.[69] 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.[70] Developing countries also have adopted or are developing eco-labels, including India, Indonesia, Thailand, and the Philippines. Thailand's Green Label involved 148 brands in 39 product categories.[71] In India, the government has established criteria for 16 product groups under its 1991 Ecomark label.[72]

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-ours 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.[73]

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 food-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.[74]

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.[75] The Australian Government, meanwhile, announced in February 2007 that all inefficient light bulbs will be phased out by 2009-2010 in favor of efficient CFLs. It expects that the move will reduce the country's greenhouse gas emissions by 4 million tons by 2012.[76]

The European Commission 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.[77]

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.[78]

Table I.3-4. Global Vehicle Fuel Efficiency and Greenhouse Gas Emissions Standards[1]

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[2]
Canada	5.3 Mt reduction	Vehicle class-based	Voluntary
California	Grams/mile	Vehicle class-based	Mandatory

[1] Standards are applicable for new vehicles only, except for Canada (new and in-use).
[2] EU is moving toward mandatory standards.
Source: Adapted from "ICCT Releases New Report Comparing Global Fuel Economy and CO2 Standards," *Green Car Congress*, July 31, 2007, at http://www.greencarcongress.com/2007/07/icct-releases-n.html.

A number of countries have adopted either minimum vehicle fuel efficiency requirements or upper allowable limits for greenhouse gas emissions. (See Table I.3-4.) 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.[79] Europe, focusing on greenhouse gas emissions, is poised to move from voluntary to mandatory measures.[80] 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.[81] China recently established standards that almost match levels prevalent in Japan and Europe, and are higher than those in the United States. (See Textbox I.3-1.)

Textbox I.3-1. 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[82], and is expected to reach 87 percent by 2030.[83] 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.[84]

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 for the lightest passenger cars to 15.5 l/100 km for the heaviest). In January 2008, a second phase tightens the allowable limits (with a range of 6.2 – 13.9 l/100 km). (China has also enacted its first compulsory limits on fuel consumption of light commercial vehicles, to take effect on February 1, 2008.[85])

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.[86] 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[87], and an environmental tax.[88]

— Yingling Liu

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.[89] 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 (it was less than 7percent in 2005).[90]

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.[91]

Outside the European Union, a growing number of countries have established renewable energy targets. In non-EU Europe, they are Norway, Switzerland, Croatia, and Turkey; in North America, Canada, the United States, and Mexico; in South and Central America, Argentina, Brazil, and the Dominican Republic; in Asia/Oceania, India, Pakistan, China, Japan, South Korea, Malaysia, Thailand, the Philippines, Singapore, Australia, and New Zealand; in the Middle East, Israel, Jordan, Egypt, Morocco, Tunisia, Syria, and Iran; and in Sub-Saharan Africa, Nigeria, Mali, Senegal, Uganda, and South Africa.[92] The Chinese government set ambitious targets—the goal is to generate at least 15 percent of electricity from renewable energy sources by 2020. (See Table I.3-5.)

Table I.3-5. 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 Panels	Million Square Meters	100	150	300
Ethanol	Million Tons	1	2	10

Source: Eric Martinot and Li Junfeng, *Powering China's Development: The Role of Renewable Energy*, Worldwatch Report (Washington, DC, November 2007), p. 14.

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 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, led to economies of scale, and to dramatic cost reductions.[93]

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.[94]

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, grant or rebates; investment excise or other tax credits; sales tax, energy tax, or VAT reductions; net metering; public investment, loans, or other financing; and public competitive bidding.[95] (See Table I.3-6.) About 40 countries, states, and provinces had enacted feed-in laws and renewable portfolio standards by 2006.[96]

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."[97]

Table I.3-6. 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 tariffs, are paid over several years, and typically decline over time to reflect cost reductions. Costs are covered by energy taxes or an additional per-kilowatt-hour charge on electricity consumers. Germany, Spain, and Denmark have 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 photovoltaic (PV) development. Under Tendering Systems, companies submit bids to a public authority for contracts to fulfill quota mandates. In the UK, this approach facilitated financing, but led to uneven progress (flurries 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 Japan, Thailand, Canada, several U.S. states, and some other countries.
Financial Incentives	A variety of mechanisms to subsidize investment in technology development or support power production from renewables—including **investment subsidies, tax credits, rebates, loans**, etc.—have been used in Europe, Japan, the United States, and India. California and India underwent wind 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, 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 offer PV rebates as well. Low-interest, long-term loans and loan guarantees are essential to overcome high upfront capital costs, as experience in China, India, Indonesia, South Africa, the Dominican Republic suggests.
Standards	Standards are essential to ensure high-quality technologies, reduce associated €480 billion 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 PVs.
Vocational Training	Training and certifying workers are essential to ensure that competent people are available to manufacture, install, and maintain renewable energy systems. Austria, Germany, and India are among the countries that have established successful training programs.

Sources: Adapted from Janet L. Sawin, *Mainstreaming Renewable Energy in the 21st Century*, Worldwatch Paper 169 (Washington, DC: Worldwatch Institute, May 2004), pp. 34-43; Janet L. Sawin, "Solar Power Shining Bright," *Vital Signs 2007-2008* (New York: W.W. Norton, 2007), p. 38; Greenpeace and Global Wind Energy Council, *Global Wind Energy Outlook 2006* (Brussels, September 2006), p .11; American Wind Energy Association, "Wind Power Outlook 2005," Washington, DC; Government Accountability Office, "Wind Power's Contribution to Electric Power Generation and Impact on Farms and Rural Communities," GAO-04-756, September 2004, p. 32.

A stable policy framework, with regard to government incentives and rules, will continue to be critical for the speedy development of alternatives. The U.S. experience with the on-and-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 that China's failure to develop a strong domestic market for solar cells are indicative of the fact that the renewables industry is not yet self-sustaining.[98]

PART II

EMPLOYMENT IMPACTS

INTRODUCTION

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 alternative (renewable) energy, the building sector (including appliances and office equipment), transportation, and food and agriculture. A later version of this report will also address prospects in selected industrial sectors and the waste management/recycling industry.

It is worth to pause for a moment to briefly consider 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 affected 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, but 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.[99]

Ideally, prevention is far preferable to remedial efforts. However, especially with regard to climate change, this is no longer an option. 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 UN Framework Convention on Climate Change 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.[100]

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.

SECTION 1. ENERGY SUPPLY ALTERNATIVES

INTRODUCTION

This section analyzes the economic and employment prospects of alternative sources of energy alternative 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 challenge. 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 1986-1990).[101]

Advocates for the coal industry have similarly argued that new technologies may give this heavily polluting energy source a new lease on life. Though often called "clean coal," these are unlikely to withstand serious environmental scrutiny. Still, with or without such technologies, 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.[102] 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 coal plants. Carbon capture and sequestration (CCS) might be of help in this regard. However, an inherent danger of a sequestration strategy is that instead of being a pragmatic measure of dealing with carbon emissions from existing plants, it might tempt governments and businesses toward a renewed and even greater commitment to coal. 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 sources of energy and greater energy efficiency.

This section discusses a range of renewables—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 advantages over fossil fuels, and some may even impose new environmental costs. A careful distinction within the biofuels sector is thus advisable—even though available employment estimates do not necessarily permit a clear-cut differentiation. A similar

word of caution is in order with regard to hydroelectricity: large-sale 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.

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. (See Table II.1-1.)

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

Country	1996	2006	Change
	(thousands)		(percent)
China[1]	9,020	5,580	-38
Romania	241	120	-50
Ukraine[2]	4,390	4,037	-7
Slovakia	34	16	-52
South Africa[3]	603	398	-34
United States[4]	569	687	+21
United Kingdom[5]	107	103	-4
Malaysia[6]	35	27	-22

Note: Includes coal and metals mining and oil and gas extraction jobs.
[1] Data are for the years between 1996 and 2002. [2] Data are for 2001 and 2006. [3] Data are for 2000 and 2006. [4]Employment has peaked three times in 1998, 2001 and 2004.[5] Data are for 1997 and 2005. [6]Data are for 1996 and 2000.
Source: International Labour Organization, *LABORSTA Labour Statistics Database*, (Geneva, 2007).

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 fall in the number of people employed in coal mining, which accounted for less than 1 per cent of the global workforce in 2002.[103] In addition, global mining and quarrying have shown an average decline of more than 20 percent in 1995–2005.[104]

- In Europe, British coal production has declined steeply, and employment evaporated from 229,000 in 1981 to about 5,500 miners today.[105] (Although about 4,000 former miners found jobs retrofitting homes to make them more energy-efficient, about 100,000 have remained long-term unemployed.[106]) 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.[107]

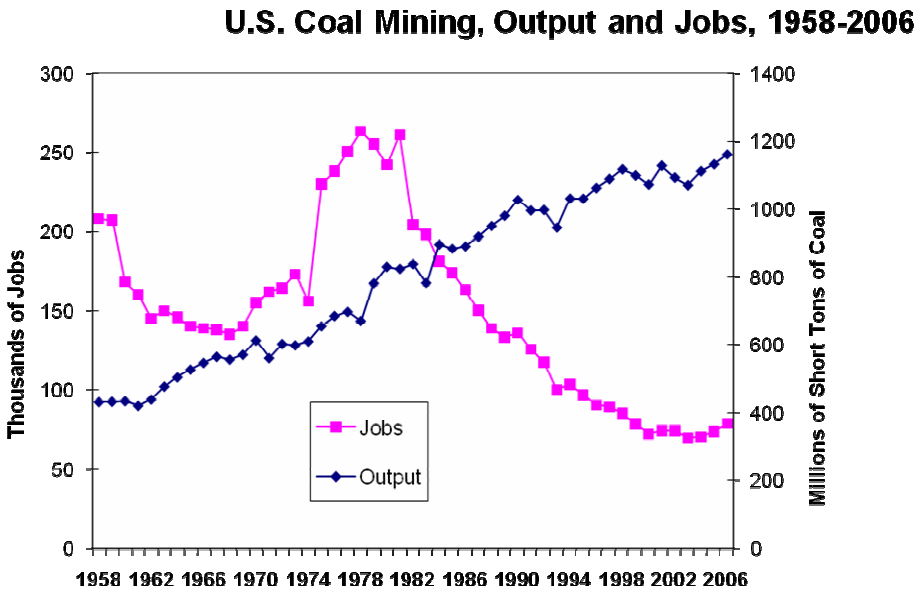
- China—the world's largest coal producer—cut some 870,000 jobs in the second half of the 1990s.[108] The growth of production has slowed in recent years, from 15 percent to 8 percent. Employment in China's quarrying and mining sectors has steadily fallen as well with total loss in jobs of 31 percent between 1997 and 2002.[109] But China continues to add huge capacities in coal-fueled 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 1,200 megawatts. This compared with older plants that employ up to 1,000 people in a 50 or 100 megawatt facility.[110]

- 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. (See Figure II.1-1)[111] 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.[112]

- 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 of time.[113]

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.[114] 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.[115] By a different reckoning, the decrease in employment in Europe's electricity-generating sector is likely to have amounted to about 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.[116]

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



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, to more than $50 billion in 2006 and an estimated $66 billion in 2007.[117] 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.[118] Although renewable energy still accounts only for 2 percent of worldwide installed power generating capacity, it garnered 18 percent of all investment in power generation facilities and equipment.[119]

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.[120]

A variety of analysts project a continued surge in investments and sales in coming decades. Based on a scenario developed by the European Renewable Energy Council, the German environment ministry projects that global capacities for electricity production from renewables will expand from 900 gigawatts in 2004 to 2,160 GW by 2020 and 4,070 GW by 2030, implying a rise in investments to €250 billion in 2020 and €460 billion in 2030.[121]

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 €75 billion market for fuel cells by 2020.
- Geothermal power might become to a $35 billion industry by 2020.
- Ocean wave power could become a $10 billion per year industry by 2012.[122]

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 PVs 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).[123]

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 gigawatts in 1965 to 71 GW in 1975. Wind capacity has expanded from 4.8 GW in 1995 to 74 GW in 2006.[124]

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. 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.[125])

Table II.1-2. Global Production Capacities[1] 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, USA, Italy, Brazil
Wind Power	59	74	Germany, Spain/USA, India, Denmark
Biomass Power	43	45	USA, Brazil, Philippines, Germany/Sweden/Finland
Geothermal Power	9.3	9.5	USA, Philippines, Mexico, Indonesia/Italy
Solar Photovoltaic (grid-connected)[2]	3.3	5.0	Germany, Japan, USA, Spain, Netherlands/Italy
Solar Thermal Electric Power	0.4	0.4	USA
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.*	*USA, 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[3]			
Ethanol *(Billion Liters)*	33	38	Brazil/USA, China, Spain/India
Biodiesel *(Billion Liters)*	3.9	6.0	Germany, France, Italy, USA, Czech Republic

[1] Cumulative production capacities.
[2] An additional 0.3 and 2.7 GW of off-grid capacity was in place in 2005 and 2006, respectively.
[3] Annual production.
Source: Adapted from REN21 Renewable Energy Policy Network, *Renewables Global Status Report 2006 Update* (Paris: REN21 Secretariat and Washington, DC: Worldwatch Institute, 2006); plus draft report of May 2007 (double-check numbers plus correct citation of final version)

To date, a small number of countries account for the bulk of renewables installations. (See Table II.1-2.) In wind power, the top 5 countries represent 72 percent of global capacity; in grid-connected solar PV installations, the top 2 (Japan and Germany) account for 87 percent; in solar hot-water, the top 5 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 2 (USA and Brazil) produce 90 percent of global output; and in biodiesel, the top 5 represent 78 percent of production.[126]

This does not mean that alternative forms of energy have limited appeal, but it is an indication 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.[127]) 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.[128]

The German Experience

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.[129] In 2006, more than 70 percent of German-manufactured wind power plants in 2006 were exported.[130] Roughly every third wind turbine and solar PV cell in the world is German-made.[131]

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.[132] 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.[133] (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.[134] This may bring employment in the renewables sector to roughly 400,000 jobs.[135] 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.[136]

Table II.1-3. Employment[1] in the German Renewables Sector, 1998, 2004, and 2006

	1998	2004	2006	Expected Growth, 2006-2010[2] (%)
Wind Power	16,600	63,900	82,100	6.8
Solar Energy	5,400	25,100	40,200[3]	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[4]**	**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.**

[1] 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.
[2] According to a poll of businesses. [3] 26,900 jobs in solar PV, 13,300 in solar thermal.
[4] Of this figure, 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 [xx].

