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The Economic Costs of Ecological Deficits

(part 3 of 3)

Facing the Climate Challenge

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The earth is getting warmer. The 15 warmest years since global recordkeeping began in 1867 have all come since 1980. Hardly a week goes by without new reports of ice melting, record temperature highs, or more destructive storms.[1]

The temperature series maintained by the Goddard Institute for Space Studies of the National Aeronautics and Space Administration (NASA) shows that the 10 months preceding June 2002 (August 2001 through May 2002) were uncommonly warm, setting several records. Temperatures for September and November were the highest ever recorded for those months in the last 134 years. Those for August, December, January, March, April, and May were the second highest on record for those months. If these record or near-record temperatures continue, then 2002 will likely set a new annual record, moving above 1998, the previous high.[2]

With emissions of carbon dioxide (CO_2), the principal greenhouse gas, continuing to rise, further increases in temperature are almost inevitable. The latest report by the Intergovernmental Panel on Climate Change (IPCC) projects that global average temperature will rise by 1.4–5.8 degrees Celsius (2.5–10.4 degrees Fahrenheit) by the end of this century. This will undoubtedly alter every ecosystem on the earth and every facet of human activity.[3]

Perhaps the most pervasive evidence of warming to date is seen in ice melting. In Alaska, where wintertime temperatures now average up to 7 degrees Fahrenheit above the norm, glaciers are retreating at an accelerating rate. A similar situation exists in the Andes. And recent data on the Himalayas indicates that glaciers there too are melting at an alarming pace.[4]

One of the concerns of scientists is that climate change will not always be a linear process. For example, if the ice in the Arctic Sea continues to melt, leaving the sea ice-free during the summers, as projected for sometime within the next several decades, the heat balance of the region could change dramatically. With the Arctic Sea largely covered with ice and snow, roughly 80 percent of the incoming sunlight is bounced back into space, while 20 percent is absorbed as heat. But an ice-free Arctic Sea during the summer would mean that 20 percent of the incoming sunlight will bounce back into space and 80 percent will be absorbed as heat. While the melting of the Arctic Sea ice does not affect sea level, a dramatic warming of the Arctic could lead to rapid melting of the Greenland ice sheet.[5]

An article in *Science* reports that if the Greenland ice sheet were to melt entirely, and this could only happen over a long period of time, it would raise sea level by 23 feet. At some point, feedback loops, such as the one just described for the Arctic, could begin to reinforce existing trends. Once certain thresholds are crossed, change can come rapidly and unpredictably—leaving a bewildered and perhaps frightened world in its wake. At issue is whether our political institutions, which could not prevent these mega-scale changes, will be able to deal with them when they occur.[6]

The Rising Costs of Climate Change

The benefits of burning fossil fuels are well known, but there are also enormous costs, many of which will be levied on future generations. Among these are changes in temperature that result in more destructive storms, rising seas, and crop-withering heat waves. More destructive storms are the product of the higher water surface temperatures, particularly in the tropical and subtropical regions, where hurricanes (typhoons in the Pacific) originate. These higher temperatures mean more energy is released into the atmosphere to drive storm systems. Rising global temperatures also mean rising seas from both thermal expansion and ice melting. Crop-withering heat waves are often accompanied by drought, with the two reinforcing each other.

At the end of 2001, Munich Re, the world's largest reinsurer (a company that helps spread risk among the various insurance companies), compiled a list of all natural catastrophes on record with insured losses of $1 billion or more. (See Table 1–7.) The first such disaster came in 1983, when Hurricane Alicia racked up $1.3 billion worth of insured damages in the United States. By the end of 2001, the list of catastrophes with insured damages of $1 billion or more had reached 34. Of these, 32 were storms, floods, and other atmospherically related events. The other two were earthquakes.

Insured damage from storms is rising for four reasons. One, more property is covered by insurance today than in the past. Two, the value of the property (as measured in dollars) has increased. Three, there is more building in coastal regions, on river floodplains, and in other high-risk areas. And four, storms are both more frequent and more powerful.

