

FOREIGN AFFAIRS

JULY/AUGUST 2003



The Future of Energy Policy

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Volume 82 • Number 4

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THE BIG QUESTIONS

A CENTURY AGO, Lord Selborne, the first lord of the Admiralty, dismissed the idea of fueling the British navy with something other than coal, which the island nation had in great abundance. “The substitution of oil for coal is impossible,” he pronounced, “because oil does not exist in this world in sufficient quantities.” Seven years later, the young Winston Churchill was appointed first lord and charged with winning the escalating Anglo-German race for naval superiority. As Daniel Yergin chronicled in *The Prize*, Churchill saw that oil would increase ship speed and reduce refueling time—key strategic advantages—and ordered oil-burning battleships to be built, committing the navy to this new fuel. Churchill’s was a strategic choice, bold, creative, and farsighted. The energy choices the world faces today are no less consequential, and America’s response must be as insightful.

Energy is fundamental to U.S. domestic prosperity and national security. In fact, the complex ties between energy and U.S. national interests have drawn tighter over time. The advent of globalization, the growing gap between rich and poor, the war on terrorism, and

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the need to safeguard the earth's environment are all intertwined with energy concerns.

The profound changes of recent decades and the pressing challenges of the twenty-first century warrant recognizing energy's central role in America's future and the need for much more ambitious and creative approaches. Yet the current debate about U.S. energy policy is mainly about tax breaks for expanded production, access to public lands, and nuances of electricity regulation—difficult issues all, but inadequate for the larger challenges the United States faces. The staleness of the policy dialogue reflects a failure to recognize the importance of energy to the issues it affects: defense and homeland security, the economy, and the environment. What is needed is a purposeful, strategic energy policy, not a grab bag drawn from interest-group wish lists.

U.S. energy policies to date have failed to address three great challenges. The first is the danger to political and economic security posed by the world's dependence on oil. Next is the risk to the global environment from climate change, caused primarily by the combustion of fossil fuels. Finally, the lack of access by the world's poor to modern energy services, agricultural opportunities, and other basics needed for economic advancement is a deep concern.

None of these problems of dependence, climate change, or poverty can be solved overnight, but aggressive goals and practical short-term initiatives can jump-start the move to clean and secure energy practices. The key challenges can be overcome with a blend of carefully targeted policy interventions that build on the power of the market, public-private partnerships in financing and technology development, and, perhaps most important, the development of a political coalition that abandons traditional assumptions and brings together energy interests that have so far engaged only in conflict. Turning this ambitious, long-term agenda into reality requires a sober assessment of the United States' critical energy challenges and the interests that can be mobilized for the necessary political change.

DECLARATION OF DEPENDENCE

U.S. DEPENDENCE on oil leaves the country's economic, security, and environmental destiny to forces beyond America's control.

Reducing this exposure—especially in the transportation sector, which is 95 percent dependent on petroleum—must be a primary goal of national energy policy.

Since October 1973, when Arab nations imposed a six-month embargo on oil exports to the United States, America has vowed to reduce its dependence on foreign oil. Each of the last seven U.S. presidents has pledged to steer the nation toward greater energy security, but the problem has only grown worse. Imports have passed 50 percent of total oil consumption and are projected to reach more

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than 60 percent by 2010. Of the one trillion barrels of world reserves, only four percent are to be found in the United States, and fully two-thirds are in the Persian Gulf. A quarter of U.S. imports are from that volatile region, and other key trading partners are substantially more dependent on the Persian Gulf: Japan, for example, buys 75 percent of its oil from that region. China's economic growth is also rapidly increasing its dependence on Persian Gulf oil.

The intensity of oil use in the transportation sector makes the American economy vulnerable to the actions of other states. A study by Oak Ridge National Laboratory estimates a \$7 trillion cost to the U.S. economy from the oil market upheavals of the last 30 years. Indeed, every economic recession in the past 40 years has been preceded by a significant increase in oil prices.

Diversification of U.S. oil imports is not an adequate answer. Oil is like any other commodity—the last unit sold determines its price. The United States could shift all its purchases to sources that are relatively safe politically, such as Canada and Mexico, and it would still not be protected. The global price is what matters most. This means, for example, that if a terrorist sets off a “dirty bomb” in the Saudi port of Ras Tanura, the price of oil will spike everywhere in the world, dramatically affecting the U.S. economy.

Nor are supply disruptions and price shocks the only risks that oil dependence creates for U.S. national security. The flow of funds to certain oil-producing states has financed widespread corruption,

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perpetuated repressive regimes, funded radical anti-American fundamentalism, and fed hatreds that derive from rigid rule and stark contrasts between rich and poor. Terrorism and aggression are byproducts of these realities. Iraq tried to use its oil wealth to buy the ingredients for weapons of mass destruction. In the future, some oil-producing states may seek to swap assured access to oil for the weapons themselves. It is also increasingly clear that the riches from oil trickle down to those who would do harm to America and its friends. If this situation remains unchanged, the United States will find itself sending soldiers into battle again and again, adding the lives of American men and women in uniform to the already high cost of oil.

