

THE MILLION-VOLT ANSWER TO OIL

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EXECUTIVE SUMMARY

Electricity—not oil—is the heart of the U.S. energy economy. Power plants consume as much raw energy as oil delivers to all our cars, trucks, planes, homes, factories, offices, and chemical plants. Because big power plants operate very efficiently, they also deliver much more useful power than car engines and small furnaces. Electricity is comparatively cheap, we have abundant supplies and reliable access to the fuels we use to generate it, and the development of wind, solar, and other renewables will only expand our homegrown options. Our capital-intensive, technology-rich electrical infrastructure also keeps getting smarter and more efficient. With electricity, America controls its own destiny.

From the beginning, electricity has progressively displaced other forms of energy where factories, offices, and ordinary people end up using it day to day. Electrification has been propelled not by government mandates or subsidies but by normal market forces and rapid innovation in technologies that turn electricity into heat and motion. Over 60 percent of our GDP now comes from industries and services that run on electricity, and over 85 percent of the growth in U.S. energy demand since 1980 has been supplied by electricity. And the electrification of the U.S. economy isn't over. Electrically powered heaters, microwave systems, and lasers outperform oil- and gas-fired ovens in manufacturing and industrial applications, and with the advent of plug-in hybrids, electricity is now poised to begin squeezing oil out of the transportation sector.

While power plants operate very efficiently from an engineering perspective, the electricity market could operate much more efficiently than it currently does. Across the country, peak wholesale prices vary by 1 to 3 cents per kilowatt-hour. On average, over the course of an entire year, about half of the total capacity available nationwide stands idle. And over the course of the same year, one-fifth of the electricity is generated with very expensive fuel.

These problems are the result of highly variable demand. Enough power plants have to be built to meet peak loads, but the peaks move from east to west with the sun, because they track human activity and the weather. Where the cheapest power is available and the expensive power is being bought shifts in tandem. Wide spreads in the price of electricity available at different points in the country at almost every minute of the day reflect huge economic opportunity still waiting to be captured.

A backbone grid built with state-of-the-art high-voltage technology and spanning the continent could readily move 25 percent of America's power over very long distances, at a cost well under 0.5 cents per kilowatt-hour moved. Overlaid on the existing, fragmented system, a backbone grid will let cheap power chase high demand around the clock and across the country. It will squeeze significantly more electricity out of every dollar of invested capital and every dollar spent on raw fuel. The economic benefits can be shared at both ends of the line, whichever way the power moves. And the savings that a backbone grid delivers will only increase as environmental costs are progressively folded into the economic spreadsheets.

The U.S. grid is the most ubiquitous and advanced energy delivery network in the country and on the planet. Building out a backbone grid—a financially modest undertaking for an industry as large as the power industry already is—will unleash innovation and competition on both the supply side and the demand side of our energy market. To get over \$4 gas, we should let American capital, labor, and know-how get on with what they already do so well, and connect us to the 4-cent electricity.

ABOUT THE AUTHOR

PETER W. HUBER is a senior fellow at the Manhattan Institute and a columnist for *Forbes* magazine. He is the author of numerous books and articles on energy, the environment, science and technology, legal policy, scientific evidence, and telecommunications. He taught mechanical engineering at the Massachusetts Institute of Technology, and clerked for Judge Ruth Bader Ginsburg of the D.C. Circuit Court of Appeals, and for Justice Sandra Day O'Connor of the U.S. Supreme Court. He has a Ph.D. from MIT, and a J.D. from Harvard Law School. His most recent book, co-authored with Mark P. Mills, is *The Bottomless Well* (Basic Books, 2005).

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THE MILLION-VOLT ANSWER TO OIL

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Electricity—not oil—is the heart of the U.S. energy economy. Power plants consume as much raw energy as oil delivers to all our cars, trucks, planes, homes, factories, offices, and chemical plants. Because big power plants operate very efficiently, they also deliver much more useful power than car engines and small furnaces. On their own, our passenger cars consume less than half as much raw energy as our power plants, and turn it into useful power at the wheels about half as efficiently. If we could plug our cars directly into the electric grid, and choose the best time and place to plug them, idle capacity in existing plants could power almost all the miles we drive. With a 10 percent boost in production, the grid could also take care of all the heating supplied by oil-fired home furnaces.

Electricity is also comparatively cheap. If we could deliver electricity straight to electric motors connected to our wheels, it would deliver miles at a price that most current car engines could match only on gasoline priced under a dollar a gallon. Delivered to our homes at off-peak prices, electrical heat would cost homeowners a lot less than \$4-a-gallon heating oil. Electricity is cheap because the gigantic furnaces and boilers that spin million-horsepower turbines and generators run almost entirely on fuels that cost much less than oil. As a result, we spend roughly half as much on electricity—about \$350 billion a year—as we're currently spending on \$100-a-barrel oil, and electrically powered systems do more, faster and better, than oil-fired alternatives.

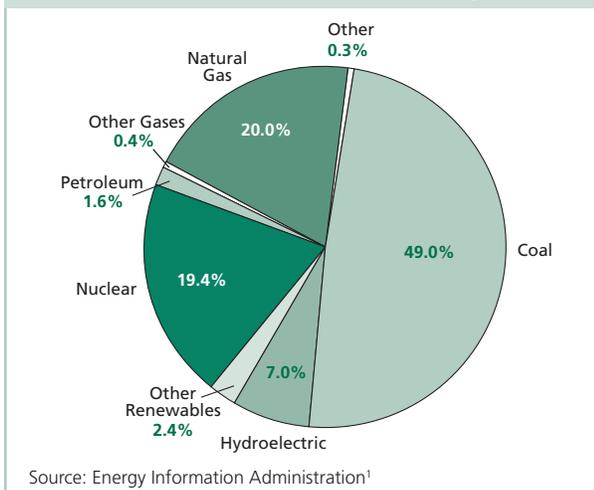
And finally, our electricity is made in America. Tomorrow's power plants, like today's, will be powered by anything but oil. We have abundant supplies and reliable access to all the fuels we currently use to generate electricity, and the development of wind, solar, and other renewables will only expand our homegrown options. Moreover, and in any event, the cost of our electricity depends mainly on the cost of capital, labor, and know-how, the most inexhaustible and renewable resources on our planet. With electricity, America controls its own destiny.

