2

Eco-Economy Indicators: Twelve Trends to Track

The dozen indicators in this section were chosen to measure progress, or the lack thereof, in building an eco-economy—one that respects the principles of ecology.

Population is selected because although it is a social indicator, it is also a basic environmental indicator. During most of the past 4 million years, our existence as a species was precarious, our numbers small. Now we are so numerous and leave such a large ecological footprint that we threaten the existence of the millions of other species with whom we share the planet. When assessing the adequacy of basic resources such as land and water over time, population size is the universal denominator, always shrinking per capita availability as it expands.

Economic growth is included because, given the way the world now does business, the size of the economy is the best single measure of the mounting pressure on the earth's environment. It combines the effects of both population growth and rising individual consumption to give us a sense of how much the pressure is increasing.

The third trend, grain production, is the best indicator of the adequacy of the food supply. On average, half of all the calories we consume come directly from grain and a large part of the remainder come from the indirect consumption of grain in the form of meat, milk, eggs, and farmed fish. Grain production is a useful indicator of growing food demand in that increased output reflects population growth and also rising affluence, with its associated rise in consumption of grain-fed livestock products.

The world fish catch is a useful measure of the productivity and health of the oceanic ecosystem that covers 70 percent of the earth's surface. The extent to which world demand for seafood is outrunning the sustainable yield of fisheries can be seen in shrinking fishery stocks, declining catches, and collapsing fisheries.

Forest cover is one of the best single indicators of changes in land use. Shrinking forest cover shows we are cutting more trees than we are planting. The shrinkage of forested area means not only that the forest's capacity to supply products is diminished, but also that its capacity to provide services, such as flood control, soil protection, and the purification of water, is also reduced.

Water scarcity may be the most underrated resource issue the world is facing today. Because water was relatively abundant throughout most of our existence, we came to take it for granted. Now we see that water tables are falling in scores of countries. The data show that these individual countries and indeed the entire world soon will be facing "water shocks" as aquifers are depleted and the water supply is abruptly reduced.

Carbon emissions are revealing because as the atmospheric concentration of carbon dioxide changes, so does the earth's temperature. Thus carbon emissions tell us a lot about ourselves and our current habits and provide clues about the kind of world we will be leaving for future generations. Will we be leaving them a stable climate, or will it be a world of searing heat waves, more destructive storms, melting glaciers, and rising sea level—a world besieged by millions of rising-sea refugees?

Just as taking our own body temperature is one of the best measures of our health and well-being, so temperature is also a measure of how well we are taking care of the earth, the only planet known to support life. For the first time in human history, our actions are linked to changes in the global temperature. Who would have thought a generation ago that the thermometer might become the device with which we assessed the human prospect?

Ice melting is included as one of our indicators because it is both one of the most sensitive and one of the most visible effects of rising temperature. There are many other indicators of rising temperatures, such as forests beginning to migrate, tropical diseases moving into higher latitudes, or tree lines moving upward on mountains, but none are quite so visible and perhaps disturbing as the melting of glaciers and ice sheets. Since so much of the world's water is stored in ice on land, its melting raises sea level, directly influencing the human prospect.

Wind electric generating capacity is included here not because of its importance as an energy source today but because of its likely importance tomorrow. Advances in wind turbine design have set the stage for wind power to become the foundation of the new energy economy. Because it is abundant, cheap, inexhaustible, and clean, wind energy is now growing by leaps and bounds. Examining the rate at which wind generating capacity is expanding compared with fossil fuels gives us a sense of how fast the eco-economy is unfolding.

Bicycles are included because their annual sales are more than double those of automobiles. Their sales also measure our ability to reduce traffic congestion, lower air pollution, increase mobility, and provide exercise—a counter to the obesity that is now engulfing urban populations everywhere.

Solar cells are a trend to track because of their likely importance as a future source of energy. On the falling cost curve, solar cells are several years behind wind. Solar cell sales in 2001 of nearly 400 megawatts of generating capacity represent by far the largest annual sales to date, but still this is the equivalent of the output of only a single power plant. The promise lies in the future, where—as it continues to fall—the cost will cross a critical threshold where production will begin to jump. At least one major manufacturer is planning a doubling of production this year.

Population Growing by 80 Million Annually

Janet Larsen

World population climbed to 6.2 billion in 2002, up almost 80 million or 1.3 percent from 2001. Population growth rates soared following World War II as health care improved and death rates fell. After peaking at 2.1 percent around 1970, annual world population growth fell to 1.3 percent by 1999. But even while global growth is slowing, there is a large disparity among the growth rates of individual nations, and human numbers overall continue to climb.[1]

For at least 25 years, 20 European countries and Japan have had below replacement-level fertility rates (2.1 children per woman). By now a total of 44 countries have fertility levels that low. Without the projected gain of 2 million immigrants a year from developing countries, many industrial nations would shortly experience population declines.[2]

In much of the developing world, however—home to nearly 5 billion people—populations are still growing rapidly. Even with anticipated declines in fertility rates, the developing world is projected to have 8.2 billion people by 2050. Six countries account for half of the world's annual addition: India (16 million), China (9 million), Pakistan (4 million), Nigeria (4 million), Bangladesh (3 million), and Indonesia (2 million).[3]

The 48 countries classified as least developed have even more rapid population growth. If current trends continue, the combined populations of these nations will almost triple by mid-century—from 658 million to 1.8 billion. Among the 16 countries with extremely high fertility rates (seven children or more per woman) are Afghanistan, Angola, Burkina Faso, Burundi, Liberia, Mali, Niger, Somalia, Uganda, and Yemen.[4]

Fertility rates in countries at the intermediate level, where women have between 2.1 and 5 children on average, are expected to drop below replacement level by 2050. This group includes India, Pakistan, South Korea, and Egypt, which were among the first to realize that rapid population growth makes it difficult to reach socioeconomic goals. With high population densities in their most fertile land areas, these countries recognized that fast-growing populations test the limits of both social services and nature's services.[5]

Although the availability of effective contraception is a key to slowing population growth, some 350 million women worldwide still lack access to family planning. Filling the unmet need for family planning could reduce population growth by as much as a third, given the estimated number of unintended pregnancies in the developing world.[6]

Fertility inversely correlates with levels of female education and employment. The more schooling women have, the fewer children they bear. Educating women and men about family planning services and making such services readily and discreetly available could profoundly reduce future world population size and poverty. Government-supported family planning programs increase access to reproductive and general health care. High per capita incomes, low child mortality, urbanization, and industrialization also can play a role in lowering fertility.[7]

At the International Conference on Population and Development held in Cairo in 1994, parties agreed to

fund a 20-year population and reproductive health program, with developing countries covering two thirds of the bill and donor countries paying the rest. The total yearly spending was expected to be $17 billion until 2000, and then climb to $22 billion by 2015. While developing countries have largely honored their commitment, donor countries have contributed only one third of their allotted share. The results of this shortfall are that training and services have not expanded as promised, which researchers calculate meant that between 1994 and 2000 some 122 million women became pregnant unintentionally. One third of them had abortions. In addition, an estimated 65,000 unintentionally pregnant women died in childbirth and 844,000 suffered chronic or permanent injury as a result of their pregnancies.[8]

Epidemics like HIV/AIDS reduce population projections by increasing morbidity and mortality and also by lowering fertility. AIDS is altering the demographics of many countries, especially in Africa. In Botswana, 36 percent of the adult population is HIV-positive. There, life expectancy has fallen precipitously from 70 years to 36, and Botswana's total population in 2015 is projected to be 28 percent smaller than it would be in the absence of AIDS. In Zimbabwe, life expectancy has dropped to 43 years, and in South Africa, to 47.[9]

Today nearly half the world's people live in cities, where concentrated populations facilitate disease transmission. Fortunately, high population densities also enable potentially efficient provision of services such as health care and education, if there is the political and community will.[10]

Urban areas are expected to absorb almost all of the population growth of the next 30 years. After centuries of rural-to-urban migration, three fourths of people in the industrial world live in cities. Developing countries are following this same pattern. In 1950, 18 percent of people in the developing world were urban dwellers. This more than doubled to 40 percent in 2000, and is projected to reach 56 percent by 2030, when 60 percent of the world will live in cities.[11]

Almost one third of the world today is under the age of 14. History's largest generation of young people is reaching or will soon reach reproductive age, intensifying population momentum. As medical advances allow people to live longer than ever before, the global population is also aging. Today more than 606 million people are older than 60—a number due to reach 2 billion by 2050.[12]

The gap between the U.N. high-growth projections for 2050 of 10.9 billion and the low-end scenario of 7.9 billion is equal to about half the world's current population. (See Figure 2–1.) With water and land in limited supply worldwide, whether the world moves to the higher or lower number may have more influence on environmental and social sustainability than any other variable.[13]

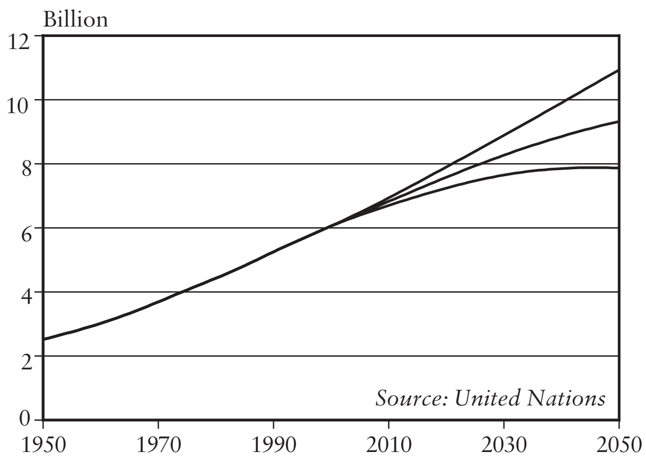

Figure 2–1. *World Population, 1950–2001, with Projections to 2050, Under Three Assumptions of Growth*