In the last 15 years, Europe has experienced a greater frequency of highly destructive winter storms. From 1987

Table 1–7. *Atmospherically Related Catastrophes with Over $1 Billion in Insured Losses, through 2001*

Year	Event	Location	Insured Losses	Economic Losses
			(billion dollars)	
1983	Hurricane Alicia	United States	1.3	3.0
1987	Winter storm	Western Europe	3.1	3.7
1989	Hurricane Hugo	Caribbean, United States	4.5	9.0
1990	Winter Storm Daria	Europe	5.1	6.8
1990	Winter Storm Herta	Europe	1.3	2.0
1990	Winter Storm Vivian	Europe	2.1	3.2
1990	Winter Storm Wiebke	Europe	1.3	2.3
1991	Typhoon Mireille	Japan	5.4	10.0
1991	Oakland forest fire	United States	1.8	2.0
1992	Hurricane Andrew	United States	17.0	30.0
1992	Hurricane Iniki	Hawaii	1.6	3.0
1993	Snow storm	United States	1.8	5.0
1993	Flood	United States	1.0	16.0
1995	Hail	United States	1.1	2.0
1995	Hurricane Luis	Caribbean	1.5	2.5
1995	Hurricane Opal	United States	2.1	3.0
1996	Hurricane Fran	United States	1.6	5.2
1998	Ice storm	Canada, United States	1.2	2.5
1998	Floods	China	1.0	30.0
1998	Hail, severe storm	United States	1.4	1.8
1998	Hurricane Georges	Caribbean United States	4.0	10.0
1999	Hail storm	Australia	1.1	1.5
1999	Tornadoes	United States	1.5	2.0
1999	Hurricane Floyd	United States	2.2	4.5
1999	Typhoon Bart	Japan	3.5	5.0
1999	Winter Storm Anatol	Europe	2.4	2.9
1999	Winter Storm Lothar	Europe	5.9	11.5
1999	Winter Storm Martin	Europe	2.5	4.0
2000	Typhoon Saomai	Japan	1.0	1.5
2000	Floods	United Kingdom	1.1	1.5
2001	Hail, severe storm	United States	1.9	2.5
2001	Tropical Storm Allison	United States	3.5	6.0

Table 1–7 *continued*

Source: Munich Re, *Topics Annual Review: Natural Catastrophe 2001* (Munich, Germany: 2002), pp. 16–17.

to 2001 the continent was battered by eight storms with insured damage of $1 billion or more. The first, in 1987, led to $3.1 billion in insured losses. In 1990 there was a clustering of four storms with damages ranging from $1.3 billion to $5.1 billion. Lothar, one of three storms to hit Europe in the winter of 1999, had insured losses of $5.9 billion and total losses of $11.5 billion, making it the most costly storm on record in Europe. Until recently, such destructive storms had been largely confined to the hurricane belt.[7]

The most destructive storm on record, Hurricane Andrew, struck Florida in 1992, racking up $17 billion in insured losses and an estimated $30 billion in total losses. Damage from this storm sent seven local insurance companies into bankruptcy. Climate analyst Jeremy Leggett points out that if Hurricane Andrew had struck land 20 miles further north, hitting Miami, total losses could have reached $75 billion. In second place among tropical storms in damages is Typhoon Mireille, which hit Japan in 1991. It caused $5.4 billion in insured damage and left Japan with a total bill of $10 billion.[8]

One of the most destructive floods on record hit China's Yangtze River basin during the summer of 1998. Although insured damage was barely $1 billion, total damage was calculated at $30 billion, and this did not include the indirect costs associated with the resultant economic disruption. This extensive flood, which lasted for several weeks and directly affected 120 million of the 400 million people living in the Yangtze River basin, came close to destabilizing the Chinese economy as riverside factories were forced to close until the floodwaters receded.[9]