Other projections are similarly marked by optimism. In April 2007, the Bundesverband Erneuerbare Energien (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.[137] Solarportal24, a Web site, states that Germany's renewables sector may see its turnover grow by 17 percent in 2007, reaching €32 billion. This figure includes domestic investments of €11.7 billion, sales of €12 billion and €8.2 billion in export sales. By 2010, the sector hopes to see its total sales grow to €45.3 billion (propelled primarily by exports). An estimated 45,000 new jobs would likely be created in the process.[138]

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.[139]

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. (See Table II.1-4.)

Table II.1-4. Estimates of Chinese Employment in the Renewables Sector

	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[1]	*25*	*50*	*40*	*10*	*125*

[1] Output value expressed in billion Yuan (1 billion Yuan = $135 million).

Source: Li Junfeng, Deputy Director General of the Energy Research Institute (ERI) of the National Development and Reform Commission in Beijing, and General Secretary of the Chinese Renewable Energy Industries Association (CREIA), as per private communication with Yingling Liu, Worldwatch Institute China Program Manager, November 12, 2007.

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 2004 report by the Apollo Jobs Alliance estimated that a 10-year federal investment of $36 billion in biofuels and other renewables could add close to 420,000 jobs.[140]

- A 2002 study by the CALPIRG Charitable Trust suggested that current demand in California would support 5,900 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. [141]

- 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. [142]

- 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.[143]

- A 2007 analysis by the Union of Concerned Scientists 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.[144]

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. [145]

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. (See Table II.1-5.) 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. [146]

Table II.1-5. Employment in the U.S. Renewables Sector, 2006

Industry Segment	Direct Jobs	Direct and Indirect Jobs
Wind Power	16,000	36,800
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: Roger Bezdek (Management Information Services, Inc.), *Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century*, Report for the American Solar Energy Society (Boulder, CO: ASES, 2007), p. 24.

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 390,000 jobs.

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.[147]

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—and 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.[148]

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.1-6.), per unit of energy produced, and per dollar of investment. 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.[149]

Table II.1-6. 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

Based on findings from a range of studies published in 2001-2004. 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: Daniel M. Kammen, Kamal Kapadia, and Matthias Fripp, *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?* RAEL Report, Renewable and Appropriate Energy Laboratory, University of California, Berkeley, 2004, p. 10. Available at http://socrates.berkeley.edu/~rael/papers.html.

Based on figures summarized in Table II.1-6., 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.[150] 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.[151]

Job per MW 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 PVs 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.[152]

WIND POWER

Global wind power generating capacity exceeded 74,000 megawatts (MW) by the end of 2006—close to ten times as much as in 1997. Germany had 20,600 MW of capacity installed, followed by Spain (11,615 MW) and the United States (11,600 MW). India remains in fourth place, with 6,270 MW, before Denmark and China. China plans to double its wind capacity by 2010 and reach 30,000 MW by 2020. More than 50 nations now produce electricity from wind, and 13 countries have at least 1,000 megawatts installed.[153]

In Europe, the market leaders are now being joined by a second wave of countries, including Portugal, France, the UK, Italy, the Netherlands and Austria. In Asia, Japan, South Korea, and Taiwan are gathering momentum. 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[154]). 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 getting some traction.[155]

Total turnover in the international wind market in 2006 was estimated at more than €13 billion.[156] 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 megawatts by 2020. [157]

Employment data by industry publications vary. According to the GWEC there were some 150,000 wind energy jobs worldwide in 2005.[158] It appears that this includes only direct jobs. Annual surveys conducted by the World Wind Energy Association 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. [159]

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[160]; they still have an 80 percent market share today. [161] Although having lost market share in recent years, Denmark's Vestas remains the leading manufacturer, with 27 percent of the global market in 2006.[162] Other leading turbine manufacturers are based in Germany, Spain, the United States, and India.[163] The leading four companies controlled 73 percent of the world market in 2006. [164] 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.[165]

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.[166] 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. (In 1998, nuclear power had 31 percent of the German electricity market but supported a comparatively meager 40,000 jobs; coal-generated power had a 26-percent market share and was the source of 80,000 jobs. [167] Update)

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 were added in 2005 and 2006, whereas Germany added 4,000 MW during that time, India 3,270 MW, or 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.[168] Denmark has been bypassed by Spain, where some 35,000 people were working in the wind power sector in 2006.[169]

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 Government and the British Wind Energy Association, in 2005 there were only about 4,000 jobs in the sector. [170]) 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, but will rather 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.[171] But a 2004 study by the Renewable Energy Policy Project (REPP) in Washington, DC 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. [172]

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.[173]

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.[174] Brazil has now lifted the domestic content requirement. [175]

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.[176] But India's domestic manufacturing of wind turbine components—and thus employment—is also 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.[177] Most of the turbines produced in India are currently exported, and several of its manufacturers are expanding their capacity to meet growing demand abroad and at home. [178]

Foreign companies—principally Denmark's Vestas, Spain's Gamesa, and U.S. General Electric—have controlled about two-thirds of China's wind turbine market in recent years.[179] But the Chinese government has encouraged 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).[180] 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.[181] (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.[182])

And the country has more than 40 other domestic firms involved in the development of turbine prototypes.[183]

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.[184] China's wind turbine industry still confronts shortages of both experienced wind engineers and a range of components.[185]

Textbox 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 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.[186]

Meanwhile, 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.[187] 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.[188]

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.[189]

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.[190]

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.[191] 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.[192] (See Textbox II.1-1)

Future Prospects

Employment projections to 2020 for the EU-25 countries by the European Wind Energy Association (as of 2004) 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. [193]

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; 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.

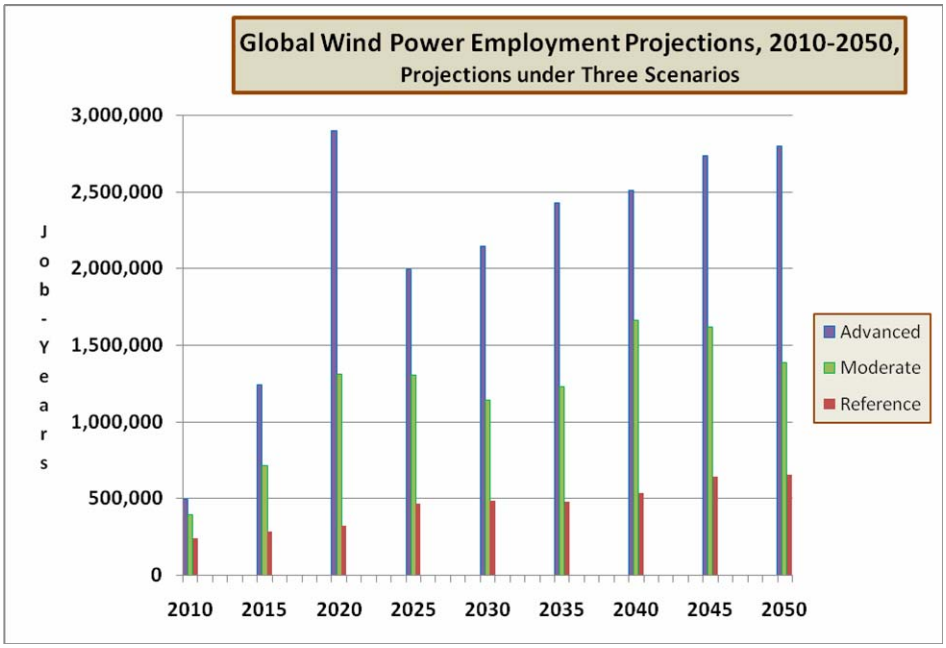
The capital costs of wind turbines have steadily fallen, but overall investment keeps growing strongly, projected by GWEO under its three scenarios to rise from under €12 billion in 2005 to €29-112 billion by 2050. (Under the Moderate and Advanced scenarios, annual investment actually peaks earlier: at €75 billion in 2040 and €141 billion in 2020, respectively.) 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 €158-186 billion. [194]

Under the Reference scenario, cumulative capacity would grow from 59 gigawatts (GW) 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. [195]

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/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.[196]) An additional 5 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.[197] (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.[198] Global sales revenues of €9 billion [$__] in 2006 are projected to rise to $27.5 billion by 2012.[199] Investment in facilities to manufacture solar cells and modules is expected to total at least €4 billion in 2007-2010, ensuring continued strong performance.[200]

Global production of PV cells rose to a record 2,521 megawatts in 2006—a nine-fold increase over 2000. Japan remains the leading PV manufacturer (with a 37-percent market share in 2006—down from 50 percent in 2004). Germany is second with about 20 percent, and it continues to dominate the installation market (with far more than half of all new installations worldwide in 2006). China and Taiwan dramatically increased their production to an estimated 547 megawatts (but most of their output—90 percent in the case of China—is for export, principally to Germany and Spain). The United States is the fourth-largest producer, just slightly ahead of Taiwan.[201] On the corporate side, the top 10 producers account for roughly two-thirds of global production. (See Table II.1-7.) Japanese and German companies are dominant, but China's Suntech has risen rapidly to become the fourth-largest manufacturer.[202]

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.[203] *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 is in research, wholesaling, and supply.[204] In light of various national employment estimates, from China in particular, these numbers appear to be on the conservative side. Global PV employment may now stand at 115,000.

Table II.1-7. 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 (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: European Photovoltaic Industry Association and Greenpeace International, *Solar Generation IV – 2007* (Brussels and Amsterdam, September 2007), p. 26 (by country); Li Junfeng et al, *China Solar PV Report 2007* (Beijing: China Environmental Science Press, 2007), p. 10 (by company).

As mentioned earlier, a German government-sponsored study estimated PV employment at 26,900 jobs in 2006. In 2007, the Bundesverband Solarwirtschaft (German solar energy association) put employment at 35,000 people—surpassing the number of jobs in the country's nuclear industry.[205]

A "PV Roadmap" produced by the U.S. Solar Energy Industries Association (SEIA) industry 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.[206]

A Renewable Energy Policy Project assessment based on the U.S. 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.[207]

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.)[208] 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).[209]

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. But relatively few companies are involved in wafers and silicon production. Chinese silicon production was limited to just over 10 percent of total use of over 3,000 tons in 2006. However, several firms were expected to add production capacity totaling more than 4,000 tons during 2007 and 2008.[210] 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.

A 2006 report by the European Photovoltaics Industry Association (EPIA) and Greenpeace International projected possible PV employment by 2025—80,000 to 100,000 jobs in Germany, 180,000 in the United States, and 430,000 in China. It reported 9,000 Japanese PV jobs in 2005 and forecast a possible increase to 92,000 by 2025 and 300,000 by 2030. A number of countries that currently don't play a major role in PVs may 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.[211]

As important as leadership in PV technology is, many jobs are also created in the installation and servicing of PV systems than in their manufacture.[212] The technology thus holds promise for economic development and employment in many locations. An assembly project has even been initiated in Kibera, a notorious slum area of Kenya's capital Nairobi. (See Textbox II.1-2.)

Textbox II.1-2. 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.[213]

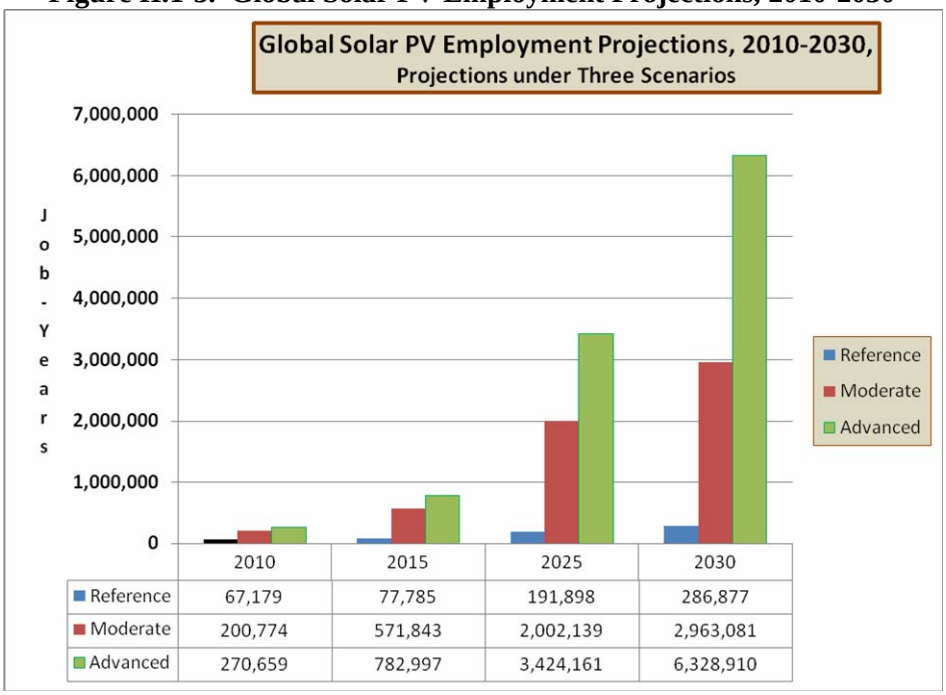
Kenya has one of the largest and most dynamic solar markets in the developing world. Kenya has about 10 major solar PV import companies, and an estimated 1,000-2,000 solar (non-specialist) technicians. Since the mid-1980s, more than 200,000 systems have been sold in Kenya. Private households account 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.[214]

Future Prospects

The 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 CO2 emissions. For the Moderate scenario, the figures are 728 GW, 1,027 TWh, and 616 million tons of CO2. For the Reference scenario, they are a mere 87 GW, 142 TWh, and 77 million tons of CO2.[215]

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



	2010	2015	2025	2030
Reference	67,179	77,785	191,898	286,877
Moderate	200,774	571,843	2,002,139	2,963,081
Advanced	270,659	782,997	3,424,161	6,328,910

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.[216] EPIA and Greenpeace project that by 2030, 6.3 million, 3 million, and 287,000 jobs, respectively, could be created under the three scenarios.[217] (See Figure II.1-3)

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.[218] 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.[219]

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.[220]

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.

