Energy is Fundamental

More Americans means more energy use, more environmental impact

by Leon Kolankiewicz

For Americans then living, the all-but-forgotten "energy crisis" of the mid and late-1970's was like a patch of rough water disrupting the smooth sailing of the American Dream. Our exuberant post-World War II expectations of a "bigger is better" consumer's paradise – an ever-growing population enjoying ever-increasing material plenty, bigger gas-guzzling cars, more luxurious homes on larger suburban spreads, more energy-devouring gadgets, gimmicks and gewgaws – had come to seem a national birthright.

Then suddenly, that dream was threatened by sinister outside forces. Far away in the Middle Eastern deserts, strangely-clad people who'd ridden about on camels only a generation before abruptly turned off the oil spigot…and pierced our bubble of blissful ignorance. Complacent, comfortable Americans were outraged when the price of gasoline at the pump quadrupled overnight and they had to wait in long lines at filling stations and put locks on their gas tanks to prevent thieves from siphoning it out. We realized reluctantly that while our inventiveness may have been the brains behind industrialized civilization, crude oil was its lifeblood.

But almost as suddenly as it burst upon us, the energy crisis faded, fuel prices dropped again into the comfort zone, and Americans went back to sleep. Popular and political concern over energy policy fizzled faster than a seabird in an oil slick. Like disco music, advertisements that featured gas mileage ratings for new cars went out of style. By the nineties, the ultimate consumer nation indulged its bottomless appetite for new products by gorging on minivans, sport utility vehicles (SUV's), and enormous pick-up trucks that grew ever more like tractor-trailers in size and power. Not surprisingly, improvements in the national auto fleet's average fuel efficiency stalled and then slid backwards. The number of personal computers, large-screen TV's, Internet connections, and other electricity-using devices exploded, and with it, the demand for new power stations and transmission lines.

> Except for electricity, the lion's share of growth in US energy consumption...is related to growth in the sheer number of energy consumers, that is, US population growth. In the 1990s alone, the US population grew by 33 million, more than in any single decade in the country's history.

But however unfashionable or passé concern over energy policy may have become, the underlying importance of energy itself to our way of life never diminished. Energy didn't cease to pervade every aspect of our existence merely because we chose to ignore it again.

Indeed, energy is fundamental to ecosystems as well as economies. Solar energy activates virtually all life, both terrestrial and aquatic, at the earth's surface; it energizes the biosphere, that thin film of living organisms and their inorganic medium that envelops the planet. Hundreds of millions of years ago, green plants evolved the ability to tap into this reliable source of energy through the complex biochemical process called photosynthesis. Without green plants, or "producers" as ecologists call them, to harvest the energy of the sun, quite simply there would be no cows, whales, humans or any other animal. To economists, people are producers as well as consumers, but to ecologists, *Homo sapiens* and every other animal are only consumers.

The human economy is equally dependent on energy. This should not be surprising, since the human

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Figure 1 – U.S. Energy Production and Consumption, 1949-2000
Source: Energy Information Administration. 2001. Annual Energy Review 2000. Figure 1.3

economy is but a subset, albeit an ever-larger one, of the biosphere, or "nature's economy." From the time of ancient hunter-gatherer societies to today's complex Information Age, humans have always depended on solar energy for all the food we eat and for many other resources that furnish indispensable commodities.

U.S. Energy Primer

In the United States, total energy consumption more than tripled over the past half-century, jumping from 32 quadrillion Btu's (32 quads) in 1949 to 99 quads in 2000. The lion's share of our energy comes from the fossil fuels – oil, natural gas and coal – and fossil fuel consumption nearly tripled over the same period, from 29 to 84 quads.[1] In 2000, of the primary energy derived by combusting fossil fuels in the United States, 45% was from petroleum, 28% from natural gas, and 27% was from coal. Figure 1 depicts rising consumption and production of overall energy in the United States from 1949 to 2000. It shows that today, domestic energy production is falling behind consumption, primarily because of the inability of declining domestic petroleum production to meet increasing domestic petroleum consumption. (The gap is made up by rising oil imports, which now account for over half of U.S. petroleum consumption.)