IT'S GETTING HOT IN HERE

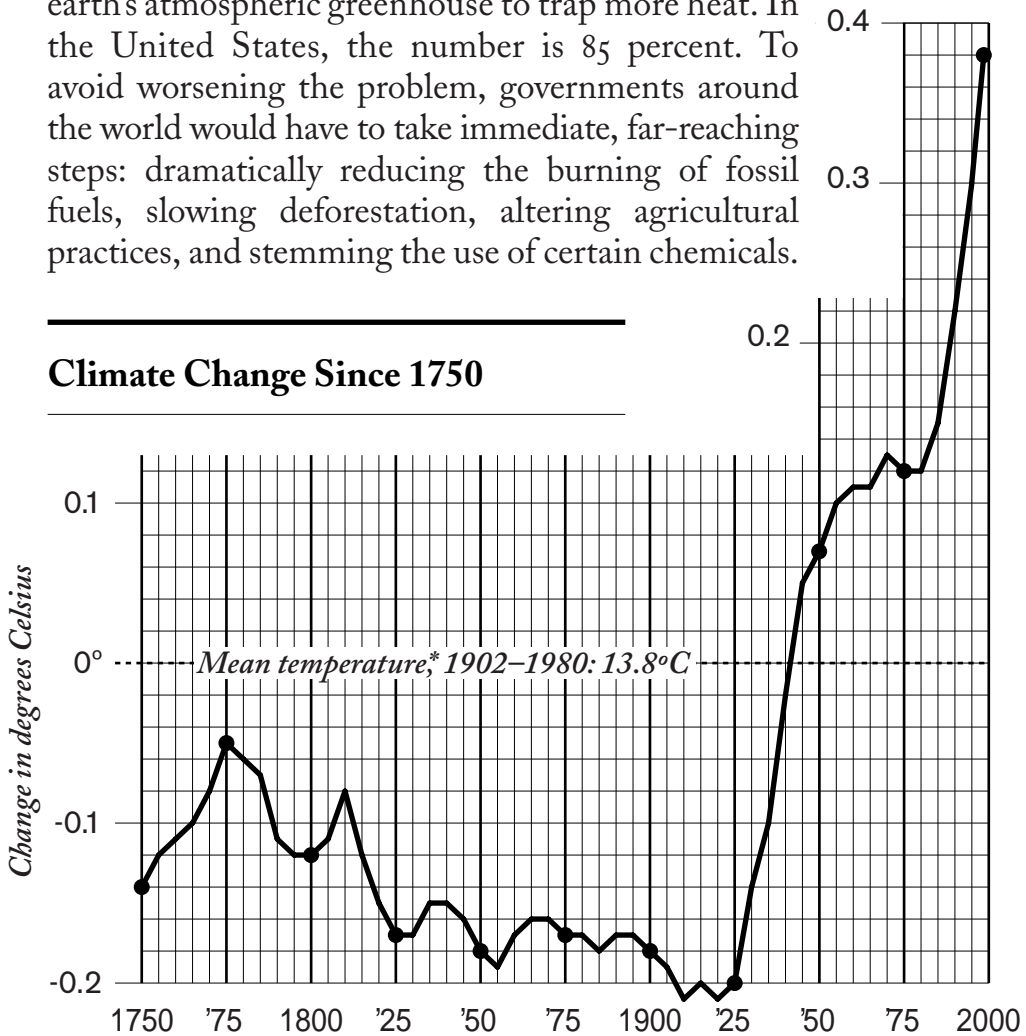
FROM THE ISSUE of local air pollution to those of regional acid rain and global climate change, energy policy and environmental policy are inextricably intertwined and must be addressed together. The prospect of climate change represents the greatest threat. There is almost complete consensus in the international community that our climate is changing and warming; the only disagreement lies in how fast it is occurring and how much this will affect the globe. Life as we know it is based on climatic conditions that result from certain concentrations of "greenhouse" gases. We alter the composition of the atmosphere at our peril. The United States cannot duck this reality; Americans must make new energy choices that reduce their contribution to global emissions and help lead the rest of the world toward an environmentally sound future.

The clearest consequences of increased concentrations of carbon in the atmosphere have now been well documented: rising temperatures and sea levels, altered precipitation patterns, increased storm intensity, and the destruction or migration of important ecosystems. Most unsettling, however, is the growing scientific concern that climatic changes may not happen gradually, as has been commonly assumed. In a recent report, the National Research Council warned:

Recent scientific evidence shows that major and widespread climate changes have occurred with startling speed. For example, roughly half the north Atlantic warming since the last ice age was achieved in only

a decade. ... Abrupt climate changes were especially common when the climate system was being forced to change most rapidly. Thus, greenhouse warming and other human alterations of the earth system may increase the possibility of large, abrupt, and unwelcome regional or global climatic events.

Preventing catastrophic climate change is, at its core, an energy challenge. Globally, fossil fuel production and use accounts for nearly 60 percent of the emissions that are causing the earth's atmospheric greenhouse to trap more heat. In the United States, the number is 85 percent. To avoid worsening the problem, governments around the world would have to take immediate, far-reaching steps: dramatically reducing the burning of fossil fuels, slowing deforestation, altering agricultural practices, and stemming the use of certain chemicals.



SOURCE: M.E. Mann et al., "Global Temperature Patterns in Past Centuries: An Interactive Presentation," World Data Center for Paleoclimatology, 2000.

*Global surface temperature.

