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Working for the Environment: A Growing Source of Jobs

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Introduction

From November 1811 to January 1813, organized bands of English artisans in the wool and textile trades attacked the textile-manufacturing machinery that was beginning to replace them in the early stages of the Industrial Revolution. Acting in the name of "General Ned Ludd"—by all accounts an imaginary, yet immensely inspiring, figure—the "Luddites" conducted nighttime raids, stormed factories, and even committed arson and burglary in their desperate struggle to forestall what they saw as a mortal threat to their livelihoods and the world they knew: craft, custom, and community.[1]

A single textile worker in 1813 could do the tasks that would have required 200 in 1770. The number of British textile looms run by steam power surged from an estimated 2,400 in 1813 to 14,150 in 1820, and to more than 100,000 in 1830. Some 100,000 handloom weavers in the cotton industry were impoverished as a result. Age-old crafts were obliterated, skills rendered obsolete, communities torn asunder. As the Industrial Revolution gathered force, hundreds of thousands of self-employed people all over Britain were driven from their workplaces. Suddenly in need of money to secure food and other basic needs, they had no choice but to move to emerging factory towns that would become known for heedless pollution of air and water and inhumane treatment of workers.[2]

Although a Luddite is now defined as "one who is opposed to technological change," the machine breakers of early nineteenth-century England were not hostile to tech-

nology per se. Rather, they protested against "machinery hurtful to Commonality," as a contemporary letter put it—an onrush of technology beyond their control, introduced without regard for the social dislocation and environmental destruction it caused.[3]

The particular technologies that triggered the Luddite movement may seem quaint today, but the key issues remain relevant. The economic system that was first brought into existence by the Industrial Revolution embodies a turbulence—a constant changing and churning—that, even as it propels society onward, injects a substantial degree of uncertainty into people's jobs and lives. In today's Europe, as elsewhere in the industrial world, more than 10 percent of all jobs vanish each year, often replaced by different jobs in new occupations and sometimes in new companies. This turbulence increases and becomes more socially disruptive in times of fundamental structural change, when new technologies and industries arise and old ones wither away. Some regions prosper as others become rustbelts, and new jobs and skills emerge as others fall victim to the march of technology. In a transformation perhaps as momentous as the one 200 years ago, the microelectronics revolution and the trend toward economic globalization are today spawning anxiety about job security, skills obsolescence, and wage trends.[4]

Responding to a shortage of skilled labor and seemingly inexhaustible supplies of natural resources, companies have sought to replace human labor with machinery ever since the beginning of the Industrial Revolution. This substitution helped launch an unprecedented economic expansion. Even as older skills and professions fell by the wayside, the growing economy absorbed the expanding labor force that resulted from strong population growth.

But today, the challenge is of a different nature. Although industrial countries may encounter tight markets for skilled labor from time to time, and in particular branches and regions, unemployment and underemployment are now key concerns. This is particularly the case in developing countries; unlike Britain and Europe at the beginning of the

Industrial Revolution, they have a tremendous "surplus" of people of working age, and the key challenge is to assure a livelihood for them.

Spreading environmental pollution was the unintended consequence of an expanding industrial system, eventually reaching the point of planetary-scale degradation and alteration of natural systems. Today, humanity is confronted with global climate change, widespread water and air pollution, mountains of waste dangerous to humans and the environment on which they depend, and sharply diminishing biodiversity. Addressing these challenges will require dramatically reducing reliance on fossil fuels, curtailing mining and logging, restructuring the utility and transportation sectors, phasing out the production of dangerous chemicals such as persistent organic pollutants, and altering industrial processes to boost the efficiency with which energy and materials are used.

The natural fear is that shifting toward greater sustainability will cause grave economic disruptions and trigger massive job loss, and such worries are eagerly cultivated by business leaders resistant to change. From the earliest efforts to protect air and water quality, to the 1990s' spotted owl-versus-loggers controversy in the U.S. Pacific Northwest, to the Kyoto Protocol on climate change, industry spokespeople have not missed a beat in predicting economic doom. In most industrial countries, the relationship between labor unions and environmental organizations has seesawed from harmonious to tempestuous at different times. But particularly in the United States, the much publicized notion that jobs and environmental protection are fundamentally incompatible goals has created tensions between the labor and environmental movements. U.S. public discussion of difficult issues of employment and environmental protection is consequently far more polarized than in Europe or Japan.[5]

Does sustainability really spell economic doom? As the economy has expanded and diversified, the environmentally most damaging activities like logging, mining, and heavy industries (like iron and steel) have become far less impor-

tant overall than they once were. 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 equaled lower growth and less employment. But as most people now realize, 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. The pursuit of greater resource efficiency holds substantial promise for far less environmentally damaging ways of producing and consuming goods.[6]

The evidence in industrial countries so far is that environmental protection measures have not caused any significant job loss. In the United States, for example, layoffs that can be even partially attributed to environment-related reasons amount to a mere fraction of a percentage point of all layoffs in any given year.[7]

Although logging, mining, and other kinds of resource extraction are likely to feel the greatest impact of moving toward sustainability in the future, blocking environmental action will not save these beleaguered jobs for long. Only diversification can save all the "one-horse" communities. 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, less disruptive action.[8]

Contrary to popular belief, alternatives to heavy natural resource use such as energy and materials efficiency, renewable energy, and recycling offer substantial employment opportunities. We can already glimpse the beginnings of a new, more sustainable economy in the jobs provided in wind power generation and the production of efficient lights, for example.

The industries that extract and process energy and raw materials are not only among the most polluting of human

activities, they also absorb substantial sums of investment money while providing only a small, and declining, number of jobs. Boosting the efficiency with which these resources are used will allow businesses, as well as societies, to redirect a large portion of the tens of billions of dollars that otherwise would continue to go into purchasing fuels and materials and constructing new mines, power stations, and metal-smelting plants. Spending this money in other, more environmentally benign, sectors of the economy will generate a larger number of jobs than spending it in resource industries, since environmentally benign alternatives typically create more jobs than are foregone in the industries they replace.

In place of the present resource-intensive economy, a sustainable economy will seek to manufacture products so that they are not only more energy- and materials-efficient to begin with, but also more durable, upgradable, and repairable, and so they can be remanufactured when their useful life comes to an end. Services built around the idea of extending the life-span of a product and maximizing its utility—deriving the best possible performance for the lowest possible quantity of resources—will bring additional job opportunities, many requiring a high level of skills.

Current tax and subsidy systems discourage job creation even as they encourage resource consumption. A key ingredient in shifting the economy to a more sustainable footing is phasing out current subsidies favoring polluting industries that use natural and financial resources inefficiently. Even more important is restructuring the tax system. Raising taxes on resource consumption, pollution, and waste generation would make resource efficiency, renewables, and "clean" production methods more attractive propositions. Deploying these 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 boost job creation without hurting workers' interests.

A new economy that provides sufficient employment without exacting massive environmental damage is possible. However, as with any fundamental economic transforma-

tion, the transition will require attention. The question facing society today is whether this change can be shaped so that the vast majority of people benefit, and so that social pain during the transition is kept to a minimum. The lessons of the Luddite resistance bear remembering: people caught in the maelstrom of change will resist if they don't see a future for themselves or they have no voice in determining it. Affected workers, communities, and regions—particularly those dependent on resource extraction—will need assistance to negotiate the move to new skills, technologies, and livelihoods. Creative policies are required to boost job creation, enhance workers' education and update their skills, and smooth the transition process.

More broadly, it is imperative that the main burden of the shift to sustainability does not fall on those least able to shoulder it. Raising the price of energy through higher taxes may be an effective market signal for companies to boost efficiency, but the poor will be hard hit unless they receive adequate transition assistance.

This paper primarily addresses the situation in industrial countries, but the policy choices of these nations have broader ramifications. Developing countries are major producers of energy and raw materials—much of which are exported to industrial nations—and many depend heavily on export revenues. Thus, increased energy and materials efficiency in industrial countries will inevitably translate into reduced earnings for exporting countries. The global quest for sustainability demands that rich and poor countries cooperate, not only in adopting environmentally benign technologies and practices, but also in devising ways to do so without triggering widespread dislocation.

Industrial countries have led the world along the path of the current, unsustainable economic system. By developing a new model of a sustainable economy, they can demonstrate to developing countries that human welfare does not have to go hand in hand with environmental destruction. These are challenges that the favored instrument of our era—the market—cannot solve alone. Pro-active government policies are needed both to jump-start the transition to greater materials productivity and to ensure that no one is left behind. All stakeholders, and particularly workers' representatives, need to be given a voice in this process. A new economy will be viable only if it is both environmentally and socially sustainable.

The Changing Nature of Work

Though varying in intensity from industry to industry and from country to country, there is widespread anxiety around the world about what a shift to an environmentally sustainable economy may entail for workers. Why does the notion of an irreconcilable clash of environment versus employment attract such credence? Perhaps the answer lies in the fact that many people already confront considerable uncertainty and adversity in their work lives, ranging from outright unemployment for some to insecure jobs and barely sufficient wages for others. As globalization has gathered pace and new technologies have undermined old work arrangements, the degree of turbulence has risen.

In this context, environmental challenges are often seen as little more than an additional complicating factor on top of existing worries. Unemployment, the lack of adequate unemployment protection, insecure employment, and uncertainty about future prospects allow those opposed to strong environmental policies to play on workers' fears about their jobs and livelihoods.

In the modern economies that emerged with the Industrial Revolution, wage employment is the primary source of income for many people. The world's labor force—those employed or available for work—surged from 1.2 billion people in 1950 to an estimated 2.9 billion in 1998. And because of strong population growth, it will continue to swell: during the next half century, the world will need to create on average 40 million additional jobs each year just to

keep up with newcomers. If past is prologue, there is reason for concern: job expansion has not matched growth of the working-age population.[9]

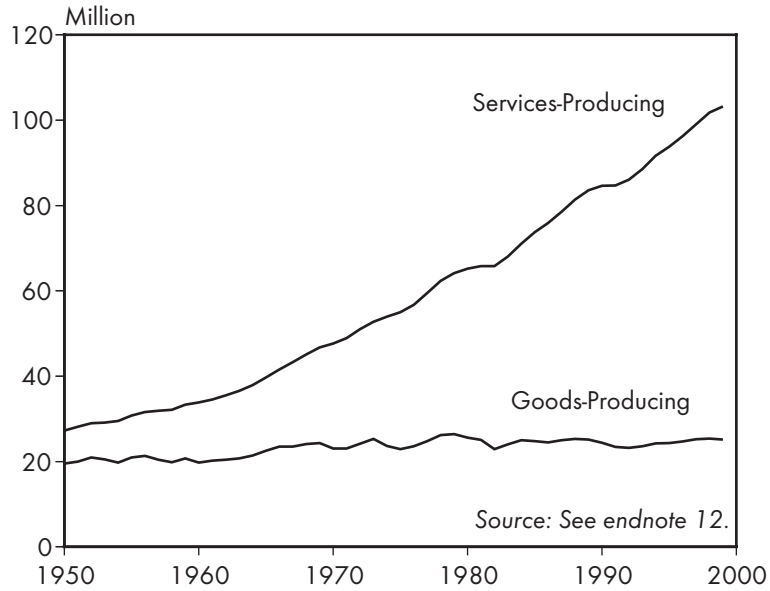
Worldwide, at least 150 million people were unemployed at the end of the 1990s. Three quarters of them received no unemployment benefits whatsoever, and many of those with benefits now face cutbacks. Long-term structural unemployment—joblessness that will not be reduced merely by cyclical upswings in the economy—accounts for a significant portion of the total. In western industrial countries, more than a quarter of the unemployed in 1997 had been jobless for a year or longer. And as many as 900 million people worldwide are "underemployed"—involuntarily working substantially less than full-time, working full-time but earning less than a living wage, or working at lower wages than their training and qualification would warrant.[10]

Then there are the "discouraged" workers, those who have given up hope of finding a job; since they no longer actively seek work, they are usually not even counted as unemployed. In the European Union (EU), for instance, some 18 million persons are officially unemployed, but at least another 9 million are discouraged. At the same time, even with millions out of work, many employed workers end up putting in large amounts of overtime—the equivalent of at least 2 million full-time jobs in the EU.[11]

Since the days of the Industrial Revolution, large numbers of people have been drawn, first, from agriculture and mining (the so-called primary sector) into factory jobs (the "secondary" sector), and then over the last few decades into service occupations (the "tertiary" sector). In recent years, manufacturing employment in industrial countries has either stayed flat or declined, even though output has almost doubled. In fact, relative to output, manufacturing employment has declined almost sevenfold since 1960 in Japan, nearly fivefold in France, and threefold in Germany and Britain. Meanwhile, service employment has roughly doubled in western industrial countries, and almost quadrupled in the United States since 1950. (See Figure 1.) For every

FIGURE 1

U.S. Goods- and Services-related Jobs, 1950–99



manufacturing job, there are now almost five service jobs in the United States; three to four in Japan, France, and the United Kingdom; and more than two in Germany.[12]

The term *services* encompasses vastly disparate activities, including wholesaling and retailing, hotels and restaurants, health care, banking and finance, utilities, communications, and transportation. These sectors comprise some highly skilled and extremely well-paying jobs, but also many at the other end of the spectrum. Retail and wholesale trade, for instance, which are among the least unionized industries in many countries, are characterized by a large proportion of part-time, temporary jobs and high turnover rates. In the United States, only 5–6 percent of employees in this sector are unionized and wages are characteristically low. In mid-1999, average U.S. hourly retail wages were $9.02, compared with $12.61 in all services and $13.94 in manufacturing. Service jobs are also by no means immune to the

turbulence of change that has taken hold in mining and manufacturing. A study by the University of Würzburg concluded that computerization and information technologies in Germany may eventually eliminate 61 percent of current jobs in banking, 51 percent in wholesale and retail, and 74 percent in transportation and logistics.[13]