In the late 1950's a promising new source of energy was exploited commercially for the first time – nuclear power. For the first couple of decades after being brought on-line, controlled fission of uranium to boil water and generate electricity was widely heralded as the clean, cheap future of electric power. But construction and maintenance costs began to skyrocket in response to unresolved safety and environmental issues. At the same time, nagging questions about waste disposal and nuclear proliferation arose and would not go away. Then came two infamous accidents: Three Mile Island near Harrisburg, Pennsylvania in 1979 and Chernobyl in the Ukrainian Republic of the USSR in 1986. Both of these, particularly the latter reactor core meltdown, badly shook public confidence in the operational safety of nuclear power plants. Of the two, Chernobyl was by far the worse in terms of actual casualties. As a result of all its technical, economic, environmental and political setbacks, in recent years the growth of nuclear-generated electricity in the United Sates has slowed considerably.

As a result of Middle Eastern political turmoil in

1973-74 and 1979-80 driving up the price of crude oil, Americans undertook a long-overdue national discussion on energy policy – how best to meet our energy needs in a way that was affordable both economically and environmentally. They also contrived clever ways of conserving energy and using it more efficiently. One consequence of these efforts was a reduction in demand for energy in the United States, and in particular for imported petroleum. Even as the economy grew, total U.S. energy consumption actually *fell* from 76 quads in 1973 to 73 quads in 1983, while consumption of imported oil dropped from 13.5 to 10.7 quads over the same period.[2] Annual energy consumption per capita declined from 359 million Btu in 1973 to 314 million Btu in 1983. As the law of supply and demand would predict, this helped bring about a drop in the price of petroleum. At the same time, the higher oil prices in the 1970's spurred greater exploration and production of crude oil. These factors combined to cause a temporary "oil glut" and a precipitous decline in the price of crude oil in the 1980's. Oil prices, both by the barrel and at the pump, have remained relatively low from the eighties to the present, as measured in constant dollars.

Unfortunately, the baby was thrown out with the bath water. While lower energy prices may be better for American consumers and the economy in general, at least in the short term, they also undermine the timely pursuit of long-term alternatives to oil in the inevitable post-petroleum era. More recently, even growing scientific evidence on the contribution of burning fossil fuels to climate change (global warming) has not been enough to convince American consumers, politicians and businesses to look at energy policy holistically and with a long-term perspective. Nor to recognize that over the long haul, energy conservation and efficiency are not merely commendable but ineffectual expressions of private virtue (as expressed by Vice-President Dick Cheney early in 2001 when he headed up the Bush administration's energy policy task force), but rather the cornerstone of any viable, *sustainable* energy strategy.

While eminent petroleum geologists like Colin Campbell, Walter Youngquist, Richard Duncan, L.F. Ivanhoe, Craig Bond Hatfield, and Kenneth Deffeyes continue to warn that global petroleum production will likely peak in the first decade or two of the 21st century, American consumers continue to splurge as if there were no tomorrow. As long as gas is cheap today, they would prefer to abandon carpooling and mass transit and indulge their fancies for gas-guzzling SUV's, minivans, and pickup trucks rather than conserve oil and the climate for tomorrow.

Unlike oil, the lion's share of natural gas and coal consumed in the U.S. comes from domestic production, as a result of the difficulties and costs inherent in the transport of these two fossil fuels over very long, i.e. transoceanic, distances. Domestic natural gas production expanded from 5.4 quads in 1949 to 19.7 quads in 2000, a nearly 4-fold increase, while coal production rose from 12 to 23 quads over the same period, a near-doubling. The United States has vast coal resources but a much more constrained supply of natural gas.

The major renewable energy sources include hydroelectric, solar, wind, geothermal, and biomass. Hydro, wind and geothermal are used primarily to generate electricity, while solar and biomass are exploited both for electricity and space heating. Unfortunately, higher prices, limited, intermittent, or diffuse supply, institutional and financial barriers, and (especially in the case of hydroelectricity) environmental constraints, have slowed the penetration of renewables into the marketplace. In the year 2000, all renewables combined accounted for just 9% of total energy produced in the U.S., of which three-quarters or more was conventional hydroelectric power, maligned by environmentalists for its devastating impacts on rivers and salmon.

Energy and the Environment

Producing and consuming energy has myriad, profound implications for the environment. Each energy source generates environmental impacts, but these vary widely in kind and intensity.