Because change of this magnitude will take so much time, and because there is so much momentum built into the current rate of carbon release, it will be impossible to hold atmospheric concentrations at the current level of 380 parts per million (which is already one-third higher than preindustrial levels). More realistically, studies for the Intergovernmental Panel on Climate Change suggest that an extremely ambitious program to reduce worldwide carbon emissions by as much as two-thirds by the end of the century will be necessary just to hold the level of accumulated carbon in the earth's atmosphere below 550 parts per million—roughly double preindustrial levels. Even if this goal is reached, the likely result is that sea levels will rise significantly and species extinction will increase.

Because energy consumption is so vital to industrialized economies, the barriers, both economic and political, to developing international agreements on climate change have been very high. Although most countries, including the United States, have ratified the UN Framework Convention on Climate Change, implementation has been much more problematic. The Kyoto Protocol, which seeks to implement the convention, is too modest in its scope and at the same time unrealistically ambitious in its timetable for the United States. It must be supplemented by U.S.-led initiatives that start quickly yet leave sufficient time for the private investment needed to achieve the treaty's objective: stabilization of greenhouse gases in the atmosphere at a safe level.

Obviously, Washington cannot hope to attain this goal unless it also engages developing countries, whose greenhouse gas emissions are growing much faster than those of industrialized countries. To help maintain stability in the world's climate system, China, India, Brazil, and others must, as their economies and populations grow, fuel their development with economically competitive clean energy options.

ARRESTED DEVELOPMENT

WITHOUT ACCESS to modern, reliable energy sources, economic development is not possible. And in this era of globalization, economic performance around the world affects U.S. economic fortunes and U.S. security. America's environmental destiny is also bound up in the

energy choices that developing countries will make in coming decades. And because poverty is such a long-term destabilizing force, U.S. national security compels an enlightened approach to international access to energy.

Of the world's six billion people, one-third enjoy the kind of energy on demand that Americans take for granted (electricity at the flick of a switch), and another third have such energy services intermittently. The final third—two billion people—simply lack access to modern energy services. Not coincidentally, the energy-deprived are the

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world's most impoverished, living on less than \$2 per day. And their ranks will grow: according to UN estimates, the total population of the 50 poorest nations will triple in size over the next 50 years.

For the poor, especially the rural poor, obtaining even a meager amount of energy comes at a high cost: exposure to hazardous indoor air pollution and the environmentally destructive drudgery of gathering fuel wood and dried animal waste. Equally important, the poor lack the benefits of modern energy services: lights to read by, refrigeration to store medicines, transportation to get products to market, let alone telecommunications and information technology—all prerequisites for economic growth and poverty alleviation.

Moreover, for most developing countries, the necessity of obtaining oil for the transportation sector saps precious foreign exchange and sends scarce dollars abroad, away from critical social needs such as education and health that are unlikely to attract private investment. Many developing countries also suffer from misdirected energy subsidies to both consumers and investors, including the use of government resources to underwrite inefficient energy monopolies and the capture of benefits by urban elites at the expense of the rural poor. This mismanagement of energy resources contributes to impoverishment and inequity, breeding unrest and violence and making the delivery of sustainable energy even more difficult.

Furthermore, global climate change disproportionately hurts the poor. Half of all jobs worldwide depend directly on natural resources

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that are potentially affected by human-induced climate change: fisheries, forests, and agriculture. For example, 70 million people in Bangladesh live in crowded lowlands near the sea, and very large populations in Indonesia and Malaysia are similarly threatened by rising sea levels. In Africa, we can already see agricultural productivity diminished by drought, less availability of potable water, and intensifying hunger and malnutrition. Mass flight from such conditions could destabilize fragile governments and erode investments in poverty reduction.

HURRY THE FUTURE

ENERGY is a common thread weaving through the fabric of critical American interests and global challenges. U.S. strategic energy policy must take into account the three central concerns outlined above—economic security, environmental protection, and poverty alleviation—and set aggressive goals for overcoming them. Leadership from Washington is critical because the United States is so big, so economically powerful, and so vulnerable to oil shocks and terrorism. This is a time of opportunity, too—a major technological revolution is beginning in energy, with great potential markets. And finally, the reality is that where the United States goes, others will likely follow. America's example for good or for ill sets the tempo and the direction of action far beyond its borders and far into the future.

Unfortunately, energy policymaking in the United States in recent years has been neither decisive nor strategic. U.S. energy policy is reminiscent of Mark Twain's quip about the weather: everyone talks about it, but no one does anything. This inertia has deep roots. Vested interests—in the oil, utility, and transportation industries, for example—have been powerful economic and political players, protecting the status quo and brooking little interference from the outside. Similarly, the environmental lobby has proved itself able to block proposals it opposes but less successful in advancing initiatives it favors. As a consequence, little progress has been made toward breaking the gridlock.

America's inability to develop a farsighted, purposeful energy policy is a reflection of the political climate as well. Too often, complex energy issues have been reduced to pithy sound bites. Every decade or so,

Washington enacts a “comprehensive” energy policy, but with few exceptions these measures do little but affect energy practices on the margin, and U.S. strategic interests are kicked down the road.

No issues symbolize the numbing lack of progress on energy policy more clearly than the debates over drilling in the Arctic National Wildlife Refuge and increasing corporate average fuel economy. Both issues have been argued over exhaustively, frequently, and fruitlessly. Indeed, the acronyms “ANWR” and “CAFE” have themselves become shorthand for a quarter century of legislative gridlock.