Even as the shift from the primary to the secondary to the tertiary sector of the economy continues, the nature of work is changing dramatically, perhaps on a scale only comparable to that experienced during the Industrial Revolution. Increasing international trade and investment and a new wave of automation are reshaping virtually every kind of human economic activity and appear to be speeding up the pace of change. Conventional economics praises the process in which mature industries shed jobs and new industries emerge to provide employment. But it is unclear whether computers and microelectronics will render jobs more interesting or more stressful, whether they will require mostly routine skills instead of problem-solving skills that stimulate human creativity, and whether they will lead to a growing polarization of the work force between well-paid and poorly paid employees. Just like the original Industrial Revolution, this transformation brings with it a "de-skilling" process, as existing abilities, expertise, and proficiencies lose in value and importance, and new skills and requirements rise.[14]

Technological development and increased international capital mobility allow growing numbers of companies to embrace measures such as temporary or part-time hiring, parceling out components of the work process (subcontracting and "outsourcing"), and tapping into a large pool of cheap labor in developing countries to either supplement or replace higher-paid workers in industrial countries. Products are now routinely made from components produced in far-flung places around the planet. Although these tactics allow companies to be highly flexible and to adapt rapidly to fast-changing market conditions, they also make job security more tenuous and weaken the bargaining power of labor unions.[15]

A crucial factor in determining wages, working conditions, and job security is the strength and independence of unions. With few exceptions, union membership is on the decline worldwide. In a 1999 survey of 92 countries, the International Labour Organization (ILO) counted 164 million union members among a nonagricultural workforce of 1.3 billion, or about 13 percent. In many countries, union membership has been pushed down by a mixture of factors, including the shift from manufacturing to services (which has been associated with the rise of hard-to-organize temporary and part-time workers), privatization and public sector downsizing, the growth of the informal economy, and a more combative stance of corporate leaders. While some workers may feel that they do not need to be represented by a union, others that want to unionize are being thwarted. The hard-won right to form and join a labor union, and collective bargaining and strike rights as well, are compromised or even under active assault in many countries.[16]

Disparities between skilled workers and those lacking skills or possessing outdated ones grow more noticeable. Manufacturing employment in western industrial countries stayed roughly even for skilled workers between 1970 and 1994, but declined 20 percent for unskilled workers. Likewise, the gap between those with full-time jobs and those working involuntarily in temporary or part-time jobs is becoming more prominent. Under the right circumstances, part-time work can be part of the solution to the employment and social challenges of our time. For the moment, however, it means mostly jobs with low pay and few benefits, limited career prospects, and no assurance that a particular position will still be available next week or next month. In Britain, part-time employment accounted for 15 percent of all jobs in 1971 but 25 percent in 1997. In Germany, 15 percent of employees were in "insecure" jobs (defined as part-time, temporary, or insufficient work) in 1970; by 1995, the figure had doubled to 30 percent.[17]

If current trends continue, the work force will become more polarized. A relatively small group of employees may emerge as "winners"—highly skilled, with secure, well-paid

jobs, and more likely than not working substantial overtime in high-stress conditions—whereas many workers will probably experience episodes of unemployment or have to accept irregular, less secure work arrangements. The true losers may face more or less permanent exclusion from gainful employment because their skills, age, or other attributes are judged as inadequate or unneeded in a fast-paced, merciless labor market.[18]

In developing countries, too, growing disparities are likely. Employees in small high-tech enclaves such as the one in Bangalore, India, are likely to benefit from world market integration. Free trade zones like Mexico's *maquiladoras* attract foreign investment and jobs, though wages and working conditions are often little better than those in English factories during the early stages of the Industrial Revolution when unions were banned. In Brazil, the gap between the best- and worst-paid workers grew from 7:1 to 8.5:1 during the first half of the 1990s.[19]

Since the 1970s, unemployment in most of the advanced industrial countries has been on the upswing. In Western Europe, it climbed from a little over 2 percent in 1970 to about 12 percent in the late 1990s; in Japan, from about 1 percent to above 4 percent. In the United States, by contrast, joblessness has been falling: after rising from 5 percent in 1970 to above 10 percent in the early 1980s, U.S. unemployment is now back to slightly below the 1970 level. (See Table 1.)[20]

But higher job creation in the United States has come at a cost: almost 29 percent of all U.S. workers now have jobs that pay wages at or below the official poverty level. From a peak in 1978, real hourly earnings for all production and nonsupervisory workers outside agriculture declined 7 percent by 1998. Disparity among workers has grown, and far more so than in other industrial countries: the top-earning 10 percent of male employees now enjoy wages almost 5 times higher than the 10 percent at the bottom, up from about 3.5 times in the early 1980s; among women, a similar trend has taken hold.[21]

On average, U.S. wages are lower, and unemployment

TABLE 1

Unemployment Rates by Region and Selected Countries, 1987 and 1997

Region or Country[1]	1987	1997
	(percent)	
Europe	10.4	10.5
Japan	2.8	3.4
United States	6.2	4.9
Latin America and Carribbean	5.7[2]	7.4
China	2.0	3.0[3]
India	3.4	2.3[4]
Other Asian countries	4.3[2]	4.2[3]
Central and Eastern Europe	7.2[4]	9.6[3]

[1]No comprehensive data for Africa are available. [2]1990. [3]1996. [4]1993.

Source: See endnote 20.

benefits and the social safety net far less generous than in many other industrial nations. Among other factors, this comparison reflects the weakness of U.S. organized labor: post-World War II union membership peaked at about 25 percent of all private sector employees in the 1950s and held to 24 percent until 1979, but then rapidly fell to less than 14 percent in 1998.[22]

Employment concerns are also high on the agenda in other parts of the world, as countries attempt to navigate the treacherous terrains of economic transition and catch up in industrial development. Since the end of the cold war, most states in Eastern Europe and the former Soviet Union have seen a rapid rise in unemployment, from near zero to close to 10 percent. Joblessness has been accompanied by lower real wages and dramatic increases in income inequality. In Russia, where the economy has severely contracted, real wages plummeted by 58 percent between 1989 and 1996, and people often receive their wages months behind schedule.[23]

The East Asian economic crisis that broke out in 1997

added perhaps as many as 20–24 million people to the world's unemployment rolls and threw substantial portions of the population there into renewed poverty, as unemployment benefits and other protective measures are sparse. These layoffs have been reversed only partially. Several other Asian countries—Cambodia, China, Laos, Mongolia, and Vietnam—face serious labor market problems resulting from the excess labor in state and collective enterprises. By 1999, state-owned enterprises in China had already laid off 17 million workers, and they are to shed another 25 to 30 million as the restructuring process continues.[24]

In Latin America, the ILO projected unemployment in the formal sector to rise from about 6 percent in the early 1990s to 9.5 percent in 1999, despite an upturn in the region's macroeconomic performance. Real wages have stagnated and minimum wages, on average, have fallen 27 percent since 1980. Those lucky enough to have work are often forced to put in longer hours in order to compensate for insufficient wages. Extensive privatization, cuts in social spending, and the passage of anti-union legislation have all contributed to heightened vulnerability in the working class.[25]

Since job creation in the formal sector is limited in many developing countries, much employment takes place in the informal sector. This is particularly the case in African countries. The informal sector is an amalgam of economic activities, including family enterprises, that are not captured by traditional categories. It involves a broad variety of small, usually irregular, and often makeshift jobs. The informal sector generates demand for semi-skilled and unskilled labor, is more likely to adopt appropriate technologies and local resources, plays an important role in recycling and reusing waste materials, and provides a major source of income for women. But working conditions are frequently poor, social security is mostly nonexistent, and wages are often very low, typically below the official minimum wage.[26]

According to the ILO, the informal sector now accounts for almost 60 percent of the urban labor force in developing countries, and an even higher share in sub-Saharan Africa. In

Latin America, 90 percent of all new jobs generated in the 1990s were in the informal sector. Furthermore, informal sector wages and working conditions are increasingly spreading to the region's formal sector.[27]

One of the most unsettling aspects of the jobs crisis is large-scale youth unemployment, which is substantially higher than labor force unemployment as a whole virtually everywhere. The ILO estimates that there are about 60 million people worldwide between the ages of 15 and 24 who are searching for work but cannot find it. In developing countries, high rates of population growth translate into massive pressure on job markets. In Africa, 43 percent of the population is 15 or younger, in Latin America 33 percent, and in Asia 32 percent.[28]

Although developing countries clearly face a growing jobs challenge, labor market data there are relatively scarce; scarcer still are studies addressing the employment-environment linkage in the developing world. Hence, this Paper focuses mostly on industrial countries. But developing countries must inevitably grapple with similar issues. If anything, they face a challenge of even greater magnitude. They need to find work for fast-growing numbers of young people entering the job market. In addition, large-scale rural-urban migration is placing increasing burdens on urban job markets. While there is an urgent need for sustainable agricultural and rural industry jobs in order to lessen the pressure to migrate, there is also a need to generate more urban employment opportunities. The challenge for developing countries is to resist the allure of unsustainable development—pollute first, pay later—and exploit opportunities to leap ahead to sustainable technologies. This strategy may offer the best opportunity to develop labor-intensive industries.

Boosting Resource Productivity

Ever since the beginning of the Industrial Revolution, businesses have sought to economize on their use of labor; although labor was scarce, land and natural resources seemed inexhaustible. And in today's globalizing economy, business seems more intent than ever on slashing labor costs as a means to stay competitive. While companies have emphasized raising labor productivity—using fewer workers to produce goods like cars, refrigerators, and computers—by comparison they have given far less attention to energy and materials productivity. This is not to say that there has been no progress in these areas; rather, that it has been of limited scope compared with the boost in labor productivity and relative to the available technical opportunities. Indeed, when people refer to productivity nowadays, they almost always mean labor productivity.

This preference for wringing more out of each hour of human work may have made perfect sense when labor, and particularly skilled labor, was scarce; when resources and ecosystems were abundant and relatively unexploited; and when substituting machines for humans promised rapid economic progress and opportunities for automating hazardous tasks. 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 reevaluate these priorities. Not only is nature scarce today, there is no substitute for it once it is depleted: no matter what technologies human ingenuity may dream up, pure air and water, intact forests and fisheries, and a stable global climate are irreplaceable.

The trouble is that human labor *appears* too expensive, while most inputs of energy and raw materials like wood, aluminum, copper, and other metals and minerals *appear* dirt cheap. As long as the relative costs are rigged to favor resources, the preference observed above will not change. Subsidies for polluting industries and for the car-centered transportation system cause severe distortions. So does a tax system that places a heavy burden on labor (in the form of payroll taxes that workers and employers pay in most industrial countries) instead of on resource use and environmental degradation.

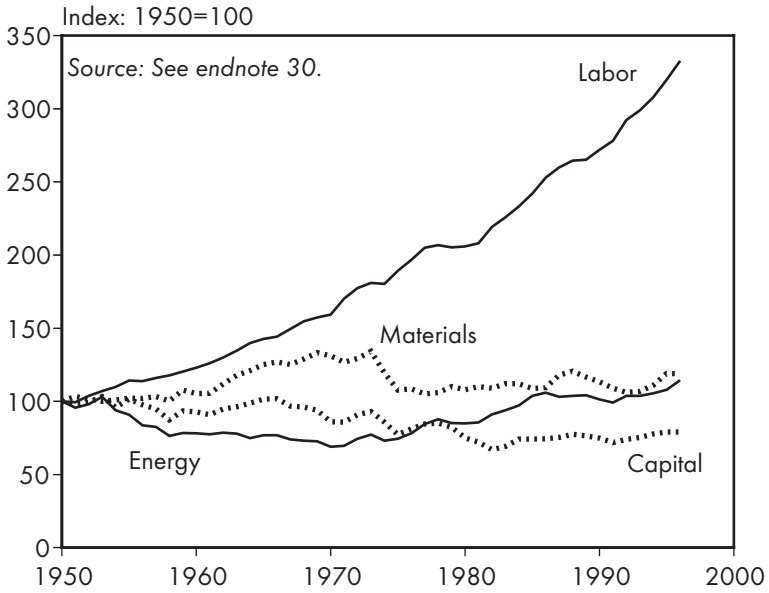
As the following U.S. data illustrate, capital, energy, and materials have steadily been replacing labor as inputs in the production process. Total U.S. manufacturing output rose by about 440 percent between 1950 and 1996. Labor inputs (measured by the total number of hours worked) increased by about 40 percent between 1950 and 1969, then remained stagnant for a decade before beginning to decline slightly. By contrast, inputs of capital (measured by the amount of dollars laid out for equipment and buildings) jumped by 525 percent during these 47 years, energy inputs rose by 369 percent, and materials inputs by 335 percent.[29]

But the productivities of these particular inputs—the output of manufactured items for each unit of input—diverged dramatically. Labor productivity more than tripled. In the auto industry, this means that where it once took nine workers to produce one car in a day, it now only takes three workers. By contrast, capital productivity has declined almost throughout the entire postwar period. Until rising oil prices in the 1970s forced the development of more efficient motors, lighting, and production processes, energy productivity, too, declined: growing amounts of oil, gas, coal, and electricity were needed to produce a dollar's worth of output. Still, by the mid-1990s energy productivity was only marginally higher than in 1950. Materials productivity rose until the early 1970s, but then lost some ground. (See Figure 2.)[30]

Although this section relies primarily on U.S. data for illustration purposes, the same mainly holds true for other industrial countries and for newly industrializing nations as well. In Germany, for instance, labor productivity more than tripled between 1960 and 1995, while materials productivity improved by only 50 percent, energy productivity by about 30 percent, and capital productivity was actually cut in half. The prime challenge in the future is not to decrease the num-

