Toward a Long-Range Energy Security Policy

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Events in recent decades have produced a broader definition of security.[1] The entry of phrases like "environmental security," "resource conflict," and "energy security" into the lexicon of security experts provides examples of this changing dialogue, but these concepts remain on the margins of the discussion for the most part. Where US energy policy is concerned, the debate generally has been limited to arguments that the United States must preserve its access to the oil reserves of the Middle East and Central Asia, and a vague sense that domestic energy supplies would be highly desirable. Cornucopian optimists continue to insist that oil will remain abundant and cheap for the foreseeable future, and indeed more concern is expressed over the unsavory character of governments in major oil-producing states than over the finite nature of the resources themselves.

The vagaries of oil politics (and the ecological problems raised by carbon emissions) are indeed serious problems, and they are not entirely separable from the questions this article means to raise, but the focus here will be on the problem of fossil fuel scarcity at the global level. This article seeks to provide an overview of the situation, including the prospects for an economy based on renewable energy, the security problems likely to result from tightening oil supplies, and a possible basis for making the transition to alternatives widely acknowledged as inevitable in the long run.

The Outlook for Energy

At the time of this writing, the price of oil has hit $70 per barrel and is projected to rise even higher in the near term. While not a record when the figure is adjusted for inflation, this was still commonly taken as a sign that the era of "cheap energy" may be coming to an end.

Other numbers bear this out. Annual worldwide oil consumption is roughly 29 billion barrels a year, and estimated to be rising at two percent annually.[2] While there is widespread disagreement over their actual size, the world's total "proven" reserves of oil come to roughly one trillion barrels. A linear projection has oil supplies running out around 2030 after a long period of rising prices and tightening supplies, likely to begin after production peaks, generally expected to be sometime between 2010 and 2020—maybe just five years away.

The consequences of a shortfall in oil supplies on the scale of such predictions are as obvious as they are terrifying. A prolonged economic contraction and possibly a desperate scramble for resources that might bring major powers to blows are not out of the question, especially when the cost of other problems likely to place more pressure on the energy base (climate change, water shortages, population growth, etc.) are taken into account.[3] In the absolute worst case, modernity might simply grind to a halt, a catastrophe that James Howard Kunstler describes in his recent book on the subject, *The Long Emergency.*

Of course, linear projections have their limitations, and any number of developments could throw them off—unanticipated changes in the character of economic productivity, or an economic slowdown, for instance. Actual oil reserves are likely larger than the proven figure, which would delay the crunch for some years. Rising energy needs will mean higher prices and shorter supplies, which will stretch out the supply by encouraging conservation.[4] They also will produce increased efforts to supplement oil with more plentiful coal, "heavy oil," and natural gas. The degree to which these alternatives can pick up the slack, however, is a subject of intense disagreement, as all these resources will mean higher energy prices.[5] Moreover, they do not eliminate the problem of the finite amount of these resources, with natural gas reserves particularly unlikely to last all that much longer than oil.

In short, the oil age may end within a generation given the present economic picture, with potentially dire consequences. The prospects of alternatives to fossil fuels are therefore the key issue, such as the expanded use of nuclear energy or, ideally, renewable energy sources. Many observers predict

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that it will be decades at the very least before these inherently more difficult energy sources can be exploited on a sufficiently large scale to meet the needs of advanced societies. The use of renewables has expanded rapidly in recent years, but these energy sources still supply only a small part of overall consumption, even in leaders like Denmark, where wind energy provides 10 to 15 percent of that country's electricity. If anything, given the scope of the problem and the length of time for which it has been around, the pace of actual progress has been frustratingly glacial. While the pace may be accelerating, a gap between desired levels of energy output and those actually attainable through these means is conceivable.

Nonetheless, the doomsday scenario posited by Kunstler and others is not a necessary outcome. The problem is not that substitutes do not exist, but that they are, in the view of many analysts, too expensive or too unwieldy to support desired levels of economic productivity and living standards. There is little doubt that there would be some significant transition costs, as there are in every major economic change. Observers hostile to these technologies, however, routinely play on popular fears that any change in the status quo will force Americans to give up their cars, or kill economic growth. Their exaggerations aside, such arguments conveniently neglect the fact that the exhaustion of oil resources in an unprepared world will be incalculably more devastating than any plausible adaptation, and that the earlier the transition begins, the easier it will be to spread the costs over time.