Economic Growth Losing Momentum

Lester R. Brown

In 2001, the global economy expanded by scarcely 2 percent, the slowest rate in many years. (See Figure 2–2.) With growth in the economy barely exceeding that of population, gross domestic product per person climbed from $7,392 to $7,454, a gain of less than 1 percent.[1]

Much of the global slowdown was attributable to the United States—both because it is far and away the world's largest economy and because it is the principal export market for so many countries. After expanding by a robust 4.1 percent in 2000, the U.S. economy grew by only 1.2 percent in 2001. Meanwhile, the Canadian economy was slowing in sync, dropping from an increase of 4.4 percent to 1.5 percent.[2]

In Western Europe, the four large industrial countries all experienced declines in growth in 2001. France, Italy, and the United Kingdom each dropped from 3 percent or better to around 2 percent, while Germany—the largest of the four—fell from 3 percent to less than 1.[3]

Growth in Latin America's large economies also slowed substantially. Brazil, the region's biggest, dropped from 4.4-percent growth to 1.5 percent. Argentina, in serious difficulty in recent years as a result of the cumulative effects of economic mismanagement, saw its economy shrink by nearly 5 percent in 2001. (Worse is yet to come there in 2002.) In Mexico, the other large economy in the region, growth dropped from 6.6 percent in 2000 to

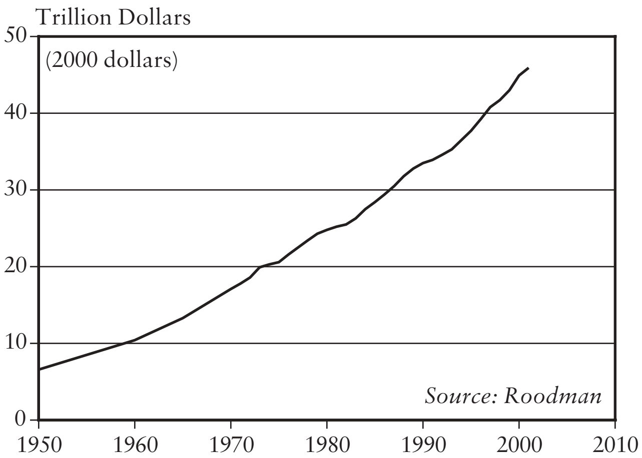

Figure 2–2. *Gross World Product, 1950–2001*

zero in 2001—one of the biggest drops recorded among the world's larger economies.[4]

Economic growth was also losing momentum in the Middle East. For Saudi Arabia, the world's leading oil exporter, it dropped from 4.5 percent in 2000 to 2.2 percent in 2001. For Iran, growth remained steady at 5 percent in 2000 and 2001. Egypt, meanwhile, dropped from 5 percent to just over 3 percent.[5]

In Asia, Japan continued to perform poorly, going from a modest growth of 2.2 percent in 2000 to an actual decline in 2001 (at –0.4 percent). Until it considers major economic reforms, including clearing up a dangerously heavy load of bad bank loans, Japan will have trouble sustaining economic growth. South Korea, which had achieved 9-percent growth in 2000, saw its expansion drop to 3 percent in 2001.[6]

The developing countries of Southeast Asia, meanwhile, did not fare well. Their overall growth rate

declined. Indonesia dropped from nearly 5 percent to 3 percent. Thailand dropped from 4.6 percent to 1.8. Malaysia, however, took a bigger hit, dropping from 8-percent growth to nearly zero.[7]

In 2001, India's growth dropped from 5.4 to 4.3 percent and Bangladesh's from 5.5 to 4.5 percent. Pakistan was stable, with an expansion of just under 4 percent in both 2000 and 2001.[8]

China continued as the star economic performer of the region, expanding by 8 percent in 2000 and dropping only slightly to 7.3 percent in 2001. Questions remain, however, about economic accounting in China, with several indirect indicators suggesting that growth has been consistently overstated.[9]

In the former Soviet republics, Russia's economic growth dropped from 9 percent in 2000 to 5 percent in 2001. In contrast, the Ukrainian economy, which has been struggling for many years, went against the tide—expanding from 6-percent growth in 2000 to 9 percent in 2001.[10]

In Africa, a few countries also countered the global trend of slower growth. Algeria's economy climbed from 2.4-percent growth in 2000 to 3.5 percent in 2001. Morocco grew from 2.4 percent to 6.3 percent. And Nigeria, helped by rising oil prices, held steady at 4 percent.[11]

Economic and social progress have not come easily in Africa. Although the region's economy resumed growth during the last decade, it was not able to match the increase in population. As a result, income per person in sub-Saharan Africa declined by some 12 percent from 1980 to 1999. Life expectancy, perhaps the best social indicator of progress, is only 50 years, and that may fall during this decade as the HIV epidemic shortens millions of lives.[12]

What these data on economic growth from the International Monetary Fund do not show is the share of economic output that is environmentally unsustainable. Available evidence suggests that as much as 8 percent of the world grain harvest may be based on the unsustainable use of water. At some point, overpumping of water will come to a halt either because it is too costly to pump from a continually falling water table or, perhaps more likely, because the aquifer is depleted. If it is a rechargeable aquifer, depletion means that pumping will necessarily be reduced to the rate of recharge. If it is a fossil aquifer—that is, nonrechargeable—pumping ends.[13]

A similar situation exists for forest products, where clearcutting and the shrinkage of the remaining forested area are reducing the long-term yield of the earth's forests. Deforestation may initially have a positive effect, but it brings its own set of costs in soil erosion and flooding.

Fisheries, too, are being overharvested in order to maximize short-term income. Some three fourths of oceanic fisheries are being fished at or beyond their sustainable yield. In some cases, governments are cutting back on the catch to try and save the fisheries. In others, the fisheries are simply collapsing. The result is the same: a reduced overall catch.[14]

These and many other trends simply underline the risks associated with dependence on economic data that do not distinguish between sustainable and unsustainable output. The failure to do so is leading to an exaggerated sense of progress and to a false sense of security.

Grain Harvest Growth Slowing

Lester R. Brown

The 2001 world grain harvest of 1,853 million tons was up 1 percent from the 2000 harvest, but below the all-time high of 1,880 million tons in 1997. (See Figure 2–3.) The U.S. Department of Agriculture reports that the harvest in 2001 fell 40 million tons short of estimated consumption. This comes on the heels of a poor crop in 2000, when output was 36 million tons short.[1]

These two consecutive disappointing harvests have reduced this year's projected world carryover stocks of grain, the amount in the bin when the new harvest begins, to 24 percent of annual consumption, the lowest level in 20 years. With stocks at such a low level, all eyes will be on the harvest in 2002. Another shortfall could lead to rising grain prices and higher prices for bread, meat, milk, eggs, and other products derived directly or indirectly from grain.[2]

The poor harvests of the last two years were largely due to weak grain prices, drought, and spreading water shortages. Grain prices among the lowest in two decades have discouraged farmers from investing in production-boosting measures.[3]

Prices that are too low to stimulate adequate production can be quickly remedied as the market responds to tighter supplies. But dealing with the water shortages that result from drought, aquifer depletion, and the diversion of scarce water to cities is much more difficult.

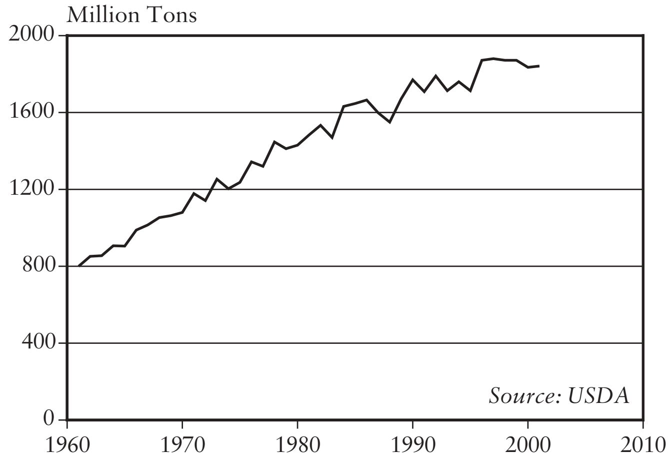

Figure 2–3. *World Grain Production, 1961–2001*

Water tables are now falling in key food-producing regions—the North China Plain, the Punjab in India, and the southern Great Plains of the United States. The North China Plain accounts for a quarter of China's grain harvest. The Punjab, a highly productive piece of agricultural real estate, is India's breadbasket. And the southern Great Plains helps make the United States the world's leading wheat exporter.[4]

In an increasingly integrated world economy, water shortages are crossing national boundaries via the international grain trade. Since it takes 1,000 tons of water to produce 1 ton of grain, the most efficient way for water-deficit countries to import water is to buy grain from elsewhere.[5]

The fastest-growing grain import market in the world today is North Africa and the Middle East, the region with the most serious water shortages. Virtually every country in this region—stretching from Morocco across

the northern tier of Africa and the Middle East through Iran—is facing water shortages. With supplies limited, countries satisfy the growing demand for water in cities and industry by taking it from agriculture. Then they import grain to offset the loss of production capacity.[6]