ELECTRICITY AND OIL IN THE 7-11 ENERGY ECONOMY

If many people don't realize that electricity is bigger than oil, it's surely because most of the huge infrastructure behind the plug stays far out of sight. Just three very high voltage lines delivering power from eleven plants could deliver all the power that the 8 million residents of New York City use on the hottest day in summer. It would take about 110,000 Pontiacs racing neck and neck, pedal to metal, to send that much shaft power to the cars' wheels. New York in fact generates much of its power within the city's limits, though most of its residents probably don't know where the plants are located. The rest of the city's electricity comes from nuclear and hydroelectric facilities in upstate New York, Connecticut, and Quebec, and from coal-fired plants in the Midwest.

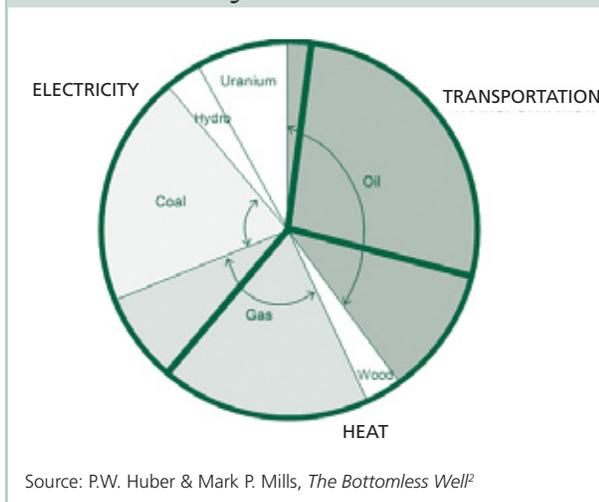
Through much of the twentieth century, America generated significant amounts of electricity with oil. When oil prices spiked in the early 1980s, however, utilities quickly switched to other fuels; our oil-electricity link has been reduced to low-grade "residual" fuel oil that's used to generate less than 2 percent of our power. We have abundant supplies of coal and substantial supplies of uranium, and we can readily obtain more uranium from Canada and Australia. Hydroelectric power provides almost 7 percent of our electricity, and other renewables are rising fast. The winds that sweep north through Texas and across the prairies make this wide, spacious, thinly populated corridor ideal for wind farms.

Fuels Used to Generate Electricity (2006)



What all this adds up to is a 7-11 energy economy. America consumes about 7 billion barrels (BBO) of oil a year and gets the energy equivalent of about 11 billion barrels of oil (BBOE) from coal, gas, uranium, and hydroelectric dams. We generate almost all our electricity with fuels from the not-oil side of the ledger, and electric power plants consume over half of the not-oil fuel.

Primary Fuels and Uses



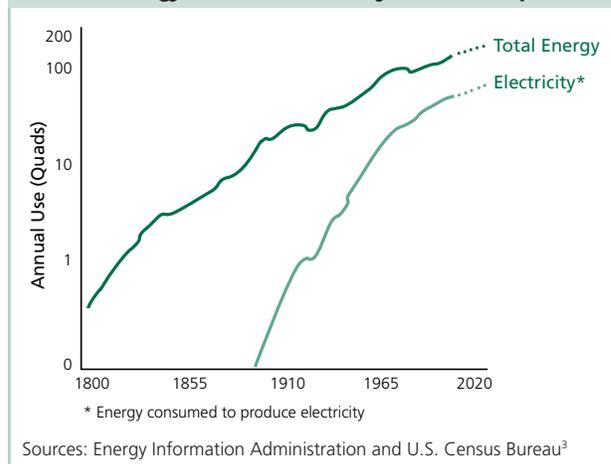
Looking to the future, power plants can run on almost anything. They can spin their turbine-generators with steam—which they can produce by burning coal, gas, oil, wood, trash, or other combustibles—or they can replace the furnace with a uranium reactor, or they

can replace the steam with water in a hydroelectric plant, or wind turning a windmill. Solar cells skip the spinning stage, transforming sun directly into electricity. The electrical grid offers the only ubiquitous, immediately practical, efficient link between windmills, large solar plants, other renewable-fuel technologies, and the rest of America.

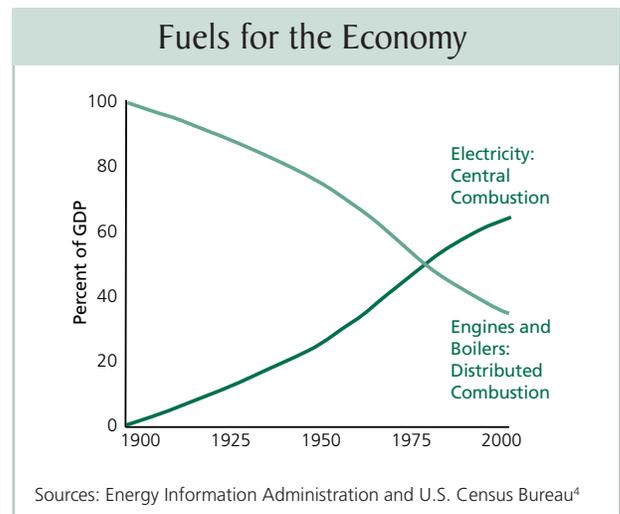
The most important economic fact about electricity, however, is that most of its cost isn't tied to fuel at all. The expensive part is the hardware that turns cheap, raw fuel into high-grade power at the plug. We generate almost 80 percent of our electricity in plants that run on coal, uranium, or water behind a dam; in all these plants, the amortized cost of the hardware dwarfs the cost of the fuel. Roughly half of the hardware is in the plant itself, and the other half is in the far-flung network of wires that moves the power from the plant to half a million (or so) dispersed users. The wires alone cost more than the fuel.

This capital-intensive, technology-rich infrastructure also keeps getting smarter and more efficient. As a result, even as fuel prices have fluctuated and fuel mixes have changed, the average retail price of the kilowatt-hour has fallen almost without interruption since Thomas Edison fired up his Pearl Street generators in New York in 1882. Where electricity rates have risen sharply, as they have in some states in recent years, the principal causes have been domestic regulatory choices and policies—some economic, some environmental.

U.S. Energy and Electricity Consumption



From its beginning, electricity has progressively displaced other forms of energy in factories, offices, and homes. Electrification has been propelled not by government mandates or subsidies but by normal market forces and rapid innovation in technologies that turn electricity into heat and motion. Most recently, electricity has emerged as the only form of energy that can power the information technologies responsible for our burgeoning post-industrial wealth. Over 60 percent of our GDP now comes from industries and services that run on electricity; in 1950, the figure was only 20 percent. Over 85 percent of the growth in U.S. energy demand since 1980 has been supplied by electricity.