The time has come to craft a long-term strategic approach to energy. A central feature must be public-private coalitions for change that bring together business, labor, and environmental advocates. The first step must be to focus on what is important and define what needs to be accomplished. Three far-reaching, 25-year goals encapsulate America’s long-term interests and should guide its energy policies.

First, America should address its dependence on oil by cutting U.S. oil consumption by a third, setting an example for the rest of the world and breaking the grip of the global oil cartel. Second, to take on the dangers faced by the world’s climate, America should cut its carbon emissions by a third, as a stimulus to a two-thirds global reduction by the end of the century. Finally, the United States should develop, deploy, and disseminate clean energy technologies and institute trade policies that can increase the access of poor people around the world to modern energy services and agricultural markets. Such moves will improve the lives of billions of people, stimulate economic growth, and create new markets for American goods and services.

Both public and private leadership will be needed to put together the technological innovation and political will to transform the American and world energy systems. Market mechanisms can help address the various economic, environmental, and security interests at stake. Aligning the interests of key stakeholders can build a coalition with enough political muscle to break the status quo. As President George W. Bush put it in his first address to Congress, government has an important role, but not one so large as to crowd out initiative and hard work, private charity, and the private economy. With the public and private sectors working together properly, government incentives and private initiatives can “hurry the future.”

A broad-based, cooperative coalition for change is the missing, indispensable ingredient in transforming a strategic energy vision into reality. Long-time antagonists who are willing to set aside historical divisions and think boldly can create a shared vision for the future that goes beyond the lowest common denominator. Wherever one sits on the political spectrum, it is clear that we need to act, and we need to act in coalition.

BRINGING IN THE MARKET

USING THE MARKET to find the cheapest possible methods to reduce pollution has proved effective in curbing acid rain and should be considered in other instances. In the case of acid rain, the winning strategy was an outgrowth of the work of Project 88, a bipartisan effort to find innovative solutions to major environmental and natural-resource problems. Fifteen years ago, Project 88 advanced the notion that inefficient natural-resource use and environmental degradation can be reduced by ensuring that consumers and producers face the true costs of their decisions—not just their direct costs, but the full social costs. It recommended a strategy of tradable permits for industrial pollutants, particularly with regard to power-plant emissions of sulfur dioxide, a principal cause of acid rain. This novel strategy was central to breaking a decade-long impasse on the issue, when President George H.W. Bush and congressional leaders agreed to a market-based, cap-and-trade system.

A dozen years later, the acid rain-control program is achieving its goals at a cost far lower than even the most optimistic initial estimates. This success owes to the fact that it combined economic efficiency with long-term planning certainty: the program set out a 20-year time line to reduce sulfur dioxide emissions from power plants by more than half, and it used the market to make the least costly reductions. The economic benefits of this policy have been estimated to exceed the costs by an order of magnitude.

The same tools can be applied to emissions of greenhouse gases and other pollution issues. Now is the time for Washington to send a signal and get investment moving toward less-carbon-intensive fuels and technologies. Because fossil fuels are so deeply embedded

in the U.S. energy system, the most practical and efficient way to cut back carbon emissions is an economy-wide market mechanism, which will, over time, provide powerful incentives for investment in renewable energy, improved efficiency, and other low-carbon options.

The myriad machines that use fossil fuels are long-lived, and change comes slowly to them. Changes aimed at reducing carbon dioxide emissions are so fundamental that they will in most cases require replacement of existing capital stock—whether power plants, industrial equipment, or even automobiles—to control emissions, increase efficiency, or redesign production. Sudden changes that force premature retirement of these assets can be expensive, wasteful, and disruptive, especially to the labor force. Well-designed policies and incentives to accelerate the turnover of capital stock can avoid this outcome by encouraging investment in new technologies that increase productivity, reduce emissions, and stimulate job creation.

Uncertainty is the bane of long-term investors, and investment in such technologies today is discouraged by corporate uncertainty about climate change. Many U.S. companies—particularly those with operations in other countries—are prepared to embark on aggressive and innovative strategies to reduce the emission of greenhouse gases. But without a market signal to justify this course, they wait. Meanwhile, investments in carbon-intensive facilities such as coal-fired power plants are held back in the United States by the specter of significant carbon costs in the future, which are surely coming.

Because the carbon dioxide emitted today will warm the planet for a century or more, we must get started immediately. Because the world's energy systems are vast, complex, and expensive, economies will need time to adjust capital investment strategies and realize the benefits of existing assets. And because the transformation will be so large, there must be a commitment to an energy future that looks very different from the system of today.

Three elements are necessary to begin. First, there should be an initial, modest restriction on carbon emissions, coupled with an aggressive emissions-trading program. This policy would start to pay a premium for increased energy efficiency and would encourage greenhouse gas reductions worldwide. Second, governments should create a transition period of 10 to 15 years, during which they provide

incentives for the development and use of low- and no-carbon technologies. Finally, it must be established with absolute certainty that at the end of the transition period, the limits on carbon will turn sharply and rapidly downward until market forces stabilize emissions at a safe and sustainable level. In economic terms, this kind of early signal informs investment and reduces the cost of change in the economy.