More important, such analyses tend to suffer from three major deficiencies that exaggerate the difficulties involved with alternatives. The first is that calculating the costs and benefits of oil against other energy sources is far more complicated than studies pointing to the cost-ineffectiveness of renewables admit. Many costs of fossil fuel use are easily externalized, distorting the picture. The cost of pollution, military expenditures aimed at securing oil sources, and other kinds of subsidies mask the actual price of "cheap" oil—as do the very low gasoline taxes Americans enjoy.[6] Certain savings from the distributed energy production that renewables might allow, while potentially substantial, are not easily or automatically factored into such calculations.[7] Moreover, solar, wind, and other sources will become relatively less expensive as oil prices rise. And it also should be noted that many experts regard wind power as already competitive with fossil fuels in some geographically favorable areas.

The tendency to underestimate the gains that alternatives may bring is reinforced by a broader tendency to stress costs more than benefits, not only on the part of oil industry boosters, but generally due to the changing nature of political debate.[8] The potential for a rapid changeover also tends to be underestimated, observers forgetting that comparably large transformations

> ***"A linear projection has oil supplies running out around 2030."***

have happened before in a relatively short period of time. Oil became cheaper than coal only in the mid-1950s, a mere 50 years ago. As a result, coal went from generating 100 percent of Europe's thermal electricity to less than half by 1973, oil picking up much of the slack even as overall energy production grew substantially.[9]

The second problem with such predictions is their built-in assumption that the relevant technologies will be static. Future improvements cannot be taken for granted, but are a near-certainty nonetheless, given the prolonged drop in the price of solar- and wind-generated energy since the 1970s, and the prospects for both continued research and development and mass production. The already low price of wind power can drop further still, given the potential of innovations like flying wind generators. Capable of exploiting the jet stream and returning the electricity to the ground through a tether, a few clusters of six hundred each could meet the entire energy needs of an industrial nation like Canada.[10]

There are even strong indications that electricity produced by photovoltaic solar cells will, assuming sufficient effort, become competitive in price with even subsidized, deceptively cheap oil and gas in a matter of years rather than decades. This may be due to new, low-cost materials; designs which use a greater part of the electromagnetic spectrum; more efficient use of their surface area; easily installed, self-assembling liquid solar cell coatings; and architectural structures maximizing output.[11] Several of these developments could be flashes in the pan, something to which energy production has sadly been prone; for half a century fusion power has been "30 years away." Nevertheless, given the long-term trend of improvement and the number of directions from which the problem is being attacked, some approaches will likely pay off.

A third problem is the tendency to view the matter as a choice between the outright replacement of fossil fuels or nothing at all. The reality, however, is that partial solutions can provide a cushion until a more complete transition can be brought about. This being the case, it matters little if renewable energy production will at first be undergirded by more traditional supplies. Solar cells and wind turbines will be made in factories powered by oil-burning plants. To state this as proof that alternatives to oil are unrealistic is nonsense. The energy base of the future will have to be created using the energy base existing now, just as the oil-based economy was built using previously existing sources. Of greater concern, many schemes for a hydrogen economy involve the extraction of hydrogen from natural gas or other fossil fuels, with power supplied by traditional electricity sources like oil, coal, and nuclear generators. Hydrogen, however, also can be extracted directly from water through photoelectrochemical processes or electrolysis, which could be powered by cheap wind and solar energy.[12]

The problem, then, is less the "technical ingenuity" needed to produce these technologies than the "social ingenuity" which will implement the technologies on a national and global basis.[13] Renewable energy technology can potentially do the job; what is really at issue is whether or not good use will be made of that potential. Nonetheless, the political problem posed by the demise of the fossil fuel era is not limited to the challenge of constructing a new energy base.

