ENERGY AND AMERICAN VALUES

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THE ENERGY CONNECTION

"Progress" was the official theme of the famed Great Exhibition in London in 1851.[1] The Exhibition centered on the magnificent Crystal Palace, where, according to the fair's sponsor, Prince Albert, the world's greatest industrial achievements were displayed. The hall of machinery reverberated with the deafening noise of locomotives, marine engines, hydraulic presses, power looms, and an Applegate and Cowper printing press turing out 5,000 copies of the *Illustrated London News* each hour. A model of Watt's 1785 steam engine—one cylinder, 40 hp—was placed alongside a modern marine engine of four cylinders, 700 hp. Symbolically, a single huge block of coal, weighing 24 tons, sat majestically in the hall.

More than labor-saving machinery, powered by steam engines, was being exhibited. Also on display was the ideal of progress—the belief that thanks to industrialization, humanity finally had gotten the upper hand over raw nature. To anyone strolling through the rows of machines, it seemed as if, at long last, human history would be the story of man's inevitable advance.

Until just 50 years earlier, in 1800, most Europeans had lived in a rural world of farms and rutted dirt roads, closer to the Middle Ages than to the present, and not far advanced from the emergence of civilization 5,000 years before. But by mid-century, Britain could celebrate a way of life literally unimagined by a prior generation: the Industrial Revolution created a world of iron, coal, steam, machinery and engines, railroads, steamships, and telegraph lines, even ingenious new devices for making life easier, like the indoor water closet, the fixed bathtub with running water, and the gas cooking range.[2] To Albert and most others, technological achievement also carried with it aesthetic achievement—as evident in the Crystal Palace itself—and human ethical progress as well. The whole world had made great advances

since the Industrial Revolution began, and the future held even greater promise.

Energy and the Coming of Industrialization

The Industrial Revolution in England that inspired this optimism was the result of an early eighteenth-century energy crisis, as much as of any other single factor.[3] England's forests had been badly depleted in order to make the charcoal that was used to produce iron. The amount of iron produced was negligible measured by later industrial standards, but it was critical to the economy of preindustrial England. In 1709 Abraham Darby developed an early "technological fix" for the problem posed by the exhaustion of wood when he succeeded in substituting coke for charcoal in his blast furnace at Coalbrookdale in Shropshire. Coal had long been available, and its qualities were well known, but the mining of coal was judged to be too dangerous, handling it was dirty and cumbersome, and to make matters worse, burning it fouled the air. All these objections were overcome, however, because of the urgent need to find a cheap and plentiful substitute for scarce wood in the production of iron—a need that coal in the form of coke served, thanks to Darby's new way of using it.

At first, the introduction of coke proved to be beneficial but not revolutionary in its effects. England's forests were allowed to regenerate, an abundant mineral was put to important use, and a continuing supply of iron was guaranteed. Before long, however, this simple substitution of one energy source for another was to transform western and world civilization. Without an abundance of relatively inexpensive and readily available energy industrialization would not have succeeded. These features often carried more weight than other factors, such as pollution, working conditions, or a changing social order.

Energy was only a part of the picture. The growth and spread of industrial production resulted from the interplay of a host of reenforcing elements, political, economic, and cultural, as well as energy resources and technological innovation. In turn, the Industrial Revolution transformed these political, economic, and cultural forces and helped point western civilization on a unique course: a remarkable preoccupation with material growth as an answer to human problems. As the Great Exhibition proudly proclaimed, the unprecedented creation of material abundance instead of humanity's perennial scarcity was a demonstration of the superiority of industrialization as a means to improve the human condition.[4]

Energy had of course always been essential to human survival and to the advance of civilization. The ability of early people to master fire made them aware of their superiority over other animals and inspired them to imagine themselves competitors of the gods, as in the myth of Prometheus. But it was human muscle power, supplemented by that of domesticated animals, that provided most of the energy used throughout the long early history of the

human race. At about 2500 B.C. the discovery of the wheel made the use of this muscle energy much more efficient and accelerated the growth of civilizations.[5] Yet, even with fire, work animals, and the wheel, constant scarcity was still a constant and a peril.

In the ancient world, human muscle power was often organized in the form of slavery. Slavery allowed the ancient Romans to neglect the newly-available waterwheel for four centuries—an attitude that prevented them from taking still better advantage of human labor power and from realizing the greater potential of a freer and more cooperative society.[6] The first "power revolution" occurred during the Middle Ages and remained dominant into early modern times.[7] This was the development and widespread acceptance of the vertical waterwheel. This wheel did the work, it was said, of one hundred slaves. Soon there was one waterwheel for every 400 people in England. The windmill was another great labor-saving device: like the waterwheel it could do the work of a hundred men. The horsecollar also appeared in the Middle Ages and was another step toward what we today call "energy efficiency." The combination of horsecollar, horseshoes, and stirrup allowed a horse to do the work of ten men.[8]

For most of human history, fossil and organic energy sources (wood, peat, coal) were used only directly for heating, cooking, and lighting, or for firing the kilns and furnaces used in smelting ores. As a prelude to the Industrial Revolution, however, it came to be recognized that fossil energy, primarily coal for the steam engine, could be used to power *machines,* which could replace hard and tedious work.[9] Such machines could supplement, at long last, the limited endurance of human and animal muscle. Mechanization was also desirable, despite its possible faults, because it would not be subject to the vagaries and seasonal changes of water and wind power. It is hard now to appreciate how this quest to establish regularity in work consumed society's attention; the intermittent and undependable quality of production had made steady progress unattainable in preindustrial times.

Steam power marked a large advance in the effort to make energy available to do civilization's work. Thanks to the introduction of the steam engine, the link between fossil energy sources and the process of industrialization became permanently established.[10] Technological improvements made the steam engine more efficient. James Watt's 1760 version used less than half the coal for the same output as the classic 1712 Newcomen "atmospheric engine," which itself was far superior to Savery's 1698 "miner's friend." Even though it was first thought to be useful only for pumping water out of the increasingly deep coal mines, the steam engine gained widespread use as a cheap, decentralized source of power, and eventually became a decisive factor in general economic progress.

From the eighteenth century on, steam multiplied the strength, versatility, and scale of available power, far outstripping all other energy sources put together.[11] Watt's introduction of rotary steam engine action powered

new technologies for spinning and weaving cotton. Textile factories transformed England from an agrarian to an industrialized nation. In the nineteenth century, steam became the motive power for railroads and shipping and began to spin turbines invented to generate electricity. Today the large generating station, whether fired by coal or nuclear energy, supplies all the electricity needed by hundreds of thousands of consumers. The modern power station is a far cry from Watt's simple engine, but the principle remains the same: boiling water to produce steam.

Preindustrial America: Laying the Foundations

Americans had their own Great Exhibition, the Centennial Fair, which opened on May 10, 1876, in Philadelphia.[12] It was criticized for its artistic mediocrity and blatant materialism, but the primary theme of the fair was nothing so much as the triumph of material progress over everything else. The centerpiece was George Corliss's huge steam engine, the largest in the world. When President U.S. Grant, together with the visiting Emperor of Brazil, arrived to inaugurate the fair, they first visited the 30 foot high, 700 ton, 1,400 horsepower engine. It was to produce power for all the machinery exhibits throughout the fair. The president and emperor jointly started the engine by turning handles that built up steam pressure. They then stood back in awe. Public opinion compared the Corliss engine to a great heart whose steady pulsations kept the entire exhibit running. Corliss also made a further advance beyond the sheer scale of the engine; it could regulate its own speed and its own consumption of fuel, depending on the load it carried. What Corliss had accomplished was a long-sought dream: a steady, uninterrupted flow of energy. Like the Crystal Palace Exhibition, the Centennial Fair demonstrated more than materialism. For Americans, the Fair also symbolized the progress achieved since the Revolution by hard work and technological innovation.

It is incorrect to suppose that for much of American history there was no such thing as an energy problem. While industrialization was taking hold in England, the new United States was still a rude "undeveloped" country. Henry Adams, writing his famous history almost a century later, looked upon conditions in the United States of 1800 as unbearably primitive. He noted that the means used to sustain life were not appreciably advanced over those used by the Jutes and Angles in the fifth century A.D.: "Neither their houses, their clothes, their food and drink, their agricultural tools and methods, their stock, nor their habits were so greatly altered or improved.... In this respect America was backward."[13] More recently, the historian Curtis Nettles has noted that the hand tools used by a typical American farmer in 1800 "would have been familiar in ancient Babylonia."[14]

But Americans had one great advantage: the American continent was well-endowed and sparsely settled. The first great task the American settlers had to face was the exploration and settlement of a vast national territory, which would become more than six times the size of the original settlements. The scope of American geography cannot be overestimated. Space, not time, has been the controlling dimension of American history: "empty land" gave this society its distinctive scale and pattern of activity.

Whereas the Europeans could draw on a vast labor pool, Americans had to contend with a shortage of labor. This very shortage was one of the impetuses behind the adoption of slavery in the southern settlements; in the North it stimulated invention. But capital for investment was also in short supply, whereas in Europe, capital accumulation had been proceeding over several centuries.[15] Under the circumstances, Americans made the best of their opportunity by taking advantage of the region's great abundance of land—well-watered, the eastern third covered with primeval forest, composed of some of the world's richest virgin soil, and all in a zone of temperate climate. Without major land and capital resources, Americans had little choice but to concentrate on exploiting easily available resources like land and wood.

Early "manufacturing" depended largely upon the physical muscle and simple equipment of blacksmiths, coopers, masons, carpenters, and weavers. Capital-intensive "factories" consisted mostly of lumber mills, shipbuilding yards, iron-making foundries, glassworks, fishing organizations, and occupations associated with building construction. Traditional waterwheels and the occasional windmill provided the only power available to grind corn and other grains into flour, other than human or animal muscle. Waterwheels and windmills also served to saw wood and to power bellows for forges and furnaces. As late as 1850 wood supplied more than 90 percent of the fuel used for energy in America, mostly for heating.[16] The rest came from small supplies of bituminous and anthracite coal. The abundance of forest resources and water power dominated the American energy picture until after the Civil War.

From the vantage point of a prosperous America in 1890, Adams wondered how the founding fathers must have set about achieving the progress towards the better life they had promised. Was Jefferson's guarantee of "life, liberty, and the pursuit of happiness" to be understood as a constantly improving standard of living? "Life" surely meant more than physical survival alone. "Liberty" required the reduction of material scarcity. "Pursuit of happiness," growing out of John Locke's original term "property," was unlikely without material abundance. As Jefferson himself insisted, a large part of human misery was the oppression induced by poverty.[17] In the new age of humanitarian awareness, it was said, thoughtful people could not be indifferent to human want.

Yet, in 1800 virtually all of mankind lived in want. This had been humanity's historic condition; it remains true that most of the people who have ever lived have been poor and hungry. But by 1800 American society was

entering an era, in the words of the modern philosopher, Alfred North Whitehead, "when even wise men hoped." Reflecting on the buoyant optimism of the period, the modern historian Russel Blain Nye writes:

> The fertility of the American soil, the enormous variety and fecundity of its plant and animal life, the vast reaches and unlimited resources of its waters and woods, the salubrity and balance of its climate, all made the United States a mighty stage for new great developments in human history.... The United States, in Jonathan Trumbull's view, was "a land of health and plenty, formed for independency, and happily adapted to the genius of the people to whom it was to be given for possession."... The United States, for the first time in history, gave men the opportunity to put into practice basic principles of society and government impossible to test elsewhere.[18]

Jefferson, Franklin, and other leaders were intensely aware that the new society they proposed must be grounded in material improvement as well as in political liberty.[19] Congress was given express authority "to lay and collect taxes, duties, imposts, and excises, to pay the debts, and provide for the common defence and general welfare." The Declaration of Independence, the Revolution itself, and the transformation of the Articles of Confederation into the Constitution, were in large part responses to economic grievances. By 1800 the test was to see to it that these vague promises of a better life were put into practice.

