Part I

Definitions and Policies

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Demonstration of workers in front of the capitol. USA.

1. Definitions, Scope, and Concepts

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

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

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

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

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

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

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

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

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

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

Source: See Endnote 3 for this section.

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

The urgent need to move toward a more sustainable economy further complicates these issues. It at once poses a profound challenge for governments, companies, communities, and individuals,

but also offers vast business and employment opportunities. Indeed, the pursuit of green jobs will be a key economic driver in the 21st century, as the world sets out into the largely uncharted territory of achieving a low-carbon global economy. Greening the economy will involve large-scale investment in new technologies, equipment, buildings, and infrastructure, and could thus be a major stimulus for much-needed employment.

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

Defining and Counting Green Jobs

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

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

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

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

We define green jobs as positions in agriculture, manufacturing, construction, installation, and

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

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

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

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

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

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

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

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

Green Jobs 'Radiating Out'

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

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

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

Green and Decent Jobs

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

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

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

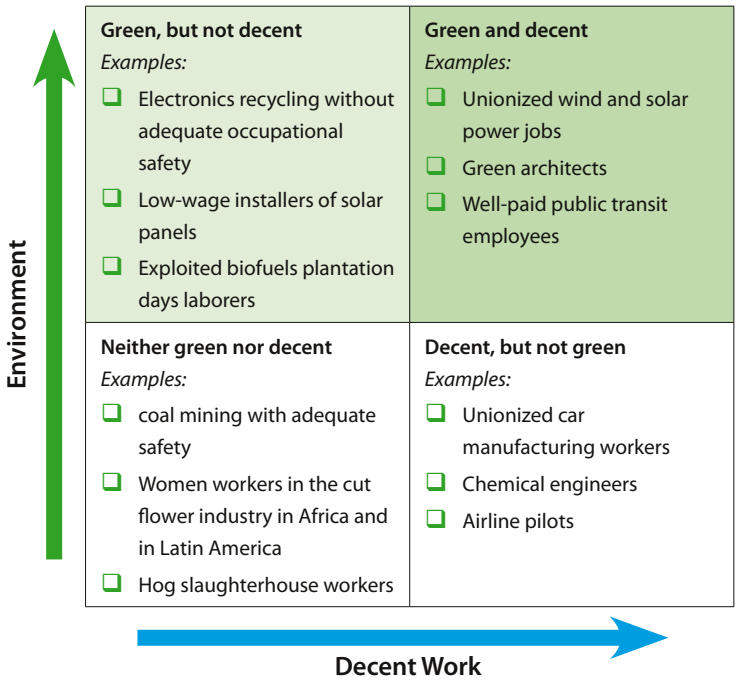
Wind power development opens up employment opportunities in a variety of fields. It requires meteorologists and surveyors to rate appropriate sites with the greatest wind potential; people trained in anemometry (measuring the force, speed, and direction of the wind); structural, electrical, and mechanical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

Source: See Endnote 7 for this section.

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

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

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



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

Shades of Green

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

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

products and services with less detrimental impact on the environment.[9]

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

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

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

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

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

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

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

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

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

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

Employment Shifts

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

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

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

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

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

Source: See Endnote 12 for this section.

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

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

Direct, Indirect, and Induced Jobs

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

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

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

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

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

Re-Spending and the Rebound Effect

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

It must be noted, however, that a "rebound effect" could limit money available for re-spending: lower per-unit energy or materials requirements through higher efficiency translate into lower consumer costs, which in turn encourage increased usage. For instance, greater automobile fuel efficiency means that motorists can drive longer distances at the same cost. An in-depth literature review prepared by the U.S. Department of Energy on behalf of the International Energy Agency (IEA) in 1998 found that the effect is less than 10 percent for residential appliances, residential lighting, and commercial lighting; less than 20 percent for industrial process uses; small-to-moderate (less than 10–40 percent) for residential space heating, water heating, and automotive

transport; and anywhere from 0 to 50 percent for residential space cooling.[13] Based on a review of studies from 2000 and 2007, a RAND Corporation report concludes that the rebound effect for automobile fuel consumption is in the range of 10–20 percent.[14] The rebound effect thus somewhat lowers the reductions in fuel use, and associated emissions of air pollutants and carbon, made possible by greater fuel efficiency.

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

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

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

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

Labor, Energy, and Materials Productivity

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

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

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

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

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

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

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

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

Source: See Endnote 21 for this section.

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

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

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

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

Winners and Losers

As the move toward a low-carbon and more sustainable economy gathers momentum, growing numbers of green jobs will be created. Overly aggregated job numbers, however, may hide

important distinctions, exceptions, and disparities. For instance, local communities and regions will want to ensure that green jobs are created within their jurisdictions; governments and unions will watch closely whether green development will benefit the domestic economy or companies and communities in other countries.

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

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

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

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

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

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

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