FIGURE 2

Selected Productivity Components in U.S. Manufacturing, 1950–96



ber of workers it takes to assemble a given product or provide a given service, but to decrease the liters of oil, kilowatt-hours of electricity, and kilograms of steel, wood, copper, or aluminum that are needed.[31]

Improving resource productivity is particularly critical in those industries that are the biggest resource consumers. Just a handful of industries today are responsible for most resource use and the environmental damage that ensues. Mining companies (including coal, metals, and oil and gas extraction) and electric utilities are major energy consumers. They are also major polluters. Data published by the U.S. Environmental Protection Agency for 1998 reveal that 48 percent of the 7.3 billion pounds (about 3.3 million metric tons) of toxic pollutants that are tracked by its Toxic Release Inventory are released by mining companies. The utility sector was responsible for another 15 percent. But at the same time, these two sectors provide only a limited, and declining, number of jobs—altogether 1.4 million, or a mere 1.3 percent of all current private enterprise jobs in the United States.[32]

Manufacturing industries generated another 33 percent of all reported U.S. toxic releases in 1998. Within the manufacturing sector, four industries—primary metals, paper, oil refining, and chemicals—accounted for a prominent share of energy use and toxic waste generation, but provided a much smaller share of manufacturing employment. (See Table 2.) (Another manufacturing industry—motor vehicles—is itself not particularly energy- or pollution-intensive, but its products, trucks and automobiles, are major energy consumers and leading contributors to air pollution.) The picture that emerges from this analysis suggests that change in the environmentally most damaging sectors of the economy will affect only limited numbers of workers.[33]

As labor productivity grows, output and consumption must grow at least as fast in order to maintain steady employment levels, and faster if the number of jobs is to expand. But failure to improve resource productivity substantially—continuing to burn large quantities of fossil fuels, use copious amounts of materials, and generate huge waste flows—will ensure growing environmental degradation. A sustainable economy must break the work-consumption-environmental-degradation connection. This can be done either by boosting the productivity of resource inputs or by reducing and entirely avoiding waste generation through "clean production" methods.

Wherever possible, reducing the amount of energy and materials used to make products is the environmentally most preferable option. Increasing the intensity of product use (maximizing the performance of the product) and extending product life are next in the hierarchy of resource productivity. These objectives can be accomplished by keeping products in good repair, upgrading them, and remanufacturing them if necessary. Recycling (or other forms of materials recovery), although most familiar to the public, is the mea-

TABLE 2

Value Added, Employment, Energy Use, and Toxic Releases, Selected U.S. Manufacturing Industries, Mid-1990s

Industry	Value Added	Number of Jobs	Hours Worked	Payroll	Energy Use	Toxics Released
	(percent within all manufacturing industries)					
Paper	4	3	4	4	12	11
Chemicals	11	4	4	6	25	36
Oil refining and coal	2	1	1	1	29	3
Primary metals	4	4	5	4	11	15
Subtotal	21	12	14	14	78	64
All other industries	79	88	86	86	22	36

Source: See endnote 33.

sure of last resort, since it promises more limited environmental benefits.[34]

Many resource-saving technologies are already available, even better ones are on the drawing boards, and opportunities for redesigning whole systems as opposed to individual products remain largely untapped. A discourse on "dematerialization" that emerged in the mid-1990s, particularly in Europe, has identified opportunities to slash energy and materials consumption by 75–90 percent or even more.[35]

Eco-business pioneer Paul Hawken and Amory and Hunter Lovins of the Rocky Mountain Institute point out how astoundingly resource-inefficient modern Western economies still are. Commenting on the U.S. economy, they write: "It has been estimated that only 6 percent of its vast flows of materials actually end up in products." In their 1999 study, *Natural Capitalism*, they offer a bounty of specific examples for achieving what they call "radical resource productivity" through such measures as better design, new

materials, improved fabrication technologies, use of innovative software programs, and changes in corporate culture. Even profit-driven organizations are often blind to obvious opportunities for product improvements and waste reduction. For instance, the authors argue that just using existing technologies (including advanced polymer composites, better aerodynamic design, and fuel cells) can reduce new-car fuel consumption by as much as 85 percent, and slash iron and steel used in car manufacturing by about 90 percent, aluminum by one third, and rubber by three fifths. One does not need to be as optimistic about the potential for technological improvements as these authors are to agree that substantial opportunities for greater efficiency exist.[36]

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.

Environmental Policy: Job Killer or Job Creator?

More environment-friendly technologies may exist, but are they affordable? Business leaders have long argued that they cannot do better by the environment without adverse consequences for the economy. It seems that hardly a new environmental regulation is considered or passed into law without industry executives complaining that it will render them uncompetitive, force them to close plants, or compel them to delay or cancel planned projects. The public has to choose between the goals of protecting the environment or jobs, they say.[37]

By now, the "job killer" argument should have lost some of its potency, because many of the dire predictions

have simply failed to come to pass. First of all, the actual costs of complying with environmental regulations have consistently been far lower than at first predicted by the affected industries. A review of roughly a dozen cases—involving anti-pollution measures or phase-outs for benzene, chlorofluorocarbons (CFCs) and halons, coke oven emissions, cotton dust, landfill leachate, sulfur dioxide, surface mining, vinyl chloride production, and asbestos abatement—shows that the initial estimates were at least double the actual costs, and in some cases far higher.[38]

Second, it has become clear that environmental regulations can have "technology-forcing" effects 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. For instance, by the mid-1990s, Novo Nordisk of Denmark had captured more than half the world market for industrial enzymes, a success based on the company's early recognition of the rising demand for biodegradable substitutes for dangerous synthetic chemicals. Such advantages will loom larger as governments take measures to move toward full-cost accounting, so that energy and materials inputs are properly priced and incentives for waste avoidance are strengthened.[39]

Third, actual job loss due to environmental regulations has been extremely limited. In the United States, the Environmental Protection Agency (EPA) estimated that in 1971–81, about 3,200 workers per year lost their jobs partly as a result of the costs of environmental regulation. A survey of 224 permanent plant closings in 1980–86 by the Oil, Chemical, and Atomic Workers' Union found that just 12 plants listed environmental reasons as a *partial* motive for closure. And surveys conducted by the U.S. Bureau of Labor Statistics from 1987–92 and again from 1995 on show that environment–related reasons for layoffs were of minute significance: 0.14 percent of all layoffs in 1995–97 (the surveys cover layoffs of 50 people or more for a month or longer). All in all, annual layoffs from plants shut down due to environmental regulation have averaged 1,000–3,000 in the United States since the 1970s. Relative to economy-wide layoffs of typically more than 2 million workers each year, this is less than one tenth of 1 percent.[40]

In a 1997 report, the Organisation for Economic Co-operation and Development (OECD) confirmed that adverse impacts among its member states have been limited to a very small number of companies. The OECD report comments that "environment-related job losses during the past two decades look almost irrelevant in comparison with job losses resulting from other corporate decisions and government policies (e.g., automation of plants, foreign investment, or budget cuts)," adding that "this picture is not expected to change much even if environmental standards are tightened further."[41]

Finally, environmental regulations have led to the creation of a sizable industry that employs a conservatively estimated number of at least 11 million people worldwide, many in traditional manufacturing and construction activities. Although the bulk of this employment is still centered on pollution control and waste management, this is beginning to shift. Jobs in pollution prevention, recycling, and alternative sources of energy are growing more rapidly than employment opportunities in pollution control operations.[42]

Still, as pollution control slowly gives way to farther-reaching pollution prevention measures and cutting-edge "clean production," as the threat of climate change increasingly points to the need for a substantial restructuring of the energy economy, and as consensus grows that resource extraction and the production of dangerous chemicals need to be scaled back, the belief in an economy-versus-environment tradeoff finds new adherents. And businesses opposed to change eagerly stoke this belief. The Kentucky Coal Marketing and Export Council, for example, contends that implementing the Kyoto Protocol would cause all U.S. primary aluminum plants to close by 2010, at least 20–30 percent of the U.S. basic chemical industry to relocate abroad,

and about 100,000 steel industry jobs to be lost. The Heritage Foundation, meanwhile, claims that Kyoto will cost 2.4 million U.S. jobs. These projections emerge from implausible worst-case scenarios that assume that businesses will not be able to become more efficient in response to higher fossil fuel prices. As Eban Goodstein, an economics professor at Lewis & Clark College in Portland, Oregon, points out, it is extremely curious that those who usually sing the praises of business acumen assume in this case that companies will be unable to innovate.[43]

But what are the true impacts of environmental policy? Before looking at any specific cases, it is useful to undertake a brief conceptual assessment. Like any other economic activity, investment in renewable energy sources as well as in energy efficiency, railroads and public transit, less-polluting industrial production equipment, and other environment-friendly activities generates a certain number of jobs directly, plus indirect jobs in supplier industries. The crucial question is, Do these investments support more or fewer jobs for each dollar laid out than expenditures in more polluting and waste-generating industries? Countless studies suggest strongly that less damaging ways of producing, transporting, consuming, and disposing of goods tend to be more labor-intensive than the more damaging ways.[44]

Beyond such specific comparisons of direct employment potential lies the larger issue of how well and efficiently an economy carries out its activities. For example, if energy services such as heating and cooling buildings, generating electricity, or powering motor vehicles can be provided more cheaply (for example, through boosted efficiency of motors, appliances, and equipment, reducing transmission losses, or recycling steel and aluminum instead of producing these materials from virgin ores), then the money saved by businesses and households—the avoided fuel costs—can be "respent" elsewhere in the economy. Just between 1979 and 1986, improvements in energy efficiency reduced U.S. annual energy costs by about $150 billion compared with what they would have been at 1973 efficiency levels. To the extent

that this re-spending benefits segments of the economy that are more labor-intensive than the conventional energy sector (coal mining, oil and gas extraction, refining, and power utilities), it generates additional employment.[45]

Except in the most energy-intensive industries, stepped-up materials efficiency promises even greater savings and re-spending potential than energy efficiency. In U.S. manufacturing, materials inputs accounted for 26 percent of the cost of all inputs into the production process in 1996, or ten times that of fuels and electricity (labor accounted for almost 38 percent, capital for 20 percent, and purchased services for the remaining 14 percent).[46]

Environmental regulations have led to the creation of an industry that employs at least 11 million people worldwide.

A substantial boost in energy and materials efficiency can also open up additional re-spending opportunities. This happens when efficiency gains cross a threshold of magnitude that renders opening another coal or bauxite mine, constructing another power station, or building another metals smelting plant unnecessary: avoided capital costs join avoided fuel and raw material costs. 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 without substantially hurting employment; the savings, in turn, could be invested in more labor-intensive sectors. For instance, the annual global investment in new plants in the electricity-generating sector has been estimated at $170–$200 billion during the 1990s. Hawken and Lovins note that "building . . . superwindow and efficient-lamp factories instead of power stations and transmission lines requires about a thousandfold less capital per unit of extra comfort or light, yet these businesses are considerably more labor-intensive."[47]

When prices do not tell the truth, however, it is difficult in a market economy to fully realize opportunities for avoid-

ed costs and for redirecting investments and operating expenditures to sectors that will provide greater environmental and employment benefits. Among industrialized countries, energy prices are particularly low in the United States thanks to subsidies and tax breaks. Phasing out subsidies that favor fossil fuel industries and other polluters and introducing environmental taxes will help society to move toward full-cost accounting for pollution, waste generation, and resource depletion and to discover unrealized re-spending opportunities.[48]

Energy subsidies in the United States, the bulk of which go to fossil fuels and nuclear power, are estimated to total anywhere from $4 billion to $30 billion annually. Similar subsidies abound in virtually every country on earth. Subsidies for fossil fuel *consumers* are particularly prevalent in former Eastern Bloc and developing countries and amounted to more than $80 billion per year in the mid-1990s. Subsidies to fossil fuel *producers* are more prevalent in Western industrial countries; though they have not been comprehensively surveyed and tabulated, they no doubt amount to many tens of billions of dollars as well. The dollar amount of these subsidies worldwide appears to have declined in the 1990s, but they nevertheless remain substantial.[49]

Although the losers are likely to be far outnumbered by the winners, some workers will 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. And at least some of the new jobs may not offer wages as high as those in more polluting industries.

The process of industry restructuring is inherently painful. Because a job provides not only economic security but often also identity and meaning, job loss—even if temporary—can be a traumatic experience. For affected individuals and families, it is little consolation that, from a macro-economic perspective, environment-related job loss is likely to be insignificant in comparison with job loss due to "normal" change in a market economy. Macro-economic statistics do not feed and clothe people; the income derived from individual jobs does. Public policy needs to facilitate the transition to a sustainable economy by assisting individuals and communities.

But most important, policy changes designed to make the economy more sustainable need to have a clear time horizon so that companies, communities, and individual employees know what they are up against. At the same time, however, the longer necessary changes are postponed, the greater the urgency later on to move speedily—and the more damaging the likely social and economic impacts. Delaying policies to mitigate climate change and to rein in other forms of environmental degradation will turn out to be a far greater job killer than embracing such policies in proactive, strategic fashion.

Natural Resource Extraction and Jobs

As the most polluting and environment-degrading of activities, extractive and primary processing industries will of necessity bear the brunt of any impacts from moving toward a sustainable society. If energy and materials use can be slashed through recycling, reuse, and more efficient ways of producing and consuming, then clearly there is less need to cut timber, mine coal, and pump oil. All things being equal, fewer raw materials extracted and processed translate into fewer workers needed for these tasks.