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.[221]

Germany has some 19,000 people employed in this industry.[222] 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.[223] 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 kWth (100 sqm) installed).[224] According to the European Renewable Energy Council (EREC), employment in the European solar thermal sector currently exceeds 20,000 full time jobs. 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."[225]

BIOFUELS

Much of the emphasis in biomass in recent years has been on biofuels for transportation purposes. World production of biofuels rose 28 percent, to 44 billion liters, in 2006. This is roughly double the production volume of 1997 and more than four times that of the early 1980s. Fuel ethanol, which is derived mainly from sugar or starch crops, accounted for the bulk—more than 38 billion liters. Biodiesel, made from vegetable oils or animal fats, is a distant second with about 6 billion liters. In 2006, the two constituted less than 1 percent of the global liquid fuel supply.[226]

Biofuels can be produced from a variety of feedstocks (including corn, soybeans, sugar cane, palm oil, 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.[227]

The United States and Brazil account for 90 percent of global ethanol production and invested a combined $24 billion in the sector in 2006 alone. Germany dominates biodiesel output.[228] Brazil is the only country where biofuels currently account for a sizable portion of total transportation fuel use—just under 22 percent 2005.[229] In the United States, ethanol use in motor fuels grew to 6.9 billion gallons in 2007, equal to less than 5 percent of gasoline consumption.[230]

Though 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 sugar cane 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 almost $50 billion since the 1970s exceed investments and subsidies almost by a factor of 10.[231]

Brazil currently accounts for about half of global ethanol exports. The country is planning to increase sugarcane production by 55 per cent over the next six years, and much of the ethanol derived is destined for the Europe and the United States. In Asia, Malaysia and Indonesia account for most of the world's palm-oil production, and both nations 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.[232]

There is vigorous and contentious debate over their economic and environmental merits of biofuels, including the question of direct competition with food production. Along with other factors, the choice of feedstock determines key outcomes such as cost, net energy balance (i.e., how the energy yield of biofuels compares with needed inputs) and carbon balance, environmental impacts (such as potential air and water pollution, deforestation, threats to biodiversity—particularly at mono-crop plantations), as well as volumes of employment. Corn-based ethanol appears to be a particularly problematic choice, as do palm oil-based fuels. 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.[233] And the 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."[234]

Environmental and human impacts of certain biofuels projects need close scrutiny, and not all associated employment can necessarily be counted as green jobs.

Job Prospects

Biofuels offer jobs both in the agricultural sector and in processing industries. 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. Testifying to 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 conservative projections that every billion gallon of ethanol production may create 10,000 to 20,000 jobs. Brazil's ethanol industry employs about half a million workers, and there are hopes that its biodiesel program, launched in 2006, might generate as many as 400,000 jobs, especially among family farmers in the north and northeast of the country.[235]

Other countries are also hopeful that biofuels can create a significant number of jobs: [236]

- In the European Union, a study by the Wuppertal Institute found that for each 1 percent share of the total fuel supply, the biofuels industry might create 45,000–75,000 new jobs, mostly in agriculture (other assessments suggest a more limited job benefit, however). *France* hopes its proposed biofuel program might lead to 25,000 additional jobs by 2010.
- *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 one 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.[237]
- *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. [238]
- *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. Further, 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. A Woods Hole Research Center report argues that at least one full time job can be created per hectare of energy plantations.[239]
- *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 half million people employed in this sector (and another million people whose livelihoods are connected to it)—many of them Indonesian migrant workers.[240] Indonesia is planning a major expansion and, according to the Singapore Institute of International Affairs, is expecting some 3.5 million new plantation jobs by 2010.[241]

The labor intensity of biofuels harvesting compares favorably with conventional fuels. According to the World Bank, biofuels require about 100 times more workers per joule of energy content produced than the fossil fuel industry. [242] 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. 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.[243] In Brazil, harvesting castor oil requires 0.3 jobs per hectare; jatropha, 0.25; palm, 0.2; and soybeans, 0.07.[244] 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.[245] Jatropha holds great promise elsewhere in the world as well. (See Textbox II.1-3.)

Textbox II.1-3. 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 kW power plant providing clean energy to more than 10,000 people. Generators were installed in May 2007.

Jatropha is not only sufficiently resilient to grow under arid conditions, but can help restore eroded land. And 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 a huge 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 in Africa.[246]

Work in biofuels processing typically requires more technical skill and thus is likely to offer better pay than feedstock production. Brazilian workers in ethanol refining receive about 30 percent more than laborers involved in cane harvesting.[247] But the number of jobs that may be created in processing bears close watch—and will vary from country to country. In the state of Iowa in the United States, 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.[248]

Small-Scale versus Large-Scale

Ownership of processing plants is critical in terms of retaining biofuel revenues in the local or regional economy. 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 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.[249]

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. 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. As an exhaustive 2007 Worldwatch Institute assessment of biofuels for the German government put it: "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.[250] Already, farmers everywhere are squeezed by seed and fertilizer companies, manufacturers of tractors and other farm machinery, food processors, and middlemen.

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 co-operative was launched in Brazil in 2005, providing improved livelihoods for around 25,000 families.[251]

But the briefing note also cautions that the Brazilian sugar cane 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 sugar cane sector, from 670,000 in 1992 to 450,000 in 2003.[252] In Brazil and elsewhere, plantation labor standards are often very poor, marked by exploitation and forced labor. (See Textbox II.1-4.)

Textbox II.1-4. 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.

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.[253]

In Indonesia, intimidation and procedural obstacles emasculate effective labor rights for plantation worker. 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.[254]

Plantation workers have few rights, especially as Indonesia and Malaysia 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.[255]

Displacements and Industry Consolidation

Oxfam and others have expressed concern that a concerted drive to produce biofuels on a huge scale could lead to the clearance of rainforests and other critical ecosystems and to 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."[256] The chair of the UN Permanent Forum on Indigenous Issues has warned that 60 million indigenous people may be driven off their land to make way for biofuel plantations. Among them, according to Oxfam, are 5 million people in Indonesia's West Kalimantan. In Colombia paramilitary groups are evicting and killing people to make room for oil palm plantations. In Tanzania, too, vulnerable groups are being forced aside to make way for biofuel plantations. The displaced lose their livelihoods. "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. [257]

There is growing consolidation in the biofuels sectors of many countries. Brazil's sugar ethanol industry may eventually be controlled by just 6 or 7 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. [258] 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.[259] U.S. corporate giants Archer Daniels Midland 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.[260]

In coming years, cellulosic biofuels 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.[261]

A wild biofuels boom could come at a steep environmental and human price. The numbers of existing and projected jobs (easily one million now and possibly climbing to at least 10 times that much in the future) need to be interpreted carefully, and not all biofuels jobs should automatically be tallied under the heading "green jobs." Close scrutiny of environmental impacts and labor standards is required.

SUMMARY

What can be said about the global employment potential of renewables? A range of findings and estimates covering individual aspects of the renewables sector have been presented above. Table II.1-8. 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. A notable gap, for instance, concerns employment in the small hydropower sector in China.

Table II.1-8. Employment Estimates in the Renewable Energy Sector, Global and Selected Countries, 2006

Renewable Energy Source	World / Selected Countries[1]	Employment
Wind	World	300,000
Solar PV	World	115,000
Solar Thermal	China, Germany, Italy, USA	624,000 +
Biomass	Brazil, USA, China, Germany	1,174,000
Hydropower	Europe, USA	39,000
Geothermal	USA, Germany	25,000
Renewables, Combined		**2,277,000**

[1] Countries for which information is available.

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 biofuels 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.

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 PVs by 2030, and on the order of 12 million jobs in biofuels-related agriculture and industry. Installations 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 and likely source of large-scale green employment, but a conducive policy environment is essential for translating this potential into full-fledged reality.

There is a potential contradiction between renewables as a global source of jobs and renewables as part of national competitive economic strategies. For instance, as discussed earlier, Germany views its investment in wind and solar PVs 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.

SECTION 2. ENERGY EFFICIENT BUILDINGS

Globally, buildings are responsible for between 30-40 percent of all primary energy use, greenhouse gas emissions and waste generation.[262] 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.[263] 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 to shift from conventional building to green building can primarily be done with existing technology with little or no net cost. Perhaps more importantly, energy efficient measures in buildings have the potential of having a negative net cost over time as the initial investment is saved over a period of time and are reinvested back into the community. The results are both positive economic and employment growth.

This section of the report will explore the growing body of evidence that links energy efficiency measures to employment opportunities and new jobs. Efficiency measures discussed include more comprehensive measures like green buildings and retrofitting as well as improving 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 report will highlight some of these major efficiency studies, specifically those in the building sector. The report will also identify types of jobs, sectors that will likely be affected, and new areas for job growth.

This section does not attempt to give a global quantitative number of jobs that can be created in this sector. Certainly in some areas of the world, like the United States and the European Union, it is possible to estimate employment numbers based on previous studies and emission reductions 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 make the connection between increased investment in green building measures and increased employment creation.

In order to underscore the significant role that buildings play in reducing emissions, this section will first briefly explain the current environmental footprint and growing global trends within the building sector. Finally, this section will address the major barriers and challenges faced in the shift toward energy efficient buildings on a global scale.

THE ENVIRONMENTAL IMPACT OF BUILDINGS AND TRENDS

When buildings are viewed in their entirety, they are one of the largest users of energy and emitters of greenhouse gases. In the European Union buildings use as much as 40-45 percent of all energy.[264] 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 CO2 emissions, 68 percent of electricity and 12 percent of water use. [265] These percentages not only include 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.

There are major differences in building emissions between the developed and developing world. Building emissions are by far the highest in developed countries where people light, heat, and cool larger square footage of residential and commercial space and use electrical appliances. Per capita the top three countries with the largest CO2 emissions from buildings are the US, Australia and Canada. [266] There are variations both between countries and within countries, but overall in the developed countries, 60 percent of the operational energy is used for heating and cooling. 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.[267]

Studies of the OECD countries indicate that energy consumption in buildings has continuously increased since the 1960s and is likely to continue into the future.[268] In the IEA countries, average home size increased by 17 percent from 1990 to 2004 and energy consumption rose by 29 percent.[269] In the United States, average new homes now reach 210 square meters (approximately 2200 square feet), more than 2 times the average home in Western Europe and Japan.[270] 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. [271] From 1990 to 2004, even though 4 out of 5 of the major large appliances- refrigerators, freezers, washing machines and dishwashers- increased their efficiency, yet there was still a 50 percent increase in energy use of household appliances, lead by the US, France and Finland with a 70 percent increase.[272] 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 efficient standards. The rise in the use of standby power in appliance also contributes to 1 percent of total carbon emissions.[273]

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. In 2007, approximately 2.4 billion people use biomass as their primary energy source and this number is projected to increase to 2.6 billion by 2030.[274] 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.[275] In both the developed and developing world, energy use in buildings is unsustainable and future projections show large increases in energy consumption.

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 collection and biomass plantations.) These advanced biomass cooking technologies include advanced combustion stoves and gasifier stoves, which are 2 times more efficient and emit 4 times fewer particles as well as biogas technology, which is 4 times as efficient and emits 20 times fewer particles. [276] Advanced biomass cooking techniques are especially important for the reduction of the negative health effects and respiratory diseases associated with traditional cooking biomass (animal dung, wood, crop waste). This is especially significant for the health outcomes of women and children.

New Construction in Asia

In countries like India and China, where expansion of the middle class and urbanization is rapidly growing, the emissions and energy use of buildings are projected to dramatically increase. 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 likely to move into urban centers [277] and China alone will add 2 billion square meters or 21.5 billion square feet of new construction each year, doubling its building stock by 2020.[278] The building sector in China is expected to grow by 7 percent annually; India and Southeast Asia will grow 5 percent.[279] 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.

The Emergence of Green Buildings

In 2005, Chinese officials announced that using existing technology, the country will transform all existing buildings into energy savings buildings by 2020 and reduce energy use by as much as 65 percent.[280] These energy efficient buildings, also known as green or high performance buildings, reduce emissions, material and water use and have been shown to reduce energy by up to 80 percent. 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. [281] Dozens of other countries have emerging or are considering forming green building councils, many of which are in emerging and developing countries. The councils adopt voluntary energy efficiency standards for buildings. The most recognized programs are BREEAM (UK), CASBEE (Japan), Green Star (Australia, New Zealand) and LEED (US, Canada, India), Passivhaus (Germany, Australia, UK), Minergie (Switzerland), and Haute Qualité Environnementale (France). In total, twenty one countries have at least one established green building certification standard.

Table II.2-1. Countries with Green Building Councils[282]

Established Green Building Councils	Emerging Green Building 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

Urban Cities and Slum Proliferation

The world's present urban population now reaches over 3.2 billion people or half of the world's total 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 5 times the rate at which new housing stock is constructed, resulting in 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.[283] By 2050, it is estimated that an additional 4 billion people, almost the entire expected world population growth, will live in urban areas. 88 percent of this projected growth is expected to occur in low and medium income countries. Without massive investment in housing in these growing urban centers, the number of slum dwellers is projected double to 2 million in the next 3 decades.

The Millennium Development Goals aim to alleviate 100 million people from slum conditions but are far from being met. A shift toward green building may provide a unique opportunity to meet these targets and other slum reduction targets. Certain infrastructure costs can be bypassed by new developments in green and energy efficiency technology. For example: dependence on an electricity grid may no longer be necessary with the installation of solar panels, solar water heating and energy efficient building components.

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 phase at the site, the vast majority of these jobs will be local.

GREEN JOBS IN THE HIGH PERFORMANCE BUILDING SECTOR

The building and construction sector employs more than 111 million people worldwide, which is approximately 5 to 10 percent of total employment at the country level. [284] Changes in the how building are designed, built and operated along with how building components are manufactured and energy is used will affect job numbers and types of employment.

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."[285] The positive result of both environmental improvements and employment increases from energy efficiency measures is known as the 'double dividend'. [286]

Energy Efficiency Studies: General

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, Energy Star in the United States, or Ecomark in India can in principle serve as a yardstick for this purpose. But they serve different purposes, hue 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." Second, appropriate production or sales-weighted data are needed to assess the actual share of efficient output. These kinds of data are not always available.

A 2007 study for the American Solar Energy Society (ASES) undertakes this kinds of determination and 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, 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 efficient share of lighting products, appliances, windows and doors, and equipment and appliances typically used in homes and offices, and on LEED-certification for building construction.[287] (See Table II.2-2.)

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. Similar efforts are needed in other countries.