The United States must also engage the developing world. Emissions of greenhouse gases are growing faster in poor countries than in rich ones, and in time the developing world will assume the majority share. Therefore, the earth's climate cannot be protected unless the developing countries take on binding commitments to limit their emissions. A global system to reduce emissions will ensure that the marketplace can find the most efficient reductions and that developing countries introduce clean energy technologies as their economies grow. Policies that reduce dependence on crude oil can also encourage the developing world to restrain greenhouse gas emissions and provide it with the resources to do so.¹

PARTNERING UP

ACCOMPANYING marketplace incentives must be a set of new public-private partnerships, smoothing and speeding the transition to a new energy future. Partnerships must be formed behind five central goals: more-advanced vehicles, better fuels to run them, carbon sequestration from coal, modernized electric grids, and new tools for financing global energy development. Strong political constituencies, allied as never before, could be found in each of these partnerships. They would be brought together by the need for a broader energy vision and partly by their own self-interest. These five new partnership initiatives are not all that needs to be done; they should complement ongoing and much-needed support for using natural gas as a transition fuel, broadening mass transit, encouraging energy efficiency in buildings

¹C. Boyden Gray, while skeptical of the climate science, believes that there are sufficient unrelated benefits from a comprehensive, market-oriented, and worldwide approach that involves all sources, sinks, and countries, and sufficient cost savings associated with such an approach, that the risk of disadvantaging the United States or endangering the world economy by proceeding in this manner is minimal.

and appliances, and greatly increasing the use of renewable energy sources. The future role of nuclear power remains unclear; its enormous potential to produce carbon-free electricity is clouded by continuing serious concerns about safety, proliferation, radioactive waste, and cost.

But these five new partnerships would have unique characteristics: they would bring together unlikely allies, energize large constituencies, and form an unusual and powerful coalition that could alter energy policy, set a truly visionary new course, and hurry the transition toward a better future.

RETOOLING DETROIT

DISPLACING OIL in the American economy will address simultaneously the problems of dependence and climate change in the United States, while providing cleaner alternatives for the millions of new vehicles that will hit the world's roadways as other nations develop in coming years. Two-thirds of the oil consumed in the United States goes into the transportation sector, particularly the gas tanks of the country's 220 million cars and trucks. The voracious consumption of petroleum simultaneously puts the nation in thrall to foreign oil producers and accounts for more than a third of all U.S. carbon dioxide emissions. In one way or another, all of the parties involved—automakers, autoworkers, environmental groups, consumers—agree on the desirability of advanced vehicles that run cleaner and go farther on a gallon of gas (or eventually dispense with gasoline altogether), yet the fuel economy of the vehicle fleet has been dropping.

New technologies have emerged in recent years that could produce substantial gains in fuel economy without compromising other consumer preferences. These technologies include hybrid electric power trains, clean diesels, incremental improvements to conventional gasoline engines, and eventually hydrogen fuel cells. But changing the fleet, within the required timetable, costs money. Automakers are understandably reluctant to increase the cost of their products with new, less-familiar technologies, especially now, when competitive pricing and soft demand are squeezing the market.

Society as a whole should be a co-investor in these new technologies. If automakers agree to reinvent their product lines and manufacturing

processes, consumers will be able to get the performance they want, and automakers the profit they need, while enabling more-efficient, more-climate-friendly vehicles to enter the market rapidly. As a priority, Washington should support sharply accelerated adoption of hybrid technology as a step toward the Bush administration's goal of a "freedom car" powered by clean-burning hydrogen.

Hybrid technology employs advanced combustion and electric motor capabilities to improve efficiency sharply. This technology is available now, not 15 or 20 years in the future. Ford will begin building a hybrid version of its Escape sport utility vehicle later this year, General Motors will release two hybrid pickups this year and plans ten more such offerings by 2006, and Japanese automakers are well down the line in integrating hybrid technology into an array of vehicles. But without some greater incentive structure, the transition to broad manufacture and consumer acceptance of hybrids will be slow, too slow to help significantly on the issues of dependence and climate in the necessary time frame. Getting millions of hybrid vehicles on the road quickly will require policy that is as smart as the technology. An aggressive set of tax incentives would jump-start acceptance of hybrid vehicles by consumers and drive penetration of the technology across different vehicle types. The result would be improved fuel efficiency throughout the fleet, millions of gallons of fuel saved, and countless tons of carbon dioxide emissions avoided. For example, a government investment of \$10 billion for a combination of manufacturing changes and direct consumer incentives would spur the production of millions, not thousands, of new hybrid vehicles; accelerate the spread of the technology; and build consumer acceptance, all without threatening the U.S. manufacturing base.

Regulatory flexibility can also help. Auto companies and fleet operators ought to be able to help finance hybrid car purchases by cutting certain emissions below baseline and then selling credits to manufacturers, utilities, and other emitters, at least on a pilot basis. For example, given the exceedingly high cost of cutting back on nitrogen oxide emissions in places such as California, opportunities for trading emission credits between car companies and industrial

Hybrid car technology is available now, not 15 or 20 years down the line.

emitters—now prohibited—could provide incentives far more powerful than tax breaks.