In recent years, grain imports into Iran, a water-short, grain-deficit country, have eclipsed those of Japan, long the world's leading wheat importer. Last year, Egypt also moved ahead of Japan. Both Iran and Egypt now import over 40 percent of the grain they consume. The populations of both countries are continuing to grow, but their water supplies are not.[7]

Grain exporters are, in effect, water exporters. Canada, where water exports are a politically sensitive issue, is one of the world's leading exporters of water in the form of grain. The 18 million tons of grain, mostly wheat, that it ships abroad each year embody 18 billion tons of water. Similarly, U.S. annual grain exports of 90 million tons of grain represent 90 billion tons of water, an amount that exceeds the annual flow of the Missouri River.[8]

The adequacy of food and water supplies are closely linked. Some 70 percent of all water that is pumped from underground or diverted from rivers is used to produce food, while 20 percent is used by industry and 10 percent goes to residential uses. With 60 percent of the world's grain harvest produced on irrigated land, anything that reduces the irrigation water supply reduces the food supply.[9]

The wild card in the world grain market is China. It accounted for virtually all of the world grain harvest shortfalls in 2000 and 2001. Indeed, in two years, it has reduced grain stocks by nearly 80 million tons.[10]

Among the forces shrinking China's grain harvest are severe drought in northern China during the last two years, spreading irrigation-water shortages as aquifers are depleted and as water is diverted to cities, and a lowering of support prices. The drought will eventually end, but water shortages will not. In a country dependent on irrigated land for 70 percent of its grain, water shortages are fast becoming a security issue.[11]

In 1994, in an ambitious and successful effort to be self-sufficient, China raised grain support prices by 40 percent. Unfortunately the drain on the treasury was too great, so the support prices were eventually lowered, dropping close to world market levels.[12]

China has absorbed the harvest shortfall of the last two years by drawing down stocks, but there are signs that supplies are now tightening. If this huge nation has another large harvest shortfall, it will likely have to import substantial quantities of grain to maintain food price stability.[13]

If the 2002 world grain harvest falls short of consumption when stocks are at a near-record low, prices will rise. Higher prices will curb demand, particularly the feeding of grain to livestock, and will encourage production. Supply and demand will again be in balance, but at a higher price.

If world grain demand continues to grow during this coming year at the 16-million-ton-per-year pace of the last decade, then the 2002 harvest will have to jump by 70 million tons to avoid a further drawdown in stocks. Whether this can occur, in the face of spreading water shortages, remains to be seen. The new reality is that if the world is facing water shortages, it is also facing food shortages.

A review of the demographic map reveals another troubling reality. Most of the 80 million people added to world population each year live in countries that already have water shortages. Restoring a balance between water supply and needs worldwide may now depend on stabilizing population in water-deficit countries.[14]

Fish Catch Leveling Off

Janet Larsen

The world fish catch in 2000, the last year for which global data are available, was reported at 94.8 million tons. After decades of steady growth, the oceanic fish catch has plateaued and since the late 1980s has fluctuated between 85 million and 95 million tons. (See Figure 2–4.) Some three fourths of oceanic fisheries are fished at or beyond their sustainable yields. In one third of these, stocks are declining.[1]

Some scientists, when correcting for suspected overreporting by China, the world's leading fishing nation, believe that global catch has actually declined by 360,000 tons each year since 1988. When catch of the highly variable stocks of Peruvian anchovetas, a species substantially affected by El Niño/Southern Oscillation events, is excluded, the world fish catch appears to have declined by 660,000 tons a year during that time.[2]

Recent evidence points to a rapid decline in production of the North Atlantic Ocean, where catches of many popular fish species, including cod, tuna, haddock, flounder, and hake, have dropped by half within the past 50 years, even though fishing efforts tripled. Previous infamous collapses, like that of the Newfoundland cod fishery, were local in scale, but this decline is ocean-wide.[3]

At least $2.5 billion of government money goes to subsidize fishing in the North Atlantic each year, supporting incomes and paying portions of boat fuel and

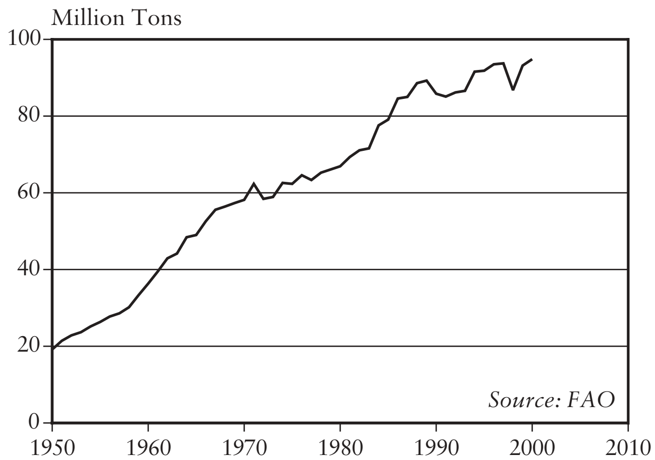

Figure 2–4. *World Fish Catch, 1950–2000*

equipment bills. Worldwide, fishing subsidies total at least $15 billion, but may be substantially higher. In 1993, the U.N. Food and Agriculture Organization reported that the operating costs of fisheries around the world exceeded commercial revenues by over $50 billion each year. Without subsidies, the world's fishing industry would be bankrupt.[4]

About 950 million people worldwide rely on fish as their primary source of protein. In addition, ocean fisheries and fish-related industries sustain the livelihoods of some 200 million people. These are high numbers to sustain on a bankrupt industry.[5]

Subsidies hide the fact that current fishing practices are unsustainable, both economically and ecologically. Subsidy money has helped to build a technologically advanced global fishing fleet of over 23,000 ships weighing more than 100 tons each. Massive ships, such as trawlers, drag big nets—quickly catching large quantities

of fish and bycatch. Some vessels have onboard processing facilities. Large ships consume a great deal of energy: it takes twice as much fuel to capture a ton of fish today as it did 20 years ago. Overall, the world's fishing fleet has the capacity to catch fish at more than twice the fisheries' sustainable yields.[6]

As fish harvests from the ocean are steady or declining, production of fish from farms (aquaculture) is booming. Since 1990, aquaculture production has grown by almost 10 percent each year, more than twice the rate for poultry, the second fastest-growing sector of the animal protein economy. Total fish-farm production in 2000 was almost 36 million tons. In 1950, aquaculture provided less than 1 percent of the fish supply; now it accounts for a full 27 percent of the world fish market.[7]

Growing fish in pens and ponds could reduce pressure on oceanic fisheries, but only if it is done wisely. A number of popular farmed fish, like salmon and shrimp, are carnivorous, requiring fish from the oceans to be harvested to provide fish meal and fish oil for their food. Some species require up to 5 kilograms of wild fish for each kilogram of fish produced. Harvesting fish for feed can empty oceans of smaller fish, depriving larger wild fish of their food supply.[8]

China, which provides 23 million tons of the world aquaculture output, has farmed fish for thousands of years. It now devotes some 5 million hectares of land to farming primarily herbivorous fish. An additional 1.7 million hectares of rice paddies double as fish ponds. China has developed an innovative carp polyculture, in which several carp species with complementary feeding habits are grown together as they would in natural ecosystems.[9]

China's onshore, integrated aquaculture and agriculture production system can serve as a model for aquaculturalists. Onshore production can minimize problems that plague marine aquaculture operations, such as coastal habitat destruction and excessive nutrient pollution, which can cause algal blooms. It also reduces the risk of introducing nonnative species through escapes and spreading diseases that fish in high-density confinement are prone to.[10]

For a number of oceanic fisheries, a deliberate reduction of fishing, along with the development of "no-take" protected areas, is the only way for stocks to rebuild. Marine reserves have been shown to increase fish populations and diversity and to produce larger fish both within their boundaries as well as in commercially accessible waters. In a matter of a few years, a nearby off-limits area can revive a foundering fishery.[11]

To protect wild stocks, consumers can reduce their overall fish consumption, or at least purchase responsibly produced herbivorous fish or those caught from well-managed fisheries. The Marine Stewardship Council, an independently operated international accreditation organization, has certified six fisheries as sustainable. Careful management of fisheries can be likened to prudent use of an endowment: if the principal, or the stock, is conserved, people can live off the interest indefinitely.[12]

Forest Cover Shrinking

Janet Larsen

Global forest cover is a key indicator of the health of the planet. An intact forest cycles nutrients, regulates climate, stabilizes soil, treats waste, provides habitat, and offers opportunities for recreation. By a conservative tally, these services are worth more than $4.7 trillion, a total equal to one tenth of the gross world product. Forests also supply goods, including food, medicines, and a large array of wood-based products.[1]

Forests worldwide cover some 3.9 billion hectares—almost a third of the earth's land surface excluding Antarctica and Greenland. Though vast, this wooded area is only half the size of forested land at the dawn of agriculture some 11,000 years ago. Most forests are no longer in their original condition, having changed in composition and quality.[2]

Global estimates of forest cover change are difficult to make because of conflicting definitions of what constitutes a forest, lack of satellite and radar data, and unmonitored land use change. The U.N. Food and Agriculture Organization conservatively estimates that the world lost 94 million hectares of forest in the last decade of the twentieth century. (See Table 2–1.) This number assumes that developing countries lost 130 million hectares while the industrial world gained 36 million hectares as abandoned agricultural areas returned to forest. The yearly loss of natural forests during this period, which includes defor-

Table 2–1. *Change in World Forest Cover, 1990–2000*

Continent	Total Forest 1990	Total Forest 2000	Change, 1990–2000
	(million hectares)		(percent)
Africa	702	650	–7.8
Asia	551	548	–7.0
Oceania	201	198	–1.8
Europe	1,030	1,039	+0.8
North and Central America	555	549	–1.0
South America	923	886	–4.1
World	3,963	3,869	–2.2