The study 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, the study suggests that energy efficiency could offer 15 million, 17.8 million, or perhaps even 32.2 million jobs, respectively, by 2030.[288]

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.

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

Category	Share Energy-Efficient (percent)	Standard Applied
Lighting and Appliances, *of which:* • Light bulbs (CFLs) • Clothes Washers • Refrigerators • Room Air Conditioners • Dishwashers	20 <5 15 23 28 40	Energy Star
Windows and doors	40	
Computers, copiers, fax machines, VCRs	90+	
Televisions	50	
Audio electronic equipment	40	
Heating, ventilating, and air conditioning	30+	
Residential and non-residential housing	3	LEED[1] Certification

[1] LEED stands for Leadership in Energy and Environmental Design. It was developed by the U.S. Green Building Council.

Source: Adapted from Roger Bezdek (Management Information Services, Inc.), *Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century*, Report for the American Solar Energy Society (Boulder, CO: ASES, 2007).

One of the first studies to link employment and energy efficiency was a 1992 study by Jochem and Hohmeyer which looked at general energy efficiency programs in West Germany between 1973 and 1990. This 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. 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 to 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.) [289]

In 2000, a study conducted by the British Association for the Conservation of Energy looked at four different sectors- residential, tertiary, manufacturing and public administration- and not only made 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 UK, France, Spain, Finland, Austria, the Netherlands, Ireland and Greece), 20 of which were in the residential sector. This 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 million Euros spent in energy efficiency programs 11.3 to 13.5 FTE (full time employment) jobs were created. [290] Jobs were mainly created were in the installation and delivery of new efficient materials or equipment, but also in management, administration, auditing and research and development.[291] Finally, this 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. [292]

Retrofitting and Job Creation

The most ambitious building retrofitting project to date is the German Alliance for Work and the Environment's project to retrofit German homes. The Alliance is a collaborative effort between the German government, unions, NGOs and employers federations. Since 2001, 1 billion Euros of public subsidies stimulated 5 billion euros in investment and resulted in 200,000 apartment retrofits. An estimated $4 billion through additional tax revenues and savings in unemployment benefits and 2% of annual emissions from German buildings were reduced.[293] The 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 photovoltaic or solar thermal systems.[294]

The German Alliance for Work and the Environment estimated that 200,000 jobs would be created; however a recent assessment of the German Alliance for Work and the Environment showed that only 25,000 FTE (full time equivalent) additional jobs were produced. Another 116,000 were saved between 2002 and 2004 during a recession in the construction sector. Even though these numbers 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 have prompted the German government not only to renew the project, but even increase the money allotted for the program. In 2005, Germany increased the funding of its building retrofit program to 1.5 billion euros.

According to the IPCC, retrofitting and replacing equipment in buildings has the largest potential within the building sector for reducing GHGs by 2030.[295] 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

Investment and Projected Job Growth

In 2005, the European Commission estimated a 20 percent reduction in EU energy consumption had the potential to create up to 1 million jobs in the EU, many of which are in the building trades.[296] The Canadian government estimates implementing a municipal retrofitting program on a national scale would result in 5600 to 7840 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 to $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. [297]

There's an abundance of studies in the United States that show investment energy efficient buildings will lead to additional employment. The Apollo Alliance New Energy for America report projects 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 US$89.9 billion dollar investment to improve financing for green buildings, providing tax incentives, investing in research and development and promoting new building codes and standards.[298] The US National Action Plan for Energy Efficiency (NAPEE) lumps energy efficiency and renewable energy together and estimates a $7 billion per year investment would generate 298,000 jobs annually.[299]

These numbers hold up in various regions of the US. A 2005 study in the Midwest, *Examining the Potential for Energy Efficiency to Help Address the Natural Gas Crisis in the Midwest*, proposes a 1% reduction in natural gas and electricity consumption resulting in 30,000 new jobs and $16 billion in saved costs from 2006-2010. [300] A 2002 report, *The New Mother Lode: The Potential for More Efficient Electricity Use*, 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. The program calls for a total investment of $9 billion over the same period of time. Energy efficiency measures mainly focused 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 used.[301]

Direct and Indirect Job Gains

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 building sector is comprised of small and medium sized enterprises. 90 percent of the global construction still occurs in microfirms which have 10 or less employees[302]. Even the largest companies in the building sector are small in comparison to the major multinationals in other major industries like energy, banking and investment, and retail. The jobs that are created in the building sector are also jobs that are performed directly at the

development site and therefore local. [303] Indirect jobs are also created in the manufacturing sector. Induced jobs are created as money that would have previously been spent on energy is freed up and respent in the community. Not only are jobs created in the building operations and construction, but they are also created in 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."[304] 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 dollars invested in the US, 21.5 new jobs are created from energy efficiency as compared to only 11.5 jobs for new natural gas generation.[305] 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.[306]

There are some variations between studies on what percentage of jobs are directly created from energy efficiency measures and how many jobs are indirectly related to energy savings and the re-spending of those savings. One study from the ACEEE showed that 90 percent were indirect and 10 percent were direct.[307] Another study from Europe showed that one third results in direct employment and two thirds is indirect.[308] Despite the differences in their conclusions, they both show that the majority of jobs are created indirectly through savings that is redirected back into more labor intensive sectors.

Types of Jobs in the Building Sector

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 directly created 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. [309] 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.

New green construction does allow for the possibility of some new jobs due to the increased investment in the construction phase; however most of the jobs created through green building practices are likely to occur from energy savings and reinvestment. The types of jobs in green building will need to be redefined 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.

Designers and Architects

In both new construction and retrofitting, green building architects and designers consider the entire life cycle of the building and aim to reduce raw material use, emissions and water use, improve energy efficiency as well as improve indoor air quality and health. Because green buildings are designed as single, integrated systems, the building 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.

In the US, there are currently over 40,000 LEED Accredited Professionals certified in green design and construction or operations and maintenance.[310] One assessment by the World Green Building Council shows 1,500 LEED accredited professionals in India, 900 Green Star professionals in Australia, and 1,197 BREEAM licensed assessors in the UK. These numbers have been increasing over the last several years. (source) This trend is expected to continue as green building takes over a larger share of the construction market.

Manufacturing Jobs

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 (heating, ventilation and cooling), water filtration, insulation systems and energy efficient appliances. Photovoltaic 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 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. [311] The US Department of Energy predicts that standards on clothes washers, water heaters and florescent lamp ballasts would create 120,000 jobs in the US through 2020. The Apollo Alliance report 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.[312]

Job Losses

Not all job news is positive. Although most sectors of the economy stand to gain employment and benefit from energy savings, some jobs in the 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. [313] This shift from energy intensive and producing fields to other sectors requires a just transition for workers.

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. [314]

The most developed ESCOs are in Europe and the US. In Berlin, more than 900 public buildings have been retrofitted through ESCOS. The German ESCO industry provides €3 billion annually in energy efficiency services.[315] The Lawrence Berkeley National Laboratory estimates that energy service companies (ESCOs) have provided $4 billion in energy efficiency investment in the US of which 25 to 30 percent of this investment is spent directly on labor to design, install, operate and maintain efficiency programs in the building sector. This area has potential to grow and create jobs.

LED and CFL Market

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, carbon dioxide emissions would decrease by 400 million tons.[316] Energy efficient light bulbs are cost effective in the long run. The total cost of burning 10,000 hours of light is 25 Euros for CFLs as opposed to 85 Euros for incandescent bulbs.[317]

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

Manufacturers, who produce CFLs and LED lighting, are likely to see tremendous growth in these areas. The three major large 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. The other two, 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.[318] In the photonics industry, which has 5 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 jobs in 2010. (source)

Textbox II.2.1 Energy Efficient Lighting Program in Mexico

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 florescent 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 helped train indigenous people to work on large scale efficiency programs. Smaller lighting programs have also been implemented in Bolivia, Brazil, Costa Rica, Ecuador, Cuba, Venezuela, Belize and Peru.[319]

Passive Houses and Zero Emission Building

Note: This section will be completed during the final phase of the project.

THE POTENTIAL OF GREEN BUILDINGS AND ENERGY EFFICIENCY: CHALLENGES AND OPPORTUNITES

New Green Building Initiatives

Many of the new green building and energy efficiency initiatives are occurring at the city level. 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 5000 new jobs in the building sector.[320] In the next 3-5 years, Mexico City's Proaire program will install energy and water efficiency systems in 30,000 units, install solar powered heating systems in 50,000 new units and retrofit 45,000 others. (source?) Seattle, Washington has mandated LEED standards for all buildings over 5000 square feet; Berkeley, California has mandated green building standards for all sold, renovated or transferred homes. In Berlin, the BEA (Berlin Energy Agency) created energy efficient incentives at no cost to the building owners.

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, Sao Paulo, Seoul, Tokyo and Toronto. This project involves 5 major banks and 4 of the largest energy services companies are providing $5 billion in funding for retrofitting of municipal buildings and provide incentives for private building owners to retrofit existing buildings.[321] They also created the C40 Large Cities Climate Leadership Group to provide support for energy efficiency programs in 40 mega-cities both in developing and developed countries. Table II.2-3 shows other municipal green building and energy efficiency programs.

Table II.2-3. Selected Municipal Energy Targets

City	Target
Berlin, Germany	Reduce energy use in public buildings by 30% by 2010; incorporate solar water heating into 75% of new buildings annually
Copenhagen, Denmark	Energy audits required for buildings exceeding 1500 square meters; all new buildings must rely on district heating (electric heating banned)
Leicester, UK	Reduce municipal building energy use 50% from 1990 level by 2025
Oxford, UK	10% of homes must use solar hot water or PV by 2010
Portland, Oregon	All new city owned construction meet LEED Gold Standard
Tokyo, Japan	5 percent renewable energy use in large municipal facilities

From Worldwatch Institute, *State of the World 2007* (New York: W.W. Norton & Co., 2007).

These initiatives are a step in the right direction but only represent a small fraction of the energy efficiency programs needed in the building sector on a global scale. The aforementioned energy efficiency measures- green building, retrofitting, lighting systems, and efficient appliances- have great potential to both reduce greenhouse gas emissions and create jobs but remain underutilized. In 2005, Canada reported that 150 building projects (1.5 percent of total construction costs) were registered as LEED (Leadership in Energy and Environmental Design buildings). The 2007 ASES study concluded

that only 3 percent of buildings in the US qualified for LEED certification. Large scale retrofitting programs are confined to a few countries in the global north.

A 2007 report by the World Business Council for Sustainable Development confirmed earlier conclusions that the building sectors key decision makers still overestimate the cost of building green. The 1400 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 US Green Building Council put increase in as little as 2 percent.[322] 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 investments. Other barriers to greening the building sector include: short term profit motives over long term saving, the fragmentation within the building sector, lack of education, lack of available funding, and the lack of mandatory standards.[323]

Funding for Energy Efficiency Programs is Critical

The sheer number of buildings that must be retrofitted is staggering. There are 12.5 million homes in Canada, over 100 million homes in the US, and 150 million homes in the European Union. China increased the number of new homes by 80 million residences from 1985 to 2000. In addition, there are millions of commercial and municipal buildings. The amount of funding available in loan programs or other incentive programs pales in comparison to the amount of capital needed to reduce emissions of buildings and make a significant dent in emissions. The German government funding is the closest example of the type of initiative that must occur at the national level.

The European Trade Union Confederation reports that it would cost 3,145 billion euros in the EU alone to retrofit the building sector in order to reduce emissions by 75 percent. Other less ambitious targets would cost less but would also fall short of the necessary reductions concluded by the IPCC. The ETUC report creates two time periods under which this 75 percent reduction could take place. In the 2050 scenario, 1,377,000 FTE jobs would be created; in the 2030 scenario 2,585,000 FTE jobs would be created. This ambitious EU scenario require that government 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 and 16 percent respectively, would create 20,000 to 62,500 FTE jobs for BAU and between 160,000 and 500,000 for the Eurima scenario. [324] 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.

The current research and development money for energy efficient buildings is much too little. Federally funded research in the US for buildings amounts to .02 percent of the annual US construction budget. [325] More money is needed to develop the zero emission buildings and passive houses as well as zero emission as well as more energy efficient appliances and building components.

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

efficiency of commercial vehicles.) Energy efficiency measures are much cheaper than creating new energy supplies to meet increasing demand.

Policy Recommendations

Due to the severity of global climate change and the rate at which a shift towards sustainable building, energy efficiency programs and retrofitting must occur, governments must play a key role in the building sector. The following is a brief list of key policy recommendations. It is not intended to be all inclusive, but focuses on the most important initiatives in this area.

- Establish minimum green building standards for all new construction. This policy measure is especially important the developed and developing world and especially China, where almost ½ of all global construction is taking place. It is more cost effective to build new green construction than to retrofit projects at a later time.

- Create financing programs for retrofitting. Buildings have an extremely long lifetime, often more than 50 years, but this number is shrinking. Reverse this trend by renovate and retrofit old buildings as opposed to building new construction. 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 effective, especially lighting programs, air conditioning, water heating, and building insulation. Provide incentives and funding opportunities for people to make these changes

- Over 50 countries currently have either standards or labeling programs, which have resulted in energy savings, but much more is needed. Create regularly updated minimum standards and standardized labeling for equipment and appliances (water heaters, HVAC, cooking, appliances, lighting, electronics, office equipment, windows and others) Inefficient lighting programs must be phased out.

- A global effort to scale up new green building, retrofitting and energy efficiency programs in the developing world is extremely necessary. Establish funds for energy efficiency programs in developing and emerging economies.

- Increase research and development to explore more energy efficient buildings, passive houses and zero emission buildings.

SECTION 3. TRANSPORTATION

Introduction: Challenge and Solutions

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 on 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. According to the International Panel on Climate Change (IPCC), the sector has the fastest-rising carbon emissions of any end-user sector.[326]

The challenge to make transportation sustainable is rapidly magnifying. 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 cars and trucks. 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. This section will briefly address aviation but primarily be focused on ground transport.

Aviation

Just on the passenger side, world air travel has exploded—rising from 28 billion passenger-kilometers in 1950 to 3,720 billion passenger-kilometers in 2005.[327] Aviation fuel efficiency can be improved via better technology and air traffic management. According to IATA—the International Air Transport Association—new aircraft are 70 percent more fuel-efficient than those designed 40 years ago.[328] 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.[329] 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 such even with additional efficiency gains.