A pragmatic "American Enlightenment" provided the dominant climate of opinion during the formative years of the new nation. This was an intellectual consensus that affirmed the powers of human reason, the utility of experience, and the essential morality of human progress.[20] Pain, suffering, poverty, and deprivation were not accepted as man's eternal lot but as wrongs that required alleviation. The imperative of the new age was to make ordinary daily life good, rational, and orderly. Notions of "standard of living" and "quality of life" began to receive significant attention in this era.

America's Future Course: Agriculture or Industry?

The proper future material growth of the new nation became the central issue of a major debate between Jeffersonians and Hamiltonians during the late eighteenth and early nineteenth centuries. Which would provide more adequately for the physical and moral well-being of Americans, agriculture or manufacturing? One historian, Marvin Fisher, has called the debate "a morality play, not an economic dispute"[21] because the question was whether agriculture or industry would satisfy Enlightenment ideals of human progress and cultural growth.

At first, most Americans would have echoed Richard Wells's statement in 1774 that "the genius of America is agriculture, and for ages to come must continue so." Crevecoeur's indulgent vision of the American yeoman in his pre-Revolutionary *Letters from an American Farmer* cleverly blended political freedom and economic prosperity with agriculture and morality. The self-sufficient, highly individualistic farmer was America's exemplary model: "The world is gradually settled... the howling swamp is converted into a pleasing meadow, the rough ridge into a fine field... hear the cheerful whistling, the rural song, where there was no sound heard before, save the yell of the savage, the screech of the owl, or the hissing of the snake."[22]

In contrast, the life of a worker in England's new factories was thought to be corrupting and debasing, inherently harmful to body and soul. Looking at the environs of Boston, the traveller John Dix cautioned, "COTTON MILLS! In England the very words are synonymous with misery, disease, destitution, squalor, profligacy, and crime! The buildings themselves are huge edifices which loom like gigantic shadows in a smoky, dense atmosphere. Around them are wretched houses, and places of infamous resort; and blasphemies and curses are the common language of those who frequent them."[23] After all, did not modern coal miners and iron puddlers quickly become infirm and die young? In ancient Greece and Rome, were not only slaves consigned to work the mines and forges because of the inherent physical danger and spiritual risk?

Mindful of the contrast between bucolic farming and industrial squalor, Jefferson in his 1787 classic, *Notes on the State of Virginia,* wrote the definitive American plea for the agricultural tradition:

> Those who labour in the earth are the chosen people of God... whose breasts he had made his peculiar deposit for substantial and genuine virtue.... Corruption of morals in the mass of cultivators is a phenomenon of which no age nor nation has furnished an example.... While we have land to labour then, let us never wish to see our citizens occupied at a work-bench, or twirling a distaff. Carpenters, masons, smiths, are wanting in husbandry: but, for the general operations of manufacture, let our work-shops remain in Europe.[24]

America's strength rested in the independent, privately-owned, small family farm. For Jefferson, the immensity of the land, especially after his Louisiana Purchase of 1803, guaranteed the availability of low cost, abundant farmland as an American birthright and as a haven of safety.

Despite the success of British industrialization, and American envy over its products, advocates of American manufacturing found themselves on the defensive. They were few and gained attention only slowly in the face of the euphoria over the bounty and virtue of American agriculture. However, the Revolutionary War had already demonstrated the strategic role of manufacturing and the importance of national self-sufficiency. In 1787 Tench Coxe pleaded for immediate industrialization:

> It will consume our native productions now increasing to super-abundance —it will improve our agriculture and teach us to explore the fossil and vegetable kingdoms, into which few researches have heretofore been made—it will accelerate the improvement of our internal navigation and bring into action the dormant powers of nature and the elements—it will lead us once more into the paths of virtue by restoring frugality and industry, those potent antidotes to the vices of mankind, and will give us real independence by rescuing us from the tyranny of foreign fashions, and the destructive torrent of luxury.[25]

Advocates of industrialization like Coxe were criticized so harshly that they felt compelled to argue that workers instilled with factory discipline also acquired high moral virtue. In self-defense Samuel Slater added a Sunday School for the children who worked in his textile mill.

Most influential, after some delay, was Alexander Hamilton's 1791 *Report on Manufactures,* which has since made him a prophet among advocates of industrialization:

> The employment of machinery... is an artificial force brought in aid of the natural force of man; and, to all the purposes of labor, is an increase of hands, an accession of strength, unencumbered too by the expense of maintaining the laborer... manufacturing pursuits are susceptible, in a greater degree, of the application of machinery, than those of agriculture.[26]

Hamilton thought human labor devoted to manufacturing was superior to agricultural work: it was "constant" not "seasonal," "uniform" not "careless," and especially "more ingenious" and hence "more productive." Manufacturing, side by side with agriculture, was therefore essential to the security and prosperity of the nation and its people. Only continued surpluses and sustained growth could guarantee material well-being and the development of a "populous, thriving, and powerful nation."

Still, Americans did not rush to industrialize. The pressing need, most Americans believed, was to settle the continent. Americans were also enormously pleased with their unprecedented agricultural bounty; Jefferson appeared to have won the fight. Advocates of manufacturing had to contend with the most successful agricultural enterprise yet known in the history of civilization.

Energy in Agricultural America: Early Growth and its Limits

The first improvements in American well-being did not come through energy systems or industrial technology. They took place in the rich farmlands of southeastern Pennsylvania, the Great (Shenandoah) Valley of Virginia, and soon the newly-acquired (1803) deep black soils of the Midwest. The first major symbol of American abundance was not mechanized energy but food.

As early as 1784 James Fenimore Cooper took plentiful food for granted as he described "American poverty": "As for bread [said the mother in a story] could take that for nothing. We always have bread and potatoes enough; but hold a family to be in a desperate way when the mother can see the bottom of the pork-barrel."[27]

Because land was available and conditions were good, the population rose at a staggering pace from four million in 1790 to nine and a half million in 1820, with only 250,000 immigrants. Ninety percent of the work force (aside from slaves) cleared and worked the land. Less than ten percent could in any way be called "employees" in some form of manufacturing. Early in the nineteenth century a French observer wrote: "There is no settler, however poor, whose family does not take coffee or chocolate for breakfast, and always a little salt meat; at dinner, salt meat, or salt fish, and eggs; at supper again salt meat and coffee."[28] In that day, meat was scarce at peasant's tables and chocolate an unknown luxury. While the diet may have been repetitious, humanity's age-old struggle to overcome the scarcity of food was not an American problem.

Just as Americans had an abundance of land and food, the vast stands of trees covering the eastern part of the continent encouraged Americans to go through an extended "age of wood."[29] There was no scarcity of wood to propel them like the English into an economic crisis and revolution. Wood was also used as a heating fuel in no less profligate a fashion. Though fireplaces were gradually replaced by wood-burning stoves, home and business heating remained inefficient. But wood supplies were abundant and cheap. Per capita lumber use was five times higher than in England and Wales.

The early agrarian affluence created expectations of further improvement. Americans in the early nineteenth century came to believe in progress long before industrial technology and high energy consumption took hold. The possibility of greater wealth and material gain was first associated with agricultural surpluses, "wood to burn," and vast land holdings. This attitude put any move toward industrial development at a disadvantage. The high returns in American farming set a high general standard of living, far superior to those in England and Europe. As early as 1760 one astute English visitor wrote about the opportunities enjoyed by immigrant workers to America: "Men very soon become farmers... nothing but a high price will induce men to labour [at manufacturing] at all, and at the same time it presently puts a conclusion to it by enabling them to take a piece of waste land."[30] He noted that day laborers are so scarce, and so attracted to farming, that an employer had to pay half a crown in New England for work that would have cost only a shilling in England.

A South Carolina backwoods farmer was typical: "My farm gave me and my whole family a good living on the produce of it; and left me, one year with another, one hundred fifty silver dollars, for I never spent more than ten

dollars a year, which was for salt, nails, and the like. Nothing to wear, eat, or drink, was purchased, as my farm provided all. With this saving, I put money to interest, bought cattle, fatted and sold them, and made great profit."[31] Not buffered from the natural world by technology, the frontier farmer was vulnerable to extreme physical hardship, the dangers of accidents, and the uncontrollable power of circumstances. But he was optimistic. He did not experience the grinding hopeless labor and deep pessimism of his counterparts elsewhere in the world. His goals were attainable. Labor-intensive farming, together with limited markets and lack of capital, did keep pioneers on a subsistence level, but with good health, reasonable skills, and basic agricultural know-how, they could manage quite well on 40 to 80 acres of fertile land. On this "owner-cultivated" farm, surpluses and cash, plus the accrued value of the land, were not diluted. Based on a "rude-plenty" standard of living, they took pride in self-sufficiency and independence, and were convinced that the future promised a good and abundant life. In most agrarian settings, ideas of growth and opportunity were unusual, but the American farmer took them for granted. There were few forces inclining him to rush into the cities to work in the factories.

These prosperous rural Americans, who quickly became the envy of Europe and Britain, did not have at their disposal many economic mechanisms that would later be judged necessary to make the transition to a modern energy-intensive society. As we have seen, the labor force was still far from matching numbers with need, and good farming prevented the rapid growth of an urban working class. Large-scale liquid capital to build industrial plants and a consumer-oriented money economy was beyond the reach even of most prosperous Americans. Unifying networks of transportation and communications, to provide rapid and efficient movement of resources, goods, and people, were urgently needed, but canals, good roads, and railroads were still in their infancy in the early nineteenth century. Markets seemed entrenched on local levels. Production of essential goods was small-scale and largely family-centered. Business organization enabling management of complex operations was still decades away.

Most noticeably, as we have seen, energy resources and energy utilization were virtually unchanged since Roman and medieval times. Farming was labor-intensive, relying on long hours of hard physical labor. While the American farmer received extraordinary results from his efforts, there were severe limits to his productivity. If the technology and agricultural know-how of the early nineteenth century had not been dramatically improved, more than half of all Americans would have had to remain farmers to feed the rest. In 1800 it appeared that American society would continue along traditional lines indefinitely, a classic Malthusian-Ricardian world of fixed resources and a growing population doomed to reach its limits wherever and whenever the frontier ended.

The Jeffersonian commitment to agriculture seemed eminently reasonable. Given the vastness of territory and the fertility of the land, the most likely future for the new society was more of the same. This was not necessarily a bleak prospect. In a continuing nonindustrial, low-energy scenario, Americans would have gradually expanded across the continent, or at least to the arid limits of the hundredth meridian. They would have acquired more of the tools, equipment, techniques, know-how, and transportation that were vintage 1800 and improved them. Ultimately, perhaps in 100 or 200 years, they would have run up against finite limits in land, wood, water, food, and mineral resources. Population growth would have reduced resources per capita, and the Malthusian checks to further expansion would have come into play, either to promote conflict and misery or a recognition of the need to accept the regimen of the stationary state.