Source: U.N. Food and Agriculture Organization, *State of the World's Forests 2001* (Rome: 2001).

estation plus the conversion of natural forests to tree plantations, was 16 million hectares—94 percent of which occurred in the tropics.[3]

During the 1990s, Brazil suffered the heaviest loss of forest—23 million hectares. South America as a whole saw net losses of 37 million hectares. In Africa, 52 million hectares were destroyed. Sudan, Zambia, and the Democratic Republic of the Congo account for half of Africa's forest loss. While the United States gained 4 million hectares of forests, Mexico lost over 6 million, although government reports reveal the loss may be even higher. The total net losses for North and Central America were 6 million hectares.[4]

A massive reforestation campaign in China meant the country added an average of 1.8 million hectares each year during this period, largely because bans on deforestation near the end of the decade heightened the country's reliance on plantations and imports of forest products from other nations. In Indonesia, where tree felling destroyed 13 million hectares over the decade, forest loss has accelerated and now averages 2 million hectares each year. Over the decade, forest cover in all of Asia declined by 4 million hectares.[5]

Although FAO data suggest that world forest loss is slowing, deforestation in tropical areas is accelerating, likely exceeding 13 million hectares each year. As tree cutting in many parts of the world accelerates, nearly half of the remaining forests are at risk. The World Resources Institute estimates that about 40 percent of the world's intact forests will be gone within 10–20 years, if not sooner, considering current deforestation rates.[6]

Wood consumption drives deforestation. Since 1960, global industrial wood production has risen by 50 percent, to 1.5 billion cubic meters, four fifths of which is from primary and secondary-growth forests. About the same quantity, 1.8 billion cubic meters, is burned directly as wood fuel each year in developing countries.[7]

Worldwide, only some 290 million hectares of forested land are under protection from logging, but even protected areas are threatened by illegal exploitation. Of 200 areas of high biological diversity worldwide, illegal logging threatens 65 percent. All told, illegal logging has devastated public forests around the globe, reducing incentives for locals to invest in sustainable forestry and accumulating losses of revenue to governments of some $15 billion annually.[8]

Forest plantations now cover more than 187 million hectares, less than 5 percent of total forested area, but account for 20 percent of current world wood production. As natural forests are exhausted or come under protection, a growing share of future wood demand will be satisfied from tree farms.[9]

Well-planned and managed plantations can efficiently satisfy timber demand. Unfortunately, the world has seen many plantations raised at the expense of old growth or other extremely diverse natural forests. In some cases, governments grant forest concessions to logging companies contingent on their planting of replacement trees, but after the companies clearcut, they leave the land bare and move to new areas. In Indonesia, for example, 9 million hectares have been allocated for development as industrial timber plantations, but only 2 million hectares have been replanted.[10]

Areas bereft of their original forest ecosystems and associated habitat have lost vegetation that stabilizes soil, cycles nutrients, and prevents erosion. These lands quickly lose utility and become a liability. Even when plantations are put in place, the functioning of a monoculture plantation is a far cry from that of an old-growth forest, where a number of species of differing ages each play a particular biological role, and ecosystem processes are thus bound to change.

A satellite-based survey of the world's forests by the U.N. Environment Programme, along with NASA and the U.S. Geological Survey, found that 80 percent of largely intact forests (those with a canopy closure of over 40 percent) are located in just 15 countries. A full 88 percent of the key closed forest areas are sparsely populated, making them hopeful targets for conservation. Short of calling for a moratorium of all logging, conservation in these 15 countries offers a reasonable starting point for forest preservation.[11]

Crucial to slowing the loss of the world's natural forests is finding alternative sources of energy for low-income countries, so that valuable wood is not burned. Innovations in reuse and recycling allow reclaimed timber and discarded paper to satisfy wood product demand.

Reduced consumption of virgin wood products is a key to saving the world's trees.

When wood products are used, governments can ensure that all domestic production and imports of wood products come from responsibly managed forests meeting rigorous environmental and social standards, like those of the Forest Stewardship Council (FSC). Worldwide, FSC-accredited bodies have certified some 24 million hectares of forests in 45 countries, numbers that are bound to increase as demand for certified wood rises and as noncertified sellers have difficulty competing.[12]

Water Scarcity Spreading

Lester R. Brown

Water scarcity may be the most underestimated resource issue facing the world today. As world water demand has more than tripled over the last half-century, signs of water scarcity have become commonplace. Some of the more widespread indicators are rivers running dry, wells going dry, and lakes disappearing.[1]

Among the rivers that run dry for part of the year are the Colorado in the United States, the Amu Darya in Central Asia, and the Yellow in China. China's Hai and Huai rivers have the same problem from time to time, and the flow of the Indus River—Pakistan's lifeline—is sometimes reduced to a trickle when it enters the Arabian Sea.[2]

The Colorado River, the largest in the southwestern United States, now rarely makes it to the sea. As the demand for water increased over the years, diversions from the river have risen to where they now routinely drain it dry.[3]

A similar situation exists in Asia, where the Amu Darya—one of the two rivers feeding the Aral Sea—now is dry for part of each year. With the sharp decline in the amount of water delivered to the Aral Sea by the Amu Darya, the sea has begun to shrink. There is a risk that the Aral could one day disappear entirely, existing only on old maps.[4]

China's Yellow River, the northernmost of its two major rivers, first ran dry for a few weeks in 1972. Since

1985, it has failed to make it to the Yellow Sea for part of almost every year. Sometimes the river does not even reach Shandong, the last province it flows through en route to the sea. As water tables have fallen, springs have dried up and some rivers have disappeared entirely. China's Fen River, the major watercourse in Shanxi Province, which once flowed through the capital of Taiyuan and merged with the Yellow, no longer exists.[5]

Another sign of water scarcity is disappearing lakes. In Central Africa, Lake Chad has shrunk by some 95 percent over the last four decades. Reduced rainfall, higher temperatures, and some diversion of water from the streams that feed Lake Chad for irrigation are contributing to its demise. In China, almost 1,000 lakes have disappeared in Hebei Province alone.[6]

Water tables are falling in several of the world's key farming regions, including under the North China Plain, which produces nearly one third of China's grain harvest; in the Punjab, which is India's breadbasket; and in the U.S. southern Great Plains, a leading grain-producing region.[7]

Water shortages now plague almost every country in North Africa and the Middle East. Algeria, Egypt, Iran, and Morocco are being forced into the world market for 40 percent or more of their grain supply. As population continues to expand in these water-short nations, dependence on imported grain is rising.[8]

Iran, one of the most populous countries in the Middle East, with 70 million people, is facing widespread water shortages. In the northeast, Chenaran Plain—a fertile agricultural region to the east of Mashad, one of Iran's largest and fastest-growing cities—is fast losing its water supply. Wells drawing from the water table below the plain are used for irrigation and to supply water to Mashad. The latest official estimate shows the water table falling by 8 meters in 2001 as the demand for water far outstrips the recharge rate of aquifers.[9]

Falling water tables in parts of eastern Iran have caused many wells to go dry. Some villages have been evacuated because there is no longer any accessible water. Iran is one of the first countries to face the prospect of water refugees—people displaced by the depletion of water supplies.[10]

In Yemen, a country of some 19 million people, water tables are falling everywhere by 2 meters or more a year. In the basin where the capital Sana'a is located, extraction exceeds recharge by a factor of five, dropping the water table by 6 meters (about 20 feet) a year. Recent wells drilled to a depth of 2 kilometers (1.3 miles) failed to find any water. In the absence of new supplies, the Yemeni capital will run out of water by the end of this decade.[11]

Another way of looking at water security is the amount of water available per person in a country. In 1995, 166 million people lived in 18 countries where the average supply of fresh water was less than 1,000 cubic meters a year—the amount deemed necessary to satisfy basic needs for food, drinking water, and hygiene. By 2050, water availability per person is projected to fall below the 1,000-cubic-meter benchmark in some 39 countries. By then, 1.7 billion people will in effect be suffering from hydrological poverty.[12]

At some point, the combination of aquifer depletion and the diversion of irrigation water to cities will likely begin to reduce the irrigated area worldwide. Data compiled by the U.N. Food and Agriculture Organization, based on official data submitted by governments, show irrigated area still expanding. For example, between 1998 and 1999, the last year for which global data are available, irrigated area grew from 271 to 274 million hectares. (See

Figure 2–5.) This reported 1-percent growth would be reassuring, but it appears to be overstated since governments are much better at gathering data on new irrigation projects than on irrigation reductions as water is diverted to cities or aquifers are depleted. It is quite possible that the historical growth in world irrigated area has come to a halt, and the area could even be declining.[13]