The insurance industry is concerned about the effect of global warming on storm intensity. As early as 1990, Munich Re observed, "If water temperatures increase by 0.5 to 1 degrees Celsius in the course of the next few decades, we can expect an extension of the hurricane season by several weeks and a considerable increase in the frequency and intensity of hurricanes.... A warmer atmosphere and warmer seas result in greater exchange of energy and add momentum to the vertical exchange processes so crucial to the development of tropical cyclones, tornadoes, thunderstorms, and hailstorms." Trends over the last decade have borne out their concerns. In May 1991 the strongest cyclone on record for the twentieth century wrought death and destruction in Bangladesh, leaving 139,000 dead.[10]

The same increase in temperature that leads to more

frequent, more powerful storms is also raising sea level. Higher temperatures lead to ocean thermal expansion and ice melting. These two trends, both contributing to rising sea level, are creating a new set of challenges that will not be limited to coastal communities. Attempting to cope with rising sea level will place serious financial burdens on coastal countries. Inland communities will be crowded with refugees from areas that are no longer habitable. Food production will be affected. The loss of output as rice-growing river deltas and floodplains are inundated and as local populations expand could lead to a worldwide shortage of rice.

Few countries have researched extensively the effect of rising seas on their economies and population distribution. A World Bank report concludes that a 1-meter sea level rise would inundate half of Bangladesh's riceland. For a country with 133 million people projected to reach 209 million by 2050, the prospect of losing half of its rice harvest is not a pleasant one.[11]

Other Asian countries where rice is grown on low-lying river floodplains include China, India, Indonesia, Myanmar, the Philippines, South Korea, Thailand, and Viet Nam. For Asia, which produces 90 percent of the world's rice and is home to over half its people, rising seas could mean rising rice prices.[12]

Three countries—Thailand, Viet Nam, and the United States—account for two thirds of world rice exports that meet the needs of the 36 rice-importing countries. In these three, only U.S. rice production is relatively immune to the adverse effects of rising seas. The inundation of deltas and river floodplains in Thailand and Viet Nam could easily eliminate their exportable surpluses. Rising sea level has many agricultural consequences, but its potential effect on the world's rice harvest is generating concern about climate change in Asia.[13]

For the United States, which has a coastline of 20,000 kilometers (12,000 miles), a 1-meter rise in sea level—the upper end of the possible projected rise for this century—would inundate 35,000 square kilometers (13,000 square miles). The regions most affected would be the East Coast, from Massachusetts south to Florida, and the Gulf Coast, from Florida to Texas. Except for a few areas, such as the San Francisco Bay area, the West Coast has much steeper, coastal topographic profiles, which limits the damage and disruption from rising seas.[14]

A study from several years ago indicates that even a half-meter rise in sea level would lead to damage and loss of U.S. coastal property totaling $20–150 billion. This figure is rising as the population in coastal counties, now 53 percent of the national total, increases. Unfortunately, growth is most rapid in coastal communities in the south, the region most vulnerable to rising seas and storm surges.[15]

Among the low-lying cities that need to invest heavily in flood defenses in the event of a 1-meter rise in sea level are New Orleans, Miami, Washington, D.C., and New York. Who will bear the cost of building the fortifications against the sea: the cities or the federal government? Should cities begin accumulating funds in advance of potential inundation to ensure that they have the financial wherewithal to build the dams to hold out the sea? If coastal communities are abandoned, are the property owners responsible for dismantling the buildings in the areas that are being inundated? Or can they just leave them as ghost towns that will gradually break up over time as they are battered by the rising sea?

A 1-meter rise in sea level would create millions of refugees. In Bangladesh alone, tens of millions of people would be displaced. Would they move into the already overpopulated interior? Or would they try to migrate to

Europe or to the less densely populated countries like the United States, Canada, Australia, Russia, and Brazil?

What will happen to the major coastal cities that could be partly inundated by a 1-meter rise in sea level, such as Shanghai? Again, will the central government finance the construction of fortifications to protect Shanghai from rising seas and storm surges, or must Shanghai fend for itself? These are questions with no easy answers. Will this generation's legacy to future generations be millions of rising-sea refugees and mega-scale public works projects as coastal communities try to protect themselves from the rising sea level set in motion today?