If this scenario went unfulfilled, it was because the Industrial Revolution transformed American agriculture.[32] The first steps were aimed at increasing the acreage that could be cultivated by a single farmer. Ironically, the improvements made saved Jefferson's idealized yeoman well into the twentieth century. The old-fashioned wheat harvesting cradle could harvest two acres a day. The Hussey reaper of 1837 increased this number to ten acres a day, and the 1849 McCormick reaper made it possible to cover two acres an hour, or as much as 24 acres a day. The cotton gin gave fateful reenforcement to the slave economy of the South. Midwestern corn production was reshaped in mid-century when the hand hoe was replaced by the mechanical cultivator and in the 1890s with the corn picker. The introduction of barbed wire fencing in the treeless Midwest in the 1880s helped open the West, as did meat refrigeration, river steamboat travel, and railroad transportation.[33] The substitution of the tractor for the horse regularized and increased food production. It also saved land. In 1920 about 90 million acres of farmland were used to feed horses and mules, or one-quarter of all cropland then available in the United States. By 1960 less than 10 million acres were needed, a significant shift of land use from animal feed to human consumption.[34]

Through agriculture Americans experienced an increase of abundance, independence, ease, and security. With the appearance of steam power, machines, efficient production, and the other features of industrialization, these very same goals began to take on different meanings and new dimensions.

INDUSTRIALIZATION: AMERICA TRANSFORMED

The American landscape in the early nineteenth century was mainly characterized by small rural villages, individual farmsteads surrounded by cultivated fields, dirt highways, water-powered grain mills, busy rivers, and

clean air and water. But by the end of the first half of the century, Americans had invented, borrowed, and occasionally stolen the missing pieces of the jigsaw puzzle of modernization. They pointed proudly to the energy, dynamism, and power of a new industrial landscape—billowing smokestacks of factories, steamboats, and locomotives and crowded canals and city streets—and looked away from the more familiar bucolic setting in which the nation had originated.

Slowly Americans worked their way through the inherent ideological tension between traditional Jeffersonian agrarianism and the full promise of the American Enlightenment and its notions of progress. In fact, the very expanse of the land encouraged Americans to depart from the historic constraints of primitive agrarian simplicity into unprecedented ventures of material growth.[35]

As we have seen, Americans gave special attention to the importance of material improvement by linking it with belief in individual rights, freedom of opportunity, progress, and a superior quality of life. Making a virtue of this egalitarian quest for material gain, Americans quickly adopted a laissez-faire, individualistic capitalism as the economic road to a better future. The result was commitment to the principle of individual ownership over the concern for social or environmental good. When this was coupled with the almost unchallenged priority of scientific progress and technological innovation, most of the now familiar features of American society fell into place. This entrepreneurial zeal, combined with the input of English capital, the discovery of a new labor force (farm girls) and the appearance of another (immigrants), the quick deployment of new and proven technologies, and unprecedented energy use, changed the picture rapidly.

In an 1803 report to the American Philosophical Society in Philadelphia, America's most prominent engineer, Benjamin H. Latrobe, examined the state of mechanized power in the nation, especially steam power. He doubted the potential for steamboats but did note the existence already of five stationary engines, one to pump water for the Manhattan Water Company in New York, another in New York for sawing timber, two in Philadelphia for pumping water and running a rolling and slitting mill, and one in Boston for an unknown manufacturing process. All but one were constructed after 1800; Latrobe failed to indicate whether they were old Newcomen engines or the newfangled Watt type. He added that Americans attempted to "improve" on the steam engine by building wooden boilers, which worked for a time, but then "quickly decomposed, and steam-leaks appeared at every bolt-hole."[36]

Henry Adams described other water-powered manufacturing at the opening of the century, notably Eli Terry's Connecticut clockworks, Asa Whittemore's Massachusetts carding machines for wool, Jacob Perkins's important Rhode Island factory capable of turning out 200,000 nails a day (compared to 100 a day handwrought per worker), and vastly-improved

machinery in flour mills. Adams noted that these inventions "transmuted the democratic instinct into a practical and tangible shape" and asked rhetorically about their social good: "as they wrought their end and raised the standard of millions, would they not also raise the creative power of those millions to a higher plane?"[37]

One precocious development that aroused curiosity was the late eighteenth century flour milling operation of Oliver Evans of Philadelphia.[38] He devised methods of transmitting water power so that several machines could be run from the same waterwheel. The grain was mechanically conveyed from one part of the mill to another while it was being cleaned, ground, cooled, bolted, and packed into barrels. But there were severe limits on reliability because of wooden parts and coarse tolerances. Nevertheless, the ideas of assembly line work, automation, and even systems functions existed in Evans's mill in very primitive form. Evans had come upon a "high-technology, labor-saving, continuous-flow, energy-intensive, production process." But this experiment in centralization remained an isolated case for generations.

The Demand for More Energy

As the new nation reeled from the War of 1812, it became clear that the United States could not survive as nothing but a pastoral, agrarian society, no matter how prosperous. Henry Clay urged his "American System" on the American people, and Congress under his leadership passed tariff, banking, and "internal improvement" measures that worked to encourage needed capitalization and industrialization.[39] By 1815, even Thomas Jefferson conceded the importance of manufacturing. National leaders were becoming intensely aware of the severe material limitations of the new nation. Rapid industrialization, using the English example of power technologies, appeared to be the only solution for the nation's survival.

Successful industrialization began with the early subterfuges of Samuel Slater, a young mechanic from England's water-powered textile mills.[40] At a time when the English zealously guarded the secrets of their remarkably successful new powered and mechanized industry, Slater slipped out of the country and settled in Rhode Island. Financed by clothing merchants, he had established in the 1790s the first American spinning mill using water power. He employed only nine persons, all children, but his success led to the appearance of other small mills, eight of which were in profitable operation by 1800. By 1815 the number increased to 94. With these new mills, and the mechanization of interchangeable parts proposed by Eli Whitney, Americans had the foundations of industrialization in sight, but not yet the scale to have significant impact.[41]

Energy use increased at an unprecedented rate in the late eighteenth and early nineteenth century, but lack of capital, labor, and transportation left Americans with "neighborhood manufacturers," small in scale and techno-

logically backward. Up until 1790, the waterwheels of mill and furnace industries were highly inefficient because they were "undershot" (water ran under the wheels rather than by gravity feed overhead). Despite Oliver Evans's innovative mill, power transmission was "so little understood that a separate wheel was generally necessary for each article of machinery."[42] Other factors retarding industrialization included the marked isolation of the American manufacturer, insufficient labor supply, and few sources of capital.

By 1815 the opportunity for future growth was clearly evident, but the ordinary American still lived an agricultural hand-labor existence. The most important need for further industrial development was an increased scale of production. This would lower the unit cost of labor and capital while increasing efficiency and productivity. Again these developments first took place in the New England textile mills. What came to be known as "the Lowell System" solved a major American dilemma not by inventing a new energy source but by "inventing" a work force that was available and reliable.[43] In 1810 Francis Cabot Lowell, while on a visit in England, memorized enough of the equipment and layout of water-powered textile mills to be able to build American mill equipment without British permission. His Boston Manufacturing Company, founded in 1813, quickly dominated the American textile industry. Lowell also managed to avoid the dismal English mill town living and working conditions that had burdened England. He attracted intelligent young farm girls "of good character" by building dormitories and rooming houses, staffing them with respectable housemistresses, and providing libraries and amusements. Towns like Lawrence and Lowell were populated by the new breed of American worker, marked by a spirit of earnestness, moral righteousness, and the aim of financial self-improvement. The French traveller, Michel Chevalier, wrote that "Lowell is not amusing, but Lowell is clean, decent, peaceful, wise."[44]

The textile machine, not powered by hand or animal muscle but by the waterwheel, captured the American imagination. It was apparent that there would be vast opportunities for unparalleled growth, if abundant energy resources currently going to waste could be linked with the new forms of mechanization. The regularity, efficiency, power, and productivity of machines run by water and later steam had not yet transformed American life as they would after the Civil War, but the momentum of change was obvious. The rate of capital growth between 1800 and 1860 rose more than ten times, faster than growth in the labor force, whose work was now measured in "machine-hours."[45] In the same era, productivity increased 50 percent as the labor force began its lengthy shift from agriculture to manufacturing, and as workmen were provided machines that were more efficient. The Gross National Product in 1860 was not only larger but its composition was also quite different from what it had been earlier.

The Jeffersonian goal of an enlightened and benevolent enjoying a higher standard of living appeared within reach; but material well-being was not to be guaranteed only by the remark perpetuating industrial mechanism Hamilton had imagined. The tion of mass production, interchangeable parts, and tariff protectio "American System"—was intended to lighten the human burden o drudgery while also conquering scarcity. In the United States, demanded higher use of energy than in other emerging industri because of the need to use a minimal labor force as effectively as Energy efficiency was of no great concern, however, because prima was cheaper and more readily available than either labor or capita

Thanks to the availability of this relatively cheap supply o automatic machines were producing nails in Massachusetts and bra Connecticut, simple items which previously had been laboriously hand. Soon, the American System gained the grudging respect of th as it systematically turned out mass-produced complex devices li (1815) and sewing machines (1846). At the British Crystal Palace E in 1851, American technology was displayed in the form of farm n and weapons with interchangeable parts.[46]

Steam Power Guarantees the American System

At first steam power was used to replace existing power source waterwheels and horses, which were less reliable and regular. Suc tution was rarely reversed. The deeper mine made possible by powered water pump could no longer function under horse powe steam engines combined and centralized factory operations, which too expensive and cumbersome to disperse again. High pressure engi early nineteenth century made steam equipment lighter and smaller, development of the steamboat, and soon the railroad locomoti steamboats were considered so superior to canal, sail, or oared boats risks were tolerated as a necessary evil. For the first 25 years steamboat's appearance in 1816, 130 boiler explosions took an appa of life. By 1850 probably 1,000 steamboats were lost, with about 3,3C killed. A public outcry led to the first attempts at government regu technology.[47] But the steamboat was far too important to be regulated or be forced out of service.

The ability of steamboats to move upstream on America's wa which carried the great proportion of trade, made them an early techr marvel. Steam power promised to forge a major series of links bet commercial and industrial East and the agricultural and frontier Fulton's *Clermont* ran upstream from New York to Albany in remarkable 150 miles in 32 hours. Henry Shreve's use of a flatboat h

lighter, less complex, high-pressure steam engine, overcame the difficulties Fulton's heavier deep-draft boats would have had on the snag-ridden, sandbar-filled Ohio, Mississippi, or Missouri rivers. Eastern steamboats were largely used for passenger travel, but in the Midwest carried not only people but vast amounts of goods. By 1860 over 700 steamboats plied the rivers between Pittsburgh, Cincinnati, Louisville, St. Louis, and New Orleans, linking key American regions more effectively than ever before.

Partly because of the need to supplement scarce physical manpower, partly to overcome the vastness of American space, partly to fulfill the material foundations for enlightened progress, and partly to satisfy the dynamic aspect of an American personality, Americans saw in the prodigious use of energy, especially steam energy, the means to material growth. A mechanized society, with seemingly infinite sources of energy, symbolized permanent and progressive human progress.