Hybrid and other advanced technologies already exist, but they will remain as stuck as a car in a traffic jam unless an unprecedented alliance breaks the gridlock. Such an alliance is taking shape now. A broad coalition of oft-warring interests from industry, labor, and the environmental ranks is currently working on an incentive package to stimulate development of advanced technology vehicles.

FUEL GROWTH

A SECOND and similar partnership is emerging around the potential for growing fuel in the United States. In this partnership, American farmers—and the large and powerful block of farm-state politicians—have an opportunity to create a potentially profitable new market, make common cause with large and small agricultural producers around the world, and contribute to a better environmental future. Through this partnership, Washington can help governments overcome the key impasse in the Doha Round of trade talks by reducing or eliminating agricultural export subsidies that distort global markets and devastate developing countries.

Many Americans know about the nascent steps the country has taken to encourage a domestic ethanol industry—transforming ears of corn into gallons of gas. But the real promise of fuel farming remains largely untapped. New industrial biotechnology processes are revolutionizing the conversion of agricultural crops and waste products to energy. By intensifying the nation's commitment to this emerging industry and diversifying bioenergy feedstocks, the United States can reduce oil consumption and carbon dioxide emissions while stimulating economic growth in rural areas and enabling the cultivation of transportation fuels in virtually every nation.

Encouraging agricultural-based fuel supplies squarely addresses one of the toughest entanglements in current trade discussions. The impasse over farm subsidies threatens the success of the Doha Round and the further expansion of global trade. Yet these subsidies have strong political support, particularly in Europe, which provides agricultural supports for social reasons—to preserve a way of life.

Subsidies for food crops and other core commodities squeeze developing countries especially hard. The World Bank estimates that the \$300 billion worth of annual agricultural subsidies in industrialized countries suppresses world prices and undermines developing-country exports. In total, these subsidies are about six times higher than current development-assistance levels. The average European cow receives \$2.50 per day in government subsidies, the average Japanese cow \$7.50, yet 75 percent of people in Africa live on less than \$2 per day. Another recent World Bank study found that full elimination of agricultural protection and production subsidies in industrialized countries would increase global trade in agriculture by 17 percent and raise agricultural and food exports from low- and middle-income countries by 24 percent. As a result, total annual rural income in these countries would rise by about \$60 billion.

As the developing countries' agricultural sector becomes self-sustaining, their farmers will be able to mix production of food and textile crops with energy crops that have a robust and growing market. Thus, shifting farm export subsidies to support biomass fuels would encourage the production and reduce the costs of agriculturally derived petroleum substitutes, while also breaking down distortions in world markets and barriers to trade for farmers in developing countries.

Offering these benefits to developing countries may also help entice them to participate in a worldwide carbon cap-and-trade system, which would bring developed-country investment to carbon dioxide reduction measures in the developing world, where such actions would be much cheaper. Cutting carbon dioxide in developing countries will address a broad range of environmental and regulatory equity issues, while also improving public health as various local air pollutants are reduced along with carbon dioxide (ozone and acid rain precursors, for example, as well as particulates and toxic emissions).

The major breakthrough for the use of bioenergy will lie in the commercialization of chemical and biological conversion techniques that can make cost-effective use of cellulosic plant material (e.g., corn stalks, wheat straw, rice hulls). Currently, ethanol is produced from the starch in corn kernels, as opposed to the woody (cellulosic) material in the stalk and leaves. Conversion of cellulose would enable the

use of agricultural waste products, providing a double dividend for farmers (only 50 percent of harvested food and feed crops are used at present). Other materials (grasses, wood wastes, even municipal waste) could also be utilized. In the long run, crops grown for energy markets—using sustainable management and consistent with biodiversity—could greatly increase the supply of cellulose.

The current ethanol industry, based on corn, produced 1.6 billion gallons of ethanol in 2000, or slightly more than one percent of total gasoline consumption in the United States. Available waste materials could increase ethanol production by a factor of ten, and low-cost

The U.S. electric power system is antiquated and inefficient, operating for the most part on 50-year-old technology.

crops grown as ethanol feedstocks could triple that number yet again. One of the great advantages of ethanol is that it can constitute both a short- and a long-term answer to oil dependence: long-term, because it will be an efficient and carbon-friendly liquid carrier of hydrogen for fuel cells, when they become cost-effective; and short-term, because ethanol can be cleanly used as an alternative fuel with today's technology in blends of up to 85 percent in flexible-fuel

vehicles. Importantly, the production of these vehicles—i.e., cars that can run equally well on ethanol or gasoline—is a simple and low-cost adjustment to conventional automotive manufacturing. About four million such cars and minivans are already on the road.

Cellulosic ethanol also can be “carbon neutral”—the carbon dioxide given off during its production and use is the same carbon dioxide that was absorbed from the atmosphere by the biomass feedstocks as they grew. Enzymatic conversion of cellulose, based on recent advances in biotechnology, would significantly reduce the energy required to produce ethanol and virtually eliminate the net increases in carbon dioxide emissions associated with the use of traditional fuels.

Washington should pursue a well-focused program to make bioenergy a low-risk commercial choice, funded at a level commensurate with its potential benefits to national security, trade, and the environment. This may be the only way that the United States can

ensure—in a few years, as opposed to a few decades—a significant supply of renewable, sustainable, and indigenous fuel alternatives to imported oil or limited natural gas reserves.