Still, it is highly misleading to portray environmental policy as the main threat to resource jobs. In the first place, the contribution of extractive industries to the overall economy is quite small. The number of such jobs is on the decline in most countries irrespective of environmental efforts, as

mechanization marches on and as mergers lead to additional layoffs. (See Table 3.)[50]

The coal industry is increasingly characterized by bigger and fewer companies, larger equipment, and less and less need for labor. It is estimated that coal-mining jobs account for just one third of 1 percent of the global work force. In Europe, employment in this field has dropped particularly fast, since production is being driven down both by coal imports and by a shift to other sources of energy. British coal production has fallen to less than half its 1980 level, and employment has dropped from 224,000 to just 10,000 miners. In Germany, productivity gains and rising coal imports may cut employment from 265,000 in 1991 to less than 80,000 by 2020. China—the world's largest coal producer—has cut some 870,000 jobs since 1994 and is expected to lay off another 400,000 workers in a bid to cut subsidies, reduce output by about one fifth to bring it more

TABLE 3

Mining Employment in Selected Countries, 1988–97

Country	1988	1997	Change
	(thousands)		(percent)
China[1]	8,320	8,510	+ 2.3
India[2]	1,049	1,100	+ 4.9
Ukraine	856	635	- 25.8
Brazil[3]	824	710	- 13.8
South Africa[4]	733	562	- 23.3
United States	713	592	- 17.0
United Kingdom	187	65	- 65.2
France	88	52	- 40.9

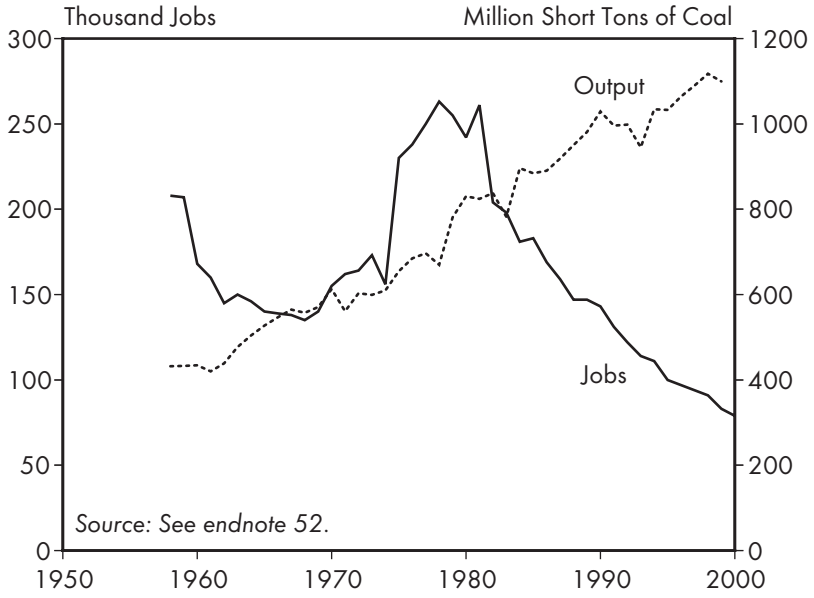
Note: Includes coal- and metals-mining and oil and gas extraction jobs. [1]Employment peaked at 9.25 million in 1993. [2]Data are for 1988 and 1996. [3]Data are for 1992 and 1996. [4]Data are for 1988 and 1993.
Source: See endnote 50.

in line with demand, and bring down the human toll of mining. (At least 10,000 people die in Chinese coal mines each year—80 percent of the global number of victims—and increasingly, these jobs are avoided by all but the most desperate workers.)[51]

In the United States, coal production increased 32 percent between 1980 and 1999, but coal-mining employment nevertheless declined 66 percent, from 242,000 to 83,000 workers. (See Figure 3.) Part of the story is that production has shifted from more labor-intensive underground mines in the eastern United States to surface mines in the West; strip-mining employs only about one third to one half the number of workers as underground mines for the same tonnage. In fairness, environmental considerations did play a role in this shift, insofar as efforts to combat acid rain led to a rising preference for lower-sulfur coal, and western coal is lower in sulfur content than eastern coal—but it was one of several

FIGURE 3

U.S. Coal Mining, Output and Jobs, 1958–2000



factors. Although the Kyoto Protocol has brought loud denunciations from the coal industry, employment is expected to fall by 36,000 workers between 1995 and 2020 even in the absence of any anti-greenhouse measures.[52]

Similar stories can be told about other extractive and primary processing industries. For example, almost 40 percent of U.S. oil-refining jobs were eradicated between 1980 and 1999; today, petroleum refining and wholesale distribution accounts only for 0.3 percent of all U.S. employment. In EU countries, more than 150,000 utility and gas industry jobs have disappeared since the mid-1990s and another 200,000 jobs—one in five—are likely to be lost by 2004, as the new market liberalization program proceeds. (See Table 4.)[53]

These examples show that increasing mechanization and automation have translated into fewer jobs even as output rises—the pace of growth in output has been insufficient to preclude a decline, and often a steep decline, in employment in these sectors. And because automation has increased potential supply, commodity prices have generally been subject to downward pressure worldwide; this, in turn, argues Thomas Michael Power, author of the 1996 study *Lost Landscapes and Failed Economies*, adds to the pressure to reduce costs, including labor costs, even further. Under these conditions, it is unrealistic to expect that simply staying the course—and rejecting overdue pro-environmental measures—will make a single resource extraction job any more secure.[54]

Jobs are also at risk when mining and logging companies deplete an area's resource base with indiscriminate strip-mining and clear-cutting operations instead of a more sustainable approach, only to move on to more promising areas, where the same experience is repeated. The U.S. logging industry, for instance, has moved first from the Great Lakes states to the South, then to the Pacific Northwest, and finally back to the Southeast, attracted by lower-wage, non-unionized labor and far fewer regulations as well as new timber supplies. And this pattern is increasingly replicated on a global level. Partly for this reason and partly because of commodity price gyrations and boom-bust cycles, extractive

TABLE 4

Output and Employment Changes in Selected Industries

Industry	Country	Time Period	Output Change	Employment Change
			(percent)	
Oil & gas production	United States	1980–99	– 28[1]	– 52
Oil refining	United States	1980–99	+ 16	– 38
Chemicals	European Union	1990–98	+ 25	– 14
Electricity generation	Germany	1991–98	+ 5	– 25
Primary metals processing	United States	1979–99	+ 15	– 40
Steel	European Union, North America, Japan, and four others[2]	1974–99	– 0.6	– 21
Forest products	Sweden	1980–99	+ 17	– 50

[1]Decline in oil production; natural gas production dipped just slightly.
[2]Other countries included are Brazil, South Africa, South Korea, Australia.
Source: See endnote 53.

industries tend to be characterized by extreme volatility. Perpetuating a region's dependence on these industries, rather than seeking economic diversification, is not a recipe for reliable and sustainable jobs.[55]

The traditional view—the so-called base model of economic development—is that the extractive sector brings wealth into a community and that its job base and overall well-being are inevitably tied to the fate of logging and mining operations. Contractions in the extractive sector,

so goes the argument, invariably translate into significant secondary job losses in the local economy, with devastating consequences.[56]

But analysts like Power and Goodstein dispute this argument. The more a region or a local community diversifies its economy, and the more it develops a complex web of local economic activities, the better able it will be to weather a downturn in the fortunes of extractive industries and demonstrate resilience. Without such changes, the revenues brought in by logging and mining operations will simply leak out to be spent elsewhere. This has been the experience of many coal communities in Appalachia, for example. It is little surprise, then, that as Power notes, "few towns devoted to these industries are prosperous." In fact, he argues that "the more dependent a community is on one such industry, the more depressed it tends to be." Having visited timber communities in the Pacific Northwest region of the United States and Canada and having scrutinized the literature on the subject, Alan Durning, executive director of Northwest Environment Watch in Seattle, draws a similar conclusion. "Extractive economies," he writes, "despite the high wages of resource workers, are so volatile that they discourage investment and the economic diversification it brings. Timber towns typically end up with low average wages and a disproportionate number of poor families."[57]

At the beginning of the 1990s, preservation of remaining old-growth forests in the Pacific Northwest—a habitat critical to the survival of the northern spotted owl—triggered heated controversy and confrontations between loggers and environmentalists. "Save a Logger. Kill an Owl" became one of the slogans distributed on bumper stickers, as timber companies portrayed the issue as an either-or choice between jobs and environmental protection, and the northern spotted owl became a symbol of the larger tensions between the health of the economy and that of the natural world. Echoing the arguments of the logging firms, then-President Bush predicted, "we'll be up to our neck in owls, and every mill worker will be out of a job."[58]

The spotted owl controversy arose against a backdrop of continued decline of the region's logging and wood products industry. Since the early 1970s, more than 500 lumber, pulp, and paper mills have closed, from southern Alaska to northern California, or nearly 40 percent of the total. The region's natural resource industries (including fishing, mining, and everything from forestry and logging to paper milling) shed about one fifth of the roughly 370,000 jobs that had existed 20 years earlier.[59]

But it is primarily the march of mechanization, rather than environmental restrictions, that is behind this downward trend. In the timber industry, Goodstein found that the number of workers needed to cut and process 1 million board feet of lumber fell by roughly 20 percent—from 9.1 to 7.4 during the 1970s and 1980s. This development was further augmented by a nationwide recession in the early 1980s, and accentuated by the industry's shifting investments. The seven largest lumber and plywood companies reduced their capacity in the Northwest by one third from 1978 to 1990, and more than doubled it in the southern United States. In Oregon and Washington, lumber and wood-products employment plummeted from a 1978 peak of 136,000 to 95,000 in just four years. Although increased timber sales from federally owned lands provided a temporary respite, another recession brought the number down to 90,000 by the early 1990s.[60]

In this context, moves to restrict logging on federal land in order to protect the spotted owl habitat raised the level of fear in timber-dependent communities to a fever pitch; the industry warned that 100,000 or more direct and indirect jobs could be lost. An analysis by Goodstein shows that these predictions were extremely exaggerated; the number of jobs lost that can legitimately be attributed to owl protection measures were actually in the range of 6,000–7,500. Overall job impacts were cushioned by an unexpected development: the number of workers required for each 1 million board feet of lumber *rose* again, from 7.4 in the late 1980s to 10.1 by 1996. This happened for three reasons: opportunities

for further mechanization were extremely limited; the export of unprocessed logs dropped and jobs shifted from logging to the more labor-intensive secondary wood products sector; and the effects of its earlier clear-cutting operations forced the industry to focus on smaller and more segmented stands of trees, which required more workers to cut. The region's predicted economic meltdown did not materialize, and, not surprisingly, tensions in the region have softened considerably in the ensuing years.[61]

The experience of the last decade in the Pacific Northwest and elsewhere in the western United States shows that many communities did far better than expected in the wake of mill or mine closings. Even as extractive industries went into decline, other parts of the economy experienced rapid expansion. "With surprising speed," writes Durning, "Northwest employment is uncoupling itself from the volume business of resource extraction. . . . Steadily, the economy is becoming more about qualities than quantities, and the ascendant industries, while not without environmental problems, pollute less, consume fewer resources, and disrupt less habitat per job and per dollar of sales than do the declining industries." He estimates that the Pacific Northwest had more than 400,000 high-tech jobs in 1997, compared with about 300,000 for all the resource extraction industries combined. As the region's economy added some 3 million jobs between the late 1970s and the late 1990s, the share of resource industry jobs fell from 9 percent to less than 4 percent.[62]

In good measure, the region was able to attract new businesses because it offers pleasant places to live in. The Pacific Northwest is living proof that communities and regions will fare better if they keep their environment pristine. As businesses become less dependent on resource inputs, it matters less where they locate; with this constraint lessened, people will be more easily drawn to the most livable and enjoyable areas.[63]

As the economy expands, it may "mop up" those displaced from the extractive industry. But some of the new jobs may pay less than the old jobs did. It is true that there was already strong downward pressure on loggers' wages in the Pacific Northwest because of non-union logging in the southern United States. But this is little consolation to those laid-off loggers who gained new employment only at lower wages.[64]

Whereas timber production in industrial countries is declining (by 20 percent in the past decade) and mechanization additionally reduces the number of jobs for each unit of output, production in developing countries continues to rise, and now accounts for roughly two thirds of the global total. But much of the increase in countries like Indonesia and Brazil is unsustainable, and as forest resources are depleted, jobs will inevitably be lost. The Philippines already experienced this loss when it liquidated much of its forest in the 1960s and 1970s. Continued large-scale logging also threatens the harvesting of non-wood forest products such as rattan, cork, nuts, oils, and medicines that provide a livelihood for hundreds of millions of people worldwide—far more than logging ever could.[65]

The Pacific Northwest is living proof that communities will fare better if they keep their environment pristine.

In developing countries, workers employed by logging companies are often poorly paid and trained—both forests and people are treated as cheap, disposable resources. Improved forest management practices and greater efficiency, however, could reduce the environmental impact of lumbering while maintaining the volume of timber actually used. Worker training is one of the measures that would not only help make timber operations more sustainable, but also make them less dangerous for the workers.