More than the steamboat, however, the railroad steam locomotive most embodied America's new fascination with energy. It was the modern machine age incarnate, and it remained the prototype of power and dynamism in an energy-intensive society for decades. Following the English lead of the 1820s, and after trials using horse-drawn cars, the Baltimore and Ohio Railroad Company in the 1830s instituted passenger and freight service to Cumberland, Maryland and the West. Soon railroad lines connected all the eastern states, and by 1860 nearly 32,000 miles of railroad had been laid east of the Mississippi. As the historian Charles Moraze put it, the railroads became the "circulatory system of the middle class."[49]

Some historians of technology have described the steam locomotive, together with the railroad system, as the single most significant technological development of any sort in American history.[50] The steam locomotive consumed America's vast forests for wood for ties and fuel. It appropriated the new iron industry for engines, rolling stock, and rails. Perhaps most important of all, it absorbed and rewarded large scale capital investment. The steam locomotive prevented the United States from becoming "balkanized" into independent states or regions. The railroads were a primary motive force for westward expansion into undeveloped frontier regions by making cheap abundant land more accessible. Hence railroad transport also led to a major expansion of American agriculture, as markets could be connected with supplies. The North's railway system helped it win the Civil War. And an early major coalition between business and government was created by the cooperation—critics would say collusion—between westward expanding railroad systems, like the Rock Island Line, and state and federal governments, based on vast land-grant subsidies, rate regulation, and other allowances.[51] Just as lithographs of cities like Pittsburgh depicted industrial might in the form of dozens of smokestacks pouring out black smoke, the steam locomotive was "an instrument of power, speed, noise, fire, iron, smoke... a testament to the will of man rising over natural obstacles."[52]

But while there were only 350 locomotives in use in America in 1838, there were 1,860 stationary steam engines powering rapidly-expanding factories. The flexibility they offered was considered remarkable, since now a manufacturing plant could be located where it would be convenient to markets, labor, and resources, rather than only where water power was available. Factory size could seemingly be increased indefinitely; there was no natural limit to available power.

This transformation produced by the American System has been called the beginning of a "democracy of things."[53] The yardstick of a superior standard of living included not only basic necessities, but increasingly items that made life convenient, comfortable, and "progressive." Items unimagined in 1800, or extremely expensive in 1815, were soon taken for granted as the rightful possessions of a large middle class. Bent pieces of iron were replaced by safety pins, wax paper was superseded by large cheap panes of window glass. The traditional flint and steel fire starter was replaced by the newfangled safety match. Machinery now turned out cotton textiles, carpeting, shoes, "patent" furniture, and tableware; wallpaper became the style instead of paint or leather wall covering. To the list must be added cast-iron stoves, spring mattresses, flush toilets, gaslights, silver-plated tableware, and even roller-shades for windows. Americans of all classes came to believe they were entitled to these benefits produced by machines run by steam and water, and they wanted more.

Coal and Steel Make the Revolution Permanent

Although Americans before the Civil War lived largely in a world of wooden artifacts, materials made of iron gradually became commonplace.[54] Iron textile machinery was far more durable and reliable than wooden machines. Iron turbines improved upon the age-old waterwheel. The unsuccessful wooden steam engine was quickly replaced by the all-iron steam engine. And more efficient and convenient iron stoves—300,000 were made in 1850 alone—replaced inefficient fireplaces. Farm tools included not only the iron plow but, by the 1820s, various hay rakes, cultivators, and reapers.

Belatedly following the English lead, Americans gradually shifted from charcoal to coke to smelt their iron. Anthracite and bituminous coal quickly replaced wood. The efficiencies in scale, and the convenience of coal, were remarkable. A blast furnace that needed 2,000 to 5,000 acres of timber now could be kept running on a half-acre six-foot seam of coal. Production integration and centralization (akin to Oliver Evans's abortive mill of the 1780s) came to the American scene in 1857 with the construction of the Cambria Iron Works in Johnstown, Pennsylvania.[55] It brought together on one site coke furnaces, puddling furnaces, and rolling mills, creating the ability to transform iron ore into finished rails.

But the brittleness of cast iron meant a continued search for a metal with high ductility, toughness, and ability to withstand stress without distortion.

As late as 1850 high-carbon steel was still scarce and expensive, used largely for cutlery and tools. Not until the high-energy Bessemer converter and large-scale production in the early 1870s at the Bethlehem and Cambria works did low-cost steel become a reality.[56] Andrew Carnegie pioneered the vertical integration of the steel industry, combining his interests in coke and pig iron supplies with blast furnaces and steel-rail mills. Carnegie also invested heavily in the high-energy open hearth process, which increased production further. Steel production rose from 16,000 tons in 1865 to an unbelievable 56 million tons in 1915. Even Carnegie was incredulous:

> To make a ton of steel one and a half tons of iron stone has to be mined, transported by rail a hundred miles to the Lakes, carried by boat hundreds of miles, transferred to cars, transported by rail one hundred and fifty miles to Pittsburgh; one and a half tons of coal must be mined and manufactured into coke and carried fifty-odd miles by rail; and one ton of limestone mined and carried one hundred and fifty miles to Pittsburgh. How then could steel be manufactured and sold without loss at three pounds for two cents? This, I confess, seemed to me incredible.[57]

The combination of cheap energy resources, new processes, industrial centralization, and intensive capitalization made American steel extremely cheap. In 1873 it had been $100 a ton, too expensive for steel rails. In one step, Carnegie's 1875 Edgar Thompson Works in Pittsburgh halved the price to $50 a ton. Ten years later it was $20 a ton and by the turn of the century less than $12 a ton, almost one-tenth the price of 25 years earlier.[58] Steel replaced iron as a universal metal for railroad bridges, girders for buildings, nails, and wire. Multipurpose steel beams, nonexistent in 1875, were produced at the rate of millions of tons in 1900.

Steam power had become a typical feature of the American scene, akin to the family farm. Steam engines and boilers still provided the major motive force in the nation. Far higher pressures, undreamed of before, were achieved with safety. Engine speeds rose to high velocity. After the middle 1880s compound steam engines were used in marine, powerhouse, and factory operations.

Between 1865 and 1915 the United States was literally made over by this new coalition of coal to burn, steel to process, and steam for power. In 1900 the annual value of manufacturing was more than twice that of agricultural products, a pace of growth and change that many countries even today would find hard to match. The United States became the leading industrial power in the world in 1895 and by 1910 its output was twice that of its nearest rival. By 1913 the United States accounted for more than a third of the world's industrial output.[59]

At the beginning of the twentieth century, three-quarters of the total energy consumed in the United States came from coal. This compares with 90

percent wood and only 10 percent coal in 1850. In the meantime total energy use more than quadrupled. Coal production still required hard and dangerous work. In 1900 the average coal miner produced only three tons in a day's work. But already coal mine cutting machines accounted for one-quarter of mine production. Mechanized loading and hauling improved labor efficiency, which rose from four and a half tons per man day in 1925 to six and a third tons by 1945. This rose to 13 and two-thirds tons by 1964 following the introduction in 1948 of the continuous mining machine. And in 1964 newly-developed strip mining techniques accounted for a third of all coal production, at the high rate of 29 and a third tons per man day, or almost ten times the productivity of 1900.[60]

Virtuous Enterprise: The "Business Ethic"

In the first half of the nineteenth century, business interests and the entrepreneurial approach were still secondary to the rural American mainstream. By the last quarter of the century, however, the businessman became a highly visible, admirable, even heroic figure on the stage of American life.[61] Inventors, management pioneers, and merchandising geniuses gained public adulation. A hardheaded quest for profits, expansion, and business success no longer needed moral justification, but became a virtue in itself. Henry Adams, in his classic autobiographical essay on "The Virgin and the Dynamo," contrasted the traditional world of agriculture, handiwork, and classical learning with modern prosperity based on coal, iron, steam, and pragmatic materialism.[62]

Who planned the industrialization of America? And for what purpose? Who established official policies to encourage large-scale steel production, electrification, and urbanization? The answer is that no one did with any deliberation. Yet the United States was literally made over in the 60 years following the Civil War. Howard Mumford Jones called it "the Age of Energy."[63] The revolutionary process, the decisions made, the direction of change were left to the market mechanism. The drive for profit in turn moved the market. This acquisitive spirit led to charges of profiteering and monopolies. Advocates of the market mechanism, however, argued that the natural controls provided by competition were the best protection for consumers. The businessman came to be caricatured as the "robber baron," represented by such successful tycoons as Jay Gould, J.P. Morgan, and Cornelius Vanderbilt. They may well have had the predatory habits of Chinese warlords, but their bold financial manipulations helped provide the investment capital that made America an industrial giant.

A preoccupation with money and success attended all ranks of society, not just the top. As Henry Steele Commager has noted, "The self-made man, not the heir, was the hero."[64] A general philosophy of "rugged individualism," symbolized in the "captains of industry" who were praised for raising

American standards of living, became the operating ethic on all levels of society. "The most wretched had aspirations," Charles Beard observed, "there was a baton in every (worker's) toolkit."[65] Andrew Carnegie called the emerging social ethic the "gospel of wealth."[66] America as the "land of opportunity" meant that hard work would lead to riches. Riches were available because high-energy, high-technology heavy industry was said to be the greatest "wealth machine" ever produced in human history.[67]

The idealization of the robber baron, supported by the supposedly benevolent "gospel of wealth" and by a Darwinian "survival of the fittest" philosophy, could not persist indefinitely.[68] As American industrial output matured in the twentieth century, the individual entrepreneur would be replaced by the cautious corporate manager and bureaucrat, practiced less in the art of risk and more in that of negotiation. The one-man, one-plant enterprise grew into large complex organizations, which dominated their industries, vertically and horizontally. By the 1920s the modern business organization was in place, defining American institutional life as much as any other organization, including government and the churches. As many have noted, the American corporation is something like a private government.[69] The exploitation of natural resources, including primary energy sources, demands vast amounts of capital, and the large corporations, interlocked with banks, are the key centers of investment. A close relationship between energy, resources, and corporate America is inevitable.

A major principle of laissez-faire individualism is that general well-being is best served when individual self-interest is left free to maximize personal gain. Justice is best served by leaving decisions over allocation and reward to the impersonal forces of the marketplace. The role of government is to encourage free contractual interchange and cooperation and to keep its own interference with the self-regulating forces of the market to the minimum necessary for security. In response to the threat of monopoly and oligopoly and to demands for alleviation of social distress, this formula has been greatly modified, but in the nineteenth century it was the lodestone and rationale of economic growth.

Industrialization and the Quality of Life

The early settlers had feared that industrialization would introduce inhuman working and living conditions in the New World, as it had in English mill towns. Hard physical work and dangerous surroundings in the new American factories, together with low wages, long hours, and no benefits, led factory workers to seek redress. Before the Civil War strikes and attempts at unionization were severely, even savagely, repressed. As immigrants changed the labor force, wages below subsistence levels continued into the late nineteenth century, working conditions became more dangerous in the steel

mills, and the 12-hour day made the condition of the worker harsher than before. Powerless men no longer saw unions as un-American. Not all social improvement came from increased industrial growth; the Knights of Labor and the American Federation of Labor fought to guarantee industrial wages sufficient to sustain a family. A maintenance standard of living was possible for the factory worker only if his wife and children also worked and the family had its own vegetable patch and cow in a tiny tenement backyard. The American farmer once lived in a largely nonmoney economy; soon the worker's life was measured in dollar income.[70] The meaning of the standard of living changed in the process, as did the understanding of the quality of life.