Intense heat waves can exact a heavy toll in human suffering and even death. A heat wave with temperatures reaching 45 degrees Celsius (113 degrees Fahrenheit) in eastern India in May 2002 took 1,030 lives in the state of Andhra Pradesh alone. Many more died in West Bengal and other neighboring states. To the northwest, in Islamabad, Pakistan, the temperature on June 14 reached a searing 48 degrees Celsius (118 degrees Fahrenheit).[16]

Heat waves can also devastate crops. In the summer of 1988, the United States experienced drought and crop-withering heat simultaneously in its midwestern agricultural heartland. Together they reduced the U.S. grain harvest below domestic consumption for the first time in history.[17]

Fortunately for the more than 100 countries dependent on U.S. grain, the United States was able to satisfy domestic demand by drawing down its vast grain reserves. If such a shortfall were to occur in 2002, the world would be in trouble because the United States no longer has such extensive grain reserves. A similar harvest reduction would translate into reduced exports and in all likelihood a dramatic climb in world grain prices.

Climate change is now a global food security issue.

Higher temperatures mean more extreme climate events. Whether they be droughts, heat waves, storms, or floods, all have the potential of disrupting production and destabilizing grain markets.

One of the difficulties in doing a cost-benefit analysis on the burning of fossil fuels is that those benefiting and those bearing the costs may live on opposite sides of the planet. The United States is the principal source of atmospheric carbon emissions from fossil fuel burning. Bangladesh, a low-lying country, may be one of the principal victims.

The costs and benefits of burning fossil fuels are also separated by time. The benefits from burning fossil fuels are immediate, but the more destructive storms or rising sea level caused by their use may lag by decades, generations, or even centuries. Fortunately, we can now gain the same benefits from more benign energy sources.

Restructuring the Energy Economy

The key to restoring climate stability is shifting from a fossil-fuel-based energy economy to one based on renewable sources of energy and hydrogen. Advancing technologies in the design of wind turbines that have dramatically lowered the cost of wind-generated electricity to the point where it can be used to produce hydrogen from water, along with the evolution of fuel-cell engines, have set the stage for a dramatic restructuring of the world energy economy. The good news is that this shift is under way. The bad news is that it is not happening nearly fast enough to avoid a climate-disrupting buildup in atmospheric CO_2 levels.

The burning of each of the three fossil fuels is now either growing slowly or declining. From 1995 to 2001, the use of oil, the world's leading source of energy, expanded by just over 1 percent a year. Natural gas, the cleanest and least climate-disruptive of the three fossil fuels, grew by less than 3 percent a year.[18]

The burning of coal, the dirtiest and most carbon-intensive fossil fuel, peaked in 1996 and has dropped by 6 percent since then. This historical peaking, marking the first decline in the use of a fossil fuel, may be followed by a similar peaking in oil use within the next 5–15 years.[19]

In contrast, renewables, starting from a small base, are growing at an extraordinary pace. Worldwide, wind electric generation grew by 32 percent a year from 1995 to 2001. (See Table 1–8.) In 2001 alone it grew by a robust 36 percent. And in the United States, wind electric generating capacity jumped by a phenomenal 66 percent in 2001.[20]

Solar cell sales, growing by 21 percent a year from 1995 to 2001, are likely to grow even faster in the years ahead. Once economically competitive only when used in satellites and pocket calculators, solar cells are now becoming competitive for residential lighting in Third World villages not yet connected to the grid. In many countries, if getting electricity to villages means building both a centralized power plant and a grid to deliver the power, it is now often cheaper for families simply to install solar cells. In Andean villages, for example, the monthly installment cost (with a 30-month payment period) on an array of solar cells to provide lighting is comparable to the cost of candles. A similar price relationship exists for the more remote villages in India that depend on kerosene lamps for light.[21]

Another renewable source, one with a largely overlooked potential, is geothermal energy, which is growing at 4 percent a year. This is a vast resource and one that is likely to figure prominently in the energy economies of the Pacific Rim, particularly where widespread volcanic activity indicates that geothermal energy is close to the