The electrification of the U.S. economy isn't over—quite the contrary, it's picking up speed. Industrial, commercial, and residential heating, welding, chemical processing, and things of that sort currently use about 15 percent of the oil we consume, along with about as much energy from natural gas. New technologies allow electricity to do the same jobs cheaper and better. Electrically powered heaters, microwave systems, and lasers outperform oil- and gas-fired ovens in manufacturing and industrial applications, just as kitchen microwave ovens are usually quicker and cheaper than gas stoves. And if the recent, sky-high prices for gas and heating oil persist, they will propel a sharp shift to electrically heated homes. At the 2008 peaks, the raw energy in natural gas and crude oil cost 4 to 8 cents per kilowatt-hour, which is more than the off-peak price of electricity available in many areas.

Oil-fired household furnaces and boilers are also at least 10 percent less efficient than electric heaters, and half as efficient as heat pumps.

Electricity is now set to begin squeezing oil out of the transportation sector as well. First, there's a cushion shot. The gas that electricity displaces from heating systems in factories and homes can be used for transportation instead. Heavy trucks, delivery vehicles, and buses, which currently burn about 20 percent of the oil we use, are easily modified to run on natural gas—many already have been—and gas-powered passenger cars are following close behind. And, as discussed further below, coal, uranium, and renewable alternatives could free up much of the 1 BBOE of natural gas that's currently used to generate electricity. That's enough gas to displace another 15 percent of all the oil we use.

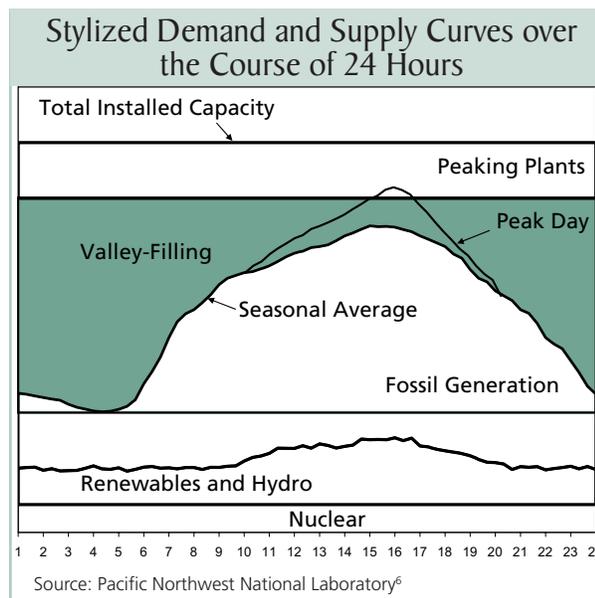
Beyond that, plug-in hybrids will soon be recharging their batteries directly from the grid. Most fuel-hungry trips are shorter than six miles and therefore well within the range that can be delivered by the nickel-metal-hydride batteries in hybrids already on the road, and easily within the range of the automotive-class lithium batteries that are expected within a couple of years. The power generated by current hybrid-car engines costs at least 30 to 50 cents per kilowatt-hour when the car runs on \$4-a-gallon gasoline. Many utilities sell off-peak power for 2 to 4 cents, and the nationwide average residential price is about 9 cents. So the technology for replacing (roughly) one pint of gasoline with coal, uranium, water power, or wind used to feed 1 kilowatt-hour of power to the wheels is now very close at hand.

SUPPLY AND DEMAND

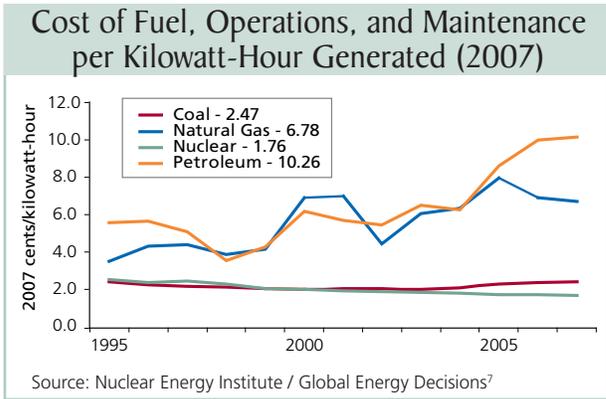
Running an economically efficient electricity market is enormously important because electricity already occupies such a central role in our energy economy, and doubly important because plentiful supplies of cheap electricity can displace a great deal of oil. By comparison with the rest of the energy economy, the electricity market is already very efficient indeed. It could, nevertheless, operate much more efficiently than it currently does.

A major study recently released by the U.S. Department of Energy, for example, explores the feasibility of using wind power to generate 20 percent of U.S. electricity by 2030.⁵ America certainly has plenty of windy sites in unpopulated areas, windmills are already up and running, the technology continues to improve, and costs will continue to fall. But wind is a fickle fuel, and the grid must deliver steady power. A new, national “transmission superhighway” will be required, the report concludes, to pool the intermittently available power from many different sites.

But why limit that kind of thinking to wind? Seen from a distance, every power plant is a fickle source of power—some of the time nearby residents need all its power, so none of it can be used farther away, but when they don't, the surplus power can be shipped out of town. The flip side of less demand is more supply, and demand varies a lot from hour to hour, day to day, and season to season.