During take-off, planes use a large share of fuel—up to 25 percent of a flight's fuel consumption on short flights—and produce the most harmful emissions. Yet it is exactly 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).[330] 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, increasingly capable virtual conferencing services may be effective alternatives to travel (and offer business and employment

opportunities in their own right) where face-to-face meetings are not essential. Companies like Credit Suisse and Bell Canada are actively pursuing alternative options.[331]

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 today are effectively heavily subsidized—via exemptions from fuel duty, value-added tax, and duty-free rules. In Great Britain, 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 £45,000 per year, or a total of £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.[332] A shift toward more sustainable transport is feasible, but it requires careful planning and transition measures.

Road Transport: An Unstoppable Force?

Road transport currently accounts for 74 percent of total transport CO_2 emissions and for the majority of transportation jobs.[333] Thus, a move toward sustainability in this sector is especially critical.

Production of passenger cars and light trucks continues to surge, reaching 67 million units in 2006, up more than 8-fold 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 out of a world fleet of 826 million, or two thirds.[334] The United States alone consumes nearly half of global motor gasoline use (44 percent in 2004).[335]

But developing countries are ratcheting up their involvement as well now. 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.[336] India is currently the 11th-largest producer and its domestic passenger car sales have doubled to 1.4 million since 2002.[337] In the summer of 2007, Tata Motors announced that it will begin offering "the world's cheapest car" in early 2008—bringing car mobility within reach of hundreds of millions of people in India and perhaps elsewhere in the developing world.[338]

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[339] are in various stages of development. 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.[340] 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 EU. But high-sulfur fuels threaten to negate the benefits of these rules.[341]

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—and 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 also 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, they are still too limited in number and scale, however, to permit any reliable projections of their future job potential.

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 diesels, 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.

Following Toyota's success with the Prius (in the decade since introducing the model, the company has increased its production to a projected 2007 figure of 430,000[342]), more and more manufacturers especially in the United States are joining the hybrid bandwagon. In the 2007 model year, 2.2 percent of U.S. light duty vehicles were hybrids.[343] A forecast for 2015 projects that hybrids (850,000 vehicles) might account for 5 percent of total U.S. sales, or possibly as high as 11 percent (2 million vehicles).[344]

However, it must be noted that automobile companies are increasingly introducing so-called "muscle hybrids"—using the technology more to boost acceleration and horsepower than to improve fuel economy.[345] To the extent that this will be the dominant application of hybrid technology, the market penetration of hybrids can be regarded as a proxy for estimating green automobile production and jobs

only within limits. 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."[346]

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.[347] 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.[348]

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.[349]

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 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.[350]

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 clearly 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.

Figure II.4-1. Actual and Projected Fuel Economy for New Passenger Vehicles, by Country, 2002-2018.

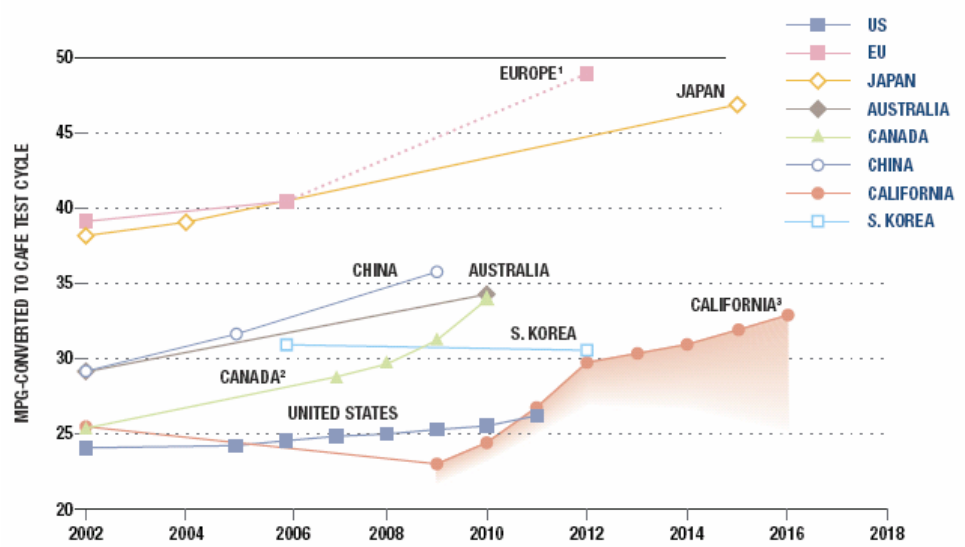


FIGURE ES-2. Actual and Projected Fuel Economy for New Passenger Vehicles by Country, 2002-2018.

Source: Feng An, et al., *Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update* (Washington, DC and San Francisco, CA: International Council on Clean Transportation, 2007), p. 9.

A 2007 report by the International Council on Clean Transportation 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. (See Figure II.4-1.) 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.)[351]

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 for fuel efficiency. 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 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, they do not distinguish between domestic production and imports. It is possible, however, that a much larger share of a country's fuel-

efficient fleet is produced abroad than domestically, in which case the calculations offered here would 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.

Fuel Economy and Low-Emission Targets in Japan

The Japanese government established fuel economy targets for passenger cars of 16.8 kilometers per liter (equivalent to 39.5 mpg), to be reached by 2015. This standard translates into CO_2 emissions of 125 grams per kilometer, according to the International Council on Clean Transportation.[352] The average fuel economy of new cars manufactured in Japan rose from 12.4 km/l in 1996 to 15.5 km/l (36.5 mpg), exceeding the previous 2010 target of 15.1 km/l (which is equivalent to 153.8 g/km).[353] In 2005, 86 percent of passenger cars sold met or surpassed the 2010 fuel efficiency target.[354]

According to the Japan Auto Manufacturers Association, 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.[355] The combined total represents 53 percent of all motor vehicles sold domestically that year.[356] 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.[357] (See Table II.4-1.) 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.4-1. Calculation of Green Jobs in Japan's Motor Vehicle Manufacturing Industry, 2006

	Vehicle Production / Employment
	Number of vehicles[1] produced
Domestically-produced vehicles sold in Japan	5,618,499
Of which:	
Hybrid and alternative fuel vehicles[2]	95,945
Low-emission vehicles[3]	2,893,028
Subtotal, all clean vehicles	2,988,873
Share of hybrid & low-emission vehicles (percent)	*53*
	Number of Employees
Automobile manufacturing workforce[4]	952,000
Percent of hybrid & low-emission vehicles, pro-rated vis-à-vis workforce total	434,070

[1] Excluding motorcycles.
[2] Includes natural gas and diesel-alternative LPG vehicles.
[3] Highest-achieving group; vehicles with emissions 75 percent below Japan's 2005 exhaust emissions standard.
[4] Includes employment in vehicle manufacturing, as well as parts and accessories production.

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 gCO_2/km by 2008 (and optionally to 120 grams by 2012). The 2008 target is equivalent to a fuel efficiency level of about 5.8 liters/100 km (gasoline) and 5.25 liters/100 km (diesel). The Japan Automobile Manufacturers Association and Korea Automobile Manufacturers Association agreed to meet this target by 2009.[358]

European Commission staff has issued reports monitoring the car makers' commitment, and their findings are the basis for calculations here of the number of jobs in manufacturing cars for the EU market that could be considered a shade of green.[359] Using thresholds of 120 and 140 gCO_2/km, this results in job numbers of 150,000 and 526,000, respectively, for model year 2004.[360] (See Table II.4-2.)

Table II.4-2. Calculation of Green Jobs in Europe's Motor Vehicle Manufacturing Industry, 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 %*	*26.3 %*
	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

According to the European Federation for Transport and Environment, 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.[361]

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.[362]

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 car makers 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.[363]

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 auto makers have churned out vehicles with ever growing weight, horsepower, and acceleration.[364] 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 SUVs) is at 21 mpg.[365]

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.[366] 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 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. (For passenger cars alone, excluding SUVs, the share was 2.3 percent.)[367] Using this percentage as a proxy for gauging the number of auto manufacturing employment that could be considered green, we arrive at a more realistic estimate of about 13,000 jobs (direct jobs only).[368] 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.[369] 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.

Legislation under consideration in the U.S. Congress in late 2007 would raise average fuel economy requirements for all new passenger vehicles to 35 mpg by 2020.[370] Yet, the United States could do better: Even back in 2001, a study by the American Council for an Energy-Efficient Economy showed that aggressive implementation of 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.[371] The Apollo Alliance suggested in 2004 that a concerted strategy to build highly efficient cars might yield close to 130,000 jobs.[372]

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.[373]

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.[374]

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).[375] 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 kilometers per liter,[376] equivalent to 63 miles per gallon). Both are following European emission standards, though with a time lag of some years.[377] 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. (See Textbox II.3-1.)

Textbox 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 8 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.[378]

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.[379] 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.[380] Thailand could thus become a regional hub of "eco-car" production. Sudjit Inthaiwong, deputy secretary-general of Thailand's Board of Investment, says "We are hoping the eco-car will be our next global niche."[381]

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.[382]

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.[383] 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.

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. A report by the American Council for an Energy-Efficient Economy (ACEEE) 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."[384]

A vehicle's weight is not only important for fuel economy, but also with regard to materials 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.[385] 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.[386] Because vehicles elsewhere are typically less heavy, for most other countries these shares are likely to be smaller.

The bulk of automotive materials are 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 that 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.[387])

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.

Transport 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.[388])

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 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.[389] 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 Vitality and Sprawl

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."[390]

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.[391] 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."[392]

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."[393] 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.[394]

Urban Transport Challenges

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.[395] 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.[396] *[add more stats on public transit employment worldwide]*

Table II.4-3. 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: International Association of Public Transport, *Better Urban Mobility in Developing Countries* (Brussels, December 2003), p. 22.

Public transit is less energy- and carbon-intensive than automobiles. (See Table II.4-3.) Seen from this perspective, jobs in public transit (and in manufacturing trams, buses, and rail equipment) can, in principle, be regarded as green.

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 (bio-diesel, hybrids).[397] Compressed natural gas (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.[398] 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.[399]

Switching to cleaner diesel fuel also offers substantial reductions in air pollutant emissions.[400] 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 side: One, the 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.[401]

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.

The BRT Model

Bus Rapid Transit (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 Mexico (see Textbox II.3-2.), Bogota, Los Angeles, Toronto, Glasgow, Beijing, Jakarta, and Sydney. Many more are planned for cities like Medellin, New Delhi, Shanghai, Lagos, Accra, and Cape Town. 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. [402]

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, well-paying.[403]

Textbox 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, 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. 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, vacations, and so on.[404]

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 3-wheelers—are ubiquitous. And 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. (See Textbox II.4-3.) Stepped-up financing is essential for retrofits to happen on a sufficiently large scale and for jobs to be created.

Textbox 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 alone 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, 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, Sri Lanka, Pakistan, and India.[405]

But changes are also needed when these vehicles are first produced. China and India are among the leading producers of two-wheelers.[406] 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 of time.[407] 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—a small electric motor 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.[408]

No good global employment statistics appear to exist for this industry, or for associated businesses such as rental services.[409] 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. (See Textbox 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, provide employment for large numbers of previously unemployed youth.[410] 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.[411]

Textbox 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.[412]

Rail

Rail transport is more fuel-efficient and more labor-intensive than road transport.[413] 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.[414] 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.[415] In the EU-25, 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.[416] 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.)[417]

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.[418]

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.[419]

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.[420] 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.[421]

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.[422]

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, still 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 CO2 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.)[423]

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, mostly in public transit, 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. The remainder, returned to taxpayers, was assumed to be re-spent on typical consumer purchases, and 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.[424]

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).[425]

Climate Change and Employment—a 2007 study jointly financed by the European Commission and several European governments—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."[426] 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.[427] 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.

SECTION 4. GREEN JOBS AND THE CHANGING FACE OF 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.[428] 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 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's a system that needs to do much more in order to become truly environmentally and socially sustainable.[429] For companies like Monsanto and BASF, biotechnology can (and is) helping farmers take great strides towards sustainability by raising yields through genetically modified seeds while at the same time reducing environmentally damaging inputs, such as nitrogen.[430] 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." [431]

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 is the key to solving the major problems of the existing food system and to meet the challenges of increasing demand.

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.[432] According to the 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.[433] But still roughly 850 million people suffer from food insecurity and a similar number are obese.[434] Every year 5 million children die of hunger.[435] 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. [436] Moreover, the demands on the global food system will increase dramatically as the earth's population rises (twofold by 2050) and diets change towards meat and processed foods. On 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 small farmers organizations 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.[437] 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.[438]

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's agriculture accounts for 15 percent of global GHG emissions, according to emissions inventories submitted to the UNFCCC. According to the Stern Review, fertilizers are the largest single source of emissions from agriculture (38 percent), followed by livestock (31 percent), and almost 75 percent of emissions are generated by developing countries. Agriculture emissions are expected to rise almost 30 percent from 2005-2020.[439]

UNFCCC data show that developing-country agriculture and deforestation contribute and estimated 22 percent and up to 30 percent of total emissions, more than half of which is from deforestation largely caused by agricultural encroachment (13 million hectares of annual deforestation globally)[440] The IPCC's 2001 Report on Mitigation 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. [441]

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, the production of which is particularly water intensive. Livestock numbers are expected to double by 2020, according to the IPCC.[442]

Rich-country subsidies, too, are having a simultaneous effect on both employment and the environment. In 2001, the U.S. accounted for two-thirds of the world's corn exports.[443] 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.[444] 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.[445]

The cheap corn from the U.S. 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 corn production is a major source of water pollution, affecting drinking water throughout the Corn Belt in the upper part of the U.S. Run-off into the Mississippi River contributes to the "dead zone" in the Gulf of Mexico, an area the size of Ireland in which all life has been destroyed. 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. water each year.[446]

The "New Agriculture"

In recent times the sharp fall in the prices of grains, sugar, and coffee has led producers to move towards higher-value exports like fruit, wine and flowers.[447] Some of these high-value products are also more energy and chemical intensive than many low-value products. The ILO, the IUF and others have documented in detail how many of workers in the "new agriculture" are required to work in hazardous conditions and often live in extreme poverty.[448] 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.[449] For the World Bank, smallholders are well advised to enter the "new agriculture" to serve the growing global demand and to achieve better returns on the produce. 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." [450]