In industrial and developing countries, reducing activities like clear-cutting and strip-mining helps to enhance the attractiveness and livability of a region, attracting new businesses and talented workers. Tourism, and more specifically, eco-tourism, arises as one alternative to resource extraction. In Alaska, for example, tourism now employs four times as many people as the timber industry. Still, this is a mixed

blessing, because the tourism industry tends to offer mostly low-skill jobs with low wages, is often seasonal, and may have its own share of environmental problems.[66]

In many regions, resource extraction has degraded the environment to such a degree that clean-up operations are becoming urgent in order to check the spread of pollutants and to restore and protect watersheds. Such activities could, in principle, provide at least temporary employment for large numbers of laid-off workers. In Oregon, for example, the Watershed Center was set up in 1994 to provide training courses, teaching idled loggers how to clean up logging sites, then giving them seminars on ecology, erosion control, wildlife habitat, and other issues. These courses have been emulated by others along North America's Pacific coast. But restorative efforts and retraining of workers for these tasks—a "Marshall Plan of ecological redemption," as Durning calls it—are badly underfunded. British Columbia's watershed program, the largest such initiative in the Northwest, provided a relatively meager 880 year-round jobs in 1998.[67]

A region that was once dominated by extractive industries does not have to be shackled to them forever. In Britain, the Department of Trade and Industry (DTI) launched a plan in September 1999 to make the northeastern region of England a center for energy jobs and projects. The area includes Newcastle-Upon-Tyne, a famous coal-mining center, where production continues to dwindle. Instead of coal, the region will increasingly focus on energy efficiency and related measures; it already produces one quarter of Britain's co-generation energy. The DTI hopes to create some 3,500 new jobs in this manner.[68]

Energy Alternatives and Jobs

Reducing fossil fuel use is central to moving toward a sustainable economy. While coal and other polluting industries are offering declining job opportunities, renewable energy and energy efficiency are beginning to make their mark as job creators. Among energy alternatives, wind power has progressed most rapidly, and it is now beginning to offer more and more jobs.

Wind power development opens up employment opportunities in a variety of fields. It requires meteorologists and surveyors to select and rate appropriate sites, structural engineers to design the turbines and supervise their assembly, metal workers to supply the rotors, and mechanics and computer operators to monitor the system and keep it in good working order.

Numerous studies find that wind power compares favorably in its job-creating capacity with coal- and nuclear-generated electricity. In Germany, although wind energy contributed a still minuscule 1.2 percent of total electricity generation in 1998, it provided some 15,000 jobs in manufacturing, installing, and operating wind machines. In comparison, nuclear power had 33 percent of the electricity market but supported a relatively meager 38,000 jobs; coal-generated power had a 26 percent market share and gave rise to 80,000 jobs. Given the rapid expansion of wind power in Germany, wind will likely overtake nuclear power as a source of jobs in 2000.[69]

Wind power generation is mostly decentralized and small-scale, and the manufacture of rotor blades and other components requires skilled labor input to ensure quality. Although the increasing size of wind turbines and growing economies of scale will in coming years translate into somewhat fewer jobs relative to each unit of energy produced, wind will still compare favorably with traditional electricity sources.[70]

The lion's share of the world's wind power-generating capacity has been installed in Europe. And because European companies are the leading manufacturers of wind turbines, most of the world's wind power-related jobs are being generated there. A 1996 study found that some 16,000 jobs were created in the Danish wind power industry, one of the world leaders. The European Wind Energy Association (EWEA, an

industry group) projects that up to 40 gigawatts of wind power capacity could be installed in Europe by 2010, creating between 190,000 and 320,000 jobs.[71]

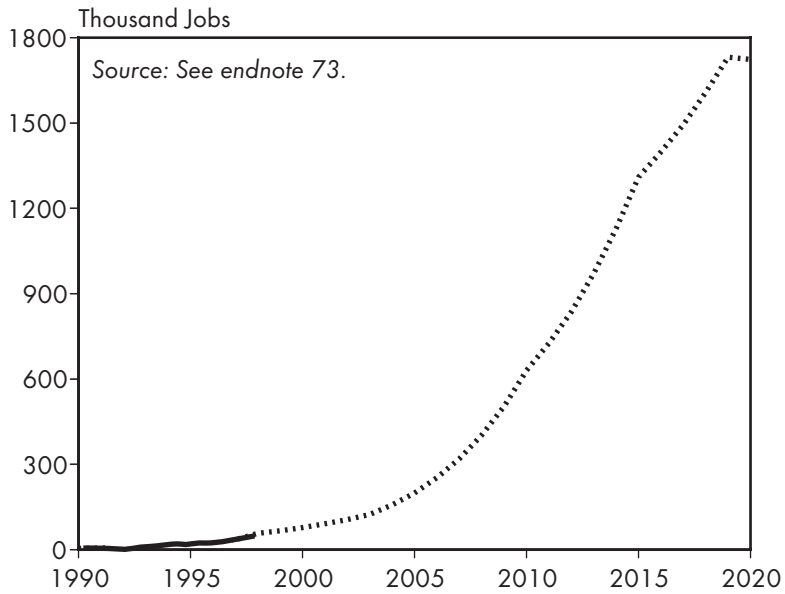
Wind power is now poised to move from a marginal source of energy to a major contributor in many parts of the world. *Windforce 10*, a study released in October 1999 by EWEA, Greenpeace, and the Forum for Energy and Development, contends that wind energy could meet 10 percent of the world's electricity demand by 2020. The report assessed the number of jobs that might be generated under this scenario. This assumes that 17 job-years of employment are created for every megawatt of wind energy capacity manufactured and an additional five job-years for the installation of every megawatt, for a total of 22 job-years. *Windforce 10* accounts for rising labor productivity, estimating that the per-megawatt job figures will gradually decrease to 15.5 by 2010 and 12.3 by 2020.[72]

On the basis of these assumptions, the study projected worldwide wind power employment to rise from about 57,000 jobs in 1998 and 67,000 jobs in 1999 to 1.7 million over the next two decades. (See Figure 4.) In fact, this may be an underestimate. Because new installations during 1999 surpassed the study's projections, the number of jobs supported that year was likely even higher—roughly on the order of 86,000. Also, offshore wind installations are expected to play a growing role in coming years, particularly in Europe, and will require larger investments and support additional employment—a development not reflected in Figure 4. These job numbers also do not include employment generated through additional investments required to enlarge nations' electrical infrastructure.[73]

The study's jobs-per-megawatt formula appears to be well within the range of other reports. The European Commission, for example, noted in a 1997 report that, as a rough rule of thumb, 1 megawatt of wind power-generating capacity installed creates jobs for 15–19 people under present European market conditions, and perhaps double that in countries with lower labor productivity. In a 1997 study,

FIGURE 4

World Wind Power Employment, 1990–99, with Projections to 2020



Greenpeace Germany estimated somewhat more conservatively that 14 jobs are created by manufacturing and installing 1 megawatt.[74]

Additional employment is generated through operating and maintaining wind turbines, though reliable numbers are unavailable. EWEA estimates that in Europe, between 100 and 450 people are employed per year for every terawatt-hour of electricity produced, depending on the age and type of turbine used. In 1999, that would have meant anywhere from 3,000 to 13,000 additional jobs. As wind power capacity expands, so will these numbers.[75]

European companies accounted for about 90 percent of worldwide wind turbine sales in 1997, and presumably will continue to garner the majority of jobs in the near future. As other regions with high wind power potential gear up, they

will only realize significant job gains if they master the technology. India and China, for instance, can in principle generate substantial wind power employment if they succeed in strengthening their indigenous production base. India already has 14 domestic turbine manufacturers, and spare parts production and turbine maintenance are helping at least some regions and villages generate much-needed income and employment. Argentina hopes to create 15,000 permanent jobs over the next decade.[76]

Asian, Latin American, and East European countries currently have labor productivity rates in the wind power sector that are estimated to be at least 20 percent lower than in Western Europe. This means that domestically manufactured wind turbines create one fifth more jobs than those imported from Western Europe do. However, Asian countries will likely continue to rely on imports for some 20 percent of their installations during the next decade; Latin American and East European nations are able to manufacture nearly all needed components within their own regions. The Middle East and Africa, by contrast, will mostly depend on imported technology and components.[77]

Like wind power, solar energy use, particularly in the form of photovoltaics (PV), is growing rapidly. The Solar Energy Industries Association (SEIA) claims that 3,800 jobs are created for every $100 million in PV cell sales. The U.S. solar industries directly employ nearly 20,000 people now and indirectly support more than 150,000 jobs in diverse areas such as glass and steel manufacturing, electrical and plumbing contracting, architecture and system design, and battery and electrical equipment manufacture. PV jobs in Europe are still very limited in number, but the European Photovoltaic Industry Association projects that the production, installation, and maintenance of PVs could directly employ up to 294,000 people by 2010.[78]

Meanwhile, the European Solar Industry Federation, a group of about 300 solar thermal companies, employed more than 10,000 people in 1997 in designing, manufacturing, marketing, installing, and maintaining systems. Just

under current market growth trends, the federation projects the creation of 70,000 additional jobs in the next ten years, and a far larger number, perhaps up to 250,000, if strong governmental support for solar energy materializes.[79]

As a group, renewables (including geothermal, hydropower, and biomass along with solar and wind energy) have the potential to become a significant source of jobs. The U.S. industry association, SEIA, asserts that more than 350,000 net jobs will be added by 2010—a number equal to the employment provided by the largest U.S. car manufacturer. In a 1997 report, the European Commission lays out the objective of doubling the current share of renewable energy sources from 6 to 12 percent by 2010. Taking job losses in fossil fuel energy sectors into account, a half-million net additional jobs could be created in the renewable energy sector and in supplier industries, and another 350,000 jobs through exports of renewables.[80]

Like the expansion of renewables, energy efficiency has considerable job potential awaiting mobilization. This includes jobs in producing, installing, and maintaining heat exchangers, more efficient burners and gas turbines, thermal insulation, and many other items. In Germany, some 100,000 jobs had been created by the early 1990s in this sector. Improving the thermal insulation of 300,000 German apartments per year, plus replacing old boilers with more efficient units, could generate an estimated 200,000 new jobs. Efficiency measures may render some utility sector jobs unnecessary, but they are a far more labor-intensive alternative. A study in Sacramento, California, shows that saving enough energy to avoid 100 megawatts (MW) worth of power plant capacity creates 39 jobs, compared with the 15–20 jobs required to operate the same amount of capacity at a modern coal- or gas-fired power plant.[81]

Large-scale job creation beckons as opportunities for greater efficiency are pursued. The American Council for an Energy-Efficient Economy (ACEEE), for example, has assessed the impact of a "high-efficiency scenario," assuming cost-effective improvements throughout the U.S. economy

between 1992 and 2010. These run the gamut from better-insulated windows to more-efficient lighting to highly fuel-efficient cars. According to this model, average annual investments of $46 billion yield a 20 percent reduction in energy consumption below a business-as-usual scenario and a 24 percent reduction in carbon emissions. The study estimates that almost 1.1 million net jobs could be created by 2010. Just 10 percent of these are direct jobs in efficiency and in supplier industries; the rest are created as consumers and businesses re-spend the money they save through avoided fuel costs on other goods and services that are more labor-intensive than the fossil fuel industry.[82]

Additional assessments have been undertaken in other industrial countries, spurred by the Kyoto Protocol and the growing sense of urgency surrounding the issue of climate change. (See Table 5.) Although they rely on different methodologies, assumptions, and econometric models, making them difficult to compare directly with each other, these studies support the overall conclusion that, for each dollar invested, pursuing energy alternatives will generate far more jobs than the fossil fuel industries can.[83]

The transportation sector, characterized by a heavy reliance on cars and trucks, is a major consumer of fossil fuels. An alternative transport policy offers not only savings in fuel consumption but also important job opportunities, as recent German and British assessments of alternative passenger transport policies show. A 1998 study by the Öko-Institut in Freiburg, Germany, compares a "business-as-usual" scenario with an alternative scenario for the 1995–2010 period designed to cut German CO_2 emissions by a quarter. Although it allows for an increase of 21 percent in passenger kilometers traveled by all modes in Germany, it posits 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 are projected to become far more fuel-efficient.[84]

A loss of 130,000 jobs in automobile manufacturing

TABLE 5

Job Impact Findings, Selected Studies on Climate Policy

Country	Policy Change	Years	Carbon Reduction (million tons)	Employment Gain (net number of jobs)
Austria	Cogeneration, energy efficiency, renewables, alternative transportation	1997–2005	70	+ 12,200
Austria	Biomass, higher taxes on fossil fuels	1997–2005	20	+ 30,000
Denmark	Greater natural gas use, district heating, co-generation, energy efficiency, renewables; total energy consumption stable	1996–2015	82	+ 16,000
Germany	Boosting efficiency, phasing out nuclear power, less oil and coal use, renewables to account for 10 percent of primary energy use, alternative transportation policies	1990–2020	518	+ 208,000
Netherlands	Efficiency gains in transport, industry, electric equipment, buildings; greater use of wind power	1995–2005	440	+ 71,000
United Kingdom	Accelerated uptake of cogeneration, efficiency, and renewables technologies	1990–2010	206	+ 537,000
European Union	Installation of high-performance double-pane windows in 60 percent of dwellings	10-year period	940	+ 126,000
United States	Improved efficiency in transportation, industry, power generation, buildings	1990–2010	188	+ 870,000

Source: See endnote 83.