Table 1–8. *Trends in Energy Use, by Source, 1995–2001*

Energy Source	Annual Rate of Growth (percent)
Wind power	+32.0
Solar photovoltaics	+21.0
Geothermal power[1]	+ 4.0
Hydroelectric power	+ 0.7
Oil	+ 1.4
Natural Gas	+ 2.6
Nuclear Power	+ 0.3
Coal	− 0.3

[1]Data available through 1999.
Source: See endnote 20.

earth's surface. The western coasts of South America, Central America, and North America have an abundance of geothermal energy. Perhaps the geothermally richest region is the western Pacific, including Indonesia, the Philippines, Japan, and the eastern and southern coasts of China. Another rich region is the Great Rift Valley, which stretches through East Africa up into the Middle East. In fact, the entire eastern Mediterranean is geothermally well endowed. Some countries have enough geothermal energy to meet all their electricity needs.[22]

Hydroelectricity, which supplies over one fifth of the world's electricity, has expanded by 2 percent a year since 1990. In contrast to the other renewable sources of energy, the growth in hydropower is losing momentum as suitable sites for new dams are scarce and as public opposition mounts to large-scale inundation of land, the associated displacement of people, and the disruption of ecosystems.[23]

One of the difficulties in restructuring the energy economy is that doing so typically depends on small, fledgling industries challenging large, well-established, often heavily subsidized industries. One way to accelerate the restructuring needed to stabilize climate is to adopt full-cost pricing, requiring that those using energy pay the full cost of doing so. This approach is discussed further at the end of this section.

Fortuitously, the fastest-growing fossil fuel is natural gas, which is the obvious transition fuel from a carbon-based energy economy to a hydrogen-based one. The natural gas infrastructure, including distribution networks and storage facilities, can easily be adapted for hydrogen as gas reserves are depleted.

As the effects of climate change become clearer, the public's desire to avoid extreme climate events will intensify. As this happens, pressure to raise carbon taxes and reduce income taxes may well rise, providing a strong economic incentive for energy restructuring.

The new century is bringing new directions in the world energy economy. The last century was characterized by the globalization of energy as oil emerged as the leading energy source. Indeed, the entire world became heavily dependent on one region, the Middle East, for a disproportionately large share of its energy. Now as the world turns to wind, solar, and geothermal as the primary energy sources and to hydrogen as an end-use fuel, the energy economy is localizing, reversing the trend of the last hundred years.

Building the Wind-Hydrogen Economy

For many years it appeared that wind would be a cornerstone of the new energy economy, but it now appears that it could become the centerpiece. Between 1995 and 2001, world wind electric generation multiplied nearly fivefold.

(See Figure 1–5.) The generating capacity of 24,000 megawatts at the end of 2001 was sufficient to meet the residential needs of 24 million people at industrial-country consumption levels, a number equal to the combined populations of Denmark, Finland, Norway, and Sweden.[24]

Wind is abundant, cheap, inexhaustible, and clean—four attributes that make it unique. By any yardstick, it is an abundant resource. In the United States, for example, a national wind resource inventory by the Department of Energy reports that the United States is richly endowed with wind energy. The Great Plains, sometimes referred to as the Saudi Arabia of wind energy, could easily supply twice as much electricity as the United States now uses. The United States is not the only country with a wealth of wind. China could double its current electricity generation from wind alone. Europe has enough readily accessible offshore wind energy to satisfy its demand for electricity.[25]

Over the last 15 years, the cost of generating electricity from wind has fallen dramatically, dropping from 38¢ a kilowatt-hour to 4¢ or less at prime wind sites today. Indeed, some recent long-term wind electricity supply contracts have been signed at 3¢ per kilowatt-hour. Wind-generated electricity is now competitive with that generated from other sources, even without including the costs of climate disruption associated with producing electricity from fossil fuels.[26]

Once cheap electricity from wind is available, it can be used to electrolyze water, producing hydrogen. Hydrogen is a way of both storing and efficiently transporting wind energy. Hydrogen is the fuel of choice for the new fuel-cell vehicles that every major automobile manufacturer is working on. Parallel technological advances over the last decade in the design of wind turbines and the evolution of fuel-cell engines have set the stage for a restructuring