Security Concerns

Even without taking into account related problems like the greenhouse effect, the security problems posed by the exhaustion of supplies of easily accessible, cheap oil and gas are highly varied and daunting. The likely result would be the exacerbation of familiar problems like resource conflict, weapons proliferation, and state failure. However, other problems are more novel, not least of all the potential for changes in the international balance of power based not only on which countries control the lion's share of the world's fossil fuel supplies, but which are most dependent on those supplies.

New Resource Wars

The most obvious concern is a reinvigoration of resource conflict. As the oil deposits believed to lie under a disputed piece of ground or sea floor become more valuable economically, governments might be more prepared to fight for them. Since the War on Terrorism began in 2001, China, seeing itself in a more vulnerable strategic position, has been more willing to negotiate its claims over the South China Sea.[14] However, the issue has yet to be resolved, and an oil-hungry China can yet take a harder line, especially if this becomes more profitable. China also has behaved provocatively elsewhere, sending naval vessels into Japanese claims around the Senkaku Islands.[15] Similar conflicts remain unresolved in other regions, including sub-Saharan Africa and Latin America.[16] Moreover, even states unlikely to go to war over territory would face greater prospects of involvement in an armed conflict, and find a powerful incentive to develop and deploy long-range power-projection capabilities.

Resource wars also can be a cause of internal conflicts or unrest. The war in the Indonesian region of Aceh is partly driven by the government's determination to hold onto an oil-rich region, and the resentment of the inhabitants has been partly a response to the damage oil production has done to local communities. Oil also was at stake in the fight over East Timor, which on the first day of its independence concluded a deal with Australia regarding its oil-rich offshore claims.

The problem may in fact be exacerbated by certain solutions to the world's energy problems. To give one example, the development of new technologies which permit cost-effective drilling for oil in deeper waters could create new flash-points. Cheaper deep-water drilling, for instance, would make the oil under the South China Sea a more valuable prize.[17] As certain kinds of alternative energy technologies are developed, the value of certain resources is also likely to become more strategically important (like platinum for hydrogen fuel cells), with similar results.

As the situation stands, two-thirds of what were the high seas in 1958 have been "territorialized" to some degree. The United Nations Convention on the Law of the Sea extended territorial waters from three to 12 miles, recognized 200-mile Exclusive Economic Zones and 350-mile continental shelf claims, and permitted the enclosure of the internal waters of archipelagic states like Japan.[18] At the same time, the mineral wealth of these regions has remained largely unexploited. While the ambitious ocean mining schemes of 30 or 40 years ago amounted to little, rising energy costs and improved technology could give them a future—and make the right to profit from them a new cause of conflict.

Increased Disorder

Resource conflict, however, is likely to be confined within particular regions. The economic effects of an oil shortage would be global. With less energy at their disposal, societies and governments everywhere will have more difficulty coping with problems likely to be of a more severe character—burgeoning populations, climate change, and shortages of such critical resources as water and arable land. The problem of the salinated and damaged farmland on which a third of the world's crops is presently grown is a case in point. Aside from expensive repair, costly methods like drip-irrigation will be needed to keep such lands arable, necessitating more, not less energy.[19]

Another likely ramification of such an energy shock is a new wave of debt crises and state failures. As in the 1970s, those most vulnerable would be developing nations short on hard currency and dependent on oil imports, which might see their development progress strangled by a spike in prices. If the prospect of 2050s America resembling a *Mad Max* movie is far-fetched and extreme, it is not so for less fortunate regions where such regressions have already happened, as in Somalia.[20] Lacking appropriate or adequate capital, institutions, and technical knowledge, their situations will much more readily degenerate to the point of collapse.[21] And, as events in recent years have demonstrated, advanced nations will not easily insulate themselves from these problems, given the refuge for criminal activity and terrorism such areas will provide, as well as the waves of refugees they may generate. It may even be possible for practitioners of a radical ideology to seize power in a major state. Even without that happening, we could see an inward turn on the part of major powers seeking to establish self-contained economic empires, as happened during the Great Depression.[22]

Nuclear Proliferation

Alternatively, oil shortages, or the prospect of them, may put pressure on states to follow France's path in the 1970s and invest heavily in nuclear technology. The problems posed by greater nuclear proliferation (or poorly built and operated reactors) need little elaboration.