Petroleum

Environmental impacts of varying types and degrees occur from virtually all phases of exploiting petroleum resources, including exploration, extraction, transport of crude oil, refining, transport of petroleum products, and ultimate consumption. Environmental impacts of producing and using oil include:

- short-term and long-term disruption of wilderness and isolated indigenous cultures during frontier exploration and extraction;
- oil spills from tankers and pipelines while transporting crude oil and refined products;

- air, water and toxic pollution from oil refineries and petrochemical plants;
- emissions of carbon dioxide (CO_2), carbon monoxide (CO), VOC's or hydrocarbons, and nitrogen oxides (NO_x) at the point of combustion.

In the presence of sunlight, VOC's and nitrogen oxides react to form ozone, a key ingredient of smog. Carbon dioxide is the leading "greenhouse gas," implicated in global climate change and global warming. NO_x emissions contribute not only to smog, but to acid rain and to the degradation of water bodies like the Chesapeake Bay, where it serves as a nutrient contributing to noxious algal blooms.

Natural gas

Natural gas is the cleanest-burning of the fossil fuels, emitting fewer conventional or "criteria" pollutants per Btu delivered as well as less CO_2 than either oil or coal. However, natural gas exploration and production entail many of the same impacts on natural or rural habitats as oil drilling, including the potential for a degree of water pollution, habitat fragmentation (from seismic surveys, road building, and well pad construction), soil erosion, and impacts on scenery.[3] Nonetheless, at both the point of extraction and the point of consumption, natural gas is clearly the least environmentally damaging of the fossil fuels.

Coal

If natural gas is the cleanest of the fossil fuels, coal is clearly the dirtiest, both in the production and consumption phases of its exploitation. Thus, it is decidedly a mixed blessing that the U.S. has far more reserves of coal than oil or gas. While there have undoubtedly been many safety and health improvements in recent decades, underground coal mines have traditionally been dangerous and unhealthy workplaces. For example, an estimated 4.5% of miners are afflicted with black lung disease, and over 14,000 deaths in the USA from 1979-1996 were attributable to it.[4]

Mining and burning coal causes a plethora of environmental problems:

- acid mine drainage, which can damage aquatic ecosystems, much as acid rain does, by reducing the pH to intolerable levels for fish and aquatic invertebrates;
- surface or "strip" mines and "mountaintop removal" for coal have disfigured countless landscapes in Appalachia, especially in eastern Kentucky and West Virginia;
- coal-burning power plants are the largest source of sulfur dioxide (SO_2) emissions, which are related to two grave environmental problems: acid rain (more properly known as acid precipitation or deposition), and reduction of visibility across various areas of the country. The first has impaired freshwater fisheries in parts of the country (especially the Northeast), while the second has tarnished landscape vistas, especially in the East.
- power plants burning coal are also a major source of mercury contamination;[5] mercury accumulates in the food chain, to levels that can be harmful to birds and people who eat fish;
- coal emits more carbon dioxide per Btu than either oil or natural gas;

There is a broad consensus among climatologists that the earth's atmosphere is gradually warming and that anthropogenic emissions of the so-called greenhouse gases, principally carbon dioxide (CO_2) and methane (CH_4), are responsible.[6] In a 2001 report, the National Research Council concluded that the "warming process has intensified in the past 20 years, accompanied by retreating glaciers, thinning arctic ice, rising sea levels, lengthening of the growing season in many areas, and earlier arrival of migratory birds."[7] Congress ordered a preliminary national assessment of climate change's ecological effects, which issued draft findings in June 2000.[8] Among the predicted changes are "potentially severe droughts, increased risk of flood, mass migrations of species, substantial shifts in agriculture and widespread erosion of coastal zones… many long-suffering ecosystems, such as alpine meadows, coral reefs, coastal wetlands and Alaskan permafrost, will likely deteriorate further. Some may disappear altogether."[9]

Oil Shale, Oilsands and Tarsands

Known resources of these low-grade fossil fuels are massive but their utilization is problematic. For instance, when the energy costs of mining, transporting, refining and waste disposal are tallied up, the *net* amount of energy recovered from oil shale, oilsands and tarsands is likely to be small. This increases the quantity that must be mined and processed for each unit of net energy obtained, which in turn increases the land surface area that must be disturbed. Mining and processing oil shale is water-intensive, in an inherently water-scarce region – the American Southwest. Finally, utilizing these fuels on a large scale would simply generate many of the same pollution problems as petroleum and coal, including emissions of VOC's, nitrogen oxides, and carbon dioxide.