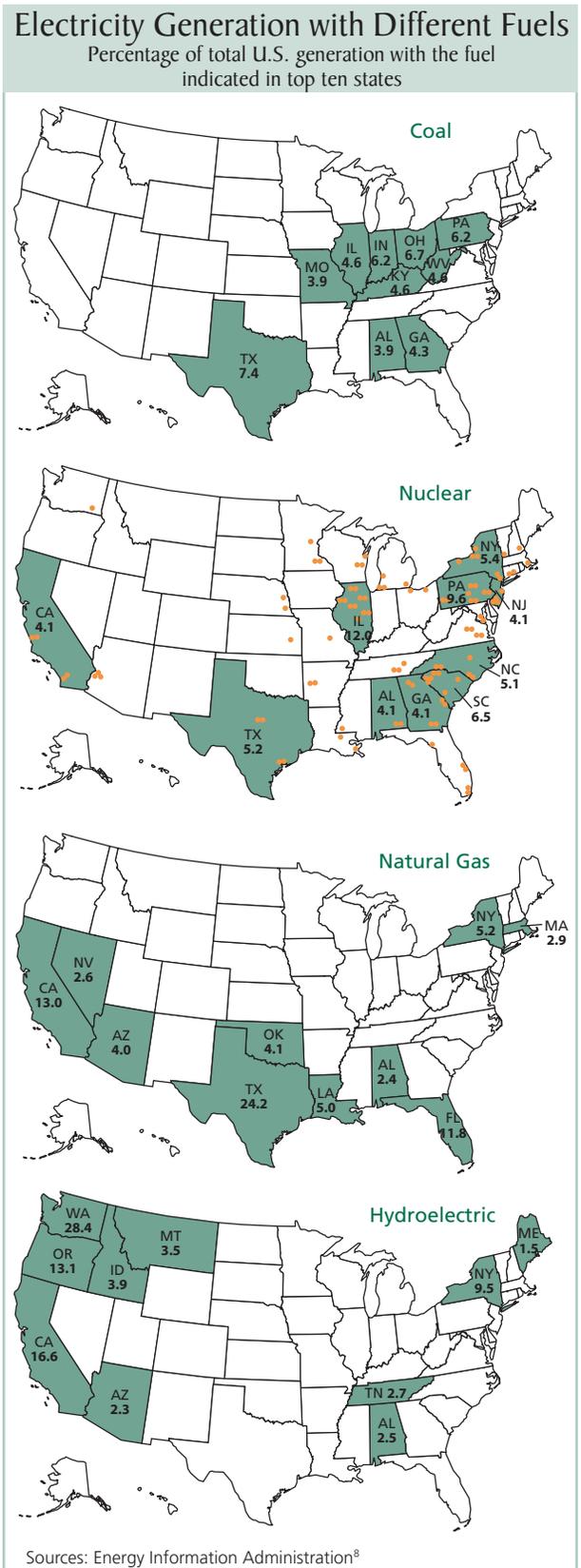
The cheapest way to meet highly variable demand is to generate baseload power in big, expensive plants running on cheap fuel, and to take care of the peaks with smaller, cheaper plants running on expensive fuel. In practice, that currently means generating baseload power with cheap coal or uranium, while meeting peaks with expensive natural gas. This minimizes the average, combined cost of capital and fuel.



But the trade-offs are much more complicated than that. Capital costs are sunk—investors can't ship a billion-dollar plant back to Sears and get their money back whenever it's idle. The cost of both power plants and fuels also depends a lot on where the plants are sited. The biggest plants are best sited far from population centers, scenic coastlines, and fragile ecosystems, in places where land is cheap, where conventional or renewable fuels are readily available, and where safety and environmental concerns can be addressed at the lowest cost. Coal plants have landed disproportionately in coal country, while much of the U.S. nuclear capacity is concentrated in several regional clusters. Texas is home to the world's two largest wind farms and accounts for almost one-third of U.S. wind capacity and almost half of the current growth. Arizona's Solana Generating Station will produce 280 MW of solar power when completed in 2011, and today would rank as the largest solar plant in the world.

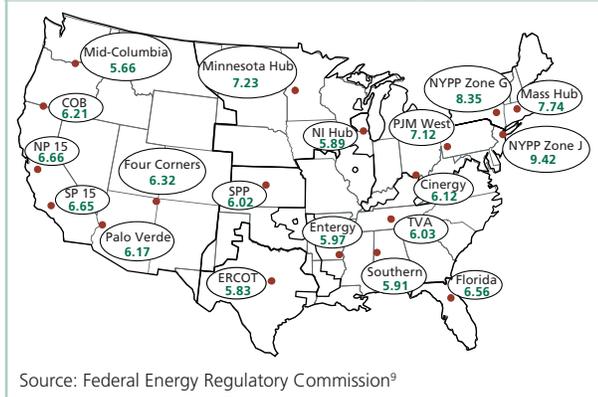
The grid cuts across all the varied costs of capital, fuel, and environmental impacts, and all variations in demand as well. A grid with a broader reach shifts the economic advantage toward bigger plants, more capital, cheaper fuel, lower environmental impacts, and cheaper mitigation of those impacts, because more grid pools more users and thus turns fickle peaks and valleys into flat, steady baseload demand. But the grid's wires aren't free, either. The hard part is working out just how much capital invested in grid will minimize costs overall.

The price of electricity is the best (though imperfect) indicator of how these various factors play out across America today. Across the country, peak wholesale prices vary by 1 to 3 cents per kilowatt-hour. Some



states export a lot of power to their neighbors, while others rely heavily on imports.

Sixteen-Hour Average Peak Spot Electric Prices at Locations Indicated (2007) (cents per kilowatt-hour)



Much larger price spreads lurk beneath the surface. Every state generates both cheap and expensive power. The cheap power comes from baseload plants, which are used heavily but not fully; the expensive power comes from peakers, which are often idle, though not often enough. On average, each company responsible for delivering power to consumers aims to ensure that peak loads never exceed about 85 to 90 percent of the generating capacity that it either owns or can count on buying from independent suppliers. But on average, day and night over the course of an entire year, about half of the total capacity available nationwide stands idle. And over the course of the same year, one-fifth of the electricity is generated with very expensive fuel.

The price of electricity sold in wholesale markets tracks rising and falling demand in the area where it's generated. Demand moves from east to west with the sun, because it tracks human activity and afternoon peaks in air-conditioning loads. Demand also shifts from place to place as weather and seasons raise and lower the temperature. Where the cheapest power is available and the expensive power is being bought shifts in tandem. Somewhere in America, some community is always paying significantly more for power—20 to 50 percent more—than the market is selling it for elsewhere. Several hours later, many of the cheap sellers and expensive buyers will have traded places.

To illustrate what that implies, the maps on the following page compare peak wholesale prices in one time zone against off-peak prices in the other three. Using time zones as a surrogate for all the factors that determine where costs are high and where they're low oversimplifies things considerably. But when analyzing electricity's economics, time of day is the place to start, and on a continent that stretches 3,000 miles east to west, that means starting with four times of day, not one.

THE GRID

As the Federal Energy Regulatory Commission has noted, price spreads between different locations “signal infrastructure needs” in the markets for electricity itself or the fuels used to generate it.¹¹ If sellers at one location are offering electricity for 2 cents less than buyers are paying somewhere else in the country, and if the electricity could be moved from seller to buyer for less than that price spread if only transmission capacity were available, more wire is needed to get the market working efficiently.