Perceiving a heightened threat environment amid more widespread resource conflict and state failure, states may be more likely to seek out such systems regardless of the inherent dangers. With greater insecurity and the need for alternatives to fossil fuels feeding each other, the nonproliferation regime will be under greater pressure than it is today.

A Return to 1973?

America's dependence on foreign oil (a problem that Arctic oil drilling will not even come close to solving) makes the nation susceptible to foreign leverage, and the Middle East aside, other major oil-producers may have strategic interests or goals conflicting with those of the United States.[23] Given the present diversity of suppliers, a future version of the OPEC embargo may be unlikely, but the contraction of oil supplies is still likely to mean shocks ahead.

Moreover, it must be noted that the pain of a shock will not be felt evenly. Efficient energy users will suffer less, and vice-versa. At present, that would be to the disadvantage of the United States relative to other developed nations like Germany.[24] Correspondingly, states which derive a higher proportion of their energy from renewables would be less vulnerable economically, a condition easier to achieve if energy use is already efficient.

This raises another issue of particular concern for the position of the United States, one generally given short shrift. The hype about information technology in the 1990s contributed to a complacent assumption of American technological dominance, which is simply baseless where renewable energy is concerned.[25] The small but rapidly growing world market in photovoltaics, fuel cell-based vehicles, and wind turbines is dominated by Europe and Japan, where the most promising research continues. In fact, America's profile has actually shrunk in this area, with its share of the world market in photovoltaics falling to 11 percent in 2004 from 25 percent just five years earlier.[26]

One result is that, short of a change in this situation, a conversion of the national energy base will likely expand the already massive US trade deficit, rather than constituting a new opportunity for American growth. The possibility must therefore be considered that an oil shock may hurt the United States more severely than the other developed nations, weakening its international position relatively as well as absolutely.

Meeting the Challenge

The most obvious response, at least from the perspective of traditional national security, is to take the dangers described above into account in threat planning. In other words, in the event of a new energy crisis, there may be more state failures, weapons proliferation, and resource conflict. Nonetheless, military force is inadequate to deal with the larger problem of relieving the dependence on finite fossil fuels—although government research and development (R&D), military as well as civilian, can play (and already is playing) a role in creating a path out of that dependence.

The predominance of neoliberal economic theory makes it easy to forget the degree to which key economic innovations have been pioneered and supported by government.[27] While it is the robber barons who are celebrated, the railroads of the 19th century were built with massive government assistance in the form of loans, land grants, and other subsidies. In the 1950s, no one waited for the private sector to step in and provide a highway system. Modern computers, the internet, and space technology all benefited immeasurably from government research, and indeed may have been inconceivable without government efforts.

The job of government is precisely to step in where a need exists when the private sector is either unwilling or unable to satisfy it. This is the case at present with renewable energy, and at this point it is worthwhile to reflect on America's history in this area. "Big Science" in the United States has been most successful when explicitly oriented toward a particular goal, as with the early space program. The Soviet launch of the first Sputnik satellite was a profound shock, but America responded effectively with massively enlarged investment in scientific education and research. Half a century later the United States is in a dominant position in space, its satellite networks a cornerstone of its unprecedented military superiority.

Where energy is concerned, the "Sputnik moment" has long since come and gone. The project of freeing the American economy from oil depend-

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ence arguably deserves the same priority the moon mission enjoyed 40 years ago, speaking as it does to a far more central national interest, and it is worthwhile considering why the results achieved to date have been so modest.

The simple fact is that US energy policy traditionally aimed at an expansion of oil and gas production, while investing heavily in nuclear energy. There was a brief enthusiasm for renewable sources and conservation in the 1970s, but the economic reforms of the 1980s are generally considered to have ended this. Research and development funding for energy was substantially reduced, and tax credits and regulations were abandoned to the end of creating a "free market" in energy.[28] The nascent alternative energy industry was not only left to sink or swim among more mature competition, but as a net result of assorted tax policies and subsidies it was put at a disadvantage, and it withered.