Older worker-owner personal relations were also lost as the size of business enterprise grew. A brass worker in 1883 lamented the new state of affairs: "Well, I remember that fourteen years ago the workmen and the foremen and the boss were all as one happy family; it was just as easy and as free to speak to the boss as anyone else, but now the boss is superior, and the men all go to the foremen; but we would not think of looking the foremen in the face now any more than we would the boss."[71] The nature of work had changed, becoming specialized, fragmented, speeded-up, and less satisfying. It was not done out of a sense of craft but for the wages it earned. Regimented working conditions, with no opportunity for belonging to or identifying with the industrial process, led to dehumanization and labor-capital conflict. The Strike and Panic of 1873, the Railroad Strike of 1885, the Haymarket Affair of 1886, the Homestead Steel Strike of 1892, and the Pullman Strike of 1894 brought on widespread fears of economic collapses, socialist and anarchist "conspiracies," and even revolution.

But workers and farmers did not rise in a sweeping rebellion. The property and lives of the middle class were not threatened. The benefits of industrialization overcame the hardships and the sense of injustice that might have led to revolution. The apparent death throes of American civilization in the 1890s were really its growing pains.[72] Rightly or wrongly, most American workers evidently felt that conditions were improving. The same fragmentation of labor that caused strife also enormously increased productivity. Fewer workers were trapped in physically-demanding tasks. The rise of a highly mechanized industry, which replaced brute strength with steam engines and electric motors, made possible the switch from hard physical work to light-labor mechanized operations.

Productivity, based on mechanical power, increased fourfold between 1865 and 1929. The reallocation of labor, not only from the farms to the factories, but also from heavy industry to consumer goods, and from factory work to service functions, signalled upward mobility to many Americans. The standard of living during the same period rose at a spectacular rate—which helps to explain why America experienced labor strife but no labor revolution. Many Americans enjoyed a transition from working class

subsistence goals to middle class aspirations, often regardless of original income or status.[73] Mobility from "blue collar" to "white collar" jobs became part of the American Dream. Most Americans believed they belonged to a middle class and had left a working class life behind them. In 1865 only slightly more than one American in ten was employed in education, the professions, personal services, trade, or government; in 1929 the number was one in five. By 1950, two of every three Americans were employed somewhere else than the factory and farm.

By any external measure, the standard of material life that Americans claimed around 1900 was remarkably high. Even by the best of European standards it was very prosperous. Americans began to demand a plentitude of goods at modern prices, with superior durability, and convenience of use, and which would create new, interesting, and useful activities. No home could be without wood stoves, sewing machines, "Cabinet" furniture, carpets and fabrics, clocks, china, glassware, and the horse-drawn buggy. Yet in 1900, 60 percent of all Americans still lived on the farm, and rural households set the pattern for American consumer expectations well into the twentieth century.

The opportunities created by the universal rush to centralized energy development quickly took hold. The historian Richard M. Abrams has described the United States in the first quarter of the twentieth century as "a land of promise where one person's gain was another person's opportunity, and the inevitable were not just death and taxes but improvement and growth."[74] Even a reformer like John Haynes Holmes found the early years of the century remarkably benevolent: "Those of you who did not live in that period before 1914, or who are not old enough to remember it, cannot imagine the security we enjoyed and the serenity we felt in that old day."[75]

Abrams cautiously concludes that the United States in that era was the most successful society yet in the history of civilization. Anchored more securely than any other society in the material abundance created by mechanization and high energy use, the United States between 1900 and 1915 was perhaps the archetypal industrial society. Material well-being, measured by Gross National Product, seemed to rise constantly and permanently. On the solid foundation of heavy industry came production of consumer goods: "Americans began to reap some of the benefits of their labors." One of the first signs of the coming of a postindustrial era was the greater dollar value of the meat packing industry over the steel industry in 1904, a difference that doubled by 1915.[76] Eating habits were transformed with the development of refrigerator cars, since fresh meat, fruits, and vegetables could be shipped long distances. Buying habits changed with the Parcel Post Act of 1912, and mail order companies came into their own. Leisure time became an important consideration as the workweek declined to 60–55 hours for industrial labor and to 55–50 hours for skilled labor.

The industrial revolution, it seemed, was fulfilling all the promise prophets of progress. Especially in America, where resources were ab and opportunity unfettered, the age-old struggle to overcome scarcity be waged with confidence that the successes already achieved would no only temporary. There was little recognition that the satisfaction of ol would raise new expectations, or that at some point these expectations run up against a variety of limits to perpetual economic growth.

2 Energy and Abundance: Advance and Retreat

ELECTRICITY AND AMERICAN LIFE

Between 1865 and 1929 total energy use in the United States rose prodigiously from 160 million horsepower to more than one and a half billion horsepower. One growing segment of this enormous increase belonged to a new development: electricity. A matter of commonplace confusion must be avoided: electricity is not a source of energy. Coal, petroleum, natural gas, water power, nuclear fission, and solar radiation are sources of energy; electricity conveniently carries and distributes energy. When first developed, it was a new way of using energy generated by the flow of water or the burning of fuel. Electricity had so many benefits that it brought on a remarkable change in the use of these primary energy sources. Between 1902 and 1919 Americans increased consumption of electrical power ten times, from 2.5 kwh to 25.4 billion kwh. By 1920 it accounted for 8 percent of all energy consumed in the United States, by 1955, 17 percent, and by 1978, 29 percent.[1] In the first 30 years of this century, investment in utilities, lighting, machinery, and appliances outstripped even the bourgeoning automobile and related industries.

The major advantages of electric power are that it is flexible and divisible. The power plant can be separated from the manufacturing plant, even by long distances. Cumbersome devices for translating and transmitting motion (i.e., from to-and-fro to rotary motion) are unnecessary. Electricity is "on-tap" when required, whether for large or small needs. In time the electricity industry became unique because of its size, its pervasiveness, the variety and diversity of its influence, and its direct social and economic impact.

At first, early in the nineteenth century, electricity was used almost solely for magic and stunts. It received serious public attention only when Samuel F.B. Morse successfully demonstrated telegraphy. Morse's breakthrough

came when he developed an adequate electric battery. The first telegraph li was strung between Baltimore and Washington. By 1848 lines went as far St. Louis. 1861 marked the first transcontinental line and 1866 the fi successful Atlantic cable. Ten years later Alexander Graham Bell demo strated the telephone at the Centennial Exposition in Philadelphia, trar mitting the human voice and other sounds over wires. The telephone spre rapidly: by 1887 A T & T had 170,000 subscribers. The first long-distance li connected New York and Chicago in 1892. By 1917 there were more than and a half million telephones in use.[2]

After 1880 interest in incandescent lighting raised a new and growi demand for electricity. Lighting required more powerful electric transmissi compared to the mere trickle needed for telegraphy and telephone. A lighting was first offered commercially in the 1870s, but it was too bright a too expensive for domestic use. In 1878 Thomas Alva Edison devised lighting filament that was inexpensive, durable, and would not decompo and blacken the inside of the bulb. He first succeeded with a carboniz sewing thread and bamboo filament. By 1882 the New York Pearl Stre Station became the first central power station, distributing its current to 1,4 lamps in 85 buildings. But direct current transmission was limited to quarter-mile for 110 volts and a half-mile for 220 volts, the latter voltage bei a practical limit.[3]

From the beginning Edison perceived his electric lighting not simply a lamp but as an energy system.[4] He had a vision of a central source of electrici that would light houses and businesses over a large section of a cit Customers could use light as needed; unlike the arc lighting of streets, t failure of one light would not affect the others. Centralization would al allow easy metering of consumption. Edison foresaw the distribution not on of lighting but also of power. At Menlo Park he and his associates worked n only to design the light bulb, but also its convenient screw base and socket; simple and clever was this patent that it gave his competitors fits as they vain sought alternatives. Out of the Menlo Park laboratory also came fus insulators, regulating devices, conduits, junction boxes, and bigger and bett dynamos. The result was the rapid spread of electric power generation; 1891 there were 1,300 incandescent lighting central stations in the Unit States, capable of lighting three million lamps.

And there was much more yet to come. Despite Edison's strenuous ar wrongheaded opposition, George Westinghouse worked to devise a practic alternating current supply, which would allow energy to be transmitted ov long distances.[5] Westinghouse acquired the patents of Nikola Tesla f alternating current and refined them for practical development. In 189 Westinghouse's banner year, he landed a contract to build dynamos for major hydroelectric development at Niagara Falls. Niagara-generated pow went on sale in 1895 in Buffalo, 25 miles away, and the era of long-distan

power transmission began. In the same year the Westinghouse Company won the contract to light the prestigious Chicago Columbian Exposition. Visitors were enormously impressed by the giant dynamos, weighing 75 tons each, and the marble switchboard 1,000 feet square. At night, when the great white buildings were bathed in the light of 5,000 arc lamps and over 100,000 incandescent bulbs, the grounds seemed a wonderland. By 1890, only ten years after Edison's first light bulb, the annual sales of the three big electrical manufacturers—Edison, Thomson-Houston, Westinghouse—were about 25 million dollars.[6]

Until 1900, the generation of electricity was no model of efficiency. Steam engines ran dynamos, which then actually produced the electricity. The widespread use by 1900 of the new steam turbine made the economies of scale of highly centralized electrical generation obvious. Although overshadowed by more glamorous and controversial technologies, the high-pressure steam turbine, invented by Charles A. Parsons in 1884, became America's energy workhorse, as it has been ever since. Factories that had been producing their own electricity found that the large centralized turbines, with higher steam pressures and temperatures, owned by utilities, could produce electricity cheaper. In 1910 a generating plant of 25,000 kw was large. Steam generation of electricity reached new measures of size, strength, and efficiency during World War II as it became the source of power for American naval ships and massive electric dynamos. In the postwar era to the present, steam turbines have generated 83 percent of America's electric power and 75 percent globally. By the early 1960s, generating plants of a million kw were appearing. The simple design of the steam turbine—blades on wheels made to spin by superheated steam—continues to be the primary device for turning raw energy into electricity.

So effective was the steam turbine that it sometimes inspired rhapsodic praise. In 1926 Chester T. Crowell exulted in the *Saturday Evening Post* that the advent of this new mechanism had provided "Nine Slaves for Each Citizen."[7] He compared them to the waterwheel, which created "one slave for each four citizens" in medieval England. He lavished praise on the New York Edison steam turbine at the foot of 14th Street, which consumed 60,000 pounds of coal not in a day but every hour and produced 80,000 horsepower to free ordinary citizens from drudgery. The steam turbine generating plant set up in Cincinnati in 1925 was said to produce the energy equivalent of the work of 9,000,000 men, serving a metropolis of 1,000,000—hence the figure of nine slaves for each citizen. As Crowell noted, when the Cincinnati plant was dedicated, Owen D. Young of New York Edison explained its larger meaning:

> This is the way America must solve her problem of maintaining higher wages than any other country in the world and at the same time keeping her goods competitive in foreign markets. We must put more energy back of the worker, in order that he may be a director of power rather than a generator of it.... I want to see this art not only run the giant industries of the cities, but I want it also to be so humble and true in its social service that we shall banish from the farmers' homes the drudgery which in the earlier days killed their wives. We have come here to dedicate a power plant—an instrument of utility. Is it only that? Perhaps it is a temple.