Hydroelectricity

Hydropower furnishes about eight percent of the nation's electricity generation by electric utilities.[10] Its two environmental advantages are that it is "clean" – it does not release carbon dioxide, sulfur dioxide, particulates, or mercury to the air – and somewhat renewable. It is "somewhat" renewable rather than entirely renewable because over a period ranging from decades to centuries, hydroelectric reservoirs (as in the case of all reservoirs) inevitably fill in with sediments, reducing the water storage capacity, and therefore the potential energy and generation capacity of the facility.

Another advantage of hydropower is that to some extent, it can be combined with facilities that also provide for flood control, navigation, water supply, and lake-based recreation (fishing, boating, water-skiing, swimming, etc.).[11]

Hydroelectricity's disadvantages are many, severe and well-documented:[12]

- permanent flooding of fertile floodplains and their forests or rich farmland;
- permanent loss of sometimes spectacular landscapes, such as those that disappeared at Hetch Hetchy Valley in Yosemite National Park and at Glen Canyon on the Colorado River;
- displacement of residents;
- flooding of archaeological resources;
- modification of hydrology and disruption of sediment transport (which can starve downstream beaches and estuaries of needed sand and silt);
- alteration of aquatic life and near-elimination of certain migratory species, like salmon;

The reality facing hydroelectricity is that, outside of Alaska, very few untapped damsites with large hydroelectric potential can be developed, because many of the best sites have already been exploited, and the political opposition to damming remaining free-flowing segments of rivers would be intense.

Nuclear fission

The beleaguered nuclear power industry is mired in a morass of economic, political and environment problems that have slowed the domestic advance of this once-promising energy form to a crawl. Still, in 2000 nuclear supplied 23% of the electricity generated by the nation's electric utilities.[13]

The environmental advantages of nuclear power are well worth noting: it produces no conventional air pollutants like SO_2 and particulates, it does not require the permanent flooding of productive or scenic valleys, and it releases no CO_2, the main greenhouse gas. Moreover, uranium mines are not as cruel to the landscape as coal mines. These are important advantages, frequently touted by nuclear power's supporters to a skeptical public and anti-nuclear activists that all too often tends to see it as an environmental villain.

Against these pluses must be weighed a number of disadvantages:

- Underground uranium mines have affected the health of miners, many of them Native Americans in the Southwest;[14] toxic tailings piles have not received adequate treatment;
- Uranium supplies are not unlimited and therefore nuclear fission is not sustainable;. breeder reactors, which to some extent circumvent limits to uranium resources, would commit the world to a "plutonium economy," which would be most unfortunate, given plutonium's deadly toxicity and long radioactive half-life; implications for nuclear proliferation, terrorism and poisoning of the environment would all be horrendous;
- Nuclear reactor operational safety and possible vulnerability to terrorist attack;
- Permanent disposal of highly long-lived, toxic and radioactive nuclear waste.

Nuclear power's problems are partly technical and partly political, and its future is clouded.

Wind Energy

Windmill technology has advanced by leaps and bounds in the last thirty years. This technical progress has led to a marked decline in generating costs, making wind energy competitive with conventional sources of electricity generation. The two major technical disadvantages of wind are that it is intermittent (not constant) and dispersed (not concentrated), so that it takes a large land area to generate a given amount of electrical energy. However, as with hydroelectric reservoirs providing multiple benefits (i.e. recreation, water supply, flood control), areas with windmills can still continue to provide for certain other land uses, such as grazing. The first problem, wind's variability, can perhaps be overcome by various means of energy storage, like hydrogen, now under research and development.

Pilot projects and the limited commercial development to date have brought to light three principal environmental problems associated with wind: noise, visual impacts, and bird kills:

- Noise – In some instances, very large, high windmills (upwards up 150-200 feet tall) with long blades have triggered complaints from nearby residents about noise. This problem can be mitigated by siting wind machines at least one kilometer from residential areas; in addition, newer designs may reduce turbine generator noise.[15]
- Visual impacts – The best sites for windmills are those that are most exposed to the wind, which include ridges, mountains, mountain passes, and seacoasts. These landscapes are often cherished for their scenic beauty, which can be impaired by incongruous visual elements. Aesthetic concerns have fueled to opposition to certain windmill proposals by environmentalists themselves. Other sites with large wind potential, such as the flat, less scenic Northern Great Plains, are far less likely to encounter opposition.
- Bird kills – Turning windmill blades have been documented to kill birds, especially migrating or soaring raptors, that is, birds of prey like hawks and eagles.[16] The extent of this problem, and how to mitigate it, have yet to be determined, but research is ongoing. But this disadvantage of wind power has already stifled its development in some places.