The expansion of the less sustainable "New Agriculture" is often having a detrimental affect on the more sustainable types of production. In Mexico, the avocado sector is universally viewed as exemplary by Mexican government officials responsible for promoting high value exports.[451] Such has been the success of this "green gold" that growers are buying up land communal (*ejidal)* lands. Forests are denuded to plant avocado trees, and are being planted in place of other crops, even on lands that can't support avocado production for climatic/ecological reasons. [452]

Globalization, "Food Miles" and 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.[453] The global nature of food production has added to air, sea and road traffic, all of which worsen pollution, compromise health, and further contribute to global warming. A UK study estimates that CO2 emissions attributable to producing, processing, packaging and distributing the food consumed by a family of four is about eight tons a year.[454]

While not all trucks are carrying food, a lot are. A 1999 study of California's produce trucking industry reported that 485,000 truckloads of fresh fruit and vegetables left the state each year and travel from 100-3,100 miles to reach their destination.[455] In the U.K., the importation of food quadrupled between 1992 and 2007, and 31% more food was flown into the country in 2006 than in 2005, according to the Department of Environment, Food and Rural Affairs (DEFRA).[456] There has been a 7 per cent rise in urban transport between 2005-2006 caused by individuals taking more and longer shopping trips.[457] 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 UK, and that food transport produces 10 million tons of carbon dioxide annually.[458]

The growth in marine freight also adds to environmental damage through ship wastes, dredging, spills, and the discharging of bilge water. Intercontinental cargo ships also bring in nonindigenous plant and animal species that also cause major public health and environmental problems and further contaminate urban harbors and ship channels with heavy metals and pesticides.[459]

Food Waste

A large portion of all food produced by the food system is never eaten and is discarded.
Food is wasted at all points in the global food chain. Thus the carbon and chemical inputs that went into the production of thrown away food, much of it edible, are not only ultimately unproductive, but the discarded food continues to generate GHGs like methane as it rots in landfills.[460]

Food waste is generated at all points of the global food system. Big food retailers have the market power to reject produce if it does not conform to certain standards pertaining to shape, color, and packaging. (These standards also increase the use of fertilizers and plastics). When standards are not met, farmers and producers are left with unsold crops which are often destroyed. Even if eventually purchased by retailers, supermarkets routinely "cull" foodstuffs that are blemished or have passed a sell-by date but are sometimes quite edible. Consumers also waste a lot of food, especially in the richer countries where food prices have fallen steadily over the last several decades. According to a study by the U.S. Department of Agriculture, the U.S. wastes 96 billion pounds of food each year. Most of the waste food goes into landfill sites, where it decomposes and causes greenhouse gases. A 1999 study conducted by the California Integrated Waste Management Board found that just over half of the 5.6 million tons of discarded food came from commercial sources such as restaurants, hotels, hotels and schools, and just under half—2.7 million tons—was generated by residences.[461] In Britain, homes waste 3.3 million tons of food per year,[462] although the total consumer and industrial wastage may be as high as 17 million tons.[463]

The level of waste appears symptomatic of the excesses of consumption engendered by the "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 US$1 per day.[464] However, the absence of both an adequate regulatory framework, systems of collection, and well resourced public educational programs probably also plays a role in elevating the levels of food that are ultimately wasted.[465]

The environmental footprint of the global food system is extremely formidable, and the true extent of the damage it causes to human health and the entire ecosystem can hardly be exaggerated. Any possibilities to create green employment in food and agriculture must therefore be pursued as a matter of urgency.

Agriculture and the Global Food System: 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. Beginning with those at the base of the supply chain, 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 to 1.3 billion people, made their living from growing food and raising livestock. In 1995, however, a quite higher proportion—44.4%—had worked in agriculture. Productivity improvements throughout the global food system have, along with the globalization of food, therefore generally *reduced* employment levels in food and related industries, at least as a proportion of the whole.[466] In the 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.[467] In the developing world, agricultural employment has not kept pace with population growth, although rural nonfarm employment has increased quite dramatically. Roughly one in four rural workers are employed full time in the nonfarm rural sector.[468] Despite these trends, agriculture remains the planet's second largest source of employment.

Consolidation

Today's food system is dominated by the market power of fewer and fewer large companies. The ten largest firms in agriculture control about 80 percent of a world market valued at $32 billion, according to an ILO study.[469] Just 2 companies distribute 80 percent of the world's grain.[470] Food retailing is today also dominated by a dwindling number of companies. In the U.S., just six companies accounted for 42 percent of the food retail market in 2001, a jump from just 24% in 1997,[471] but a similar pattern of consolidation is visible in many parts of the developed and developing world.[472]

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 towards large retailers, resulting in lower returns to those who plant and grow the food. 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.

Textbox II.5-1. Example – The United States

The U.S. 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 year 2000, or around 2 percent of the economically active population. 2.5 million farmworkers are hired to work in the U.S., the majority of whom are seasonal and predominantly foreign-born and Mexican.
Livestock production showed the most significant employment losses (roughly 200,000 jobs) during the previous 10-year period as a result of consolidation. To illustrate the impact of this consolidation, the

number of hog farms fell dramatically from 191,000 in 1992 to 109,000 in 1997 according to the U.S. Agricultural Census. The U.S. inventory of pigs, however, climbed from 57 million to 61 million over the same 5-year period.[473]

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 4 firms, which grew from 28.4 percent of slaughtered cattle in 1980 to 67.3 percent in 1995.[474] 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.[475]

In addition to those employed in agriculture and its related subsectors, 1.66 million 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 trade-impacted leather trades like footwear. In 1990, 152,000 people were employed in these trades; by 2000 the number had slumped to 92,000. [476]

The decline in employment in farming and food manufacturing stands in marked contrast to the growth in retail employment. In 1994, 13.5 million were employed in retail, growing to 15 million ten years later. The U.S. Department of Labor expects retail employment to grow to 16.7 million in 2014.[477] Some of this increase is being driven by the sale of ready to eat foods. An increasingly large percentage of food purchases are happening in large 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 U.S., 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.[478]

Global Trends

The trend towards consolidation and the growing market power of retailers that's occurring in the U.S. 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.[479] 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.[480] In China, 81 percent of workers were employed in agriculture in 1950; in 2000 the figure was 50 percent. [481]

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.[482] 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.[483] 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. [484] And rural communities in both the global North and South also suffer difficulties as the social fabric built up around farming over generations disintegrates. [485]

The Growth of Waged Labor in Agriculture

The waged agricultural labor force now amounts to roughly 450 million workers, although many smallholders also work for wages for some or part of the time. The trend towards waged employment is generally upward, although in some countries there has been a growth in informal labor contracts which has intercepted or reversed the trend towards waged labor. [486] Employment in soy and palm oil production has increased, but the employment gains in these instances are often small. For example, soybean production is capital-intensive. A 1000 hectare soybean farm employs only three people.[487]

Textbox II.5-2. Decent Work Deficits in Agriculture

The International Union of Food and Agricultural Workers[488] 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 also reports that 70% of all child labor takes place in agriculture alone. These, say the IUF, 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.

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.[489] 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 [490] The cut flower industry is a major employer of mainly women workers in countries like Columbia (130,000 directly and indirectly), [491] Ecuador, Tanzania, (9,000 workers in horticulture), Zambia (10-12,000) and Kenya (56,000 directly in cut flowers)[492]

The Un-Greening of Agriculture

The expansion of the less sustainable "New Agriculture" is often having a detrimental affect on greener and thus more sustainable types of production and employment. For example, the emergence of the "global avocado" has marginalized the multitude of historical varieties in favor of a standard one or two, and has impacted on subsistence production, especially of maize, by indigenous communities, endangering water and forest resources.[493] Just as corn subsidies have driven small farmers into environmentally damaging practices, the same is often true of the "New Agriculture." The expansion of avocado production has itself denuded forests, and what forests remain are being cleared by illegal

loggers displaced by the changing use of land. According to one account, "An important source of employment is woodworking in family or community workshops, using forest wood to make, among others, wooden crates used in harvesting avocados." [494]

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, since 1990 more than 100,000 logistics sector jobs have been added in Southern California alone.[495] In 1965 there were 787,000 combination trucks registered in the U.S.; in 1995 there were almost 1.8 million registered.[496] Today in the U.S., there are 2.8 million truck drivers and the number is increasing at around 3 percent per year.[497] Overall, the trade, transport and utilities sector 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 by 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.[498] The warehousing and storage sector is projected to grow rapidly at 24.8 percent, adding 138,000 jobs.[499]

However, 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 U.S. 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 tones in 1986 to 303 million tons in 1995.[500]

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 also shown a marked decline in many regions of the world.[501]

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.)[502] The UK-based National Retail Planning Forum reports that many of the new superstore jobs are also part-time, lower paying and generally of poorer quality.[503] Another report from the UK notes:

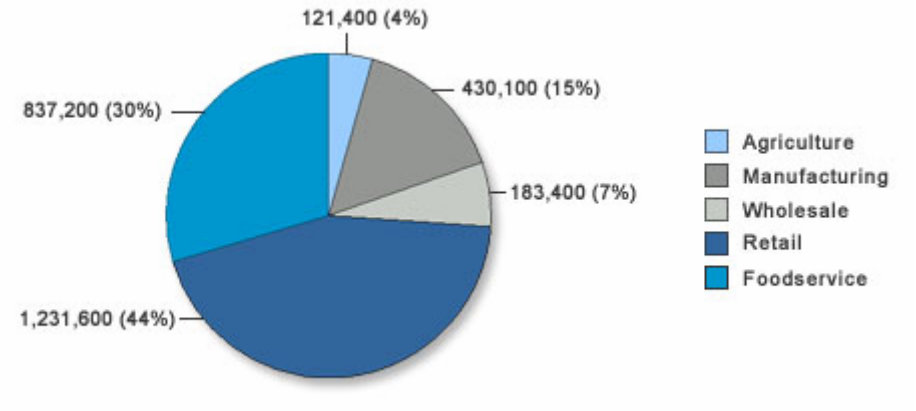
A job that is lost at an independent store cannot simply be replaced by one job at a supermarket. Superstores benefit from economies of scale and computerization, and are designed that the individual employee can shift the maximum number of products per customer visit. Asda has the highest number of sales per employee, at £104,490 pa. This is compared to Tesco - £91,591, Sainsbury - £85,986, and Safeway, £94, 897 [504]

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 UK, food and grocery chain workers numbered 2.3 million in 2004, of which 44 percent were in retail and just 4 percent

in agriculture. The food and grocery chain is one of the UK's largest employers, providing at least 2.8 million permanent jobs, or 11% of all UK jobs.[505]

In the developing world supermarkets are growing at a spectacular pace. For examples, supermarkets now control 55 percent of food retailing in South Africa; 50 percent of fresh produce retailing in Brazil, and 60 percent in Argentina and Mexico.[506] 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." South East Asia and Southern Central Europe appear to be heading in a similar direction. [507]

Figure II.5-1. Food Sector Employment in the U.K.



Source: Adapted from government data, at
http://www.statistics.gov.uk/downloads/theme_labour/Index_2006.pdf

The growth of supermarkets in the global South is having a marked affect on farmers, and some maintain that this growth has had a bigger effect on farmers than trade liberalization.[508] Leading supermarket chains have shifted away from the wholesale markets where small farmers make their living; instead they procure the food they sell 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…", and it concludes that some farmers in certain regions may need to "transition out of agriculture" and move into "the provision of environmental services."[509]

The consolidation of retail has meant that farmers and producers often receive dwindling returns on their produce as large retailers are today in a position to lay down take it or leave it conditions.[510] 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.[511]

OPPORTUNITIES FOR GREEN EMPLOYMENT IN THE EXISTING FOOD SYSTEM

Part 3 of this section will look at the potential for green job creation (and retention) across the present global food system.

World Bank, IPCC and WTO approaches

Ever since the UN's Earth Summit in 1992 and the adoption of "Agenda 21" the idea 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.*[512]

Reports released in recent years by leading agencies have echoed these concerns, and have examined issues of environment and sustainability in agriculture. In its World Development Report 2008, the World Bank makes a range of proposals for sustainability. Regarding climate change, the IPCC's year 2000 report *Land Use, Land Use Change and Forestry* makes proposals regarding how altered practices in agriculture can aid GHG mitigation and contribute to carbon storage. These proposals have been developed in subsequent reports. In a 2007 report the FAO concerns itself with adaptation to climate change in agriculture, forestry and fisheries.[513] Finally, the United Nations Develop Program's Human Development Report for 2007-8 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.[514]

Limited Attention to Employment

It's important to note that employment issues do not feature in these reports, and specific details pertaining to jobs—green or otherwise—are almost invariable absent. The World Bank's 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. However, the proposals do invite speculation with regard to the employment potential of these proposals and they 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, 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.(FAR 64-66) Some rural development and anti-poverty policies are also synergistic with mitigation, such as water management and agro forestry. 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 a jobs-environment trade off when few economic options exist.[515] 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." (FAR 66) In other words, people are getting paid to cut down trees, or can make money in the business of doing so.

The World Bank's World Development Report for 2008 focuses on agriculture, although the present structure and trajectory of the global food system is taken more or less as a given and viewed in a generally positive light. The Report calls for the introduction of 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.516 The Bank maintains that agriculture will become more sustainable when more capital, knowledge and labor are directed towards 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 in order to pull business towards these activities, or they will depend on high levels of public investments and a more "command and control" approach.

Natural Resource Management and Preservation

The Bank's proposed improvements in natural resource management appear to have employment-creating potential. For example, activities like terracing or contouring of land, building irrigation structures, etc., are labor intensive and are urgently needed to prevent further depletion and degradation.517 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 and that if users were required to pay for water then 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.518 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. 519 The move towards integrated water management, which involves canal lining and microirrigation, also involves labor inputs. Other sources of work include rehabilitating dams, barrages and embankments which improve the flow of rivers. There also appears to be employment potential in combating soil erosion involving tree planting and straightforward stone bunding.520 The IPCC has developed a similar list of mitigation measures. (FAR 65)

Reducing Harmful Inputs, Managing Livestock

The greening of high-input farming is also critical to achieving sustainability. Here modern inputs like fertilizers and pesticides can, says the 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 makes its presence felt.521 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 biodiversity 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." 522 Developing the ecological literacy of farmers could, therefore, create significant employment.

Managing intensive livestock systems is another challenge. For the 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, of course, by training and employing more of them.