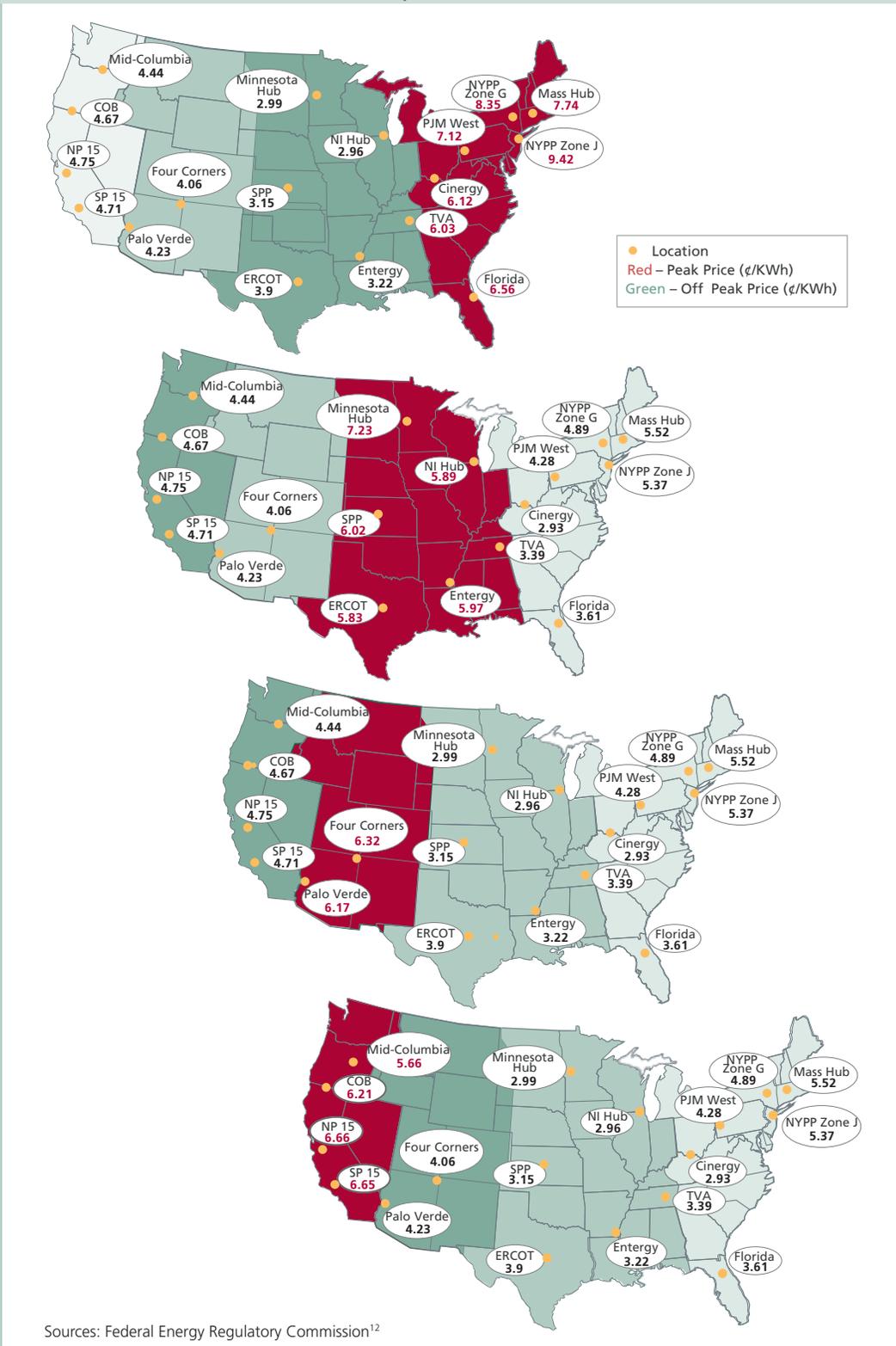
High-voltage wires mounted on towers erected on narrow (200-foot) rights of way can quite easily move huge amounts of power, over thousands of miles, with very modest losses. Direct-current systems operating at about 600,000 volts are optimal for certain applications; alternating-current systems operating at close to a million volts are more suitable for many others. A single line operating at 765 kV AC can transmit almost 1 percent (4 GW) of the total average power generation

Percent of Total Idle U.S. Capacity (2002)

Region	6 pm – 6 am	24 hour
Southeastern Electric Reliability Council	11	21
East Central Area Reliability Coordinating Agreement	11	18
Electric Reliability Council of Texas	9	13
Northeast Power Coordination Council (U.S. segment only)	6	10
Southwest Power Pool	6	9
Mid-America Interconnected Network	5	8
Mid-Atlantic Area Council	4	6
Mid-Continent Area Power Pool (U.S. segment only)	2	4
Florida Reliability Coordinating Council	3	4
Arizona-New Mexico combined with Nevada Power Area and the Rocky Mountain Power Area within the WECC	2	4
California and Southern Nevada	3	4
Northwest Power Pool Area (Sub-region of the WECC)	1	2

Source: Derived from Pacific Northwest National Laboratory¹⁰

Peak and Off-Peak Wholesale Spot Prices in Different Time Zones (2007) (Cents per Kilowatt-hour)