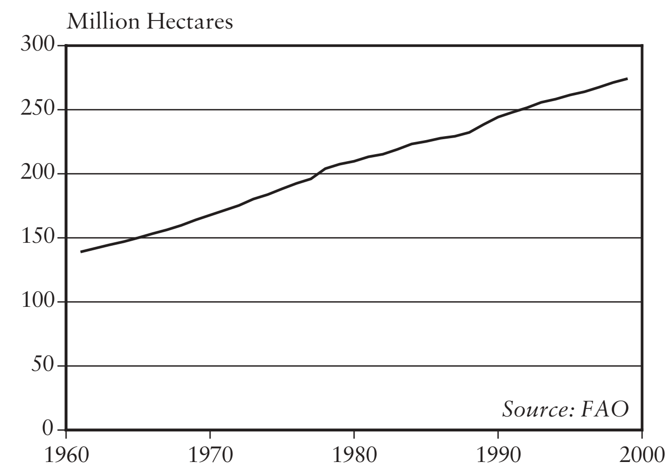

Figure 2–5. *World Irrigated Area, 1961–1999*

Carbon Emissions Climbing

Bernie Fischlowitz-Roberts

Though economic growth slowed throughout much of the world during 2001, world carbon emissions from burning fossil fuels continued their relentless upward trend, surpassing 6.5 billion tons. (See Figure 2–6.) As a result of the consistent growth of emissions, the atmospheric concentration of carbon dioxide (CO_2) has increased from the preindustrial level of 280 parts per million (ppm) to today's 370 ppm, a 32-percent increase. In the last 20 years, the atmospheric concentration of CO_2 has increased at the unprecedented rate of 1.5 ppm a year.[1]

In 1950, carbon emissions stood at 1.6 billion tons. By 1977, that had more than tripled, to 4.9 billion tons. In 2000, carbon emissions approached 6.5 billion tons, a quadrupling in just 50 years. Since the atmosphere's capacity to fix carbon is fairly constant, as the volume of emissions rises, the earth fixes a decreasing percentage of emissions. The increased atmospheric concentrations of CO_2 and other greenhouse gases (GHG) trap more of the earth's heat, causing temperatures to rise. These in turn are responsible for melting ice, rising sea levels, and a greater number of more destructive storms.[2]

Three fourths of the carbon emissions from human activities are due to the combustion of fossil fuels; the rest is caused by changes in land use, principally deforestation. Global energy consumption is projected to rise 60 percent over the next 20 years. Coal use is expected to

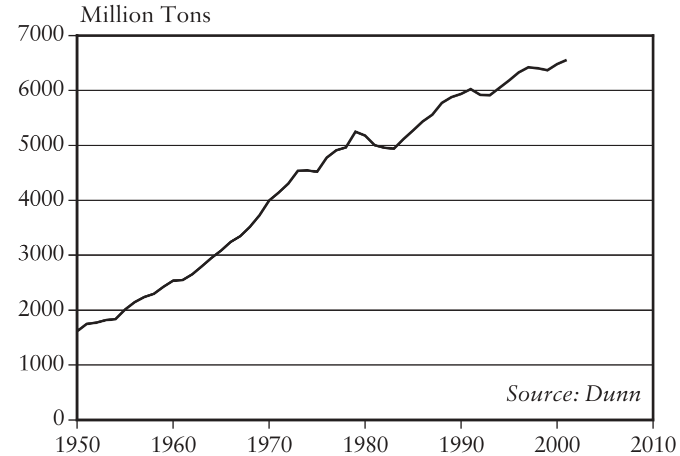

Figure 2–6. *World Carbon Emissions From Fossil Fuel Burning, 1950–2001*

increase by 45 percent, oil consumption by 58 percent, and natural gas by 93 percent, according to the U.S. Department of Energy. Since coal consumption has actually declined by 6 percent since its peak in 1996, however, there is reason to believe its use will either continue to drop or will increase less than projected. Yet even if coal usage remains steady over the next 20 years, the current level of emissions from all fossil fuels is simply too high. The increasing use of fossil fuels will only exacerbate changes in global climate.[3]

According to the Intergovernmental Panel on Climate Change (IPCC), atmospheric CO_2 concentrations by 2100 will be in the range of 650 to 970 ppm—more than double or triple preindustrial levels. As a result, the global average surface temperature will likely rise between 1.4 and 5.8 degrees Celsius between 1990 and 2100, an unprecedented rate of increase.[4]

Four major sectors produce carbon emissions. Electricity generation is responsible for the largest share—42 percent. Transportation generates 24 percent of global emissions. Industrial processes account for 20 percent, and residential and commercial uses produce the remaining 14 percent.[5]

Fortunately, changes can be made in each of these sectors to reduce carbon emissions using readily available technology. Shifting to wind, solar, and geothermal power for all electricity generation could greatly reduce the use of fossil fuels. Increased appliance and machinery efficiency could lower industrial and residential energy use. In the short term, shifts away from personal vehicles toward mass transit, along with increases in fuel efficiency, can reduce transportation emissions. And in the longer term, use of hydrogen-fueled cars and buses could cut emissions even further.

The United States is far and away the world's leading producer of carbon emissions, with 24 percent of the global total. China is responsible for 14 percent, and Russia accounts for 6 percent. Japan, whose economy is the second largest in the world, and India, whose population is second only to China, are each responsible for 5 percent of world emissions.[6]

Various policy measures have been put forward to address climate change and reduce concentrations of CO_2 and other greenhouse gases. The most prominent is the Kyoto Protocol, which commits industrial nations to reduce their emissions by at least 5 percent below 1990 levels by 2008–12. To enter into force, 55 countries representing 55 percent of emissions from industrial and former Eastern bloc nations must ratify the treaty. As of early June 2002, 74 countries responsible for 35.8 percent of global GHG emissions have ratified the protocol, including Japan and all nations of the European Union.

But with the United States and Australia refusing to ratify, the likelihood that it will enter into force is considerably diminished.[7]

In the United States, the Bush administration's "Clean Skies" proposal requires a decline in carbon emissions per unit of economic output (known as carbon intensity), but not overall carbon emissions. The flawed premise underlying the proposal is that economic growth cannot be achieved without significant carbon emission increases; thus "Clean Skies" will not fundamentally alter the U.S. emissions trajectory. The U.S. economy has consistently improved its carbon intensity, yet emissions have continued to increase. According to the American Council for an Energy-Efficient Economy, the carbon intensity of the U.S. economy was cut by 17 percent between 1990 and 2000, yet total emissions increased during that time by 14 percent due to a 39-percent increase in economic activity.[8]

The Kyoto Protocol, even if implemented, is only a first step. According to the IPCC, stabilizing atmospheric levels of CO_2 at 450 ppm would require fossil fuel emissions to drop below 1990 levels within a few decades, and eventually to decline to a small fraction of current levels.[9]

Regardless of the ultimate fate of the Kyoto Protocol, other policy initiatives show promise. Decreasing or eliminating government subsidies to fossil fuels, which total $300 billion annually worldwide, can move the energy economy away from heavy reliance on carbon-intensive fossil fuels. Decreasing taxes on income while instituting or increasing carbon taxes would constructively align economic and environmental goals. Increasing funding for further research and development of clean energy technologies can also help move the world from a carbon-based and toward a hydrogen-based energy system. Finally, stabilizing human population sooner rather than later will help reduce future emissions.[10]

Global Temperature Rising

Lester R. Brown

Last year, 2001, was the second warmest year since recordkeeping began in 1867. Following the all-time high of 1998, last year's near-record extends a strong trend of rising temperatures that began around 1980. The 15 warmest years since 1867 have all come since 1980. (See Figure 2–7.)[1]

This new year of temperature data provides further evidence that a trend of rising temperature is bringing to an end the period of relative climate stability that has prevailed since agriculture began some 11,000 years ago.

Monthly global temperature data compiled by NASA's Goddard Institute for Space Studies, in a series based on meteorological station estimates going back to 1867, show that September 2001 was the warmest September on record. November also set an all-time high. And six recent months—August and December 2001 and January, March, April, and May 2002—were each the second warmest respective months on record.[2]

The global average temperature for 2001 is calculated at 14.52 degrees Celsius (58.1 degrees Fahrenheit). The all-time high in 1998 was 14.69 degrees Celsius. Over the last century, the average global temperature climbed from 13.88 degrees Celsius in 1899–1901 to 14.44 degrees in 1999–2001, an increase of 0.56 degrees. But four fifths of this gain came in the century's last two decades.[3]

The rise of nearly 0.6 degrees Celsius during the last

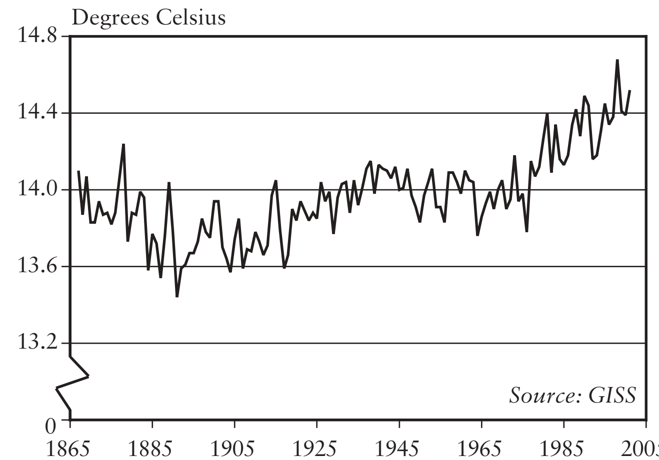

Figure 2–7. *Average Global Temperature, 1867–2001*

century is quite small compared with projections by the Intergovernmental Panel on Climate Change (IPCC) of the temperature rise for this century of 1.4–5.8 degrees Celsius (2.5–10.4 degrees Fahrenheit). Even the lower figure in that range would be more than double the increase of the last century. And the upper-end projection would be nearly 10 times as much.[4]

The contrast in sea level rise for the last century and that projected for this one is similarly worrying. During the last century, sea level rose an estimated 10–20 centimeters (4–8 inches). The IPCC projects that during this century sea level will rise 9–88 centimeters (4–35 inches).[5]

Rising temperature is not an irrelevant abstraction. It brings countless physical changes—from more intense heat waves, more severe droughts, and ice melting to more powerful storms, more destructive floods, and rising sea level. These changes in turn affect not only food security and the habitability of low-lying regions, but also the species composition of local ecosystems.