Wind energy, while clean and renewable, is not entirely "green." It can be an important partial solution to our energy supply dilemma, but it is not a panacea with unlimited prospects for expansion.

Biomass

Biomass includes everything from burning firewood in residential woodstoves, to the use of hog fuel or woodwaste in sawmills to generate process heat or electricity, to the conversion of crops such as corn or sugar cane into ethanol or methanol. One of the serious long-term issues confronting biomass is whether some of the products actually generate any net energy for society. For example, the energy expended to produce one liter of ethanol from corn with an energy content of 5,130 kilocalories (kcal) is 10,200 kcal – a net energy loss.[17]

Where biomass is a byproduct of some activity, or when crops, such as trees, can be harvested in a truly sustainable manner, then biomass may make environmental sense. But this also establishes a fairly restrictive limit. Harvesting crop residues as a fuel can expose agricultural soils to wind and water erosion, as well as remove organic materials that add soil structure and essential nutrients from the land that must be replaced by fossil fuel-based fertilizers. Biomass energy can also compete with other critical land uses for high-quality land and soils. Generally, the combustion of biomass generates more air pollutants than gas, but less than coal.

In sum, while biomass does play an important role in today's and tomorrow's energy mix, its potential to expand is severely constrained.

Solar Energy

Solar energy comes in many different forms. Centralized forms include solar thermal electricity-generating and photovoltaic (PV) plants, which can produce electricity for the electric grid. Decentralized technologies include passive solar space heating, solar hot water heaters, and photovoltaic panels for rooftops and dispersed applications (road signs, telephones, etc.) Solar energy will last as long as the sun does, has little or no emissions of greenhouse gases, sulfur dioxide, nitrogen oxides, volatile organic compounds (hydrocarbons); it does not generate significant quantities of solid waste or water pollutants. On the other hand, solar thermal plants use fairly large amounts of water.[18]

Solar is about as "green" as it gets, but as with wind energy, it is no environmental panacea. The main reason is that solar energy is relatively diffuse or dispersed compared to other energy sources, particularly the fossil fuels and nuclear energy. It is estimated that five acres of land are needed for each megawatt of capacity,[19] or about 5,000 acres (almost eight square miles) for a typical 1,000-megawatt power plant. This means it takes large areas to capture a given amount of solar energy. If U.S. energy supply were to be met entirely by solar energy, a sizeable percentage of the country's land area would have to be expropriated for this purpose. One estimate thrown around over the years is 10% or so. On the other hand, another estimate is that only 60,000 square kilometers, or about 20%of Arizona would need to be covered by photovoltaic cells to meet the USA's entire electricity demand.[20]

This is still an enormous amount of land. Unlike wind turbines, the solar panels of a centralized generation facility completely alter its ecology and appearance every bit as much as a hydroelectric dam and reservoir modify a river. The native flora and fauna of the site, if not completely displaced, are radically changed and biodiversity reduced or eliminated. If America's Southwestern deserts were to be sacrificed wholesale to solar energy production, it would not take long before at least some conservationists would begin to oppose the conversion of vast areas of wild desert landscapes and ecosystems to energy factories as passionately as they oppose any new dams now.

Geothermal Energy

Geothermal energy is derived from heat contained in certain geologic formations beneath the ground surface within the earth's crust. In comparison with other energy sources, geothermal energy has some significant environmental benefits: greenhouse gas emissions are virtually nil; sulfur dioxide emissions are negligible; and geothermal facilities demand relatively little land surface area. Within their footprint, they resemble most light industrial facilities.[21]

Environmental concerns raised by geothermal energy include air and water pollution, the safe disposal of hazardous waste, siting, land subsidence, and potential adverse effects on rare hydrogeological formations, like geysers and hot springs.[22] As with several other energy sources, one drawback of geothermal energy is that many hydrothermal reservoirs are located in or near outstanding natural areas like Yellowstone National Park and the Cascade Mountains. Proposed developments in such areas have been intensely opposed by environmentalists and wilderness advocates.[23] Thus, the potential for substantial future expansion of this energy resource is uncertain.