Crowell noted that electric-powered machines brought "a revoluti
compared with which Marxian Socialism or Russian Bolshevism would
puny and futile, a mere dance in the wind." Life in the new America wa
"great, romantic adventure" of "beauty and comfort" for the average pers

Today, such ebullience over energy technologies has a naive ring, bu
the early decades of the century it obviously reflected genuine exciteme
Crowell concluded that the creators of the machine age, even more th
political reformers, prophets, or poets, had liberated the common m
"When mechanical slaves replace human drudgery the general welfare
mankind must inevitably be advanced." Energy and the pursuit of happin
are directly linked: "the time has already come when the variations betwe
the standards of living in two different countries closely approximate
difference between the amounts of mechanical power they use... the ra
between primary power and standards of living will be predicted with alm
as great accuracy as are ocean tides." The results of mechanization, he add
are tangible, providing real services to mankind through "the liberation
elbows and the enfranchisement of brains." He coined an appropriate slog
for the era: "Knowledge is horse power and kilowatt hours." Crowell end
his dramatic essay by writing euphorically: "Humanity is just peeping over
mountain tops, catching the first glimpse of dawn in a new world. They ha
boundless faith that men and women will find this new world lovely."

Lovely or not, growth in electrical generation was certainly spectacul
For approximately the first 50 years of the twentieth century, when to
energy consumption grew fivefold, electrical generation grew more than
times, or 20 times faster. In the same period, efficiency in the use of fuels a
improved. In 1900 it took almost seven pounds of coal, or the equivalent,
produce one kilowatt hour of electricity. In 1920 it took only three pounds a
by 1955 less than one pound—a sevenfold increase in efficiency.[8] (Even
however, more than half of the raw energy is lost in the process of conversi
to electricity—a point that modern advocates of thermodynamically appr
priate energy use often raise against it.)

Following the use of electricity in communications and lighting, the ne
major development was its adaptation to machinery.[9] The first uses of elect
motors to turn machinery took place on a limited but practical scale in t
1880s. The advantages of electric motors were immediately obvious a
quickly made them universal. Exact power ratios were available for ea

machine. The motor could be cut off and on as necessary. Power could be distributed throughout a plant without the complex, inefficient, and dangerous shafting and belting previously required. Factories became better lighted and more open. Electricity allowed more efficient organization of production. The electric motor mounted on the machine delivered 70 to 90 percent of its power to the machine, while a steam engine, driving a series of machines by the usual system of belts and pulleys, had a 10 percent efficiency. The rapid increase in productivity following the First World War is directly linked to the growth of electrification in manufacturing. In 1901 only 2 percent of all industrial machinery was powered by electricity; by 1929 it was 80 percent.

In 1888 electricity from a central station was first used to power a streetcar system in Richmond, Virginia. This was so superior to horsecars that three years later over 5,000 streetcars were in operation and by 1900 horsecars had disappeared. By 1914 a traveller could go from New York City to Portland, Maine, or to Sheboygan, Wisconsin, on the new, clean, efficient, safe, and reliable interurban electric lines. The first elevated electric railroad appeared in Chicago in 1883 and the first electric passenger elevator in 1892.

Electricity was also responsible for a dramatic change in domestic life. Although appliances did not completely festoon the kitchen until after World War II, early appliances were attached to light fixtures, and soon included electrified fans, hot plates, cigar lighters, stew pots, irons, and sewing machines. By 1900 the wall outlet and plug appeared, together with the heating pad, curling iron, and glue pot. By 1910 the array of electrified gadgetry included electric frying pans, toasters, portable grills, waffle irons, and cornpoppers, together with exotica like electric shaving mugs and sealing wax heaters. By the affluent 1920s they included electric stoves, vacuum cleaners, hair dryers, washing machines, dishwashers, and such novel necessities as marshmallow toasters. Electric thermostats allowed for the first time remote control of heating and later of cooling.[10]

The convenience, efficiency, and flexibility of electric motors made the machine even more pervasive and all-embracing in everyday life. The revolution of convenient mechanization to serve all purposes, some liberating, like washing machines, and some of more trivial utility, changed both home and office life. The Xerox copier is the result not only of optics and chemicals; its development presupposes electrical mechanization. The need for electric power became as universal as that of heating and lighting, and created a lifestyle far more comfortable and convenient than the richest medieval emperor or oriental satrap could boast. Lenin had said that the essence of the Bolshevik Revolution was "the Soviets plus electrification." Lincoln Steffens, who had been an early enthusiast for the new Soviet way, ended up saying of American prosperity in the late 1920s, "Big business in America is producing what the socialists held up as their goal: food, shelter, and clothing for all."[11] Macy's department store in New York advertised, "Goods suitable for

millionaires at prices in reach of millions." Perhaps more from electricity than from any other power system came a sense of national well-being: "food clothing, and shelter for all" became goals within the reach of all Americans not merely distant dreams.

LIQUID FUELS AND THE AUTOMOBILE

Oil came into American lives because of an early energy scarcity. Even a preindustrial society needs lighting for homes and shops and grease for its wooden and iron gears in mills, canal locks, and axles. Animal and vegetable oils became more scarce and costly as demand increased. Petroleum, which was known from seepages in the ground, occasional oil springs, and salt wells was an obvious new source of lubrication. Entrepreneurs recognized that a vast market could be developed if capital interests could be persuaded to search for large quantities of oil. The rest of the story is well known. On August 27, 1859, oil was struck at 70 feet at Titusville, Pennsylvania, and the rush for "liquid gold" was on.[12] One year after the first well was drilled, 15 refinery plants had sprung up in the area. By 1863 Pittsburgh had 60 plants with a capacity of 26,000 barrels weekly. Wooden and iron pipelines fed railheads, and soon hundreds of wooden tank cars made oil a widely-available national energy resource. Production rose from 500,000 barrels in 1859 to almost four and a quarter million barrels ten years later. This was equivalent in energy to nearly a million tons of coal. While it had taken the coal industry more than 80 years to develop that energy level, oil production required only ten years to reach it. But in 1900 expert opinion said supplies of oil would last only ten more years. From the first, the oil business was highly speculative and potentially rewarding beyond ordinary expectation. Prices and production fluctuated enormously.

Early oil exploration involved considerable waste. Primitive oil production technologies could not control oil flow. Gushers, pressured by natural gas, blew thousands of barrels daily into the air until they were capped by hard, dangerous work. The first Spindletop well of 1907 blew off and burned as much as 100,000 barrels a day for ten days. Gushers, overproduction, oil and gas seepage, and simple burning off of natural gas as a nuisance, became commonplace. In 1913 the oil field of Cushing, Oklahoma lost more in potential natural gas value than all its oil was worth.[13] Between 1922 and 1934 one and a quarter trillion cubic feet of gas was wasted daily in the oil fields, the equivalent of 250 million tons of coal. Even as late as 1950 more than half of the natural gas was burned off because prices were too low. This was trillions of cubic feet a year of a nonrenewable resource.

Crude oil was first widely used without processing. Gradually, refined petroleum products entered the market, notably kerosene, distillates, lubri

cating oils, and later gasoline and petrochemicals. About 1900, a 42-gallon drum of crude yielded upon refining 24 gallons of kerosene, six gallons of fuel oil, and five gallons of gasoline. In 1913 the new revolutionary cracking method increased gasoline yield more than 10 gallons per barrel, and yield has increased since.

Energy historians Sam H. Schurr and Bruce C. Netschert distinguish between three eras of petroleum use: "the period of illumination," "the fuel oil period," and "the internal combustion fuel period."[14] Until the first decade of the twentieth century, kerosene accounted for most of oil production. It was used as an illuminating fuel and for heating and cooking. Today it continues as an agricultural equipment fuel and jet aircraft fuel. Distillates were used mostly for heating, steam generation, and diesel fuel.

The third period began with the development of the internal combustion engine. Early on, the most successful automobile engine was not driven by internal combustion but by steam. Electric cars were known at the turn of the century but were expensive and had to be recharged frequently. Internal combustion engines had been known for 200 years, but attempts to make them operate on benzene from coal, illuminating gas, and even gunpowder had failed to make the "explosion" engine successful. It was the marriage between the internal combustion engine and the new fuel, gasoline, that started the revolution of the automobile in the late nineteenth century. Gasoline-powered motor cars were so relatively efficient that the basic principles have not been significantly modified for the last 90 years, a long time for an energy mode.

Gasoline gradually took half of all oil consumption in the United States. Between 1925 and 1955, annual gasoline consumption per motor vehicle rose from 473 gallons to 790 gallons. By the 1970s half of America's energy consumption took place in internal combustion engines. As much as the steam locomotive symbolized the forward thrust of American life in an earlier day, so the automobile reshaped the American way of life by the second quarter of the twentieth century. It extended long-cherished views of mobility, individuality, growth, freedom, and power. But the auto also symbolized American materialism and waste, especially in its fuel consumption and in the energy expended in its manufacture.

The automobile transformed the growing metropolitan regions of the nation. It tied together city and country. It helped destroy America's small towns even as it built up suburbia. In 1900 the average distance to work was one mile; most people walked to work. In the 1970s they commuted by car an average of 15 miles. American lifestyles, from courtship to work habits, from place of residence to use of leisure time, from the experiences of childhood to the practice of religion were all changed by the popular appeal of the automobile. The auto became the second most important investment of the large American middle class, superseded only by the private home. To some Americans the car was their most valuable possession by far.

Any present or future oil shortage would be greatly alleviated balance between mass transit and the private automobile could someh changed. Such radical change would be felt to be a regressive step, aln repudiation of the "American way of life." The arguments against the pei auto are strong: it can easily be blamed for raising accident rate pollution, for expanding highway pork barrels, urban and rural c industrial dirt and ugliness, and the irresponsible waste of energy. B American economy and the American lifestyle can hardly be ima without it, and without its related manufacturing industries, oil produ road construction, travel-oriented tourism, and unnumbered other asp

NUCLEAR ENERGY: CAUGHT BETWEEN TWO WORLDS

On September 24, 1977, Toledo-Edison's Davis-Besse Unit 1 nı power plant, located at Oak Harbor, Ohio, between Toledo and Cleve operating at 9 percent full power, experienced a malfunction in its cc system. A pressure-relief valve jammed open and released water tha cooling the reactor. Without this cooling the reactor would overhea quickly reach meltdown conditions—the infamous "China Syndrome. main feedwater system failed, and the emergency feedwater system can but because of an easily misread water-level gauge, the plant's oper concluded that the reactor was receiving too much cooling, and shut o emergency cooling pumps. As a result, water poured out of the reactor cc system and none was allowed in. It took 22 minutes for the operat discover the open relief valve and to correct the failure before damage coı done.