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 are 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 assumes that higher gasoline taxes would help bring about the shift toward public transport. Close to half the additional tax revenues of 25 billion German marks ($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. This re-spending accounts for some three quarters of the total net job gain of 208,000. However, if the surplus tax revenues were used to cut wage costs instead (by reducing employers' social security contributions), the net employment effects might be far higher, perhaps reaching some 400,000 new jobs.[85]

A British study by Friends of the Earth assesses 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 assumes that the total number of passenger kilometers traveled would decline by 11 percent from 1990 levels. It concludes 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, could help create another 35,000 jobs (because of greater attention to upkeep, leased cars lead to more maintenance jobs).[86]

While this discussion has focused on industrial countries, there are implications for developing countries as well. Given the substantial potential for wind and solar energy in developing countries, these energy sources could become important job creators. But there, too, a key employment benefit of moving away from energy-intensive, fossil fuel-

focused patterns of development lies in spending less of a society's financial resources on oil, coal, and natural gas and more on labor-intensive sectors of the economy. Seeking out investment and consumption choices that promise greater job creation than the traditional energy industries is of particular interest in countries with surging numbers of job seekers and scarce economic resources. If the opportunities at hand are to be realized, not only national priorities, but also those of international lenders will need to change. If the World Bank, for instance, were to switch the bulk of its loans for fossil fuels—nearly $14 billion in 1992–98—to renewables and efficiency, it would help generate much-needed jobs in developing countries.[87]

Durability, Remanufacturing, and a New Service Economy

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. 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. In any event, a durable product with a higher up-front cost of purchase will, over time, be economically more advantageous to consumers than cheaper, flimsier items that must be replaced frequently.[88]

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.[89]

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.[90]

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. A fuller evaluation of the employment implications of a shift toward durability would require detailed assessments of the specific changes and how they translate into job losses and opportunities for new employment. (See Table 6 for a rough conceptual exploration.)

Already, recycling and remanufacturing have become substantial industries. The Bureau of International Recycling in Brussels, Belgium, estimates that in more than 50 countries worldwide, the recycling industry now processes more

TABLE 6

Employment Implications of Durable, Repairable, and Upgradable Products

Product Life-Cycle Phase	Observation	Employment Effect
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 or 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 greater recycling, plus disassembly of parts and components for reuse; more labor-intensive than landfilling and incineration	Positive

Source: Worldwatch Institute.

than 600 million tons annually, materials diverted from the waste stream for the purpose of reuse or recycling. This includes ferrous and non-ferrous metals, stainless steel and special alloys, paper, textiles, plastics, and rubber. With an annual turnover of $160 billion, the industry employs more than 1.5 million people. Recycling makes an important contribution to reducing energy consumption and associated pollution of air and water.[91]

Remanufacturing is also becoming a serious business, particularly in areas like motor vehicle component manufacture, and has the potential to employ many more people than it does now. 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.[92]

In the United States, remanufacturing is already a $53 billion per year business and employs some 480,000 people directly in 73,000 different firms; this is double the number of jobs in the U.S. steel industry or roughly equal to that of the entire U.S. consumer "durables" industry, or about 0.6 percent of GDP. Walter Stahel of the Product-Life Institute in Geneva, Switzerland, estimates that the remanufacturing sector in European Union member countries accounts for about 4 percent of the region's GDP. Xerox and Canon are among the companies that have pushed this concept. Canon began remanufacturing photocopiers in 1992. Xerox has developed a photocopier of which every part is reusable or recyclable; by 1997, as many as 28 percent of the copiers that the company produced were remanufactured, and Xerox is aiming to boost this to 84 percent. 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. Clearly, there is enormous room for expansion of this activity.[93]

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 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.[94]

Aside from transportation, other aspects of the service sector, too, will undergo change in a sustainable 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.[95]

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.[96]

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." Likewise, people do not want the two liters of gasoline and 1,000 liters of water that it now takes on average to produce one liter of Florida orange juice. They do not want the kilogram of raw materials that go into producing a single 10-gram sheet of office paper. Neither do they desire the almost 12 tons of waste generated in producing a laptop computer that may weigh no more than 3 kilograms. German consumers, for instance, do not insist that the full 22 tons of materials per capita, and another 64 tons of waste,

be mobilized on their behalf annually, but rather that they derive comfort and well-being. 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.[97]

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 well-being." 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.[98]

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.[99]

In a move that will assist the trend toward selling product performance rather than the physical product per se, Germany has pioneered the concept of "extended producer

responsibility," which essentially means that once a company makes a product, it is responsible for it throughout that product's life and its eventual disposition. A growing number of countries are copying the concept. Still, the service aspect—the shift from selling goods to selling the performance of these goods—has so far gone much further in the United States than it has in Europe and Japan.[100]

The authors of *Natural Capitalism* point out 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).[101]

In the United States, remanufacturing employs 480,000 people, or double the number of jobs in the steel industry.

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. The city of München, Germany, for example, has calculated that more than 5,000 new jobs could be created by the year 2010 if the local authority hired performance contractors to root out energy waste.[102]

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.[103]

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. In the 1990s, the firm 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.[104]

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.[105]

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.[106]

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.

Labor and Environmentalists: Finding Common Ground?

Organized labor and the environmental community share an interest in shifting emphasis from labor productivity to resource productivity. Obviously, by joining forces, they might have a far greater chance to achieve their respective goals. But the history of relations between workers and environmentalists alternates between cooperation and conflict. Different concerns, organizational structures, campaigning styles, decisionmaking processes, and time horizons make for perspectives that do not always align well. In times of economic recession or uncertain economic transformation, workers and their representatives have often felt that environmental protections were a luxury compared

with the immediate need to secure their livelihoods and to put bread on the table. To be sure, environmentalists have at times shown themselves insensitive to worker perspectives, or failed to consult or communicate with unions. They have not had to worry about the measures they advocate threatening their own jobs.[107]

In some well-publicized cases, workers and environmentalists have angrily confronted each other. For instance, mutual boycotts and blockades were employed in 1997 in British Columbia when Greenpeace and Friends of the Earth challenged the Industrial, Wood, and Allied Workers of Canada and the Pulp and Paper Workers of Canada over logging and pulping restrictions demanded by environmentalists. Industry management has in some cases eagerly courted labor to side with it against environmentalists. In 1996, for example, the chlorine industry helped stage a demonstration by 5,000 workers in Düsseldorf, Germany, protesting Greenpeace's actions against polyvinyl chloride (PVC).[108]

Though it is often the loud confrontations that make the headlines, there are many instances where both sides have engaged each other, and sometimes they have cooperated closely. European unions, for example, have long regarded environmental policy more in terms of an opportunity than a threat. In the late 1990s, the Danish General Workers Union and European Environmental Bureau jointly coordinated a project, funded by the European Commission, that studied "green jobs" in a number of countries. In Britain, for instance, Friends of the Earth and two unions, GMB and Unison, examined manufacturing, energy, transportation, water, and agriculture; in Germany, Bund für Umwelt und Naturschutz Deutschland (the German affiliate of Friends of the Earth) and Gewerkschaft Öffentliche Dienste, Transport und Verkehr (the public service and transport workers' union) collaborated on a study of the energy and agriculture sectors.[109]

Even in North America, where labor-environment relations have been more charged than in other industrial countries, cooperation is far from unusual. In the United States,

for instance, environmentalists and labor joined forces early on to help win passage of the Clean Air Act and the Occupational Safety and Health Act in 1970. More recently, a broad alliance of fishers, pulp workers, Native Americans, and environmentalists combined in the early 1990s to successfully press British Columbia's provincial government to implement a zero-dioxin-discharge policy. In 1999, several environmental groups and unions like the United Steelworkers forged a new coalition, the Alliance for Sustainable Jobs and the Environment, to struggle against the anti-labor and anti-environment practices of Houston-based Maxxam Corp. That same year, more than 60 representatives of U.S. unions and environmental groups came together to form the Blue-Green Climate Change Working Group to advance more worker-friendly carbon reduction policies. The anti-World Trade Organization protests in Seattle also showed that the rising concern about economic globalization may increasingly generate opportunities for labor and environmental groups to come together.[110]

A substantial part of the labor movement has taken a proactive role in the environmental discussion, based on the understanding that while there may at times be costs—job losses or disruptions—associated with environmental protection, the costs of inaction could be substantially higher. A 1996 ILO survey demonstrated that unions in a range of countries have developed a sophisticated understanding of environmental issues, working with environmental and community groups, local and national authorities, or management to minimize the environmental impacts of economic activities. Particularly in countries like Japan, Germany, Sweden, Spain, Canada, and Australia, labor groups have worked hard to advance clean production methods, identify opportunities for greater energy efficiency, and support recycling and alternative forms of energy. They have emphasized worker training and awareness programs, have demanded that worker right-to-know clauses, eco-audits, and other environmental provisions are included in collective bargaining agreements with management, and have

sought to strengthen their involvement in determining how environmental agreements and rules are implemented.[111]

Rather than being irreconcilable opposites, labor and environmental concerns are closely tied together. As the Maxxam case—where forest clearcuts and worker lockouts were two sides of the same coin—suggests, a company that cares little about a pristine forest is unlikely to care much about its workers, either. Those companies that push resource exploitation to the maximum, like Maxxam, are in effect following a "take-the-money-and-run" strategy; they are interested in liquidating the resource as quickly as possible, lining the pockets of management and shareholders, and then moving on, thereby pulling the plug on the local community. In such cases, the number of jobs may increase for a while, but once the resource is gone, so are the jobs.

Environmental dangers for society at large typically mean direct safety and health dangers in the workplace. "The chemicals in our water supply and high rates of cancer and birth defects near some industrial sites are examples of the clear links between the environment in the workplace and the outside community," notes the Canadian Autoworkers Union in its "Statement of Principles on the Environment." Although most industrial countries have seen clear progress toward a healthier and safer workplace, dangers remain, and new industries and the evolving nature of work are posing new hazards. The toll is particularly heavy in developing countries, where large numbers of workers are concentrated in hazardous activities such as logging and mining. According to ILO statistics, more than one million work-related deaths occur annually worldwide. In a workforce of nearly 3 billion, workers suffer an estimated 250 million occupational accidents and contract 160 million occupational diseases each year, numbers that are expected to double over the next 20 years.[112]

While unionists and environmentalists may in the past have dabbled in a variety of limited coalitions, the employment and environmental crises make it increasingly imperative that a more strategic, transboundary alliance

for jobs and sustainability be forged, and that it involve as many partners as possible. Without cooperation, neither environmentalists nor unionists are likely to achieve their respective goals.

Aside from the mightier political punch of a labor-environment alliance, it is workers who, in their respective workplaces, can make all the difference between business as usual and an environmentally more enlightened approach. Workplace eco-audits allow unions and workers to make crucial suggestions for more efficient, less wasteful, and more environmentally benign and safe operations. Outside the United States, worker participation in environmental and conservation measures at industrial facilities is commonplace. Unions and management at the German chemical company BASF reached agreement in 1993 that provides for substantial union involvement in environment-related questions. In Japan, employee participation routinely yields large savings of energy and materials.[113]

Environmental dangers for society at large typically mean direct safety and health dangers in the workplace.

If environmentalists expect to receive solid labor support for many of their demands, they in turn need to recognize the priorities of unions and provide support for their objectives. Strong, independent unions are far more likely to engage in a serious give-and-take on what is needed to create a sustainable workplace than weak, embattled ones. Therefore, it is smart for environmental organizations to support the right to organize unions, help push for improved occupational health and safety rules and their enforcement, endorse worker right-to-know provisions, and advocate legislation that gives worker representatives a meaningful voice in determining how environmental issues are being dealt with by corporate management.

Equally important is environmentalist support for adequate transition assistance for those workers that do lose their jobs in the move toward a sustainable economy. From

a perspective of human well-being, it is not enough to say that, in the end, economic transitions often leave societies better off. "Environmental measures that do not recognize a worker's right to a fair chance in the new economy," writes Northwest Environment Watch's Alan Durning, "are equally menacing to our future" as jobs that depend on despoiling nature.[114]

As in the days of the Luddites, it is Britain that offers an illustration. In the mid-1980s, the British government restructured the coal industry, closing large numbers of mines and slashing coal subsidies—motivated at least as much by the intent to save the treasury money and to break the power of labor unions as by the desire to avert climate change. While this policy did reduce carbon emissions, it also caused high local unemployment and unleashed an array of associated social ills in coal-mining regions, not least because the bitterly disputed policy was forced through in a short stretch of time.[115]

Environmentalists also need to recognize that the issue is not merely one of the number of jobs, but also of the quality of employment. The appeal of new jobs is limited if they involve substantially less pay. For instance, jobs at recycling centers—sorting through waste materials—tend to be dirty, tedious, and low paying. The tourist industry and the retail sector are rapidly growing, but loggers, miners, or refinery workers are unlikely to see them as their salvation. At any rate, these kinds of occupations are not all a sustainable economy has to offer. A considerable portion of jobs in constructing wind turbines, for instance, involve skills that have traditionally been well remunerated. And the new type of service economy described earlier will require well-trained, capable individuals.

In any event, a number of factors play a role in determining wage levels, including skill and productivity, but also the strength of unions. It was indeed union strength and the political struggle for government intervention in the economy (through minimum wage laws and other measures) that turned mining and manufacturing jobs into high-wage occupations—not some preordained or immutable law of economics. Without union clout and government support, labor productivity gains do not necessarily mean rising wages, as evidence from the United States since 1989 demonstrates. While U.S. labor productivity has risen an average of 1.2 percent per year, the median wage declined through 1996. (By contrast, rising labor productivity still translates into growing wages in Europe and Japan.)[116]

In many industries, moving toward sustainable practices will involve numerous workplace changes, but not necessarily job loss. As argued throughout this paper, it is primarily resource extraction and a handful of other highly polluting industries that will bear the brunt of the impact. For them, a transition to new jobs, skills, and livelihoods presents the biggest challenge. If individuals and communities have reasonable hope that the transition to a sustainable economy will not translate into pain for them, they will be far less likely to oppose change. Creating opportunities for affected workers to learn new skills and providing adequate assistance in their shift to new careers will be key. An appropriate policy package would entail setting up a transition fund to provide income and benefits for displaced workers seeking a new career, tuition support to pay for vocational and other training programs, career counseling and placement services, plus aid in relocating to find a new job.