The Role of Population Growth

How much of our rising energy demand is due to: 1) increasing per capita consumption, and how much is explained instead by, 2) an increase in the number of energy consumers, that is, population growth?

Using a straightforward mathematical method described in a 1991 paper, it is possible to show what percentage of the growth is associated with increasing per capita consumption and what percentage is related to increasing population.[24]

A society's aggregate energy consumption at any given time or period of time can be expressed as follows:

$$E = P \times e$$

where 'E' equals total energy use, 'P' equals population size and 'e' equals per capita energy use.

Over a given period of time then, the share of growth in energy consumption related to population growth is obtained by the following equation:

Population's share of growth =

$$\text{Ln}\,((\Delta P + P)/P) \;/\; \text{Ln}\,((\Delta E + E)/E)$$

Using this equation, we can examine the following energy-related trends:

1. increase in total U.S. energy consumption from 1970 to 2000;
2. increase in total U.S. electricity consumption from 1970 to 2000;
3. increase in total U.S. petroleum consumption from 1970 to 2000;
4. increase in total U.S. carbon emissions from 1990 to 1999.

Here are the raw data used in the analysis:

Table 1 – Recent Trends in Key Energy-Related Variables in the United States

[1] Source: U.S. Census Bureau, historical census data on the World Wide Web at http://www.census.gov/population/censusdata/table-2.pdf and http://www.census.gov/main/www/cen2000.html.

[2] In quadrillion BTUs (quads; Source: U.S. DOE, Energy Information Administration (EIA), Annual Energy Review 2000, Figure 1.1 and Table 1.1.

[3] In billion kilowatt-hours; Source: Annual Energy Review 2000, Figure 8.2 and Table 8.2.

[4] In million barrels per day; Source: Annual Energy Review 2000, Figure 5.1 and Table 5.1.

[5] From fossil fuel consumption (1999), in million metric tons of carbon; converted from carbon dioxide emissions in teragrams on p. 38 of *U.S. Climate Action Report 2002* (U.S. Department of State), released May 2002.

Table 2 presents the results of this analysis.

Table 2 – Shares of increases in Key Energy-related Consumption and Waste Generation Related to U.S. Population Growth

* Petroleum consumption declined from 1980-1990.

Conclusion

POPULATION GROWTH RAISES ENERGY USE (AND ENVIRONMENTAL IMPACTS) MORE THAN RISING AFFLUENCE OR CHANGING TECHNOLOGY

United States population growth explains the preponderance of the increase in the nation's overall energy consumption, petroleum consumption and greenhouse gas emissions. Population growth is an important, but not the primary, factor in the country's rising electricity consumption.

Except for electricity, the lion's share of growth in U.S. energy consumption and related residuals or waste products (i.e. carbon dioxide, the primary greenhouse gas) is related *not* to increased affluence, rising disposable income, and technological advance. Rather, it is related to growth in the sheer number of energy consumers, that is, U.S. population growth. In the 1990's alone, the U.S. population grew by 33 million, more than any single decade in the country's history.

The relationship between population and economic growth, technological advance, energy use and environmental impacts is highly complex, chock-full of "nonlinearities," interdependent variables, feedbacks, and synergistic and cumulative effects that are glossed over by this basic analysis. Still, it is a good approximate gauge of population growth's key role in raising energy consumption.

To date, since below 10% of U.S. energy supply is renewable, population growth is pushing the country down an ever-more precarious, polluting path of dependency on fossil fuels. While it might be technically and economically feasible to transition toward more renewable, "greener" energy sources, none of these is cheap, unlimited, or entirely free of environmental problems. If the United States were entirely dependent on renewable energy sources, it would still not be able to support an ever-growing population indefinitely.

The U.S. Census Bureau projects more than 400 million Americans by 2050 and somewhere between half a billion and a billion by the year 2100. U.S. fertility rates have been at or below "replacement" levels for more than a generation, and thus birth rates are no longer the driving force behind our population growth, unlike the Baby Boom years from 1945 to 1064. Immigration levels, on the other hand, have quadrupled over the last four decades, and are now responsible for 60-70 percent of the nation's population growth. As the demographic momentum of sub-replacement level fertility continues to ebb, U.S. immigration policy will determine virtually all future population growth.