When considering the character of the energy business, it is hardly surprising that they did not pick up the slack. Energy firms invest relatively little in R&D, about 0.5 percent of revenue, compared with 10 percent in high-tech fields, the figure actually declining in the 1980s and 1990s.[29] Moreover, the emphasis has not been on "system-shattering" research, but on "conservative innovations able to pay off in the short term," a category which generally has excluded renewables.[30]

All of this made alternative energy an especially poor candidate for the free-market path, though to be fair, previous energy technologies typically required massive government support before becoming sustainable. Of some $150 billion spent subsidizing solar, wind, and nuclear energy between 1947 and 1999, more than $145 billion went to nuclear (96 percent of the total).[31] This may seem appropriate, given how much more energy nuclear generators are producing today compared with wind and solar. Between 1947 and 1961, however, federal subsidies toward nuclear energy on a per-kilowatt basis were 40 times those provided to wind (which had then been comparably important), and it is difficult to imagine nuclear energy's comparative efficiency having come about without such massively disproportionate early investment.[32]

Since then research dollars have continued to favor fossil fuels and nuclear energy, arguably beyond a point of diminishing returns.[33] R&D spending for renewables has been about $10 billion, compared with $20 billion and $40 billion for fossil fuels and nuclear energy, respectively.[34] While that figure still appears large, it is less impressive when broken down by area. American spending on hydrogen fuel in the 1970s, for instance, totaled a paltry $24 million and represented only a third of Western Europe's spending on the same area of research.[35] The quality of that research spending also has been questionable, as the spectacular success of Denmark's much smaller R&D program in wind turbine technology demonstrates.[36]

In short, renewables were never given a proper chance because of a conventional wisdom that says "let the market do it," no matter how unwilling the market proves to be, and the disinterest of the powerful oil, gas, and nuclear lobbies, which have continued to receive the lion's share of government support.[37] The progress of sources like wind and solar energy since the 1970s occurred not because of but in spite of the policies of the last quarter-century, and, given political realities, this seems unlikely to change. Nevertheless, with each passing year it becomes harder to deny that change is called for, and that the arguments against a change simply do not hold water.

The resistance to planning that left the United States without an industrial policy has resulted in a $700 billion annual trade deficit, caused in large part by American imports of manufactured products once made at home. With the beginning of the end of the oil age possibly around the corner, the United States cannot afford to be without an energy policy. A logical starting point is a program to nurture renewable sources and conserve fossil fuels on a scale far more ambitious than anything previously attempted or currently being considered.

Even the aforementioned $10 billion figure is modest in comparison with the sums spent on major national projects like the Manhattan Project and the Apollo moon missions in much shorter periods of time, adjusting for inflation and economic growth. For that matter, it is modest in comparison with public R&D spending generally, which exceeds $100 billion a year—despite the continuing decrease of federal spending as a share of the country's total R&D funding.[38]

Whatever its precise size, this program ideally should be aimed not only at making the United States a world leader in the field of renewable energy sources, but at reducing America's fossil fuel consumption below present levels in absolute terms before 2020 and *eliminating* fossil fuel dependence no later than 2040 and preferably earlier. To that end, the United States should pursue a broad range of approaches, not only hydrogen (the production of which should be delinked from fossil fuels and rare minerals to the extent possible), but also photovoltaics, wind, ethanol, biomass, and, while they are more dependent on geography, tidal and geothermal. The characteristics of some of these energy sources offer a variety of practical benefits, making them worthy of military R&D dollars.