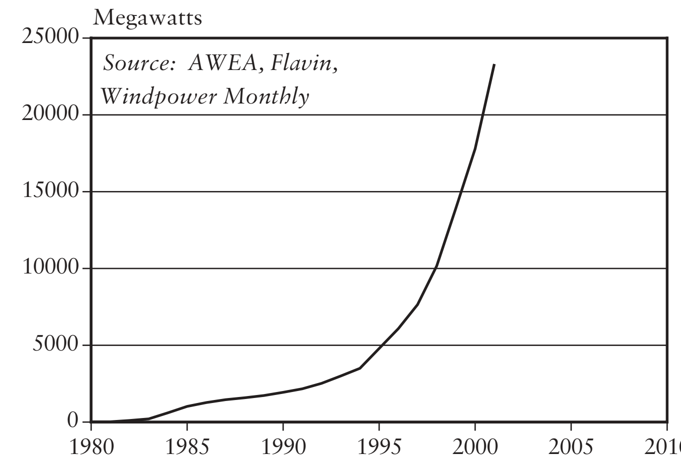

Figure 1–5. *World Wind Energy Generating Capacity, 1980–2001*

of the world energy economy. In the United States, for example, farmers and ranchers, who own most of the wind rights, could one day not only meet most of the country's electricity needs but also supply much of the fuel used in automobiles.

The hydrogen era is beginning to unfold. Both Honda and DaimlerChrysler plan to be on the market with fuel-cell automobiles powered by hydrogen in 2003. Ford expects to be in the market in 2004 with fuel-cell vehicles that run on compressed hydrogen. It will initially concentrate its marketing on fleets of cars that can easily be fueled from a central fueling station.[27]

The Icelandic government is working with a consortium of companies led by Shell and DaimlerChrysler to become the world's first hydrogen-powered economy. The first phase of this program begins in 2003 with the conversion of 3 of Reykjavik's 80 buses from internal combustion to fuel-cell engines. Shell will open its first hydrogen station in Iceland to supply the buses with fuel.[28]

Singapore, anticipating the arrival of fuel-cell-powered automobiles in 2003, has signed a letter of intent with BP to build several hydrogen stations. Air pollution concerns apparently are driving this shift to the non-polluting fuel-cell engine.[29]

Farmers and ranchers are beginning to mobilize in support of developing wind energy. Local political leaders are starting to understand the economic benefits for rural communities of developing their wind resources. In contrast to fossil-fuel power plants, the income from wind-generated electricity tends to stay in the community.

Among the countries moving rapidly to develop their wind resources are Germany, Denmark, Spain, and the United States. Denmark now gets more than 15 percent of its electricity from wind. In Schleswig-Holstein, the northernmost state in Germany, the figure is 28 percent; in the state of Meckenburg-Vorponnen, it is 21 percent. In Navarra, a northern industrial province in Spain, 22 percent of the electricity comes from wind. Wind-generated electricity in California is sufficient to meet the residential needs of San Francisco.[30]

Once a country's wind-generating capacity reaches 100 megawatts, wind resource development tends to accelerate, acquiring a momentum of its own. At this point, countries appear to have the engineering experience, the financial structures, and the professional expertise in place to develop this vast but largely untapped resource. Some 16 countries, home to half the world's people, are now in this group.

In the wind-hydrogen economy, wind turbines will replace smokestacks. Hydrogen generators will replace oil refineries. Fuel cells will replace internal combustion engines. Fuel cells run on hydrogen do not produce any

pollutants nor do they make any noise. Quiet cities with clean air will replace noisy, polluted cities.