CLEANING UP COAL

JUST AS more-efficient cars and trucks that run on domestically grown fuel will address the dependence and emissions problems caused by oil, so, too, an innovative partnership is focusing on the future of coal, the world's most abundant but most carbon-intensive fossil fuel. This novel and unlikely partnership among industry, labor, and environmental advocates is coalescing around a far-reaching clean-coal technology—the sequestration, through underground disposal, of carbon generated from coal combustion—that has the potential to enable the continued use of coal as a primary energy source while also protecting the climate.

Electricity is the fastest growing form of energy worldwide, critical for industrial nations and developing countries alike. Over the past decade, total world electricity demand grew by 29 percent, and it is likely to continue growing. According to the 2002 *World Energy Outlook*, two-thirds of the world's total power-generation capacity that will be on-line in 2030 has not yet been built. Coal is fueling the largest share of power generation now and will supply an increasing percentage of growth in the future, particularly in the developing world. Over the next 30 years, China and India alone will account for two-thirds of the increase in total world coal demand, principally for electricity.

But the history of coal has also been characterized by environmental degradation. The climate-change issue arose on the heels of acid rain concerns, blackened skies, and local air-pollution issues. Globally, coal combustion now accounts for almost 40 percent of all fossil-based carbon dioxide emissions (just behind oil, the leading emission source), and coal burning results in more carbon emitted per unit of energy than any other source. But coal also has very significant advantages: availability and price. So the challenges are to make this cheap, abundant resource more climate-friendly and to make its valuable product—electricity—more accessible and available.

Technologies that allow the capture and sequestration of carbon emissions can transform the future of the coal industry. Carbon dioxide, the most pervasive byproduct of coal burning, can be captured in gaseous form prior to or as a byproduct of combustion and stored underground in deep geologic formations (e.g., depleted oil and gas wells, coal seams, deep saline aquifers). Initial steps toward a broader sequestration strategy are already being taken in commercial practice. Thirty-two million tons of carbon dioxide are injected into oil fields in the United States annually for enhanced oil recovery. Off the coast of Norway, one million tons of carbon dioxide a year are being pumped into a saline formation underneath the seabed.

The key challenges related to managing carbon dioxide from coal are the costs of capture and storage. Industry and government have begun work on both. The Bush administration recently launched the “FutureGen” project, a \$1 billion partnership with industry to develop a cost-effective new generation of coal-fired power plants that emit no greenhouse gases into the atmosphere. And a variety of partnerships are underway to explore the best long-term sequestration options.

Perfecting and commercializing carbon capture and sequestration would allow the United States and others to exploit vast coal reserves in a climate-friendly fashion. And global demand for technically effective and financially feasible sequestration presages very large new international markets. A successful carbon sequestration program would be a boon to technology suppliers and the mining industry alike. In addition, carbon-capture technology, which leaves behind a hydrogen stream, could make coal a low-cost source of hydrogen for fuel cells in buildings and cars and reduce U.S. dependence on oil.

The transition to this future will be tricky. The greatest danger the coal industry faces in the United States is that as carbon emissions are gradually constrained, it will give up market share piece by piece to natural gas and lose its ability to recover. Washington must promote policies to mitigate that outcome, such as aggressive research and development on cheaper capture and storage of carbon, subsidies for advanced coal technology for sale in domestic and overseas markets, and incentives for power plants that commit to switching to carbon-free technology by a certain date. All of these tools could lessen the harm to the industry and its workers as coal is cleaned up.

DIGITAL REVOLUTION

THE ELECTRICITY DISTRIBUTION SYSTEM in the United States is perhaps the most underappreciated and vulnerable part of the country's national infrastructure. In this digital age, the need for high-quality, reliable electricity makes the transmission grid almost as vast and as important as the highway system. The electricity business now generates \$224 billion a year in revenues, accounting for about four percent of the U.S. GDP. Its value to the economy is multiples of its cost.

Yet the nation's electric power system is antiquated, fragile, and inefficient, operating for the most part on 50-year-old technology. Running today's digital society through yesterday's grid is like running the Internet through a telephone switchboard. Routine outages and power-quality disturbances cost U.S. businesses tens of billions of dollars a year. A serious accident or an act of sabotage could cripple major regions for days or weeks and do enormous damage to the economy, much like a disruption in oil supply.

Lack of investment in critical infrastructure and surging demand for high-quality, digital-grade electricity have taxed the transmission and distribution system to its limit. Most credible forecasts predict that this underinvestment will continue. Additionally, microprocessor-based technologies have radically altered the nature of the electrical load, resulting in electricity demand that is incompatible with a power system created to meet the needs of an analog economy. This has led to problems with quality and reliability that particularly affect such high-tech industries as telecommunications, data storage and retrieval services, the financial industry, biotechnology, electronics fabrication, and other businesses that use continuous-process manufacturing.

Rewiring the grid with advanced computer controls would allow power to be distributed more efficiently, safely, and securely and would facilitate the spread of distributed generation (via fuel cells and solar panels, for instance). It would at once save energy, create jobs, reduce emissions, and enhance American security.