Eighteen months later, on March 28, 1979, a strikingly similar mal tion took place at Metropolitan Edison Company's Three Mile Island U working at 97 percent capacity, ten miles south of Harrisburg, Pennsylv In this case, the pressure-relief valve stuck open, the water-level instrur again were improperly read, the emergency cooling pumps were turne but it took about two hours and 20 minutes to discover that the relief valv open. A partial meltdown took place and the plant is still radioactiv closed. While malfunctions in cooling systems of other nuclear plants been corrected automatically or by plant personnel, at Three Mile Islar first "general emergency" ever to arise in a commercial nuclear power was declared.[15]

One set of commentators cites the Three Mile Island accident as evi that the nuclear industry, the utilities, and the government regulators been exceptionally careful and successful in developing nuclear energy. I the first such case, after years of generating nuclear power, no one was in or killed, and the technology worked exceptionally well: final blam

placed on the operators in the control room, who were held to be inadequately prepared for their responsibilities. Another set of observers point to the same accident as evidence of the dangers of relying on nuclear reactors. In particular they cite inherent design flaws, lax attention to safety problems by the manufacturer, the utility, the operators, and the regulatory agency, as well as the potential for catastrophic harm in the event of an uncontrollable accident. Critics say we were lucky; advocates say they were proven right—the system works.

From the day—December 2, 1942—that the first man-made nuclear reactor reached critical mass, until December 18, 1957, when the Shippingport commercial reactor went on-line, 15 years had passed. In Richard Rhodes's words, "That is rapid development or surprising delay, depending upon one's perspective."[16] Under the Atomic Energy Act of 1946, atomic energy was made a government monopoly; all discoveries and inventions concerning atomic energy were defined as "born" secret. All fissionable materials were the property of the U.S. government. Only by government contract could a reactor be built, and it could not become private property. The Atomic Energy Commission (AEC) was called "the most totalitarian governmental commission in the history of the country."[17]

In 1948, the policy of the Congressional Joint Committee on Atomic Energy was "that reactor development should proceed with all possible speed." In 1949, in an unusual step, the AEC contracted with Westinghouse to begin work on a power reactor for submarines. Hyman Rickover was put in charge, and it would be Rickover who later personally directed the building of the first civilian reactor at Shippingport. The Navy's high-pressure, water-cooled reactor came to become the standard for American industry.[18] In 1953, the AEC concluded that "now is the time to announce a positive policy designed to recognize the development of economic nuclear power as a national object... to promote and encourage free competition and private enterprise."[19] On October 22, 1953, the AEC announced that an AEC-owned nuclear power plant of 60,000 kw would be constructed at Shippingport, to be built jointly with Westinghouse Electric Corporation and the Duquesne Light Company of Pittsburgh. Duquesne Light made its commitment because of Pittsburgh's serious coal pollution problems and AEC's promising economic subsidies and guarantees. President Eisenhower made his famous "Atoms for Peace" speech before the General Assembly of the United Nations on December 8, 1953, Rhodes writes that "'Atoms for Peace' did... encourage Congress, industry, and the press to consider nuclear power, and notably private nuclear power, as peaceful, patriotic, and benevolent."[20]

Before the federal government offered inducements, industry had not rushed forward to embrace the new energy technology, because it was not considered commercially attractive. Conventional electric power generation

cost about four to eight mills per kwh; Shippingport first cost 55 to 60 mills p kwh, but the AEC sold it for eight mills to Duquesne Light.

The Atomic Energy Act of 1954 established new patterns to encoura nuclear power. For the first time it allowed private industry to own a operate plants; the government monopoly was broken. Rickover, hard work at Shippingport, told the Joint Committee, "I think we have babied a of people in this country too long with the glamour of atomic energy... think as soon as possible we have got to get down to do it like any otl business." But he also said, "All we have to have is one good accident in t United States and it might set the whole game back for a generation."[21]

Although given a virtually free hand by government, the nuclear indus still had to compete in the free market, and quickly learned that nucl energy, in Alvin Weinberg's regrettable statement, was not going to be ' cheap it could not be metered." In the 1950s and 1960s electric rates fr conventional systems, like coal-fired power plants, were actually falling. the same time, Shippingport was experiencing construction cost overruns 50 percent. The industry quickly learned that nuclear plants could comp only if they were several times larger than conventional plants, th benefitting from economies of scale. Very large scale plants ran a high risk overheating more intensely and rapidly during a cooling system malfunctic but this risk had lower priority than the potential cost advantages.

In 1974 Congress established the Nuclear Regulatory Commissi (NRC) as a partial successor to the old Atomic Energy Commission. T NRC was authorized by law to develop new regulations covering every asp of plant design and construction down to the last nut and bolt and last rule operating handbooks. But the only basic changes that actually result involved an effort to streamline the licensing process. To many critics appeared that comprehensive and strict regulation came a poor second to t continued government commitment to rapid nuclear reactor expansion at t hoped-for rate of "one or two per week for every week in the years from 19 to 2000." Peter Bradford, one of the NRC's five commissioners, said that t regulatory process fell into "fundamental disarray." The conflict was over t sets of priorities: expansion of nuclear power, without undue and cos regulatory delays, or a more active federal supervision of nuclear safety, w inevitable delays "in the public interest." The Presidential Commission set to investigate the accident at Three Mile Island severely attacked the NRC f being "unable to fulfill its responsibility for providing an acceptable level safety for nuclear power plants."[22]

In the wake of Three Mile Island and of the resulting public outcry, t further development of nuclear power has been enmeshed in heated contr versy. As one analyst has remarked, the nuclear debate is "proceeding with t intelligence, grace, and charity of a duel in the dark with chain saws."[23]

ENERGY AND ABUNDANCE

In 1950 the historian David Potter examined American affluence in his book *People of Plenty*[24] and concluded that the achievement of this society's declared values depended heavily on the success of its industrial efforts. American industry makes the most of human labor, reduces hazardous or degrading work, exploits natural resources efficiently, and promotes well-being by producing cheap durable goods and services. From this perspective, more industrialization, not less, is the proper course if American values are to be promoted.

Potter noted that mankind has lived with scarcity throughout history, and that American society was the first to break out of the pattern and build a civilization based on abundance. Abundance has both economic and political effects. Economically, the promise of a better life is realized with the availability of "food, clothing, and shelter for all." Politically, abundance reinforces belief in the founding ideals of liberty, equality, opportunity.

By the 1950s, belief in mass consumption seemed to dominate other aspects of American life. The goal was "more, bigger, better, and still more convenient." This consumerism depended on a privileged use of energy and other resources. Over 40 percent of the world's aluminum and a third of the world's fuel is consumed in this country. While it is impossible to measure personal happiness, a sense of individual freedom, fruitful leisure, and other satisfactions, Americans have translated many of these goals into material terms. And these material satisfactions have usually been associated with energy-intensive production.

As Potter showed, economic growth forms part of the promise of democracy. It has encouraged a social climate for continuous "modernization" through scientific discovery, technological innovation, business enterprise, capitalistic enterprise, and successful management of large, complex systems. The belief in quantitative growth has become a traditional conviction.

Efficient use of energy has been one of the most important conditions of material progress. In the 1850s, energy consumption per person was the equivalent of four tons of coal; by 1880 it was down to two and a half tons; in the 1950s to less than two tons.[25] Solomon Fabricant describes this technological improvement as society's "intangible capital": "all the improvements in basic science, technology, business administration, and education and training, that aid in production."[26] Energy efficiency was 8 percent in 1850, 12 percent in 1900, and over 30 percent in 1950. A diesel railroad engine did the same work as a coal-fired steam locomotive at one-sixth the energy consumption. The long-term trend was away from direct consumption of raw energy to the use of processed and converted energy products, as in the change from coal to diesel oil for the railroads, or the nationwide switch to electric power generation.

In the 1880s a little over 26 million horsepower was consumed in United States, slightly more than half a horsepower per person. Almost ha this was from work animals and less than half was from fossil fuels. In the l hundred years the use of fossil fuels multiplied four times (as did population). But with higher technological efficiency, by 1970 horsepowe capita was over 90, or almost a 200-fold increase since 1880.[27]

Abundance, and the democratic liberties it produces, also rests up "production ethic." Fundamental responsibility rests with private initia aided by government. From this perspective, America's greatest proble the troubled state of its industrial capacity, especially the decline in the rat innovation and productivity.

But the assumption that growth in industrial production is a li function of energy consumption needs reexamination. Total energy c sumption over the last hundred years has increased at less than half the ra the Gross National Product.[28] There is good reason to suppose th relatively high rate of economic growth can be accomplished witho corresponding increase in energy consumption—provided capital and tec logical ingenuity can once again come to the rescue.

HISTORIC CRITIQUE OF ENERGY AND INDUSTRIALIZATION

Casting doubt on the benefits of the new industrial system has be constant contrapuntal theme during its history.[29] Criticism of the capitali merchant and iron-working guild "mechanick" is actually preindustrial, s they were seen as latter-day intruders upon the feudal order of society were never allocated a place as links in the all-important sacred-secular "G Chain of Being" that controlled all medieval relationships. With the comin the Industrial Revolution, the semimythical Luddites between 1811 and 1 attacked English textile mills and smashed power looms. They bla unemployment and low wages on the machines. English farm wor attacked the new threshing machines in 1830. French textile workers u their wooden shoes, *sabots,* from which the word *sabotage* comes, to k machines to pieces. Complaints had long been lodged, particularly England, and laws passed, against the pollution and working condition mill towns.

Critics also attacked the mechanization of life which the new st power imposed. In contrast with the craftsman's pride in his handiwork, s was instead built into the machine. The new factory organization of time the division of work into separate disconnected operations were designe make the most of machinery but turned out to be detrimental to satisfaction and well-being. "It was forgotten," Bertrand de Jouvenal wr "that 'hands' also had hearts and minds as well." The loss of time-hono principles of a "fair and just wage," the growth of an impersonal relations

between owner and worker, and the single-minded obsession with "productivity for profit" seemed too high a price to pay. "The new organization of work by the factory system brutally shattered these warm, human, and inefficient concepts and substituted for them the cold, sharp notion of 'competition.'"[30]

Part of the critique also came from idealistic but impractical advocates of a "back-to-nature" movement. Drawing extensively from the Romantic views of Goethe and Wordsworth, as well as vaguely-understood oriental religious views, the American Transcendentalist movement questioned the increased gulf between man and nature, which was an explicit goal for industrialization.[31] Emerson's landmark 1836 essay, *Nature,* promoted a pantheistic harmony between man and nature through a common spiritual experience in a unifying Oversoul. A highly mechanized society, he complained, wrenched man out of his natural origins. Humanity could recover its fullness only through a mystical immersion in nature. Later this creed would give rise to Victorian sentimentality, with its worship of the picturesque natural world. Henry David Thoreau's *Walden,* based on a year and a half spent exploring self-sufficiency in a quasi-domesticated wilderness, is the other major Transcendentalist testament. Like *Nature, Walden* is one of the early American statements of an environmental philosophy. It argues for the purity, simplicity, and clarity of human life and in favor of escape from modern civilization and a return to nature.

But the Transcendentalists failed dismally with their utopian Brook Farm experience in New England, partly because their philosophy was so uncompromisingly antimaterialistic, stressing the spiritual aspects of a return to nature and often a quasi-mystical union with God or a universal spirit. Tocqueville echoed this Transcendentalist critique when he wrote of the dangers of an "ennervating materialism" that could destroy the American character if it became preoccupied with industrialization. A bridge can easily be seen between these early antitechnology, nature advocates and the modern ecology-oriented environmentalists through the writings and work of George Perkins Marsh and John Muir.[32]

But even the most embittered critics of industrialization could not deny that the new steam-powered factories created a dazzling prospect. Humanity seemed embarked on an historic and revolutionary move from perpetual scarcity to an economy of abundance. John F. Kennedy spoke of a "rising tide which lifts all boats." Despite job loss or displacement, despite the filth and ugliness of industrial towns, and the hardships of factory life, workers sought out factory employment. They rushed from the life of the farm to the new factory cities. Steam power, the new machines, and the new organization of work promised abundance and created a new atmosphere of hope.