Among the countries setting ambitious wind development goals are Germany, Spain, the United Kingdom, France, Argentina, India, China, Brazil, and the United States. A 3,000-megawatt wind farm in the early planning stages in South Dakota is one of the largest energy projects being contemplated anywhere. Some wind-rich countries could become hydrogen exporters in the new energy economy: Canada, which is richly endowed with wind but sparsely populated, and Argentina, with world-class wind resources in Patagonia, could become leading hydrogen exporters. Both countries could generate vast quantities of hydrogen, supplying it in perpetuity, to more densely populated countries with less favorable wind/population ratios.[31]

In the northwestern United States, where hydropower is already well established, cities such as Salem, Oregon, are now moving to get the rest of their electricity from wind, making them entirely independent of fossil fuels for electricity. The shift from a fossil-fuel-based economy to a renewable-energy-based one is under way. The challenge now is to accelerate that transition before climate change spirals out of control.[32]

Fixing the Market

The market is a remarkable institution. It allocates scarce resources with an efficiency that no central planning body can match. It easily balances supply and demand and it sets prices. As noted earlier, however, it does have three fundamental weaknesses, namely its failure to incorporate the indirect costs of providing goods or services into prices, its inability to value nature's services properly, and its lack of respect for the sustainable-yield thresholds of natural systems such as fisheries, forests, rangelands, and aquifers.

Throughout most of recorded history, there was little reason to be concerned about the sustainable yields of natural systems, the value of nature's services, or the indirect costs of economic activity because they were rarely an issue. But with the 19-fold expansion in the world economy over the last century, the failure to address these market shortcomings will be costly.[33]

As the global economy has expanded and as technology has evolved, the indirect costs of some goods and services have become far larger than the price fixed by the market. As noted earlier, the price of a gallon of gasoline includes the cost of production but not the expense of treating respiratory illnesses from breathing polluted air or the repair bill from acid rain damage. Nor does it cover the cost of rising global temperature, of more destructive storms, and of relocating future millions of rising-sea refugees. As the market is now organized, the motorist burning the gasoline does not bear the cost of rising sea level and the potential losses of ocean-front property, the evacuation of coastal cities, or the loss of the rice harvest from the inundation of low-lying river deltas and floodplains.

A recent study from the Centers for Disease Control and Prevention, a U.S. government agency, on the indirect costs of smoking cigarettes illustrates the kind of analysis needed for burning fossil fuels. The study reports that the market price of a pack of cigarettes, which includes the cost of growing the tobacco and processing it into cigarettes, is $2.80 in the United States. But the cost to society of smoking a pack of cigarettes, including both the medical costs of treating smoking-related illnesses and the cost of lost worker productivity as a result of absenteeism, is $7.18. The issue is not whether the additional $7.18 is paid—clearly it is paid by someone, either

the smoker, the smoker's employer, or taxpayers. The full cost of each pack of cigarettes smoked is thus $9.98.[34]

If the indirect costs of burning a gallon of gasoline were incorporated into its price, would the $1.60 that Americans typically pay be $4, $6, or maybe $10 per gallon? Would the cost to society of burning a gallon of gasoline be more or less than the $7.18 from smoking a pack of cigarettes? Intelligent investment and purchasing decisions for society, whether by government policymakers, corporate planners, or individual consumers, depend on estimating these costs and incorporating them into the price of the gasoline. If the unlevied cost of using a product, such as cigarettes or gasoline, leads to extreme market distortions, it could eventually lead to economic bankruptcy.

Another market shortcoming is its failure to price properly the many services that nature provides, which are often taken for granted. Nature converts salt water from the oceans into fresh water through evaporation. It pollinates crops, recycles nutrients, and purifies water. The destruction of natural systems deprives society of these services—services with a value that society is only beginning to recognize.