Payment for Environmental Services

Payment for environmental services (PES) is another strategy which would appear to have apparently very significant green employment potential. A description of the full range of these services is not possible here, but they include activities like 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.523

The FAO's *State of Food and Agriculture* report for 2007[524] explores PES in considerable depth. It concludes that PES 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 has to date has been relatively limited. In the OECD countries farmers have been compensated for forgoing 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 developed in Columbia, Costa Rica and Nicaragua to conserve forests. In the latter cases, the incomes of cattle farmers normally 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 respending or taking on additional paid help.

A number of studies in the developed countries point to real employment benefits of PES. In the UK, the English Countryside Stewardship Scheme has created jobs for farmers, contractors and other small rural businesses[525] The Tir Cymen scheme in Wales was created to promote sustainable farming in 3 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 was 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 alien invasive vegetation.[526] 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 that blanket assumptions that PES programs will assist the poor or stimulate employment thus remain problematic.[527][528] Moreover, the overall magnitude of PES programs is still small and most of them exist in the 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 notes that, compared to other sectors, relatively little work has been done on how to cut emissions from the agriculture sector.529 The Review's proposals focus on more efficient use of fertilizers to cut nitrous oxide emissions; reducing methane from animals by way of nutritional supplements and capturing the methane for fuel, and by stopping the burning of crop residues. Some of the World Bank's proposals referred to above may also contribute to the effort to limit GHGs. As mentioned above, the IPCC has developed its own list of priorities in terms of 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 in others. Certainly, changes in agricultural land management, such as conservation tillage, agroforestry, rehabilitation of degraded crop and pasture land could create jobs.530
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 Giga tons from 1600 million hectares of cropland. This soil carbon loss can be reversed by techniques that increase the rate of carbon input into agricultural soils or reduce the rate of carbon loss. 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 Giga tons of carbon over the next 50 years if these methods were applied to all cropland. [531]

Conservation tillage, however, is presented to farmers as a way of reducing labor inputs. It also uses half as many tractors to cultivate a field as conventional tillage, translating to 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, and row cleaners that brush aside heavy residue concentration.[532] If conservation tillage became far more widely practiced by farmers, then demand for these technologies would presumably increase and manufacturing jobs would also grow accordingly. However, demand for equipment germane to conventional ploughing (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.[533]

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 also create employment. 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"[534] 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.[535]

Funds for Mitigation and Adaptation are Insufficient

In general, the financial commitments made by rich-country governments as signatories to the UNFCCC back in 1992 have not been met. 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." [536][537] 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.[538]. 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 (.) (FAR 70)

Meanwhile, the contrast between the money being spent on climate change adaptation efforts in the rich countries to the amounts being spend in the poor countries could not be more stark. The UK, Germany, the Netherlands, Italy and the U.S. have spent billions of dollars on flood defenses and other protection measures, creating thousands of jobs in the process. However, currently only $26 million has been spent multilaterally for adaptation measures—a figure that, notes the UNDP, is the equivalent of one week's worth of spending on flood defenses in the UK. 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 and 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 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. Climate related disaster response could add another $2 billion. This total of $86 billion would require developed countries to mobilize around 0.2% of GDP in 2015 – or roughly one tenth of what they currently spend on defense. The IPCC also draws attention to…..

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. It is not possible here to speculate with any degree of accuracy regarding what this might amount to in terms of numbers of jobs, but the quality of the work generated is likely to be high. 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. The Project 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 2000-2001 period. These Councils spent an estimated $21 million on other environmental protection and an estimated $16 million on natural resource management activities

during this period. This created employment for Environmental Officers and a Biodiversity Officers, and Perth local governments dedicate 41 full-time equivalent officers to on-ground bush regeneration.[539] However, a 2002 survey conducted in Australia identified training needs and skills shortages being experienced in environmental occupations, particularly in bush regeneration skills; organic agriculture; environmental impact statement preparation; and environmental assessment and monitoring. If such shortages are evident in Australia, it seems they are likely to be more evident in the developing world where the resources to develop them are unfortunately even more scarce. [540] The study showed a marked increase in the number of "environmental workers" being hired, especially in the private sector. Among the occupations experiencing the most growth were those concerned with "earth repair" and "resource renewal." Along these lines, UNEP maintains that a prerequisite to achieving sustainable use of land is the adequate support by governments for national land resource institutions, and for building up the capacities of land resource planners, farmers and managers at local and national levels.[541]

Offsetting Trends?

Taken together, these proposals are part of an effort to make existing agriculture more sustainable. It presents a scenario where jobs may be gained, but they may also be lost—and far more 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 mitigation, the IPCC documents the global trend towards energy intensification in food produced on arable lands, and projects a "4 to 7 fold increase in current commercial energy inputs into agriculture, particularly in developing countries"[542] Therefore, 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."[543] In its Fourth Assessment Report, the IPCC sees the potential to reduce GHG emissions per unit of 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….

Supermarkets and superstores are proposing measures to limit their own environmental footprint. 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 as a result of lighting and refrigeration.[544] Large retailers like Sainsburys and Wal Mart have proposed action to green their operations.

In 1999, Sainsbury's built what it described as the UK's most environmentally responsible supermarket in Britain. The 35,000 sq. ft. store was designed to reduce energy consumption by up to as much as 50% compared to a standard store of a similar size and operation. The store created 380 jobs, although it's not clear how this number would have changed has the store been constructed in a conventional way.[545] In 2005 Wal-M art, the largest retailer in the world, unveiled a new store outside of Dallas, Texas that combined a host of renewable energy technologies including numerous solar PV arrays, two small wind turbines, a bio-fuel boiler to recycle and burn recovered oil from store operations and a nearly endless list of energy-saving and sustainable design principles.

The company announced it would invest $500 million in technologies to reduce its stores' greenhouse-gas emissions by 20 percent in seven years, increase its truck fleet's fuel efficiency by 25 percent in three years and double it in 10 years, design a 25 percent more energy-efficient store within four years, work to reduce packaging, and pressure its worldwide network of suppliers to follow its lead.[546]

In 2006, the largest UK-based food retailer, Tesco, generated 4.13m tons of carbon dioxide equivalent (CO2e) globally. The UK food retail sector is estimated to emit 9.2m tons CO2e annually, plus the associated distribution emissions of approximately 2.4m tons CO2e. Tesco's effort to reduce its carbon intensity is producing results. "(O)ur footprint in tons of CO2e 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 tin 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."[547]
The employment implications of these early efforts to green food retail (and retail general) require further analysis.

Wal Mart "sustainability commitments" include being supplied 100% by renewable energy, to eliminate 30% of energy use in its stores by around 2012, and to sell more organic produce. It also plans to reduce its CO2 output by 20 million tons.

….and a Civil Society Critique

Wal Mart's proposals for sustainability have elicited a sharp reaction from many civil society organizations. According to one calculation, the companies' greenhouse gas emissions equaled 562 million through its supply chains and retail operations—almost half the amount generated by France in 2004—thus putting into perspective the company's proposed cuts. The company's plan to sell more organics has also been attacked by organic watchdog organizations for pricing out other organic producers and for misrepresenting conventional food products as organic. Indeed, just about all of Wal Mart's sustainability commitments have been severely criticized. [548]

Reducing Food Waste – Uncertain Employment Opportunities

A large portion of all food produced by the food system is never eaten and is discarded, and the discarded food continues to generate GHGs like methane as it rots in landfills.[549] The reduction of food waste should therefore be a top environmental priority. As noted above, big food 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 which are often destroyed. Even if eventually purchased by retailers, supermarkets routinely "cull" foodstuffs that are blemished or have passed a sell-by date but are sometimes quite edible.

Supermarkets could do more to prevent waste. However, it's unclear just how many jobs this might create or preserve. In New Jersey, 25 Shop Rite supermarkets together divert 3,000 tons of organic waste for off-sire composting and rendering. Composting responsibilities are integrated into employee job descriptions, but the scheme does create jobs for employees of rendering companies. [550] The California Integrated Waste Management Board part of the Environmental Protection Agency employs around 400

workers to deal with 5.6 million tons of discarded food.[551] Over half—2.9 million tons—come from commercial sources such as restaurants, hotels, 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 like food to useable energy and to stop the release of this toxic greenhouse gas into the atmosphere. In principle, the widespread development of LFGTE could generate considerable employment. Of the estimated 2,500 landfills currently operating in the U.S., approximately 340 have landfill gas projects and a further 60 projects are under construction. [552] The IPCC found 1150 plants operating globally in 2003.[553]

According to a United States Department of Energy survey, LFGTE projects currently utilize about 10% of the potential LFG in the US, and it estimates that the application of the controlled bioreactor technology to 50% of the waste currently being landfilled could provide more than 270 billion ft.3 of methane gas per year to meet about 1% of the electrical energy needs in the US [554]
LFGTE is capital intensive, and reduces emissions through engineered gas extraction and recovery systems consisting of vertical wells and/or horizontal collectors (FAR73). Nevertheless its widespread deployment would appear 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.[555] The IPCC has cited capture rates of just 20% in some cases, far lower than the 75% capture rate sometimes claimed by waste management companies. Some in civil society have expressed concern that the 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%, and accelerated decomposition may actually increase the release of methane into the atmosphere.

In the EU, landfill gas recovery is mandated at existing sites, while the landfilling of organic wastes is being phased out via the landfill 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, noting that "low technology recycling activities can also generate significant employment through creative microfinancing and other measures to essentially pay people to sort through garbage.

In the U.S. recycling and yard waste collection and composting programs already exist, and 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 greenhouse gases, these programs create their own benefits such as soil stabilization and improvement through composting. Recycling leads to indirect energy savings and reduced greenhouse gas 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, any individual or enterprise that reduces food intake may become a green job candidate, but public education on food waste reduction, and on better use of food in the homes could generate green employment in schools, government agencies, and NGOs.

BEYOND THE AGRO-INDUSTRIAL MODEL

The fourth and final part of this section examines the employment implications of radically altered global food regime. Here we explore the likely employment implications of several key features of a post-industrial model based on "grow local" policies and practices and small farm production. We come at this question from two angles or perspectives. The first angle or perspective is that of supporting small farming systems in the developing world. Here large numbers of them continue to grow food and raise animals for themselves and local communities. Here the issue of green jobs is somewhat concerned with the securing of local food economies, which entails keeping what's already relatively green and perhaps making it greener still. 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 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, towards 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, as well as 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 an unsustainable system, and those who see small farmers as an important part of the global food system for years to come, but who will nevertheless ultimately adapt to or be eclipsed by the purportedly more productive agro-industrial system.

It's also not possible here to consider the political and social changes that might be necessary for this model to function. Small farmers' organizations and agricultural workers' unions stress that land reform, access to markets, affordable finance, and other resources are all essential.[556] 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 to one side. Also beyond the scope of this report is any assessment of the productive potential of this system. 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, using biopesticides and biofertilizers, as well as harvesting enough water for an extra irrigated crop during formerly unproductive seasons. But issues of yields and productivity can not be adequately dealt with here.

This 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.[557] According to the World Wildlife Fund 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."[558]

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.[559] It also makes use of the knowledge and skills of farmers.[560]

The Developing World

Small farmers play a critically important role in the developing world. For example, in Brazil, over 70 percent of food consumed by the Brazilian population 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. The most recent agricultural census in Brazil (1995-96) showed that, using the average productive strategies of small scale agriculture, each 8 cultivated hectares produces one rural job, whereas large-scale mechanized farms require an average 67 hectares for each unit or rural employment.[561] 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. [562]

Textbox II.5-3. The Cuban Experience

The Cuban experience perhaps 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. An Urban Agriculture Department was established 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 decrease of 36 percent. 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.[563]

Adaptation to Climate Change and Local Production

The impact of climate change on agriculture in the poorer regions of the world is already obvious. However, the adaptation potential of local food systems has not always been recognized. According to the World Wildlife Fund:

> 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, as in Peru

Despite scarce resources and underfunding, farmers and communities are taking adaptation measures into their own hands. The UNDP documents a number of 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 rainfed environments already invest their labor in small scale water harvesting. Women farmers in Bangladesh are building "floating gardens" to grow vegetables in flood-prone areas.

Paying farmers to keep rainforests intact helps the fight against climate change:

> 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.[564]

Urban Agriculture

Urban agriculture is an important expression of sustainable methods, the expansion of which could generate much-needed urban employment, particularly in areas with high levels of underemployment and informality.

Urban agriculture has been expanding "more rapidly than urban populations, and in many countries more rapidly than their economies."[565] Urban agriculture takes place on both public and private land, and more than 800 million urban dwellers were involved in urban agriculture in 1993. In Sao Paolo, agriculture is a major planned land use is the city's metropolitan master plan, which was adopted in the 1990s. Urban agriculture is not however, unambiguously green. The improper use of chemicals has contributed to land and air pollution. However, the activity recycles organic matter and solid wastes can be composted and used to fertilize soils. Smit's study in Zimbabwe notes that the expansion of urban agriculture reduced municipal costs for landscape maintenance and waste management, and created hundreds of jobs.[566]

Green Job Potential in Organic Farming and Local Food Systems

The worldwide demand for organic agricultural produce grew 20 percent every year for most of the 1990s and is estimated to have reached $100 billion in sales in 2006, a nine fold increase from 1997's $11 billion figure.