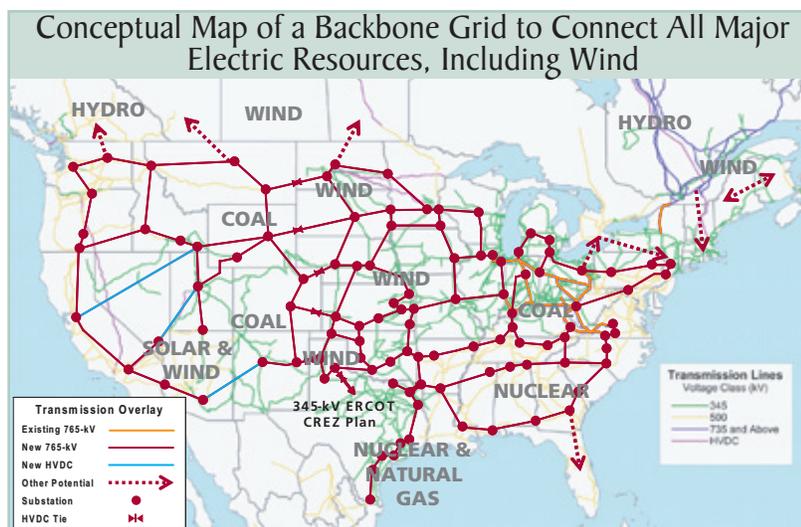
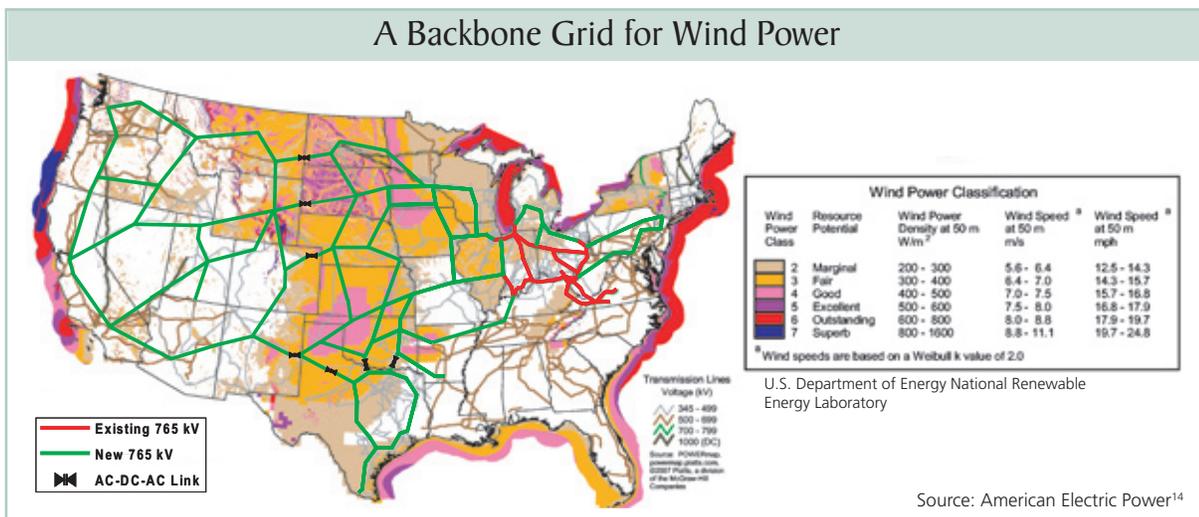


of the entire United States, or 0.5 percent of the power that Americans collectively consume during the most power-hungry minute of the year.

According to one recent analysis, windmills located principally in the heartland could meet over 25 percent of current U.S. electricity requirements (or 20 percent of projected demand in 2030) if linked to population centers across the country by 19,000 miles of high-voltage grid.¹³ Such a grid would cost an estimated \$60 billion to build. A somewhat larger, 21,000-mile grid designed to network all major sources of electricity, including wind, might look something like the one shown in the accompanying conceptual map, and would cost about \$75 billion. That would add roughly 0.3 cents to the current 9-cent average retail price of electricity.¹⁵

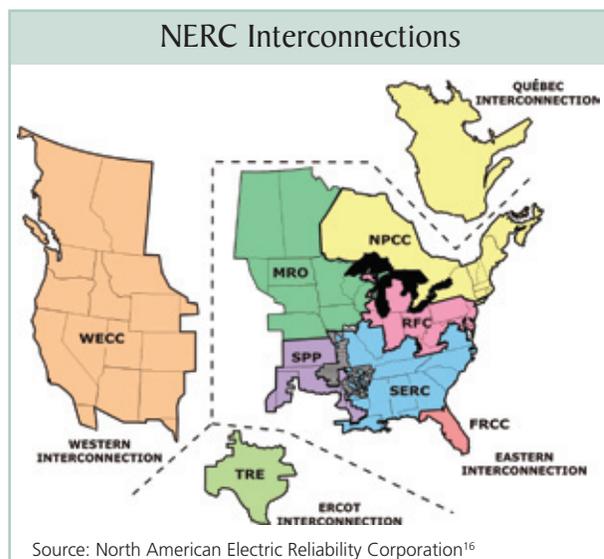
Backbone lines operating at very high voltage are extraordinarily efficient, both electrically and economically. This isn't drawing-board technology; thousands of miles of these very high voltage lines are already up and running. But they certainly don't constitute a national network—the wide price spreads in the wholesale electricity market prove it. A kilowatt-hour of electricity toasts as many Pop-Tarts in Palo Alto as it does in Poughkeepsie; an efficient, integrated market with cheap, long-distance transmission available would charge everyone the same price for toasting them. America doesn't.

Until quite recently, the technology needed to knit electricity markets together via a backbone grid spanning the country wasn't practical—and policymakers weren't interested, in any event. The lines used to transmit power over larger distances had



quite limited capacity, and because they operated at much lower voltages, they had much higher losses. Power plants and wires were owned and operated as a unit and regulated as a single, monopoly service. Utilities were franchised to provide power within a designated geographic area. When they were authorized to build new plants, it was to keep the local wires lit, and state regulators often made sure that the cheap power stayed close to home.

As utilities serving adjacent areas gradually linked their grids, three largely discrete interconnection areas evolved: one east of the Rockies, one west, and one serving most of Texas. Except for a few limited interties, these three areas remain electrically independent. And even within each area, the grid was designed mainly by engineers, working for many different owners, each one serving a smaller market.



Economists began muscling in on the engineers in the 1970s, when changes in state and federal laws began requiring utilities to offer some competing producers of electricity “open access” to their wires. In the 1990s, Congress defined a new class of independent wholesale generators and expanded Washington’s authority to de-regulate the price of power transmitted across state lines. Competitive “merchant generators” now supply about one-third of the nation’s power and account for most of the new plant construction. Before it ever lights a bulb or a computer screen, close to half of all our power is now traded, commodity-like, among wholesalers.

Economic policy is still constrained, however, by engineering reality. Power is traded over wires, and the trading ends where the wires end, and stops when the wires are fully loaded. By enabling the development of huge power plants that use cheap fuels and operate extremely efficiently, capital invested in the existing grid has already done far more to raise efficiency and push down fuel costs in the U.S. energy economy than all the improvements made in our car engines since Henry Ford first rolled out the Model T. But wide spreads in the price of electricity available at different points in the country at almost every minute of the day reflect huge economic opportunity still waiting to be captured.

GRID ECONOMICS

Overlaid on the existing, fragmented system, a backbone grid would let cheap power chase high demand around the clock and across the country. It would squeeze significantly more electricity out of every dollar of invested capital and every dollar spent on raw fuel. Just how much money this would save is quite easy to calculate in principle, but the details get complicated fast. The numbers included here are very rough, but they’re good enough to show that a good bit of easy money lies scattered across America’s 3-million-square-mile electrical table.