New York City, with its population of nearly 17 million, recently discovered just how valuable nature's water purification service is. Faced with the residential and industrial development of the Catskill forest region and the associated pollution of water in the watershed that is the source of New York's water, the city was told it needed a water purification plant that would cost $8 billion to build and $300 million a year to operate. The bill for this would reach $11 billion over 10 years. City officials realized that they could restore the watershed to its natural condition for only $2 billion, and let nature purify the water, thus avoiding the need for the purification plant and saving taxpayers $9 billion.[35]

The Chinese have learned the hard way the value of the flood control services provided by forests. During the summer of 1998, several weeks of some of the worst flooding on record in the Yangtze River basin wreaked enormous havoc. Direct damage caused by the flood totaled some $30 billion, according to Munich Re. Some 120 million people were directly affected by the flooding. Up until mid-August the Chinese government had been describing the catastrophe as an act of nature. But they finally recognized that deforestation, specifically the loss of 85 percent of the original forest cover in the Yangtze River basin, was a major contributor to the flooding. Once they understood this, they banned tree cutting in the basin. They justified the ban by noting that trees standing are worth three times as much as trees cut. Chinese leaders were acknowledging that the flood control value of the forests in the Yangtze River basin was worth three times as much as the lumber in the trees. The market values lumber in the trees, but not the flood control service provided by the forests. In addition to the ban on tree cutting, the government launched a tree planting program to restore the flood control service.[36]

The $30 billion worth of damage from the Yangtze flood, plus the disruption it caused in the heavily industrialized Yangtze river basin, nearly derailed the Chinese economy. To put the loss in perspective, China is the world's leading producer of both wheat and rice, but the $30 billion of flood damage exceeds the value of the annual wheat and rice harvests combined. It was the recognition in Beijing of the scale of the damage and disruption from the flooding that led to the abrupt shift in policy from tree cutting to tree planting.[37]

The market's lack of appreciation of the value of nature's services is pervasive. In the two cases just cited, the governments of New York City and China made major policy changes once they recognized the value of nature's services, values that were not reflected in the market. Will the world one day reach a similar judgment on the costs of climate change?

Another area in which the market is inept is in recognizing the sustainable-yield thresholds of natural systems. If an oceanic fishery's catch increases over time in response to demand until it exceeds the fishery's sustainable yield and stocks begin to decline, then fish prices will begin to rise. The market's response to higher prices is to invest more in fishing trawlers, a response that ensures collapse of the fishery. Further exacerbating this problem are the subsidies that governments pay the fishing industries, which distort the market.

What some governments are realizing is that protecting an economy's natural resource base depends on introducing the concept of sustainable yield into the market place. Australia, concerned in 1986 about the overfishing of its lobster fishery, estimated the sustainable yield of the fishery and then issued fishing permits totaling that amount. Fishers could then bid for the permits. In effect, the government decided how many lobsters could be taken each year on a sustainable basis and then let the market decide how much the permits were worth. Once the permit trading system was adopted, the fishery stabilized and has operated on a sustainable basis ever since.[38]

A similar situation exists with aquifers. As the demand for water increases, the pumping eventually exceeds the sustainable yield of the aquifer and the water table starts to fall. The market simply says, "drill deeper." But all this does is allow the use of water to continue to increase while the aquifer is being depleted. Once that happens, the rate of pumping is necessarily reduced to the rate of recharge. But if the level of use at this point is double the rate of recharge, which can easily be the case, then water use is abruptly cut in half. Needless to say, the adjustments to aquifer depletion can be abrupt and destabilizing.

Enlightened government policy could intervene by establishing the sustainable yield of the aquifer and auctioning off the rights to pump that amount of water. This lets the market allocate the water to the more high-valued uses, while stabilizing the water table.

There are two dimensions of overpumping that are of concern. One, once the rising level of water use exceeds the sustainable yield of the aquifer, the gap between that use and the sustainable yield widens each year until the aquifer is dry. This means that if countries delay until depletion occurs, they will face wrenching reductions in the use of water. Two, the overpumping of aquifers is proceeding simultaneously in literally scores of countries, which means that at some point in the not-too-distant future the world will face simultaneous "water shocks" as aquifer depletion forces abrupt and, in many cases, substantial reductions in water use.

Unless governments are prepared to intervene in the market to get prices to tell the ecological truth, to value nature's services, and to respect the sustainable yields of natural systems, then the economy will eventually destroy its natural support systems. Thus far the ecological and economic consequences of market distortions in our modern civilization have been mostly local and manageable. But if they continue to increase, they will eventually become worldwide, setting the stage for global economic decline.