Development of a self-healing transmission and distribution system—capable of automatically anticipating and responding to disturbances, while continually optimizing its own performance—will be critical for meeting the future electricity needs of an increasingly

digital society. The benefits of a self-healing grid would include not only enhanced reliability, but also innovative customer services, real-time load management, reduced costs, and increased throughput on existing lines via more-effective power-flow control. Standardized “plug and play” interfaces for both power and communications systems would allow distributed generation to proliferate. The self-healing grid would also increase grid security in response to the threat of terrorism.

Public recognition that the electricity network is inefficient and shockingly vulnerable to disruption and attack is the first step toward building support for a “smart” grid. Policy change must follow. A mechanism is needed to compensate both public and private investors. Regulatory agencies at the state and federal level will need to provide appropriately attractive rates of return to deploy this new technology. Interconnection standards should be clarified and barriers removed. Performance metrics should be incorporated in voluntary system standards set by the North American Electric Reliability Council.

Transformation of the power grid would result in greater productivity growth, higher economic growth, lower carbon emissions, and increased national security. These advantages, in turn, can help grow the smart-grid partnership among private-sector beneficiaries—whether in Silicon Valley or in a biotechnology manufacturing plant—and those in government whose involvement is needed to repair this fragile system.

PAY IT FORWARD

OF ALL THE PARTNERSHIPS forged to create a new energy future, the one with the world’s poor may have the most effect on collective security, the environment, and common economic prosperity. The world is looking at a tripling of energy use by 2050, as the economies of China, India, and other developing nations increase economic output. Even with that growth, the modern energy-services gap faced by nearly two billion people will not be closed. And if that growth occurs using outdated and polluting energy sources, climate-altering emissions will grow dramatically. In human and environmental terms, this scenario presents an unacceptable future and a daunting challenge.

An international response that faces up to the scale and scope of the challenge requires three broad and complementary actions: improved national policy and governance frameworks, increased national and international resource commitments, and targeted investment strategies. The United States can make an enormous difference in all three areas—and advance its own national interests—with policy, regulatory investment, and resource assistance to developing countries. In addition, by providing international leadership in energy technology and policy, the United States can help create potentially enormous new markets for American suppliers of goods and services in the energy sector.

Approximately \$50 billion per year is spent on international aid by all the countries in the Organization for Economic Cooperation and Development combined—representing only one-third of one percent of their aggregate GDP. Clearly, this formal “aid” funding does not reflect the potential of OECD nations to spur development. And only a minor fraction of official development assistance is spent on energy. Although development assistance can be catalytic in nature (particularly in reorienting policy frameworks), financing on the order required must depend on the mobilization of public resources in developing countries and of private capital, both local and international.

To help encourage local enterprise, Washington needs to galvanize the international community around community-based projects that actually work and target policies and scarce resources to help bring them to scale. The current patchwork quilt of bilateral and multilateral efforts is simply too balkanized and spread too thin. A new “Global Rural Energy Fund” that allocates assistance on the basis of “what works” would help bridge the yawning gap between pilot projects that are actually delivering results and the capital needed to make them standard practice.

In order for private investment to spur market adoption of clean energy technologies, at least three critical financial barriers must be overcome: high transaction costs (for small projects), high

The world faces a tripling of energy use by 2050, as China, India, and other developing countries grow.

capital costs (relative to traditional alternatives), and inability to capture life-cycle cost savings (for instance, over a period of 30 years for hydroelectric projects and 20 years for solar ones). To overcome these barriers, innovative financing techniques are needed that can reduce risk to and mobilize investment by the private sector—for example, with extended-term financing for low-carbon energy technologies.

In addition, the United States should create a new category of investment securities, called “Global Development Bonds.” These would combine tax benefits, political risk insurance, and matching funds from the U.S. government, subject to the funds’ being used in selected countries (consistent with the president’s Millennium Challenge Account initiative) and for specified sustainable-development purposes. Other nations could create similar instruments.

By authorizing these securities, the United States would benefit in several ways. It would leverage private-sector funds in a way that foreign aid now does not. It would improve the effectiveness of dollars flowing overseas because the funds would flow through many competing channels, seeking best applications through market forces. It would improve the efficiency of moving money into key developing countries because the private sector works faster and at much lower overhead cost than government. And it would open up new export opportunities for U.S. businesses and help restore American esteem in the international community.

COALITIONS FOR CHANGE

THE PROBLEM of global oil dependence has long been apparent, whereas concern about climate change is comparatively new. Both issues suffer from their sheer size and scope: many people simply believe that the problems are intractable and that practical solutions are beyond our reach and imagination. Focusing on practical solutions of the kind described above is a strategy for political change, a strategy based on restoring hope that the world’s energy systems can be turned in a new direction.

A strategic energy policy will unite diverse political constituencies and forge common cause among stakeholders that are often at odds. The environmental community’s objective is not to shut down coal,

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it is to shut down carbon; zero-carbon coal thus is something to agree on. The automotive and oil industries' objective is not to prop up dictators in the Middle East or to sully the natural world, it is to provide a return to their shareholders; making fuels, cars, trucks, and buses that are clean and profitable thus is something to agree on.

Most of all, a collaborative strategic approach holds out hope for ending dependence on oil, eliminating excess carbon dioxide emissions, and providing clean and reliable energy services and agricultural opportunity to the world's poor. The result would be to "hurry the future" by unleashing a torrent of innovation that will stimulate economic growth, create new jobs, improve productivity, and increase prosperity and security for the United States and the world. 🌍