One advantage is the potential that renewable sources offer for distributed power.[39] Given the prospect that US forces will increasingly be based in less-developed regions like the Middle East, Central Asia, and even sub-Saharan Africa, not being dependent on local power grids can be an advantage. For example, at present the self-sustaining Navy base at Guantanamo Bay, Cuba, has a wind turbine installation which produces 5 to 12 percent of its energy during the spring, and up to 25 percent during the windy period of the fall months, reducing diesel imports by 650,000 gallons annually.[40]

At the same time, the unique needs of military programs make them a logical starting point for at least some research in this area. Running information-age campaigns with industrial-age logistical systems is already problematic, and renewable energy sources or conservation technologies might provide a partial solution. The Army is presently funding a program to develop flexible solar panels that may ultimately be woven into the fabric of tents or uniforms to supply power for communications equipment, computers, and other electrical appliances.[41] A hydrogen fuel cell able to get more miles per gallon could be a considerable boon to mechanized Army units, to say nothing of Navy and Air Force units, which may see benefits even sooner. Submarines using fuel cells are not only possible, but, in the form of the Type 212A, are already entering service with the German navy.[42]

Research into technologies facilitating conservation also would play a role in a balanced strategy, since more efficient energy use makes it easier for still-developing renewable energy power sources to meet a given need—and, in any event, these are seen by many observers as more promising in the near term. Energy savings can come from sources less familiar than the typical examples of hybrid or electric cars, more efficient appliances, and solar water heating. The use of strong, ultralight materials such as new, carbon-based ceramics can reduce fuel consumption. A car made out of carbon nanotubes, for instance, would weigh 50 pounds, and while a 50-pound car may be unattractive for one reason or another, it demonstrates the potential for very large fuel economies. The development of substitutes for oil in products like plastics, fertilizers, and pharmaceuticals also can assist, as can improved mass transit systems, a modern rail system, modernized power grids, support for zero-energy housing, and practical superconductors.[43]

All of the above hold the promise of reducing electricity and fossil fuel consumption to a fraction of present levels without sacrificing modern conveniences. There also are ways in which technology can aid conservation by enabling people and goods to move less without sacrificing economic productivity or the quality of life (and in some cases, perhaps increasing them), as by enlarging telecommuting.[44] Another is a reduction of "production sharing," the practice of widely dispersing the manufacture of a single item or, more radically, the movement of production closer to markets via replicating technologies like the three-dimensional printer, a technology that exists today, albeit in its infancy.

Beyond research and development, every reasonable effort should be made to facilitate the mass production of these technologies and adopt them at home and abroad, including carefully thought-out tax credits and buyback rates for net-excess power. Should American companies seriously enter the market in new types of energy and conservation technologies, the broadening of effort, greater production, and increased competition could drive prices down further. Purchases of the relevant technology can be subsidized, and government and military facilities can assist by purchasing their power from such sources, boosting the market. Protectionist measures, however, are uncalled for as a way of bringing about this end. Indeed, cooperation would be a preferable approach, given that this already belated process might be disrupted by very little interference. Such a project also could be a basis for collaborating with allies irked by a perceived lack of US concern for the natural environment.

Moreover, it must be remembered that the greatest increases in oil consumption are coming not from the developed nations, but from developing ones like China and India. These represent perhaps an even more promising market than developed nations for the technology in key respects. Precisely because their energy consumption is growing more rapidly than anywhere else, their infrastructures are still being built; according to one estimate, a third of the world's population is still unconnected to an electric grid. Additionally, their energy consumption will be lower for the foreseeable future, making at least some of their demand more easily met through renewables.

Sales of the technology can be facilitated through foreign aid programs, and such an action shouldn't be viewed as charitable. To the extent that the access of other nations to this technology will reduce the emission of greenhouse gases, conserve the fossil fuel supplies which will continue to meet much of America's energy needs for decades to come, expand the market for US companies working in this arena, and diminish the security burden resulting from a scramble for cheap oil, then doing so will be very much in the national interest of the United States.

The program proposed here no doubt appears exceedingly ambitious, and it certainly is, but this is a different matter from saying that it is impossible, undesirable, or unnecessary. One might also protest that despite the unease surrounding oil prices of $70 a barrel, there is no "emergency" yet. The point, however, is to prevent the situation from ever becoming one.

NOTES

1. Barry Buzan, "Security Analysis: Conceptual Apparatus," in *Identity, Migration and the New Security Agenda in Europe*, ed. Ole Waever et al. (New York: St. Martin's Press, 1993), pp. 21-47.