Climate change affects food security in many ways. In 2000, the World Bank published a map of Bangladesh showing that a 1-meter rise in sea level would inundate half of that country's riceland. Bangladesh would lose not only half its rice supply but also the livelihoods of a large share of its population. The combination of a population of 134 million expanding by 2.7 million a year and a shrinking cropland base is not a reassuring prospect for Bangladesh.[6]

Widespread changes in ecosystems are also being triggered. Recent years have brought heavy investments by governments and environmental organizations to protect particular ecosystems by converting them into parks or reserves. But if the rise in temperature cannot be checked, there is not an ecosystem on the earth that can be saved. Everything will change.

An additional year of temperature data reinforces the concerns expressed by the team of eminent scientists who produced the latest IPCC report, *Climate Change 2001*. They make clear what is now becoming obvious even to nonscientists: fossil fuel burning is changing the earth's climate.[7]

The bottom line is that altering the earth's climate is serious business—not something to be taken lightly. We can curb climate change by shifting from a carbon-based energy economy to one based on hydrogen. We have the technologies to do it. The economics are falling into place. Do we have the wisdom and the will to restructure the energy economy before climate change spirals out of control?

Ice Melting Everywhere

Lester R. Brown

Several new studies report that the earth's ice cover is melting faster than projected by the Intergovernmental Panel on Climate Change (IPCC) in its landmark report released in early 2001. (See Table 2–2.) Among other things, this means that the IPCC team, which did not have the ice melt data through the 1990s, will need to revise upward its projected rise in sea level for this century—currently estimated to range from 9 to 88 centimeters (4 to 35 inches).[1]

A study by two scientists from the University of Colorado's Institute of Arctic and Alpine Research found that melting of the large glaciers on the west coast of Alaska and in northern Canada is accelerating. Earlier data indicated that the melting of glaciers in these areas was raising sea level by 0.14 millimeters per year, but new data for the 1990s indicate that the more rapid melting is causing an increase of 0.32 millimeters a year, more than twice as fast.[2]

The Colorado study is reinforced by a U.S. Geological Survey (USGS) study that indicates glaciers are now shrinking in all 11 of Alaska's glaciated mountain ranges. An earlier USGS study reported that the number of glaciers in Glacier National Park in the United States had dwindled from 150 in 1850 to fewer than 50 today. It projected the remaining glaciers would disappear within 30 years.[3]

Another team of USGS scientists, using satellite data to

Table 2–2. *Selected Examples of Ice Melt Around the World*

Name	Location	Measured Loss
Arctic Sea Ice	Arctic Ocean	Over the last 35 years, ice has thinned from average of 3.1 meters to 1.8 meters. Could have ice-free summers before 2050.
Greenland Ice Sheet	Greenland	Has thinned by more than a meter a year on its southern and eastern edges since 1993.
Glacier National Park	Rocky Mtns., United States	Since 1850, the number of glaciers has dropped from 150 to fewer than 50. Remaining glaciers could disappear in 30 years.
Larsen B Ice Shelf	Antarctic Peninsula	Over the past five years has lost 5,700 square kilometers, 3,250 of which disintegrated in early 2002.
Ross Ice Shelf	Ross Sea	In March 2000, a piece of Ross Ice Shelf the size of Connecticut broke off, making one of the largest icebergs ever seen.
Dokriani Bamak Glacier	Himalayas, India	Retreated by 20 meters in 1998, compared with 16.5 meters over the previous five years.
Tien Shan Mountains	Central Asia	In the past 40 years, 22 percent of glacial volume has vanished.
Caucasus Mountains	Russia	Glacial volume has declined by 50 percent in the past century.
Alps	Western Europe	Glacial volume has shrunk by more than 50 percent since 1850.
Kilimanjaro	Tanzania	Ice cap shrunk by 33 percent from 1989 to 2000. Could disappear by 2015.
Quelccaya Ice Cap	Andes, Peru	Rate of retreat increased to 30 meters a year in the 1990s, up from only 3 meters a year; will likely disappear before 2020.

Source: See endnote 1.

measure changes in the area covered by glaciers, describes an accelerated melting of glaciers in several mountainous regions, including the South American Andes, the Swiss Alps, and the French and Spanish Pyrenees.[4]

Glaciers are shrinking faster throughout the Andes. Professor Lonnie Thompson of Ohio State University reports that for the Qori Kalis glacier, on the west side of the Quelccaya ice cap in the Peruvian Andes, the annual shrinkage from 1998 to 2000 was three times that which occurred between 1995 and 1998. And that, in turn, was nearly double the annual rate of retreat from 1993 to

1995. Thompson projects that the large Quelccaya ice cap will disappear entirely between 2010 and 2020.[5]

The vast snow/ice mass in the Himalayas, which ranks third after Antarctica and Greenland in the amount of fresh water stored, is also retreating. Although data are not widely available for the Himalayan glaciers, those that have been studied indicate an accelerating retreat. For example, data for the 1990s show that the Dokriani Bamak Glacier in the Indian Himalayas moved back by 20 meters in 1998 alone, more than during the preceding five years.[6]

Thompson has also studied Kilimanjaro, observing that between 1989 and 2000, this famous mountain in

Tanzania lost 33 percent of its ice field. He projects that the ice could disappear entirely within the next 15 years.[7]

Both the North and the South Poles are showing the effects of climate change too. The South Pole is covered by a continent the size of the United States. The Antarctic ice sheet, which is 2.5 kilometers (1.5 miles) thick in some places, contains over 70 percent of the world's fresh water and 90 percent of the earth's ice.[8]

While this vast ice sheet is relatively stable, the ice shelves—the portions of the ice sheet that extend into the surrounding seas—are fast disappearing. Over the past five years, the Larsen B ice shelf on the Antarctic Peninsula has lost more than 5,700 square kilometers of ice, half of which disappeared in the early months of 2002. Delaware-sized icebergs that have broken off are a threat to ships in the area.[9]

While the South Pole is covered by a huge continent, the North Pole is covered by the Arctic Ocean. Arctic sea ice is melting fast. Over the last 35 years, the ice has thinned 42 percent—from an average of 3.1 meters to 1.8 meters. It has also shrunk by 6 percent since 1978. Together, thinning and shrinking have reduced the mass of sea ice by half. A team of Norwegian scientists projects that the Arctic Sea could be entirely ice-free during the summer by mid-century, if not before.[10]

If this melting materializes as projected, the early explorers' dream of a northwest passage—a shortcut from Europe to Asia—could be realized. Unfortunately, what was a dream for them could be a nightmare for us.

If the Arctic Ocean becomes ice-free in the summer, it would not affect sea level because the ice is already in the water, but it would alter the regional heat balance. When sunlight strikes ice and snow, most of it is reflected back into space, but if it strikes land or open water, then much of the energy in the light is absorbed, leading to higher temperatures. This is what computer modelers refer to as a positive feedback loop, a situation where a trend creates self-reinforcing conditions.

Richard Kerr, writing in *Science*, notes that summer "would convert the Arctic Ocean from a brilliantly white reflector sending 80 percent of solar energy back into space into a heat collector absorbing 80 percent of [incoming sunlight]." The discovery of open water at the North Pole by an ice breaker cruise ship in August 2000 provides further evidence that the melting process may now be feeding on itself.[11]

This prospect of much warmer summers in the Arctic is of concern because Greenland, which has the world's second largest ice sheet, is largely within the Arctic Circle. In a *Science* article in 2000, a team of U.S. scientists from NASA reported that the vast Greenland ice sheet is starting to melt.[12]

The team also reports that the melting there appears to be accelerating because the ice sheet on its southern and eastern edges has thinned by more than a meter a year since 1993. If all the ice on Greenland were to melt, it would raise sea level by 7 meters (23 feet), but even under a high temperature rise scenario, it could take many centuries for it to melt completely.[13]

The accelerated melting of ice, particularly during the last decade or so, is consistent with the accelerating rise in temperature that has occurred since 1980. With the IPCC projecting global average temperature to rise by 1.4–5.8 degrees Celsius (2.5–10.4 degrees Fahrenheit) during this century, the melting of ice will likely continue to gain momentum.[14]

Our generation is the first to have the capacity to alter the earth's climate. We are also, therefore, the first to wrestle with the ethical question of whether the capacity to change the planet's climate gives us the right to do so.

Wind Electric Generation Soaring

Lester R. Brown

World wind electric generating capacity climbed from 17,500 megawatts (MW) in 2000 to 24,000 MW in 2001—a dramatic one-year gain of 6,500 MW or 37 percent. As generating costs continue to fall and as public concern about climate change escalates, the world is fast turning to wind for its electricity.[1]

Since 1995, world wind generating capacity has increased an astounding fivefold. In stark contrast, the use of coal—the principal alternative for generating electricity—peaked in 1996 and has declined by 6 percent since then.[2]

One megawatt of wind generating capacity typically will satisfy the electricity needs of 350 households in an industrial society, or roughly 1,000 people. Thus, the 24,000 MW of generating capacity now in place is sufficient to meet the residential electricity needs of some 24 million people—equal to the combined populations of Denmark, Finland, Norway, and Sweden.