While fuel costs don’t account for most of the 9-cent average price of electricity, they do largely determine how much the price varies from hour to hour, place to place, and year to year. A kilowatt-hour contains 0 cents worth of raw fuel if generated with wind or sun, about 0.5 cents if generated with uranium,¹⁷ 2 cents if generated with \$50-a-ton coal, and about 7 cents if generated with natural gas priced at \$8 per thousand cubic feet. The fuel-cost spreads, in other words, are almost as large as the average price of electricity. A grid that pools demand enough to let cheaper fuels displace the more expensive can thus cut the cost of electricity by as much 40 percent wherever and whenever it does.

Still more can be saved by using invested capital more fully. An analysis of 2002 data by the Pacific Northwest National Laboratory (PNNL) concluded that using

idle nighttime capacity in existing power plants and wires to recharge plug-in hybrid cars would lower the average cost of electricity in a fairly typical urban market (Cincinnati's) by about 8 percent.¹⁸ These savings would come from making productive use of power-plant capacity that currently stands idle—"valley filling" in the figure on page 4. But why limit that kind of thinking to hybrids? The grid fills valleys, too, by allowing idle capacity to power distant air conditioners rather than nearby hybrids. Some areas have considerably more idle capacity than others. PNNL's analysis indicates that half of the idle capacity is located in just three areas located in the southeast and east-central regions and in Texas.

Idle Power Plant Capacity (2006)

Fuel	Percent of U.S. Capacity (Total: 1 TW)	Percent of Electricity Generated (Total: 4,000 TWh)	Idle Capacity (percent)
Nuclear	10	20	10
Coal	30	50	25
Natural Gas	40	20	80
Petroleum	6	2	85
Hydroelectric	10 ^a	7	60 ^a
Other Renewables	2 ^a	2	55 ^a
ALL	100	100	55

^a Limited by weather-related supplies of water and wind.

Source: Energy Information Administration¹⁹

Any plant linked to a grid that spans four time zones need not be idle often. With current transmission technology, a plant located in, say, Lebanon, Kansas, the geographic center of the contiguous United States, would be within easy reach of peak loads on both coasts and everywhere in between, as the peaks roll from east to west across the continent. If a backbone grid allowed the average plant to be fully used an average of fifteen hours a day rather than the current twelve, the average capital-related cost of electricity would drop 20 percent.

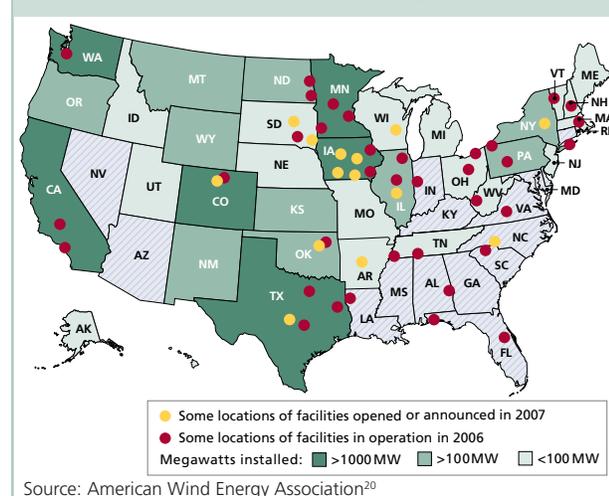
These savings would be realized wherever more grid puts idle capacity to productive use, whatever the fuel used. By flattening demand, however, a backbone grid would also shift generation toward bigger plants that use cheaper fuels—coal, uranium, water, wind, or sun. With a backbone grid in place, new plants will also be

built where the capital costs are lower from the get-go. Windmills and solar plants occupy very large amounts of real estate, and land costs alone make these technologies prohibitively expensive in all but the most rural areas. Building conventional coal and nuclear plants on existing sites alongside plants already up and running is usually much cheaper, too, but that means adding new capacity where it's least needed by anyone nearby.

The savings that the grid delivers will only increase as environmental costs are progressively folded into the economic spreadsheets. Emission-abatement technologies, trading schemes, and waste-disposal costs raise the effective cost of both power plants and fuels. By shifting demand toward bigger, more centralized power plants, a backbone grid will also shift it toward plants that run very efficiently, that are maintained well, that can afford a lot of pollution control, and that are easy to monitor and regulate. Per unit of useful energy produced, very big power plants are, on average, much cleaner than all other widely used alternatives, with the exception of smaller gas-fired facilities, which limit their emissions by using very expensive fuel.

The cost of wind power depends especially strongly on finding buyers for the electricity around the clock. Most Americans live within 100 miles of the coast, while the best locations for windmills are in the heartland. A backbone grid's ability to wheel wind power across the continent in sync with the sun would allow free wind to displace expensive gas electricity at least several additional hours per day, and coal-fired electricity the rest of the time.

Where the Wind Is



CHEAPER ELECTRICITY

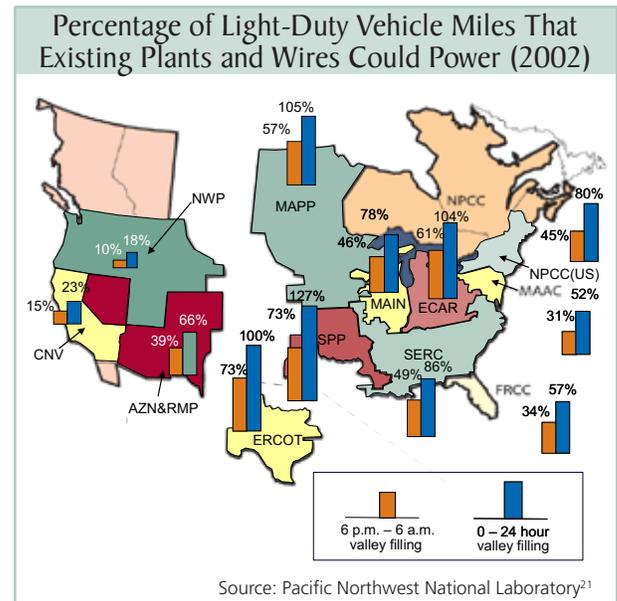
A backbone grid built with state-of-the-art high-voltage technology could move 25 percent of America's power over very long distances, at a cost well under 0.5 cents per kilowatt-hour moved. Price spreads tied to fuel costs alone often run 5 cents or more, and idle capital currently adds about 1 to 2 cents to the average cost of generation. Moving that much power across a 5-cent price spread would cut America's electricity bill by about 10 percent directly, and by considerably more than that over the longer term.