2. US Central Intelligence Agency, "World," in *CIA World Factbook 2005*, 9 August 2005, http://www.cia.gov/cia/publications/factbook/geos/xx.html#Econ; US Department of Energy, Energy Information Administration, *International Energy Outlook 2005—Highlights*, July 2005, http://www.eia.doe.gov/oiaf/ieo/index.html, and *International Energy Outlook 2004*, April 2004, http://www.eia.doe.gov/oiaf/archive/ieo04/index.html.

3. See Colin Mason, *The 2030 Spike: Countdown to Global Catastrophe* (London: Earthscan Publications, 2003.)

4. Such factors combined to make the United States more energy-efficient in the past, dropping the amount of oil and gas needed to produce a dollar of Gross Domestic Product by half since 1973, especially before the drop in oil prices after the mid-1980s. According to one analysis, energy savings already have become the largest "source" of US energy. See Amory B. and L. Hunter Lovins, "Mobilizing Energy Solutions," *American Prospect*, 28 January 2002.

5. Carbon capture technologies may, however, make the inevitable, expanded use of fossil fuels more palatable from an environmental perspective. S. Julio Friedman and Thomas Homer-Dixon, "Out of the Energy Box," *Foreign Affairs*, 83 (November/December 2004).

6. For two conflicting views of the matter, see Douglas Koplow and Aaron Martin, *Fueling Global Warming: Federal Subsidies to Oil in the United States* (Washington: Greenpeace, June 1998), http://archive.greenpeace.org/climate/oil/fdsuboil.pdf#search='fueling%20global%20warming%20greenpeace'; and American Petroleum Institute, "Fueling Confusion: Deceptive Greenpeace Study Premised on Flawed Estimates of Subsidy," November 1999, http://www.earthtrack.net/earthtrack/library/APIGreenpeace.pdf#search='fueling%20global%20warming%20greenpeace'.

7. To give two examples, there are "co-generation" (using the heat generated by electricity for other purposes), and the energy savings which come with the generation of power near the end user's location, since five to eight percent of electricity generated is lost in transmission over long-distance lines.

8. See Zaki Laidi's writing on "avoidance strategies" in *A World Without Meaning*, trans. June Burnham and Jenny Coulon (London: Routledge, 1998).

9. Paul Bairoch, *Economics and World History* (Chicago: Univ. of Chicago Press, 1993), p. 62.

10. Given the very high levels of relatively inexpensive power that a small number of such clusters can produce, this approach would seem especially attractive for the purposes of a rapid changeover and may therefore be deserving of special attention. Lawrence Solomon, "Flying Windmills," *National Post*, 19 March 2005.

11. "Discovery May Spur Cheap Solar Power," *CNN.com*, 2 October 2003, http://www.cnn.com/2003/TECH/biztech/10/02/solar.cells.reut/; Charles Choi, "Nanotech Improving Energy Options," *SpaceDaily*, 27 May 2004, http://www.spacedaily.com/news/nanotech-04zj.html; Ian Sample, "'Self-Assembling' Solar Cells Developed," *New Scientist*, August 2001; "Solar Cells Go Organic," *Economist*, 20 June 2002; Stephen Leahy, "Solar Tower of Power," *Wired News*, 24 February 2005.

12. For that matter, hydrogen also can be recovered from ethanol, sunflower seed oil, and other substances, in some cases even more efficiently. Mark Clayton, "One Step Closer to Hydrogen Economy?" *Christian Science Monitor*, 19 February 2004; Gabe Romain, "Sunflowers Seed Hydrogen Economy," *Better Humans*, 25 August 2004, http://www.betterhumans.com/News/3868/Default.aspx; Daithi O Hanluain, "Hydrogen Fuel Closer to Fruition," *Wired News*, 2 September 2004. Another procedure uses algae to generate the product. Michael Mechanic, "It Came from the Swamp" *Wired*, April 2002. A less tractable problem is the use of rare and expensive platinum as a catalyst in fuel cell designs, though substitutes are presently being explored, including one based on iron. "Researchers Investigate Iron-Based Electrocatalyst as Platinum Substitute," *The Hydrogen & Fuel Cell Letter*, 1 March 2005.