Research cases provide some evidence that organic farming and local food systems generate positive sum employment gains while protecting the environment. For examples:

- A study conducted in the U.K. of 900 food businesses in Devon which showed that producers involved in the local economy hired more workers on average than those that were not. The study found that 38 percent of producers have created new jobs, at an average of 0.5 per farm, 3.4 full time equivalents (FTE) per farm compared to 2.34 FTE's for the regional average.[567]

- A larger study of 1144 organic farms in the U.K. and the Republic of Ireland showed that organic farms employed 135 percent more FTEs per farm than conventional farms. In the UK and RI organic agricultural land amounts to 4.3% and 1% of the total farm area, respectively. If 20% of farm land became organic in both countries, there would be an increase of 73,200 jobs in the UK and 9.200 in the RI[568]

- An input-output analysis of organic apple production in Washington State discovered that, for every $1 million in sales, organic apples generated 29.4 FTEs whereas conventional farms generated 25.9 FTEs.[569]

Other studies show that purchases from local growers through such means as organic box schemes generates considerably more income for the 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. According to one study, if the people living in Iowa purchased 10 percent more of their food from local growers, they would cut the state's CO2 emissions by 7.9 million pounds 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.[570] A UK study on a local food market in East London found that, aside from its other benefits, "the Market provides twice as many jobs per square foot of retail as supermarkets…The market delivers twice as many jobs per square metre as a food superstore. Queens Market provides significant employment providing 581 jobs, and 308 people employed at the market live in the immediate local area. Market jobs are 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." [571]

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, in contrast to the livestock and dairy farms (where the jobs dividend between organic and conventional farms was 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. [572]

The UK-RI study also suggested that, in the case of organic farms, the larger of number of workers per farm might yield social benefits by helping to breakdown the social isolation felt by sole farmers and sole employees. [573] And farmers' markets have community-building value also. One study estimated that people have ten times as many conversations at farmers' markets than at supermarkets to the benefit, presumably, of both workers and consumers alike. [574] A pilot survey conducted 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.[575]

While these findings tend to point to 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 squeezed by cheap imports on the one hand and large wholesale operations on the others, so much so they complained that their own wages and benefits were, along with their mainly immigrant employees also extremely low. Fully two thirds of these farmers opposed guaranteed collective bargaining rights for waged employees.[576] Also in the U.S., organic soybean producers have been subjected to the same downward pressures on prices as have the producers of non-organic produce. However, in 2000 several organic farmers formed an organization (OFARM) which among other things substitutes collective actions for one-on-one negotiations with large buyers. Organic milk producers in the U.S. have also 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.(source needed)

If the social benefits of organic production are not always clear cut, the same is sometimes true of the environmental benefits. For example, organic produce is not necessarily synonymous with the local food production and a reduction of food miles. The global trade in organics is on the increase, with Chinese organic 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.[577] The growing market for organic produce provides an incentive for Chinese farmers to convert their farmland from chemical-dependent farming techniques back to traditional, pesticide-free, sustainable farming methods. If the consumption of organic produce continues to grow in both the developed and developing world, then employment growth in this area could become a more generalized and global phenomenon.[578] The UK, for example, imports 70 percent of its organic produce—along with 50 percent of its vegetables, 90 percent of its fruit, and 70 percent of its meat. [579]

Organic Production and Developing Countries

While demand for organic produce is growing across the industrialized countries, organic methods of farming are also visible in the developing world. This trend was examined at a 2007 "International Conference on Organic Agriculture and Food Security" organized by the FAO.[580] A number of submissions made note of the social benefits of organic production. In the Dominican Republic, one study described how the establishment and maintenance of organic crops such as cocoa, coffee and banana, require intense use of hand labor, as mechanization is still not available for the majority of farm operations. In this way, the ongoing trend of urbanization is, to some extent, limited, claimed the study, "as the movement from rural to metropolitan areas is reduced by the availability of local employment opportunities." [581] In the former East Germany, since 1990 the number of employees in the agricultural sector of north-eastern Germany has been reduced by 80 percent. However, larger organic farms were developing there and generating employment and other social benefits.[582] And in India, "organic farming is spreading fast to many agro-ecological zones in India…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) provides more employment to members of the farming families"[583]

The growth of organics is to some extent contingent on labeling. As government regulation in agriculture has retreated, the large retailers and 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. For example, in Mexico *Coyote Rojo* ("Red Coyote,") is an organic bioregional label which began to certify producers in August 2007. Its purposes are to safeguard and promote biodiversity, uphold cultural practices of seed saving, methods of production of crops and typical foods, to protect natural resources (water and forest) 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 sources of energy, promoting and preserving organic agriculture – and development of 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* therefore 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's 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 "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."[584]

Fair Trade Coffee

The demand for "Fair Trade" products has grown dramatically in recent years, especially in tea, coffee, cocoa and bananas. In 2003, 18.5 million pounds of green coffee was Fair Trade certified with a retail value of $208 million, roughly 15% of the $1.7 billion specialty coffee market in the U.S.

As a result of the "Fair Trade " certification, workers and farmers in the fair trade systems have better rights and protections than is the case in conventional industries and the production methods are 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 by those farmers who rely principally on their own families' labor. This makes Fair Trade potentially representative of an estimated 75% of all coffee farmers.

A look at one large company involved in Fair Trade, Equal Exchange, shows an average annual growth between 1986 and 2006 of 32.5 percent. In 2006 the company's sales was approximately $23.6 million and it employed 94 full-time employees.[585] The combined efforts of the Fair Trade movement have generated significant numbers of green jobs. While the numbers of green jobs may typically be only a few dozen in each cooperative, the numbers 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. [586]

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.[587] 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 Fair Trade carrots as a means to help farmers in central England? While considerable economic differences exist between farmers North and South, many of the economic dynamics are nonetheless very similar.[588]

Green Employment in Food and Agriculture: Challenges and Opportunities

From the overview provided above, it's 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, at least to the extent that smaller farms generally use less energy and chemical inputs than larger scale livestock-intensive or plantation systems.

- Smallholders and entrepreneurs are quickly moving into higher-value products like cut flowers (the "new agriculture"), products that generally require more environmentally damaging inputs and create often 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 in areas where land is increasingly exploited to meet food needs without adequate economic and political support to adopt appropriate agricultural practices.[589]

- Rising incomes in some parts of the developing world is raising the demand for meat and therefore 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 environmentally sustainable will therefore have employment implications.

The above constitute challenges to green employment creation. The present reality is that much of the employment in the existing global food system can not 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 towards them. It's 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 the 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 towards more unsustainable practices.

SECTION 5. INDUSTRY

Note: This section will only be completed during the final phase of the research project. It will provide a detailed assessment of prospects and constraints regarding Green Jobs and Green Workplaces within a number of key industrial sectors.

PART III

OUTLOOK AND CONCLUSIONS

SECTION 1. 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 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, greater attention to 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 have 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.[590]

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.[591]

There is also a need to question whether a system of unbridled consumption—well-entrenched in Western industrialized countries, but spreading rapidly to 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, 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 those 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.

CRADLE TO CRADLE

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 by-products of one factory become the feedstock of another, instead of becoming environmental time bombs.[592]

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.[593]

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.[594]

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 quick replacement.[595]

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 EPR laws do not as such address the issue of product longevity, they can be an incentive for companies to move in this direction.[596]

Job Implications

What are the job implications? 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 be clearly 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.4-1 offers a rough conceptual exploration of the likely employment implications. A fuller evaluation would require detailed assessments of the specific changes and how they translate into job losses and opportunities for new employment.

Table III.1-1. 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: Michael Renner, *Working for the Environment: A Growing Source of Jobs*, Worldwatch Paper 152 (Washington, DC: September 2000), p. 52.

Recycling and Remanufacturing

Already, recycling and remanufacturing have become substantial industries. Recycling makes an important contribution to reducing energy consumption and associated pollution of air and water. The Bureau of International Recycling in Brussels, Belgium, estimates that its members in 60 countries worldwide 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.[597] While this is a substantial number, it is not a complete

tally of recycling jobs worldwide, as the discussion of ship breaking and e-waste recycling operations below indicates. It also does not include community-based recycling and composting programs—such as one implemented in Dhaka, Bangladesh—for which employment numbers are hard to come by.[598] Recycling practices vary widely across the planet, some subject to strict laws and others essentially unregulated.

While recycling is of great value in terms of resource conservation, it can entail dirty, undesirable, and even dangerous work. For example, ship dismantling has become 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 value steel and other scrap metal but also many hazardous materials, including asbestos and polychlorinated biphenyls (PCBs).[599]

High turnover of electrical and electronic equipment has led to mountains of electronics waste. In principle, this can lead to a growing electronics recycling industry. But discarded items like computers, telephones and mobile phones 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 domestic discards (another 20 percent goes to India, Pakistan, Bangladesh, and Myanmar). In Taizhou and Guiyu (Guangdong Province), two of China's recycling centers, small family-owned workshops employ about 100,000 workers who dismantle some 3.7 million tons of e-waste annually. The industry is fast-growing and anarchic. This makes it difficult to enforce safety and environmental rules, even though the government has adopted regulations similar to those in force in the European Union.[600] In Guangdong Province, plastic recycling is mostly done by very poor people, including migrant laborers. According to Recycling Magazine, in total some 10 million people are involved in recycling in all of China. The Magazine notes: "Whereas in the Western world it [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."[601]

Textbox III.1-1. 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) 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.[602]

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.[603]

Besides recycling, remanufacturing is also becoming a serious business, particularly in areas like motor vehicle components, aircraft parts, compressors, electrical and data communication equipment, office furniture, vending machines, photo copiers, 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.[604]

In the United States, remanufacturing was a $40 billion business in 2003.[605] An estimated 480,000 people are employed by companies in this sector.[606] 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. [607]

Xerox and Canon (which began remanufacturing photocopiers in 1992[608]) are among the companies that have pushed this concept. (See Textbox I.4-1) A French producer of automotive driveshafts 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.[609] But clearly, there is enormous room for expansion of this activity.

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 other firms that can make use of components and materials.

TOWARD 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 part 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, providing distribution (wholesale and retail) channels 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.[610]

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.[611]

Such changes in the way products are retailed build on an argument that has been put forward by Amory Lovins, cofounder 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.[612]

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 affluence 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.[613]

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.[614]

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).[615]

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.[616] 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 2001-2004, they have experienced annual growth of about 20 percent in their business since 1990.[617]

The concept of focusing on performance rather than increasing inputs is catching on even in one of the most pollution-intensive industries. 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.[618]

Textbox III.1-2. 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.[619]

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.[620]

In perhaps its most audacious move, Interface launched an "Evergreen lease" in 1995. Under this, the company retains ownership of the carpet and remains responsible for keeping it clean in return for a monthly fee. Regular inspections would permit the company to focus on replacing just the carpet tiles that show most of the wear and tear instead of the entire carpet, as in the past. This more-targeted replacement helps reduce the amount of material required by some 80 percent.[621]

But only about a half-dozen or so leases were actually signed, as most customers opted for a traditional purchase instead. The program did not succeed for a variety of reasons, some specific to the carpet business. Some customers felt the lease agreement was too complex or too inflexible, locking them into a long-term arrangement that limited their future options. But perhaps the biggest problem was cost—a reflection of Interface's emphasis on high-quality material and high quality maintenance services. In the end, the company felt compelled to drop the Evergreen lease.[622]

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. (See Textbox I.4-2) The Interface story is at once encouraging and cautionary. It is clear that the new business model the company was proposing is still facing enormous hurdles. As with all radical challenges to established practice, broad acceptance will not come quickly.

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. Avoided material costs are the principal reason why the company has, to date, saved $130 million with an investment of less than $40 million. Although its pro-environmental changes were not a business necessity in the short term, Interface executives are convinced that they are fundamental to assuring competitive advantage in the mid to long term.[623]

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."[624] And Wolfgang Sachs of the Wuppertal Institut 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, home owners 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 OECD has referred to an "infrastructure of consumption" that compels people to engage in involuntary patterns of consumption.[625] 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 up-front 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, long-lasting, 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.[626] 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 nineteenth 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.

Table III.1-2. 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, child care, 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: Michael Renner, "Moving Toward a Less Consumptive Economy," in Worldwatch Institute, *State of the World 2004* (New York: W.W. Norton & Co., 2004), p. 115.

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. (See Table I.4–2.) These may form the basis for new concepts of how to better share available work.

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.

RETOOLING ECONOMIC THOUGHT AND PRACTICE

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 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 reins 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 coauthors 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 affluence 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.[627] And such an economy would offer much broader scope for green employment.

SECTION 2. FAIR TRANSITION

Note: This is a copy of the brief text in the Executive Summary and This section will be substantially expanded in the final phase of the project.

The transition toward a low-carbon, sustainable economy entails both opportunities and challenges. This section briefly considers both aspects.

Investment to create green jobs is one side of the jobs coin; training and skill building is the other. Both are necessary to bring green employment to its full potential. 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.

Green employment gains need to be balanced against significant and unavoidable job losses incurred as a result of the movement towards a low-carbon and sustainable society. Overall, far more green jobs will be created in the move toward a sustainable economy than jobs lost. But for affected workers, as well as their families and communities, transition assistance is needed.

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 primarily being driven 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 towards renewables. But they can be expected to accelerate under a climate stabilization policy.

Employment in other industries, too, may suffer from substantial efforts to move toward a low-carbon, high-efficiency economy. For example, while greater vehicle fuel efficiency does not necessarily harm auto industry jobs, a far-reaching modal shift would.

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 pro-active assistance in creating alternative jobs and livelihoods, acquiring new skills, and weathering the transition to new industries.

The transition to new and sustainable patterns of production and consumption and a low carbon future will entail major shifts in employments patterns and skill profiles. 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 still more principle than reality.

Today's turbulent labor markets are characterized by growing informality, precariousness, and a tendency to replace stable terms of employment with fixed-term contracts and casual arrangements. As already noted, employment in extractive industries, chemical and allied

products, shipping, food, and elsewhere in manufacturing is trending downwards as a result of technological change, efficiencies, and also offshoring. A green jobs strategy must therefore be situated within a just transition framework, but this framework must extend far beyond the needs of specific groups of directly impacted workers to include all workers. This underscores the importance of the Decent Work Agenda and for a global approach to social protection where every society establishes a social floor.

The role of the trade unions is critical to the success of the green jobs strategy, and an implacable commitment to just transition on the part of policymakers will ensure maximum trade union cooperation within a framework of social dialogue and freedom of association. Unions internationally have immense experience in worker training and education, and can both expedite change and enhance the quality of new and reconfigured jobs. Meaningful trade union input into the many policy and workplace decisions, both large and small, is also essential. However, the green jobs strategy must be pursued with the view to providing decent work to those who have until now been excluded from better quality jobs as a result of inadequate skills and education or because of race, gender, ethnic, and other forms of discrimination.

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The BLS notes: "(M)ost red meat arrives at grocery stores partially cut up, but a growing share of meat is being delivered prepackaged, with additional fat removed, to wholesalers and retailers. This trend is resulting in less work and, thus, fewer jobs for retail butchers."

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End piece that may be useful later:

Several cases, however, show what might be accomplished on a much broader scale. For example, in the Australian fishery for Western Rock lobster collective decisions managed to balance harvesting to the collective yield of the resource. The impact on employment in this instance is unclear beyond the general rule that overexploitation of the resource may create additional jobs in the short term, only to see the same jobs disappear through (in this instance)

the overpotting of lobsters. Better to preserve steady levels of employment over the long term as a result of creating a sustainable balance between the resource and its use. [588]

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