A number of federations, such as the AFL-CIO in the United States, the Canadian Labour Congress, the International Confederation of Free Trade Unions, the European Trade Union Congress, and the International Federation of Chemical, Energy, Mine and General Workers' Unions, have strongly endorsed such a "Just-Transition" program. On the environmental side, Greenpeace has promoted the idea of a planned transition that would help smooth the impact of eliminating dangerous chlorinated chemicals. The U.S.-based Oil, Chemical, and Atomic Workers Union (OCAW, recently merged with the United Paperworkers Union) has closely consulted with Greenpeace and called for a tax on chlorine products to finance a transition. But not all unions

are convinced. Bill Banig, an official of the U.S. United Mine Workers, argues that the just-transition concept amounts to "talking about having a good funeral."[117]

It is not enough just to focus on retraining. A sustainable economy will not come about by leaving things to the market alone. It is imperative, therefore, that governments adopt proactive policies to promote research and development in environmentally benign technologies; encourage an initial market for alternatives like wind power, fuel cells, super-efficient lights, and clean production methods, both through government procurement and incentive programs for businesses and private households; and establish a clear timeline for the transition to a sustainable economy. In areas where logging, mining, and other heavily polluting industries play a disproportionate economic role, governments will need to design programs to assist regions with unsustainable and declining industries in an effort to diversify the economic base.

By rethinking their tax and subsidy policies, governments can accelerate the process of moving toward a sustainable economy. Current tax and subsidy structures in many countries reinforce the overuse of fossil fuels and other resources and encourage the underuse of human labor. Worldwide subsidies for environmentally destructive activities absorb hundreds of billions of dollars each year. Phasing them out and shifting at least a portion for research and development of renewables, efficiency, and clean production methods would provide a powerful boost to the shift toward sustainability and help create a large number of jobs in the process. (Clearly, some of the subsidies that currently help people with low incomes cope with fuel bills and other expenses will need to be maintained in a transition phase. But eventually, far greater resource efficiency and cheaper renewables should lower such costs and permit a reduction in these subsidies as well.)

Ecological tax reform is key to addressing both the challenge of adequate job creation and environmental protection. If they are well designed, eco-taxes—such as landfill fees,

taxes on nonrenewable energy, and emissions charges—promise several benefits. While boosting energy and materials productivity, they provide an incentive for moving away from heavy fossil fuel use and from wasteful and polluting activities. They also raise revenues to fund environmentally benign alternatives. In the context of the environment-employment nexus, however, another aspect is critical: using eco-tax revenues to reduce the payroll taxes that fund social security programs. In effect, some of the tax burden now falling on labor would thus be shifted, to be levied instead on resource use and pollution. This shift is based on the recognition that current tax systems are severely out of balance: they make energy and natural resources far too cheap (inviting inefficiency and waste) and render labor too expensive (discouraging new hiring and encouraging layoffs). The predictable result is an overuse of natural resources and underuse of human labor. It is not an overstatement to argue, as the authors of *Natural Capitalism* do, that "taxes extracted from labor subsidize patterns of resource use that in turn displace workers …"[118]

Current tax and subsidy structures reinforce the overuse of resources and the underuse of human labor.

In western industrial countries, payroll taxes and mandatory social security contributions accounted on average for 25 percent of all tax revenues in 1995, up from 18 percent in 1965. Energy taxes and nonenergy environmental taxes, in contrast, accounted for only about 7.5 percent, and taxes on capital have decreased in most countries. Given this situation, it is little wonder that companies have put far greater emphasis on boosting labor productivity than on enhancing resource productivity—with the result that unemployment and environmental degradation are both higher than they would otherwise be. The potential impact of a tax shift is likely to be greatest in countries where labor taxation is particularly high, as it is in most of Europe. The United States, by contrast, has less leeway to decrease the tax burden on

labor, but it has greater opportunities to effect a tax shift by raising its extremely low taxes on resource use.[119]

During the 1990s, a growing number of studies, principally in Europe, modeled the economic and employment impacts of ecological tax reform. Although the underlying assumptions about the nature and size of eco-taxes, as well as the precise ways in which the tax revenue would be used, vary widely, the key conclusion was that a tax shift is good news for job creation. For instance, a 1998 British study found that an array of U.K. energy and environment taxes designed to shift 6 percent of the tax burden from labor to environmentally damaging operations had the potential to create some 717,000 additional jobs between 1997 and 2005. An influential German study undertaken in 1994 modeled the impact of a tax on all nonrenewable sources of energy and on electricity use that would be imposed and increased by 7 percent annually over 15 years. Energy consumption and carbon emissions would decline by 21 percent, and up to 800,000 new jobs be created. And a 1994 European Commission study projected potential job gains of 2.2 million with the adoption of tax shifts.[120]

In the United States, the Economic Policy Institute (EPI) and the Center for a Sustainable Economy (CSE) published a study in April 2000 that assessed the effects on employment of imposing a $50 per ton carbon tax and cutting payroll taxes by an amount equal to the revenue gained. These tax shifts were to be accompanied by a package of measures to promote energy efficiency and renewable energy sources. Using an input-output model, the EPI-CSE study found that, by 2020, industries employing 91 percent of all U.S. workers would experience lower overall production costs as a result of such policies, with the remaining 9 percent—employed in energy-intensive branches—experiencing a rise in production costs. The "winner" industries would gain 260,000 jobs, whereas the "loser" industries, particularly coal mining, would shed some 55,000 jobs. The EPI-CSE study notes that providing a generous transition assistance package to workers losing their jobs would take less than 1 percent of the annual carbon tax revenues. It also points out that measures to help energy-intensive industries adjust and become more energy-efficient would reduce negative job impacts.[121]

The potential benefits of eco-taxes are such that the concept has been endorsed both by environmental organizations and some labor groups. The European Trade Union Congress (ETUC), an umbrella group of national union federations, has supported a tax shift since the early 1990s, and issued a joint statement with the European Environmental Bureau. But the ETUC emphasizes that, in order to make them truly effective, eco-taxes will have to be embedded in a whole range of policy measures including standard setting by public policy, regulations, eco-audits, public awareness campaigns, and other measures.[122]

Discussed theoretically since the late 1970s, eco-tax shifting started to become a reality in the 1990s, as Denmark, Finland, the Netherlands, Norway, Sweden, the United Kingdom, and Germany linked a variety of such taxes to reductions in income taxes or social security contributions. The tax shifts in these countries have so far ranged from a tiny 0.2 percent to a still very modest 2.5 percent.[123]

In the countries that have initiated a tax shift, energy-intensive industries are partially exempted from the eco-tax (either by paying a reduced rate or by receiving reimbursements). In Germany, for example, all manufacturing firms are assessed at only 20 percent of the full tax rate, and coal and jet fuels are not taxed at all. So far, exemptions there are still so generous that the intended incentives of the tax remain very limited—particularly since the liberalization of the European electricity market is expected to push prices down and counter the eco-tax effect. But the German government, like many of its counterparts, is reluctant to be seen as weakening its industries' ability to compete internationally, and recent oil price increases have in fact fueled opposition to the new eco-tax in Germany.[124]

Unless exemptions and preferential treatments are phased out over time, and national policies reconciled so that worries about staying competitive are eased, the incen-

tive to cut energy use and carbon emissions will be diminished considerably. Less progress toward energy efficiency means that money continues to be bound up in the energy sector that could create more jobs if invested elsewhere. Although a truly far-reaching tax shift has not been undertaken yet, it is encouraging that a growing number of governments are taking the initiative on such a path-breaking concept.

New priorities in national subsidy and tax systems allow societies to mobilize sufficient funds to finance just-transition programs for affected workers and to ensure that the move toward sustainability does not entail massive social pain. But more broadly, they help correct the misleading economic signals and incentives that are at the root of the jobs and environmental crises alike. These signals have long encouraged the overuse of natural resources while discouraging the use of human labor.

The key challenge for governments, companies, labor unions, and environmentalists is to undertake measures to de-link employment from a high volume of material inputs. Apart from the extractive industries, jobs do not need to depend on maintaining a huge flow of raw materials, and particularly not on the one-way flow that turns natural resources into mountains of waste at a rapid pace.

Far from being a fatal threat to many jobs, environmental norms and policies can stimulate the creation of new kinds of jobs. From existing jobs in pollution control, to the growing employment in recycling and remanufacturing, to emerging jobs in connection with stepped-up energy and materials efficiency projects and the development of renewable energy sources like wind and solar power, to future occupations in providing goods and services that are more durable, repairable, and reusable, there are many opportunities for sustainable employment.

Those industries that contribute the most to environmental degradation, which are therefore likely to be the most affected by environmental policies, employ very limited numbers of people. Most mining and logging jobs in particular will not be safe even in the absence of environmental measures. Continued automation is rapidly decimating this type of occupation, and the livelihoods of loggers and miners are often abruptly extinguished when the resource base is depleted and companies move on to exploit the resources of new regions.

It is widely understood that building a sustainable economy depends on developing technologies and practices that allow humanity to reduce its "ecological footprint." But there is less clarity about the fact that success depends equally on tapping the experience and ingenuity that humans bring to their workplaces. A sustainable economy needs both different technologies and a new appreciation of the contribution that workers can make to preserving the natural environment.

Many labor leaders increasingly understand that environmental health and economic well-being are inseparable. A 1990 report by the United Steelworkers of America still rings true: "In the long run, the real choice is not jobs or the environment. It's both or neither. What kinds of jobs will be possible in a world of depleted resources, poisoned water and foul air, a world where ozone depletion and greenhouse warming make it difficult even to survive?" Without social sustainability, environmental sustainability may be a pipe dream. The implications of decoupling job creation and economic well-being from environmental destruction are in some ways no less revolutionary than the changes that confronted society at the start of the Industrial Revolution.[125]

Notes

1. Kirkpatrick Sale, *Rebels Against the Future: The Luddites and Their War on the Industrial Revolution* (Reading, MA: Addison-Wesley Publishing Co., 1995).

2. 1770 and 1813 comparison from Paul Hawken, Amory Lovins, and L. Hunter Lovins, *Natural Capitalism: Creating the Next Industrial Revolution* (Boston: Little, Brown and Company, 1999); Sale, op. cit. note 1.

3. Sale, op. cit. note 1.

4. Pace of job destruction and creation in Europe from European Commission (EC), *Living and Working in the Information Society: People First* (Brussels: Employment, Industrial Relations and Social Affairs, 1996).

5. Richard Kazis and Richard L. Grossman, *Fear at Work: Job Blackmail, Labor and the Environment* (Philadelphia: New Society Publishers, 1991); Eban Goodstein, *The Trade-Off Myth: Fact and Fiction about Jobs and the Environment* (Washington, DC: Island Press, 1999); Ulrich Petschow, "Jobkiller oder Jobknüller?" *Politische Ökologie*, March/April 1997.

6. Decreasing materials intensity from Gary Gardner and Payal Sampat, *Mind Over Matter: Recasting the Role of Materials in Our Lives*, Worldwatch Paper 144 (Washington, DC: Worldwatch Institute, December 1998). Opportunities for boosting energy and materials efficiency are explored, and many practical examples offered, by Hawken, Lovins, and Lovins, op. cit. note 2.

7. Goodstein, op. cit. note 5.

8. Organisation for Economic Co-Operation and Development (OECD), *Environmental Policies and Employment* (Paris: 1997).

9. International Labour Organization (ILO), *World Employment Report 1998–99* (Geneva: 1998).

10. Unemployment and underemployment from ibid.; lack of unemployment benefits from Elizabeth Olson, "Globalization Is Said to Cause Job Losses," *International Herald Tribune*, 21 June 2000; long-term unemployment from United Nations Development Programme (UNDP), *Human Development Report 1999* (New York: Oxford University Press, 1999).

11. ILO, op. cit. note 9; EC, op. cit. note 4; overtime from Peter Merry, "Green Works," as posted on the British Green Party Web site, <www.gn.apc.org/www.greenparty.org>, viewed 5 August 1999.

12. Output and job trend in manufacturing and manufacturing-to-service employment ratio calculated from U.S. Department of Labor, Bureau of Labor Statistics (BLS), "Comparative Civilian Labor Force Statistics, Ten Countries, 1959–1998" (Washington, DC: 13 April 1999); Figure 1 from BLS, "National Employment, Hours, and Earnings," data extracted from BLS database, <146.142.4.24/cgi-bin/surveymost>, viewed 12 July 1999. Because developing countries experienced the agriculture-to-industry shift later than the industrial countries, the share of manufacturing jobs worldwide actually grew from 17 percent in 1960 to 20 percent in 1990; however, among industrial nations, there was a slight decline from 35 to 33 percent during the same period of time, while service jobs grew from 38 to 57 percent. UNDP, *Human Development Report 1996* (New York: Oxford University Press, 1996).

13. Characterization of retail and wholesale, and unionization rate from ILO, "ILO Reports Significant Jobs Growth in Commerce Worldwide during 1990s," press release (ILO/99/34), Geneva, 25 October 1999; U.S. hourly earnings from BLS, op. cit. note 12; University of Würzburg from Wolfgang Bonß, "Das Ende der Normalität," *Politische Ökologie*, May/June 1998.

14. In assessing the impact of new technologies and automation on factory and office workplaces, Fred Block observes a "tension between the impulse to reduce workers' skill and the need for improved quality and flexibility." Fred Block, *Postindustrial Possibilities: A Critique of Economic Discourse* (Berkeley: University of California Press, 1990).

15. Richard J. Barnet, "Lords of the Global Economy," *The Nation*, 19 December 1994; U.N. Research Institute for Social Development, *States of Disarray: The Social Effects of Globalization* (Geneva: 1995); Keith Bradsher, "Skilled Workers Watch Their Jobs Migrate Overseas," *New York Times*, 28 August 1995.