In wind electric generating capacity, Germany leads the world with 8,750 MW, more than a third of the total. The United States, which launched the modern wind power industry in California in the early 1980s, follows with 4,250 MW. Spain is in third place, with 3,300 MW. Denmark, which is fourth with 2,400 MW, now gets more than 15 percent of its electricity from wind. Almost two thirds of the capacity added in 2001 was concentrated in the top three countries: Germany added 2,600 MW; the United States, 1,700; and Spain, 930. For the United States, this translates into a growth in generating capacity of some 67 percent in 2001.[3]

Despite this spectacular growth, development of the earth's wind resources has barely begun. In densely populated Europe, there is enough easily accessible offshore wind energy to meet all of the region's electricity needs. In the United States, the wind-rich states in the Great Plains have enough harnessable wind energy to meet the country's electricity needs. And China can easily double its current electricity generation from wind alone.[4]

The cost of wind-generated electricity at prime wind sites has fallen dramatically in the United States over the last 15 years—from 35¢ per kilowatt-hour in the mid-1980s to 4¢ per kilowatt-hour in 2001. (See Figure 2–8.) A few long-term supply contracts have even been signed recently for 3¢ per kilowatt-hour. With the U.S. adoption of a wind production tax credit (PTC) in 1993 to offset established subsidies for oil, coal, and nuclear power, growth surged. New wind farms came online in Colorado, Iowa, Kansas, Minnesota, New York, Oregon, Pennsylvania, Texas, Washington, and Wyoming. In March 2002, the PTC was extended until the end of 2003, setting the stage for continuing rapid growth.[5]

Low-cost electricity from wind brings the option of electrolyzing water to produce hydrogen, which can easily be stored and used to fuel gas-fired turbines in backup power plants when wind power ebbs. Over time, hydrogen produced with wind-generated electricity is the leading candidate to replace natural gas in gas-fired power plants as gas reserves are depleted.

Hydrogen is also the ideal fuel for the fuel-cell engines that every major automobile manufacturer is now working on. Honda and DaimlerChrysler both plan to have

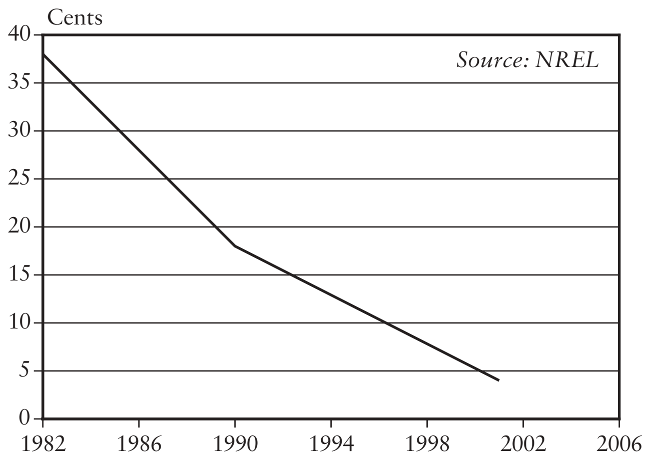

Figure 2–8. *Average Cost Per Kilowatt-Hour of Wind-powered Electricity in the United States, 1982–2001*

fuel-cell-powered vehicles on the market in 2003.[6]

Wind power offers long-term price stability and energy independence. Not only are costs low and falling, but with wind-generated electricity there are no abrupt price hikes, as there are with natural gas. There is no OPEC for wind, because wind is widely dispersed. An inexhaustible source of energy, wind offers more energy than society can use, and it does not disrupt climate.

Investment in wind turbine manufacture and wind development has been highly profitable. While high-tech firms as a group suffered a disastrous fall in sales, earnings, and stock value in 2001, sales in the wind industry soared. At Danish-based Nordex, for example, one of the world's largest turbine manufacturers, turnover during the first half of fiscal year 2001/2002 was up 47 percent.[7]

Even more impressive than the recent growth in generating capacity are the plans for future growth. The

European Wind Energy Association has recently revised its 2010 wind capacity projections for Europe from 40,000 megawatts to 60,000 megawatts.[8]

France, which for years had ignored wind power, announced in December 2000 that it would develop 5,000 megawatts of wind-generating capacity during this decade. A few weeks later, Argentina announced it was planning to develop 3,000 megawatts of wind-generating capacity in Patagonia. In April 2001, the United Kingdom sold offshore lease rights for an estimated 1,500 megawatts of wind-generating capacity to several different bidders, including Shell Oil. And in early 2002, China announced plans to develop up to 1,200 megawatts of wind capacity by 2005.[9]

In the United States, wind generating capacity is growing by leaps and bounds. The 261-megawatt Stateline Wind Project on the border between Oregon and Washington will be expanded to 300 megawatts later this year, making it the world's largest wind farm. Texas added some 900 megawatts in several projects during 2001, including a 278-MW wind farm at King Mountain in west Texas, currently the world's largest. In South Dakota, Jim Dehlsen, a pioneer in developing California's wind energy, has secured the wind rights to 90,000 hectares (222,000 acres) of farm and ranchland in the east central part of the state. He plans to develop a huge 3,000-megawatt wind farm and to transmit the electricity across Iowa, supplying Illinois and other states in the industrial Midwest.[10]

In Europe, offshore projects are now springing up off the coasts of Belgium, Denmark, France, Germany, Ireland, the Netherlands, Scotland, Sweden, and the United Kingdom.

The German Wind Energy Institute projects installation of 2,900 MW in 2002, and 2,400 MW in 2003. If these installations materialize as projected, total installed capacity in the country will easily surpass the German government's 2010 goal of 12,500 MW by the end of 2003.[11]

Projecting future growth in such a dynamic industry is complicated, but once a country has developed 100 megawatts of wind-generating capacity, it tends to move quickly to develop its wind resources. The United States crossed this threshold in 1983. In Denmark, this occurred in 1987. In Germany, it was 1991, followed by India in 1994 and Spain in 1995.[12]

By the end of 1999, Canada, China, Italy, the Netherlands, Sweden, and the United Kingdom had also all crossed this threshold. During 2000, Greece, Ireland, and Portugal joined the list. And in 2001, it was France and Japan. So as of early 2002, some 16 countries—home to half the world's people—have entered the fast-growth phase in wind power development.[13]

Wind energy in the form of electricity and hydrogen can satisfy all the various energy needs of a modern economy, and it promises to become the foundation of the new energy economy. We can now see the shape of this new economy emerging as wind turbines replace coal mines, hydrogen generators replace oil refineries, and fuel-cell engines replace internal combustion engines.

Bicycle Production Breaks 100 Million

Janet Larsen

Over 100 million bicycles were manufactured in 2000, the most since the all-time high of 106 million in 1995. (See Figure 2–9.) This production level is double that of 25 years ago.[1]

China manufactured a record 52 million bicycles in 2000—over half the world total. Nearly two thirds of these were exported, with 17 million going to the United States. The United States itself produced just over 1 million bikes, down sharply from the 1995 output of nearly 9 million. With over 43 million cyclists, the United States is the world's largest bicycle export market, with imports meeting 97 percent of demand.[2]

The European Union, led by Germany, produced some 12 million bicycles in 2000. Italy closely trails German production of 3.2 million bicycles, although cycle sales in Germany reached 5.3 million in 2000, compared with 1.6 million units in Italy.[3]

India produced more than 11 million bicycles. Most of these are ridden domestically or shipped to Africa. Africa is a potentially large bicycle market, but recently sales have declined in many countries despite the continued need for low-cost, non-motorized transportation. One reason for this trend is a shortage of moderately priced, modern bikes and bike parts.[4]

This shortage is seen in Senegal, which levies prohibitive tariffs on imported cycles to protect a small

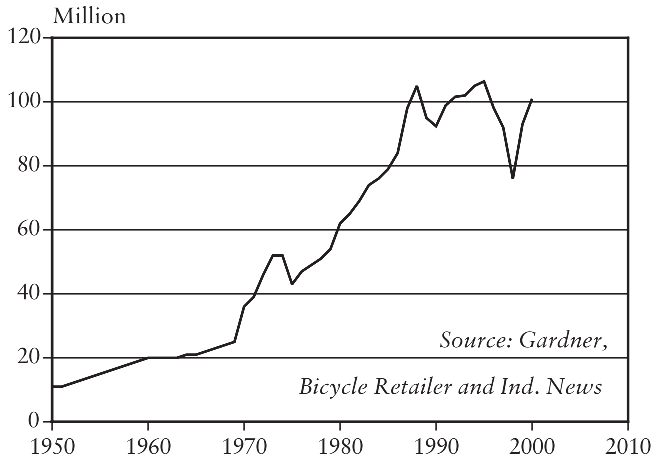

Figure 2–9. *World Bicycle Production, 1950–2000*

domestic manufacturer that sells only 2,000 bikes annually. Until 1989, Ghana imposed similar tariffs and taxes on imports, but after their removal, bike sales soared.[5]

To meet Africa's high demand for modern and sturdy bicycles, the Institute for Transportation and Development Policy, an organization that promotes environmentally sustainable and equitable transportation policies worldwide, and Afribike, a nonprofit South African company, designed the Africa Bike. This is an alternative to the traditional Black Roadster, which now sells poorly because it does not meet performance standards and because many associate it with rural, elderly, and poor people. Both models retail at about $60. Afribike alone has provided over 10,000 South Africans with low-cost transportation since 1998 and plans to expand its programs to Senegal, Guinea, and Ghana.[6]

Bicycle ownership greatly enhances personal mobility, contributing to substantial increases in income. Giving

women in rural areas credit to buy bicycles allows for increased access to education and facilitates the transport of produce to market. Thus rising bicycle sales have been correlated with higher farm output. In Ghana, bikes have helped HIV/AIDS outreach workers reach 50 percent more beneficiaries.[7]