Unless Americans can muster the political will to return to more traditional immigration levels, then population growth will continue unabated for the foreseeable future, and with it growth in national energy consumption and intensifying impacts on the environment and natural resources. However, the "foreseeable future" is not forever, and ultimately, growth in both energy consumption and population will come to a halt. Whether this occurs in a more benign manner of our own choosing or a harsher manner if left to nature to impose upon us, still remains to be seen. •

NOTES

1. Energy Information Administration (EIA). 2001. *Annual Energy Review 2000.* Table 1.3. U.S. Department of Energy.

2. EIA, 2001. Note 1. Table 1.1.

3. U.S. Forest Service. 2001. *Finger Lakes National Forest Oil and Gas Leasing, Draft Environmental Impact Statement.* U.S. Department of Agriculture. May.

4. American Lung Association. 2001. Fact Sheet: Occupational Lung Disease. Accessed 20 September 2001 on the World Wide Web at http://www.lungusa/diseases/occupational_factsheet.html.

5. National Center for Atmospheric Research. 2001. August 24 News release.

6. Joby Warrick, "Global Warming Is 'Real', Report Finds," *The Washington Post.* 13 January 2000. p.A4.

7. National Research Council, Committee on the Science of Climate Change. 2001. "Climate Change Science: An Analysis of Some Key Questions;" The National Academies News. 2001. "Leading Climate Scientists Advise White House on Global Warming." Press release. June 6. Accessed September 29, 2001 on the World Wide Web at www4/nationalacademies.org/news.nsf/isbn/0309075742?OpenDocument.

8. National Assessment Synthesis Team. 2000. *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change.* Overview. US Global Change Research Program. New York: Cambridge University Press.

9. Curt Suplee, "Drastic Climate Changes: Global Warming Likely to Cause Droughts, Coastal Erosion," *The Washington Post*, 9 June 2000; also see Anon., "Report: Warming will reshape U.S.," MSNBC News, 9 June 2000. http://www.msnbc.com/msn/418229.asp.

10. EIA. 2001. Note 1. Figure 8.2.

11. U.S. Army Corps of Engineers. 2001. *Final Environmental Impact Statement: Title VI Land Transfer to the State of South Dakota,* Volume 1. Omaha District. November.

12. There is a vast popular and technical literature on these adverse impacts. See, for example, *The Economics of Natural Environments: Studies in the Valuation of Commodity and Amenity Resources* by John V. Krutilla and Anthony C. Fisher (1975, Resources for the Future, Inc./Johns Hopkins University Press) for an economic study of the impacts of constructing a hydroelectric dam on Hells Canyon of the Snake River, a tributary of the Columbia.

13. EIA. 2001. Note 1.

14. Leon Kolankiewicz. 1988. "Activist protests planned mining." *New Mexico Daily Lobo,* September 7. p. 1.3.

15. David Pimentel, G. Rodrigeus, T. Wane. R. Abrams, K. Goldberg, H. Staecker, E. Ma, L. Brueckner, L. Trovato, C. Chow, U. Govindarajulu, and S. Boerke. 1994. "Renewable Energy: Economic and Environmental Issues." *Bioscience.* Vol. 44, No. 8, September.

16. National Wind Coordinating Committee. 1999. *Studying Wind Energy/Bird Interactions: A Guidance Document.* Washington, D.C. December.

17. See note 15, Pimentel et al.

18. Anon. 2000. Electricity from Solar Energy. Accessed on the World Wide Web on 27 May 2002 at http://www.powerscorecard.org/tech_detail.cfm?resource_id=9.

19. Ibid.

20. United States Environmental Protection Agency. 2001. "Environmental Benefits of Solar Energy." Accessed on the World Wide Web on 26 May 2002 at

http://www.epa.gov/globalwarming/actions/cleanenergy/sol/factsheet.html.

21. U.S. Department of Energy. 1997. Environmental Impacts of Geothermal Energy. Accessed on the World Wide Web on 26 May 2002 at http://www.eia.doe.gov/cneaf/solar.renewables/renewable.en rgy.annual/appd.html. Appendix D in *Renewable Energy Annual 1996*. Released April 1997.

22. Michael Brower. 1992. Environmental Impacts of Renewable Energy Technologies. Accessed on the World Wide Web on 26 May 2002 at http://www.uscusa.org/energy/brief.renimpacts.html.

23. Ibid.

24. John P. Holdren. 1991. "Population and the Energy Problem." *Population and Environment*, Vol. 12, No. 3, Spring 1991.

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