16. Unionization rates from Karen Taswell, ILO, Bureau of Statistics, Geneva, e-mail communication with author, 10 August 1999; restrictions on union rights from ILO, "Pioneering ILO Global Report Calls for More Widespread Respect for Rights at Work," press release, Geneva, 25 May 2000, <www.ilo.org/public/english/standards/decl/vaw/newsroom/press01.htm>.

17. Skilled and unskilled manufacturing employment from ILO, op. cit. note 9; Britain from Merry, op. cit. note 11; Germany from Bonß, op. cit. note 13.

18. Bonß, op. cit. note 13; Martine Bulard, "What Price the 35-Hour Week?" *Le Monde Diplomatique*, September 1999, on-line English language version at <www.monde-diplomatique.fr/en/1999/09/>.

19. Developing-world disparities from Jeremy Rifkin, *The End of Work* (New York: G.P. Putnam's Sons, 1995), and from Diana Bronson and Stéphanie Rousseau, "Working Paper on Globalization and Workers' Human Rights in

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20. International Monetary Fund (IMF), *World Economic Outlook* (Washington, DC: May 1999). Table 1 from ILO, op. cit. note 9.

21. U.S. real hourly earnings and poverty-level wages from Economic Policy Institute (EPI), "Real Average Weekly and Hourly Earnings of Production and Nonsupervisory Workers, 1967–98," <epinet.org/datazone/aheawe.html>, and "Share of Employment for All Workers by Wage Multiple of Poverty Wage, 1973–97," <epinet.org/datazone/povertylevelwages_all.html>, both viewed 14 June 2000; wage disparity growth from "The Best ... and the Rest," *Economist*, 8 May 1999.

22. Comparison of manufacturing compensation from BLS, "International Comparisons of Hourly Compensation Costs for Production Workers in Manufacturing, 1998," <stats.bls.gov/news.release/ichcc.toc.htm>, viewed 5 July 2000. Comparison of benefits and social protections from IMF, op. cit. note 20, and from OECD, *Making Work Pay: Taxation, Benefits, Employment and Unemployment*, The OECD Jobs Strategy Series (Paris: 1997); decline of union membership from EPI, "Union Coverage in the United States, 1979–1998," The Datazone, <epinet.org/datazone/union.html>, viewed 14 June 2000, and from Peter T. Kilborn, "Encouraged but Still Wary, Union Leaders Gather," *New York Times*, 15 February 1993.

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32. Toxics release inventory data from U.S. Environmental Protection Agency (EPA), at <www.epa.gov/tri/index.htm>; employment numbers from BLS database, <146.142.4.24/cgi-bin/dsrv>.

33. Table 2 calculated from U.S. Department of Commerce, Census Bureau, *1996 Annual Survey of Manufactures. Statistics for Industry Groups and Industries* (Washington, DC: U.S. Government Printing Office (GPO), February 1998), from U.S. Department of Energy (DOE), Energy Information Administration (EIA), *Manufacturing Consumption of Energy 1994* (Washington, DC: GPO, December 1997), and from EPA, *The 1997 Toxics Release Inventory*, <www.epa.gov/opp tintr/tri/tri97/drhome.htm>.

34. See John E. Young, "The Coming Materials-Efficiency Revolution," in: *Extended Producer Responsibility: A Materials Policy for the 21st Century* (New York: Inform, Inc., 2000).

35. See, for example, Gardner and Sampat, op. cit. note 6; E.U. von Weizsäcker, Amory Lovins, and L. Hunter Lovins, *Factor Four: Doubling Wealth, Halving Resource Use* (London: Earthscan, 1997).

36. The so-called "Hypercar," a super-efficient concept promoted by the Rocky Mountain Institute, would be made from new composite materials (carbon-fiber) that can be easily molded to the desired shape instead of the

complex and expensive processes needed for current auto-body making. Currently, carbon-fiber is an expensive specialty product, but using it extensively in car manufacturing would help lower its cost to acceptable range. Hawken, Lovins, and Lovins, op. cit. note 2.

37. Kazis and Grossman, op. cit. note 5.

38. Eban Goodstein and Hart Hodges, "Polluted Data: Overestimating the Costs of Environmental Regulation," *The American Prospect*, November/December 1997; Hart Hodges, "Falling Prices: Cost of Complying with Environmental Regulation Almost Always Less Than Advertised," *EPI Briefing Paper,* Number 69 (Washington, DC: EPI, 1997).

39. OECD, op. cit. note 8; Rainer Walz et al., *A Review of Employment Effects of European Union Policies and Measures for CO_2-Emission Reductions* (Karlsruhe, Germany: Fraunhofer Institute for Systems and Innovation Research, May 1999); Novo Nordisk from "Novo Nordisk's Mean Green Machine," *Business Week*, 14 November 1994. Industrial enzymes are used in products and processes such as fabrics, detergents, food processing, pulp and paper, leather, industrial cleaning, and agricultural applications.

40. Goodstein, op. cit. note 5.

41. OECD, op. cit. note 8.

42. Number of pollution control jobs worldwide is a Worldwatch estimate based on Environmental Business International, "The Global Environmental Market and United States Environmental Industry Competitiveness" (San Diego, CA: undated), on David R. Berg and Grant Ferrier, *The U.S. Environment Industry* (Washington, DC: U.S. Department of Commerce, Office of Technology Policy, September 1998), and on Roger H. Bezdek, "Jobs and the Economic Opportunities During the 1990s in the U.S. Created by Environmental Protection" (Oakton, VA: Management Information Services, Inc., June 1997). Pollution prevention, recycling, and alternative energy most likely account for less than 10 percent, although existing industry data appear not to capture many activities, and jobs, that fall in these categories.

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44. Michael Renner, *Jobs in a Sustainable Economy*, Worldwatch Paper 104 (Washington, DC: Worldwatch Institute, September 1991).

45. U.S. efficiency savings from Hawken, Lovins, and Lovins, op. cit. note 2.

46. Calculated from BLS, op. cit. note 29, and from Rosenblum, op. cit. note 29. Steel-making is one of the most energy-intensive industries; in the United States, energy purchases account for 15–20 percent of the total manufacturing costs. American Iron and Steel Institute, "Significant Strides in Energy Efficiency," <www.steel.org/facts/power/energy.htm>, viewed 21 July 2000.

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48. For a detailed discussion of subsidies, see David Malin Roodman, *The Natural Wealth of Nations* (New York: W.W. Norton & Company, 1998).

49. For a recent assessment of U.S. subsidies, see Friends of the Earth, Taxpayers for Common Sense, and U.S. Public Interest Research Group Education Fund, *Paying for Pollution. How Taxpayers Subsidize Dangerous and Polluting Energy Programs* (Washington, DC, 2000), available at: <www.foe.org>; international fossil fuel subsidies from David Malin Roodman, "Fossil Fuel Subsidies Falling," in Lester R. Brown, Michael Renner, and Christopher Flavin, *Vital Signs 1998* (New York: W.W. Norton & Company, 1998).

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51. Coal jobs as a share of worldwide employment from Seth Dunn, "King Coal's Weakening Grip on Power," *World Watch*, September/October 1999; British miners from Peter Colley, *Reforming Energy: Sustainable Futures and Global Labor* (Chicago: Pluto Press, 1997); coal mined from British Petroleum, *BP Statistical Review of World Energy* (London: Group Media & Publications, various years); Germany from Uwe Fritsche et al., *Das Energiewende-Szenario 2020* (Berlin: Öko-Institut, 1996); China from James Kynge, "China Plans to Close Down 25,800 Coal Mines This Year," *Financial Times*, 11 January 1999, and from Erik Eckholm, "Dangerous Coal Mines Take Human Toll in China," *New York Times*, 19 June 2000.

52. Figure 3 and U.S. trends from DOE, EIA, *Annual Energy Review 1999*, (Washington, DC: 1999), and from BLS, "National Employment, Hours, and Earnings," op. cit. note 12, data extracted from database on 15 July 2000; employment in underground versus surface mines and expected further employment decline from Goodstein, op. cit. note 5.

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56. Goodstein, op. cit. note 5; Power, op. cit. note 54.

57. Goodstein, op. cit. note 5; Power, op. cit. note 54; Alan Thein Durning, *Green-Collar Jobs: Working in the New Northwest*, NEW Report 8 (Seattle: Northwest Environment Watch, 1999).

58. For additional information regarding the spotted owl controversy, see Renner, op. cit. note 44; Bush quoted in Goodstein, op. cit. note 5.

59. Durning, op. cit. note 57.

60. Goodstein, op. cit. note 5.

61. Ibid.

62. Durning acknowledges that the industries replacing extraction are not without their own environmental hazards: manufacturing each computer chip generates 7 pounds of hazardous waste and consumes about 2,300 gallons of water. Durning, op. cit. note 57.

63. This argument is made by Power, op. cit. note 54.

64. Lower wages for re-employed loggers from Goodstein, op. cit. note 5.

65. Timber production trends include industrial roundwood, fuelwood, and charcoal production and are derived from Janet N. Abramovitz, "Roundwood Production Levels Off," in Lester R. Brown, Michael Renner, and Brian Halweil, *Vital Signs 1999* (New York: W.W. Norton & Company, 1999). Abramovitz and Mattoon, op. cit. note 53.

66. Alaska and potential for tourism's environmental problems from Durning, op. cit. note 57.

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68. "Historic British Coal Region Goes for Renewables," Environment News Service, <ens.lycos.com/corpus/ens/sep99/19991%2D09%2d23%2D02.html>.

69. Nuclear jobs and market share from VDEW, "38 000 Kernenergie-Arbeitsplätze," <www.strom.de/zf_bz_b7.htm>, and "33 Prozent Kernenergiestrom," <www.strom.de/zf_sz_32.htm>, both viewed 15 July 2000; coal market share and coal and wind jobs from Bundesverband Wind Energie e.V., *Windenergie—25 Fakten* (Osnabrück, Germany: 1999); wind overtaking nuclear is a Worldwatch projection, based on various sources cited in this section.

70. The average size of wind turbines installed grew roughly three- to four-fold during the 1990s and is expected to double again during the next decade to about 1.5 megawatts per plant, and even larger sizes for the emerging offshore wind industry. EWEA, Forum for Energy and Development, and Greenpeace, op. cit. note 47.

71. Danish Wind Turbine Manufacturers Association, "Employment in the Wind Power Industry," *Wind Power Notes No. 2*, March 1996; EWEA estimate from EC, "Energy for the Future: Renewable Sources of Energy," White Paper for a Community Strategy and Action Plan, Brussels, COM(97)599 final (26/11/97).

72. EWEA, Forum for Energy and Development, and Greenpeace, op. cit. note 47.

73. EWEA, Forum for Energy and Development, and Greenpeace, op. cit. note 47; estimate of 86,000 jobs is a Worldwatch estimate, based on a 1999 installation figure of 3,900 megawatts (see Christopher Flavin, "Wind Power Booms," in Lester R. Brown, Michael Renner, and Brian Halweil, *Vital Signs 2000* (New York: W.W. Norton & Company, 2000)) and applying the 22-jobs-per-megawatt formula. Figure 4 is derived from EWEA, Forum for Energy and Development, and Greenpeace, op. cit. note 47, and

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76. European firms' market share from General Accounting Office, *Renewable Energy: DOE's Funding and Markets for Wind Energy and Solar Cell Technologies* (Washington, DC: May 1999); India turbine manufacturers from Christopher Flavin, "Wind Power Blows to New Record," in Brown, Renner, and Halweil, op. cit. note 65; spare parts and maintenance from Raman Thothathri, "The Wind Brought Jobs and Prosperity," *New Energy*, November 1999; Argentina from Peter Korneffel, "The Lull Before the Storm," *New Energy*, May 1999.

77. EWEA, Forum for Energy and Development, and Greenpeace, op. cit. note 47.

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84. Martin Cames et al., *Hauptgewinn Zukunft: Neue Arbeitsplätze durch umweltverträglichen Verkehr* (Freiburg and Bonn, Germany: Öko-Institut and Verkehrsclub Deutschland, 1998).

85. Ibid.

86. Tim Jenkins, *Less Traffic, More Jobs* (London: Friends of the Earth Trust, May 1997).

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90. See <www.daimlerchrysler.com/index_e.htm> and <www.smart.com>, viewed 12 April 2000.

91. Bureau of International Recycling, "Recycling Information," <www.bir.org/biruk/information.htm>, viewed 21 July 2000.

92. Fraunhofer Institute study from Remanufacturing Institute, op. cit. note 89.

93. U.S. remanufacturing industry from Remanufacturing Institute, "Frequently Asked Questions," <www.remanufacturing.org/frfaqust.htm>,

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94. The term "making-unmaking-remaking" is used in OECD, op. cit. note 8.

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97. Lovins quoted in John E. Young, *Discarding the Throwaway Society*, Worldwatch Paper 101 (Washington, DC: Worldwatch Institute, January 1991); examples of products and associated waste generated are based on, or derived from, Hawken, Lovins, and Lovins, op. cit. note 2; German data from Deutsches Institut für Wirtschaftsforschung, Wuppertal Institut für Klima, Umwelt, Energie, and Wissenschaftszentrum Berlin für Sozialforschung, *Zwischenbericht Projektverbund Arbeit und Ökologie* (Berlin and Wuppertal, 22 December 1998).

98. Hawken, Lovins, and Lovins, op. cit. note 2.

99. Change in corporate interest from Edward D. Reiskin et al., "Servicizing the Chemical Supply Chain," *Journal of Industrial Ecology*, vol. 3, no. 2–3 (1999).

100. Gardner and Sampat, op. cit. note 6; U.S. advantage from Stahel, op. cit. note 93.

101. Hawken, Lovins, and Lovins, op. cit. note 2.

102. Ibid.; München from BUND and ÖTV, op. cit. note 81.

103. Hawken, Lovins, and Lovins, op. cit. note 2.

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