13. For more on the concepts of "technical ingenuity" and "social ingenuity," see Thomas Homer-Dixon, *The Ingenuity Gap* (New York: Random House, 2001).

14. Thomas K. Kane and Lawrence W. Serewicz, "China's Hunger: The Consequences of a Rising Demand for Food and Energy," *Parameters*, 31 (Autumn 2001), 63-75.

15. John J. Tkacik, Jr., "Japan's Islands and China's Illicit Claims," Heritage Foundation press release, 14 April 2005.

16. For a broad survey of the problem, see Michael Klare, *Resource Wars* (New York: Metropolitan Books, 2001).

17. Mark J. Valencia, "China and the South China Sea Disputes," *Adelphi Paper*, No. 298 (London: Oxford Univ. Press, 1995).

18. Charles E. Pirtle, "Military Uses of Ocean Space and the Law of the Sea in the New Millennium," *Ocean Development and International Law*, 31 (January-June 2000).

19. Russell Clemings, *Mirage: The False Promise of Desert Agriculture* (San Francisco: Sierra Club Books, 1996).

20. Robert Kaplan, "The Coming Anarchy," *The Atlantic Monthly*, March 1994, pp. 44-76.

21. Thomas Homer-Dixon, "On the Threshold: Environmental Changes as Causes of Acute Conflict," *International Security*, 16 (Fall 1991), 76-116.

22. Harold James, *The End of Globalization* (Cambridge, Mass.: Harvard Univ. Press, 2001).

23. Americans are prone to forget that "the oil weapon" was not an innovation of disgruntled Middle Eastern states, but of the United States itself, which used it with considerable effectiveness in the past—for example, in the embargo against Japan prior to America's entry into World War II, and in the Suez crisis in 1956 against Britain and France.

24. Germany gets by on one-half as much energy for every dollar of GDP it produces, despite deriving a greater share of that GDP from energy-intensive manufacturing. Ricardo Bayon, "The Fuel Subsidy We Need," *The Atlantic Monthly*, February 2003. In the future it may be necessary to look at productivity not only per manhour, but also per watt-hour to gain a sense of a nation's competitiveness.

25. This complacency is perhaps reinforced by very high levels of scientific output (as measured in papers published and frequency of citation) and R&D spending, which far exceed those of any other nation in the world. America's lead, however, is less formidable when compared with those for the European Union as a whole, rather than single member states, and when expenditures on military R&D are excluded from the figure. See Robert L. Paarlberg, "Knowledge as Power: Science, Military Dominance, and US Security," *International Security*, 29 (Summer 2004), 122-51.

26. Eugene Linden, "Selling the Sun . . . And the Wind," *Time*, 16 July 2001.

27. Kevin Phillips, *Wealth and Democracy: A Political History of the American Rich* (New York: Broadway Books, 2002).

28. Salvatore Lazzari, *Energy Tax Policy*, report, Congressional Research Service, 24 August 2001. At the same time, the abandonment of fuel efficiency regulations (and dropping oil prices) caused fuel efficiency to drop in important areas like automobile design. Efficiency there generally flat-lined in the 25-30 mile per gallon range by the mid-1980s, with car manufacturers instead looking to build large, powerful vehicles rather than efficient ones, though a market for more efficient hybrids is growing. Lovins, "Mobilizing Energy Solutions."

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30. Ibid.

31. Ibid., p. 3. Fossil fuels also were subsidized on a scale comparable to nuclear, some $268.5 billion from 1918 to 1980 (in 1999 dollars). Battelle Report, "Analysis of Federal Incentives Used to Stimulate Energy Production," Pacific Northwest Laboratory, February 1980 (Revision #2), p. 276. Cited in National Environmental Trust, *America, Oil and National Security: What Government Data Really Show* (Washington: National Environmental Trust, 2002).

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