Boosting consumption of electricity by 30 percent for heating and recharging plug-in hybrids during off-peak hours would lower the average price of electricity by another 15 percent or so. These savings would result from fuller use of the expensive wires. Long-distance transmission is cheap, but the wires used for local distribution account for about one-quarter of the average price of electricity. And most of the time, these local wires are severely underused because their usage so closely tracks the ups and downs of local demand. Using them more heavily entails no additional cost and allows their capital cost to be spread across more kilowatt-hours.

San Diego Gas and Electric, for example, owns one nuclear power plant and buys the rest of its power (almost two-thirds of it) from others. The PNNL analysis concludes that using idle capacity in the wires to recharge plug-in hybrid cars during off-peak hours would reduce their average cost by almost 60 percent. Cincinnati Gas and Electric, which generates most of its own power close to its customers, would realize a 6 percent reduction in average wire costs.

Significantly increasing energy consumption of any kind isn't generally viewed as desirable, but the pathologies of the global oil market and the convergence of the not-electric and electric sectors of our 7-11 energy economy make such an increase on the electric side of the divide inevitable and desirable. The PNNL analysis concludes that idle capacity and today's grid could power about 85 percent of all the miles driven by passenger cars, pickups, and SUVs. That would displace about one-

third of total U.S. oil consumption. By allowing Texas to export power to other areas, a backbone grid would boost the total by several more percentage points. By providing access to more idle capacity and significantly cheaper off-peak electricity, a backbone grid would also accelerate the transition to plug-in hybrids and support close to 100 percent electricity-for-oil displacement in vehicles that are themselves idle enough of the time to be refueled at the plug rather than the pump.



Residential heating presents a similar opportunity—current electrical loads peak on summer afternoons when all the air conditioners are running full blast; heating loads peak at night in winter. Together, the heaters and cars could pick up the electric load when most of the air conditioners, appliances, and lights shut down. And because heating and transportation require so much energy, their electrification would flatten out demand for electricity almost completely. The electricity market's strange cost structure aligns perfectly with the needs of the two biggest sectors of the U.S. energy economy that don't yet run on electricity: transportation and plain old residential heat.

Pinning down just how much a backbone grid could save will require much more detailed analysis than has been sketched out here. What's beyond dispute is that the U.S. market for electricity currently operates very

much less efficiently than it might. The price spreads in the wholesale market far exceed what it would cost to haul the cheap power to the expensive buyer. On average, half of our generating capacity and even more of our distribution capacity stand idle. We also generate about one-fifth of our electricity with natural gas, which costs considerably more than other widely used fuels. A backbone grid will deliver big savings by addressing price dislocations in a very big market.

The economic benefits can be shared at both ends of the line, whichever way the power moves. A community near a plant with low-cost power to spare can lower its own electric bill, too, when it puts idle capacity to productive use. And most areas will end up buying distant power when their own loads peak, and selling it the rest of the time. It is sometimes suggested that trading power can only lower prices for some by raising them for others. That view is simply wrong. Purchases and sales can be structured so that everyone connected to the grid saves money when capital assets are used more fully and when cheaper fuels displace more expensive ones.

Going forward, a backbone grid will lower costs much further by allowing investors to site new plants where they're welcome, where land is cheap, where environmental objectives can be attained at the lowest cost, and where renewable fuels are most readily available. And further still by propelling the use of cheap electricity to displace large amounts of more expensive oil in the heating and transportation sectors of the energy economy.

DOMESTIC POWER, GLOBAL STAKES

Visionary schemes for getting over oil generally end with a call for more money from Washington. The grid doesn't need government money; it just needs better government. Its oversight currently depends on a tangle of local, state, and federal authority that reflects its past and obstructs its future. Private investors can't make plans to invest \$60 billion in a backbone grid because no one has concomitantly broad authority to approve the construction.

Oil is very portable. That's why it's used to power cars and jets, and why its price is set by the global market. If it's light enough to run your car, it's light enough to be shipped 5,000 miles to run a higher bidder's in Paris or Shanghai. Our electricity, by contrast, is tightly tied to the U.S. grid and is under the complete control of U.S. capital, U.S. fuel, and U.S. policy. We already trade significant amounts of power with Canada and Mexico, and further integration of the North American grid is both likely and desirable, but a high-voltage line to Caracas isn't coming anytime soon. Electricity is also the one immediately practical, affordable, near-term answer to oil, because technologies that substitute electricity for oil are here and now, and because we already generate electricity in quantities huge enough to displace really serious amounts of oil. Electricity is therefore the key to U.S. energy independence.

On the electric side of our energy economy, we're far better off than all the countries that worry us because they own or want to buy so much oil. Our grid weaned itself from oil almost thirty years ago. Much of the rising demand for oil in China, India, and other developing countries, by contrast, can be traced to diesel generators. We are poised to propel cars with cheap electricity, while they are still scrambling to generate expensive electricity with truck engines and string wires to form their first real grid.

They're going to get past that stage as fast as they possibly can, and then past oil in their heaters and cars, too. Japan has good reason to focus so heavily on hybrids—it has little but nuclear electricity to count on for its energy going forward. India and China will be firing up a new coal-fired plant about once a week for the next 25 years and will be adding nuclear plants equally fast. The rest of the world will catch up; our challenge is to keep improving our energy economy fast enough to maintain the competitive edge that affordable, high-grade energy supplies.

Attempting to spell out exactly what mix of fuels and power-plant technologies will provide the cheapest, greenest, most reliable power going forward isn't useful—generating technologies change too fast, and fuel prices are too volatile. The grid, however, embraces

them all. Whether generated with coal, uranium, gas, water, wind, sun, or biomass, electricity is the stock exchange and common currency of the energy market. Ships and airplanes aside, it can power anything.

The U.S. grid is by far the most ubiquitous and advanced energy delivery network in the country and on the planet. Building out a backbone grid—a financially

modest undertaking for an industry as large as the power industry already is—will unleash innovation and competition on both the supply side and the demand side of our energy market. It should therefore be built, and on the double. To get over \$4 gas, we should let American capital, labor, and know-how get on with what they already do so well, and connect us to the 4-cent electricity.

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FELLOWS

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