In urban areas, bicycles can substitute for automobiles, reducing traffic congestion and lowering air pollution and noise. Bicycles take up one thirtieth the road space used by cars traveling at a moderate pace. Biking also offers exercise at a time when more people are overweight or obese than ever before, even in developing countries. For those who need help traveling long distances or in hilly terrain, increasingly popular electric bicycles that run on batteries often fit the bill. By 2003, bicycles powered by fuel cells will hit the market.[8]

A number of cities, particularly in industrial countries, are promoting the bicycle as a sustainable form of transportation by developing cycleways and offering incentives for using bicycles for commuting. In Copenhagen, one third of the population commutes to work by bicycle. By 2005, Copenhagen's innovative City Bike program will provide 3,000 bicycles for free use within the city. The city's total cycle fleet is expected to grow, as city planners intend to increase already high car parking fees by 3 percent annually for 15 years, impose high fuel taxes and vehicle registration costs, and concentrate future development around rail lines.[9]

Stockholm, one of the world's wealthiest cities, has seen car use decline in recent decades. There, urban development is concentrated around city centers, allowing for greater public transportation efficiency. Rail and buses are linked with pedestrian and bicycle-oriented routes. In all of Sweden's urban areas, 1 out of every 10 trips is taken by bicycle, about the same number by public transit, and almost 40 percent on foot. Just 36 percent of trips are taken by car, a low for Europe. In the Netherlands, bicycles are used for 27 percent of all trips.[10]

Yet with the world automobile fleet climbing to over 530 million, bicycles are losing out to a growing collection of motorized vehicles in some parts of the world. In Beijing 10 years ago, 60 percent of all trips were made on bicycle. Now that incomes have risen, residents have begun to favor the car, which is viewed as a symbol of progress, and bike trips have fallen to 40 percent. In Shanghai, where many major streets have recently been closed to bicycles during rush hour, the share of trips made by bike has dropped to 20 percent. The Shanghai government reportedly has plans to ban bicycles altogether from the city center by 2010.[11]

In the United States and Canada, where development is much less concentrated, 84 and 74 percent of trips are made by car respectively. In both countries, only about 10 percent of trips are pedestrian, and just 1 percent is by bicycle. Many residents use bicycles for recreation, not for transit.[12]

Cities at risk of being overrun by polluting, land-hungry automobiles could benefit by ensuring that bicycles receive consideration in transportation planning and urban development schemes. Tax incentives can encourage development in areas close to mass transit, and trains and buses can be equipped to carry bicycles. Making streets and pathways safer and accessible to cyclists will encourage more people to pedal to work and to use bikes for recreation.

Annual world bicycle production has grown to more than double automobile production since the mid-twentieth century, when the two nearly coincided. The bicycle is an affordable, space-efficient, low-maintenance method of personal transportation, and its usefulness promises future growth in the industry.[13]

Solar Cell Sales Booming

Bernie Fischlowitz-Roberts

In 2001, world solar cell production soared to 395 megawatts (MW), up 37 percent over 2000. (See Figure 2–10.) This annual growth in output, now comparable in size to a new power plant, is set to take off in the years ahead as production costs fall. Cumulative solar cell or photovoltaic (PV) capacity now exceeds 1,840 MW.[1]

The top five producers in 2001 were Sharp, BP Solar, Kyocera, Siemens Solar, and AstroPower, accounting for 64 percent of global output. Japanese manufacturers, with 43 percent of the world total, benefited from government policies to encourage solar cell use. The 70,000 Roofs Program, which initially provided a 50-percent cash subsidy for grid-connected residential systems, has been the primary driver of Japan's PV market expansion. The subsidy declined to 35 percent in 2000 as production increased and solar cell prices dropped. In addition to residential subsidies, government spending of $271 million in fiscal year 2001—on research and development, demonstration programs, and market incentives—was key to the growth.[2]

In contrast to Japan, the U.S. government spent only $60 million on solar programs in 2000. The U.S. share of the global market—24 percent—was surpassed in 2001 by the European Union (EU), which now accounts for 25 percent. Government commitments to renewable energy are more robust in the EU than in the United States. In

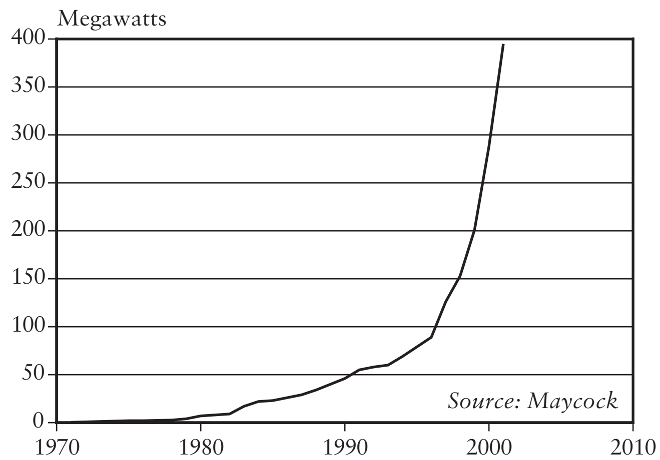

Figure 2–10. *World Photovoltaic Shipments, 1971–2001*

Germany, the Renewable Energy Act of 2000 offers citizens preferable loan terms for purchasing solar systems, and gives them a guaranteed price when feeding excess energy back into the power grid (known as net metering). As a result of such support, the German PV industry—the most advanced in Europe—is projected to grow from its current installed capacity of 113 MW in 2001 to 438 MW by 2004.[3]

Due to government policies in Japan, grid-connected residential installations totaling 100 MW dominated sales in 2001. Germany's grid-connected systems accounted for around 75 MW. The 32 MW installed in the United States were divided between grid-connected systems and those in remote areas not linked to a power grid. All of India's 18 MW were for such off-grid installations. The 120–130 MW installed in some 50–60 developing nations were also for off-grid projects.[4]

Both Japan and the United States were net exporters

of solar cells. Almost two thirds of U.S. output was exported, while Japan exported 42 percent of its total.[5]

The cost of electricity from solar cells remains higher than from wind or coal-fired power plants for grid-connected customers, but it is falling fast due to economies of scale as rising demand drives industry expansion. Solar cells currently cost around $3.50 per watt for crystalline cells, and $2 per watt for thin-film wafers, which are less efficient but can be integrated into building materials. Industry analysts note that between 1976 and 2000, each doubling of cumulative production resulted in a price drop of 20 percent. Some maintain that prices may fall even more dramatically in the future.[6]

The European Photovoltaic Industry Association suggests that grid-connected rooftop solar systems could account for 16 percent of electricity consumption in the 30 members of the Organisation for Economic Co-operation and Development by 2010. If costs of rooftop PV systems fall to $3 per watt by the middle of this decade, as projections suggest, the market for residential rooftop solar systems will expand. In areas where home mortgages finance PV systems and where net metering laws exist, demand could reach 40 gigawatts, or 100 times global production in 2001.[7]

More than a million homes worldwide, mainly in villages in developing countries, now get their electricity from solar cells. For the 1.5–2 billion people whose homes are not connected to an electrical grid, solar cells are typically the cheapest source of electricity. In remote areas, delivering small amounts of electricity through a large grid is cost-prohibitive, so people not close to a grid will likely obtain electricity from solar cells. If microcredit financing is arranged, the monthly payment for photovoltaic systems is often comparable to what a family would spend on candles or on kerosene for lamps.

After the loan is paid off, typically in two to four years, the family obtains free electricity for the remainder of the system's life.[8]

Photovoltaic systems furnish high-quality electric lighting, which can improve educational opportunities, provide access to information, and help families be more productive after sunset. A shift to solar energy also brings health benefits. Solar electricity allows for the refrigeration of vaccines and other essentials, playing a part in improving public health. For many rural residents in remote areas, a shift to solar electricity improves indoor air quality. PV systems benefit outdoor air quality as well. The replacement of a kerosene lamp with a 40-watt solar module eliminates up to 106 kilograms of carbon emissions a year.[9]

In addition to promising applications in the developing world, solar also benefits industrial nations. Even in the United Kingdom, a cloudy country, putting modern PV technology on all suitable roofs would generate more electricity than the nation consumes in a year. This would eliminate all greenhouse gas emissions from nationwide electricity generation, removing almost 200 million tons of carbon dioxide annually from the atmosphere.[10]

Recent research on zero-energy homes, where solar panels are integrated into the design and construction of extremely energy-efficient new houses, presents a promising opportunity for increased use of solar cells. Julius Poston, a progressive builder in the southeastern United States, builds homes that use half the energy of typical ones. His company, Certified Living, has constructed two prototype zero-energy homes with integrated solar panels. If eventually adopted on a wide scale, this groundbreaking concept could eliminate the pollution associated with fossil fuel–generated electricity for households.[11]

Continued strong growth suggests that the solar cell market will play a prominent role in providing renewable, non-polluting sources of energy in both developing and industrial countries. A number of policy measures can help ensure the future growth of solar power. Removing distorting subsidies of fossil fuels would allow solar cells to compete in a more equitable marketplace. Expanding net metering laws to other countries and the parts of the United States that currently do not have them will make owning solar home systems more economical by requiring utilities to buy electricity back from homeowners. Finally, revolving loan funds and other providers of microcredit are essential to the rapid spread of solar cell technologies in developing nations.

Solar cell manufacturers are beginning to sense the enormous growth in the market that lies ahead. Japan-based Sharp Corporation, already the world's leading producer of solar cells, plans to double its capacity in 2002, going from 94 to 200 megawatts. For the industry as a whole, output is expected to increase at 40–50 percent annually over the next few years, bringing the solar age ever closer.[12]