Yet the great riddle of the modern age of energy persisted. Industry was expected not only to produce profits and jobs, but to conquer the three

archenemies of civilization: poverty, ignorance, and disease. Neverthe large numbers of people still lived under conditions of poverty, hard insecurity, and hopelessness. The critique of Western industrial capita was led by socialists, some Marxists, labor reformers, and utopians. criticism received wider attention in the twentieth century and became pa the West's preoccupation with its own decline.[33] A new "holistic" or ecolo approach claimed that a profit-oriented system could not achieve the intr harmony between energy, technology, and society that was now requ Critics like Lewis Mumford, Jacques Ellul, and Ian McHarg denounce "cowboy ethic" and the "Faustian bargain."[34] American industry was sa have forced a consumer "cargo-cult" psychology upon the mass of pe who had come to worship the false gods of growth and material gain.

THE CONSERVATION MOVEMENT BEFORE 1973

Some historical precedents exist for modern energy conserva although America is hardly the birthplace of energy frugality. The first s of a conservation ethic appeared early in the nineteenth century du problems with soil exhaustion and replenishment in the East. Later, n widespread interest appeared as water resource management became cri in the far West.

Modern environmentalists can claim Romantic and Transcendent forebears ranging from Emerson and Thoreau to the later activities of C and Muir. Muir's formation of the Sierra Club in 1892 marked a turning p in environmental activism,[35] because it represented a broad challenge tc assumption that industrialization was bringing "progress." Muir and followers argued that wilderness was at least as necessary to life as ur civilization and that industrialization was corrupting mankind by substitu artificial wants for natural needs.

The movement was divided, however, by a conflict between "prese tionists" and "conservationists." Preservationists wanted nature to be alone; underground fossil fuel resources in wilderness regions were to ren untouched. This wing of the movement urged the development of the nati park system, which made it a responsibility of the federal government to k selected places off limits to energy development.

The conservationists first came into their own during the Progressive mainly due to the efforts of Gifford Pinchot and Theodore Rooseve Prevailing attitudes in the departments of Agriculture and Interior, stres multiple land use based on economic need and national strategic priori were shaped by the conservationists. Soil conservation is still a major acti of the USDA. Forest Service land management, combining use for pu recreation and for private enterprise in the lumber industry, is a m

conservationist activity. Beginning with the reform efforts of President Cleveland, who in the 1880s boasted that he had recovered 80,000,000 forest acres, the conservationist approach dominated American attitudes towards natural resources.

Responding to the conservationists, politicians launched a federal program to withdraw lands and resources critical to national security, beginning with presidents T. Roosevelt, Taft, and Wilson. The resources included phosphates and coal and Naval Petroleum Reserves in California, intended to fuel warships in time of crisis. Fears were also expressed that the nation's oil supply would be depleted in two generations because of wasteful extraction methods.[37]

Precedents less favorable to conservation were set during the Taft administration in the use of water power sites for hydroelectric development. Federal control was based on the principle of regulation-by-leasing, but the power industry sought long-term unregulated leases with virtually automatic renewal. As the public clamored for more electrical power, the 1901 Right-of-Way Act did allow the Department of the Interior to grant permits for power transmission lines across public lands and to build dams on public land sites, with the right of revocation. A water power bill in 1920 provided for long-term (50 year) leases with regular payment to the government.[38] On a state level a multiple-use trend was established at the turn of the century in California when the pristine Hetch-Hetchy Valley, part of Yosemite National Park, was nevertheless turned into a major water reservoir for San Francisco after a lengthy national controversy.[39]

Significant energy conservation did not come to the United States until the 1970s, when it was induced by oil shortages and rising prices. Regional natural gas shortages in the winter of 1977–78 also led to reallocations of limited supplies to residential areas and compelled industrial conservation and shorter work hours. In these emergencies, energy conservation was defined in ad hoc terms as a means to extend oil and gas supplies to forestall anticipated shortages and to minimize hardships. More recently, there are signs that a more long-term commitment to conservation may be taking hold, perhaps marking a historic transition from prodigality to frugality in the use of energy resources. These signs include the adoption of mandatory speed limits and improved average automobile mileage in new models and dramatic voluntary cutbacks in consumption by consumers reacting largely to higher prices.

THE LAST TWENTY YEARS: NEW FORCES

Historically, American energy development took place in a climate of relative harmony between the energy industry and consumer interests. Industry was anxious to promote the use of energy, and consumers were

equally eager to use more and more energy, as long as prices remained Prices were kept low partly by efforts of industry to develop and ex domestic and foreign resources and partly by political interference market forces—in the form of subsidies for power projects and regulati interstate natural gas prices. From time to time, strikes, especially in the industry, produced temporary shortages, but there was rarely a ge concern, in industry, government, or public consciousness, with the lon consequences of escalating energy demand. In 1952, the Paley Commi issued a prophetic warning of impending difficulties, including the likeli of overdependence on imported oil, but it fell on deaf ears. Indu priorities centered on exploitation of resources but not on conserva efficiency, and the search for alternatives to nonrenewable resou Profitability, productivity, stability, free-market mechanisms, and a sy thetic government and public were more important goals. Over the la years this attitude of business-as-usual has been jarred by new and unexp developments.

Environmental Awareness

Among the new forces, the first to make itself felt was a st environmental awareness. The opening shot of the modern environm movement was not directed against energy consumption. It was R Carson's 1960 critique of the use of DDT, which launched the first n public debate in American history about an inherent defect in an impo and useful technology.[40] In this controversy, the public first disco technological sin. Carson's emphasis on the harmful effects of DDT not put the question of technological effectiveness in a larger social contex suggested that the thoughtless application of a host of modern technolc including new drugs as well as new chemicals, might be producing more l than good. There were overtones of guilt and evil such as those that revolve around the use of nuclear energy. The use of DDT for pest contro been considered a necessity by farmers, but the new environmental aware together with intense pressure from organized public interest activists, l judicial, administrative, and legislative action resulting eventually ir banning of the use of DDT.

The environmental movement quickly broadened its critique to incl wide variety of the side effects of industrialization. Air pollution first ga major attention when a deadly killing smog hit Donora, Pennsylvania in When pollution from burning coal was identified as the culprit, environ talists had ammunition to gain passage of the Clean Air Act of 1963 an Air Quality Act of 1967. The National Environmental Policy Act of 1969, the later creation of the Environmental Protection Agency (EPA),[41] wa single most important achievement. EPA established a policy that fav health and welfare-based standards as opposed to traditional standards b on technological and economic criteria. "Technology-forcing" laws incl

the Clean Air Act of 1970 and the 1972 Federal Water Pollution Control Act, both with explicit goals, timetables, procedures, and methods. For the EPA, as the standard-bearer of the environmental movement, there were six problem areas: air, water, pesticides, radiation, noise, and solid wastes. Americans were to have clean air by 1975 and clean water by 1985. Other notable actions included the Wilderness Act of 1964 and the numerous automobile pollution laws of the 1960s and 1970s. More recently, due to the pressures of economic decline and the energy situation, as well as a changing political climate, major environmental controls have been eased. Pollution control costs per person in the United States rose from $47 in 1974 to $187 in 1977, with job losses estimated at 20,000 and adding as much as a half percent on inflation annually. In reaction, the Clean Air Act was substantially amended by Congress in 1977 in order to reduce pollution control costs for industry.

Before 1960 environmental concerns over pollution, conservation, waste, despoliation, and scenic preservation generated mostly local or special interests. But by April 22, 1970—Earth Day—a powerful and sophisticated environmental awareness had become embedded in the national conscience and had made a profound influence on public policy. In the past, the quadrennial presidential campaign platforms rarely had an environmental plank. In recent times, a statement on the environment has become standard. Environmental impact statements and interventions were unknown a decade ago. Today, environmental protection costs are a significant factor in the balance sheet of virtually every major industry.

An Aging Industrial Plant

Some tensions and polarities that prevent resolution of the energy problem result from a certain lack of resiliency and flexibility in America's economic capacity to respond to challenges. The United States, its industrial plant undevastated by World War II, now has what is probably the oldest industrial structure in the world. In view of the rapid pace of technological change, the United States can be described in economic terms as a prematurely old nation. The patterns of capital development and technological implementation did not have to be fundamentally changed to overcome the devastation of war. Long-term undisturbed technological and industrial development was once a desirable and beneficial condition, but in time it can lead to stagnation. There are probably many reasons for the recent decline in American productivity, but one of them certainly is that the nation is burdened with outmoded plants and equipment.

When there is a widespread recognition of crisis, as occurred in the defeated countries after World War II, major social groups have an incentive that is otherwise lacking to cooperate for the common good. In such an environment, the industrial system can develop resiliency in high risk

situations by dispersing or minimizing the effects of the crisis. In contr industrial system beset by conflicting social demands, creaky in its pla unable and unwilling to innovate cannot easily respond to ecc challenge, especially when the challenge has only a gradual impact. H are intensified and localized rather than dispersed. There is less ability with surprises and the unexpected, and short-term answers end up long-term negative results. In the case of energy, the result is that transi more secure and efficient patterns of energy use is likely to take plac slowly and without the universal and concerted effort necessary to m industrial leadership in an increasingly competitive world.

Risk and Safety

Another new feature of contemporary life is the widespread and i preoccupation with personal safety.[42] This interest in safety is in part th of the country's very success in developing and introducing new techno In the past Americans would tolerate occasional derailed steam e exploding steamboats, and the intermittent and very gradual improver automobiles, airplanes, and appliances. Today the situation has cl considerably, in terms of both technology and social attitudes. The p technological innovation is more rapid than in the past. Different sta for social acceptability have emerged. There may be no such thin perfectly risk-free technology, but minimally-acceptable safety standa apt to be higher today than they were in America's past.

Despite all the defensive rumblings about the limits of technolo American public still expects American industry to guarantee product and reliability. This consumer demand is based on a historic t technological "fixes" as solutions to technological problems. America to believe that industry is quite capable, if compelled, to produc products at no great increase in cost. Such expectations have been because technologies have historically become progressively saf cheaper. Unfortunately, the reality is more complicated. Some improv in safety can only be introduced at significantly higher costs—cos consumers may be unwilling to bear and that handicap American produ foreign markets. Difficult tradeoffs must therefore be made in order to both the new demand for safety and the older expectation of cont technological improvement.

Stagflation

A third new feature is the phenomenon awkwardly called "stagfl Certain combinations of economic conditions, such as inflation and rec were historically supposed to be mutually exclusive, or mutually cor Instead they have now combined to create a seemingly intractable ec problem. As a result, the conventional view of the link between

development and economic trends is open to serious question. One conventional doctrine of industrial efficiency had it that intensive energy use lowers other costs of production. Now that energy costs are rising, this no longer holds. Formerly, increasing prices for energy services, coupled with the increase in demand that could be taken for granted, would stimulate investment in new capacity, but higher capital costs and uncertainty over future demand now inhibit such investment. Productivity, moreover, no longer seems to be so much a function of higher energy use; at some point it seems to require restructuring of organization and incentives rather than simply a more efficient use of energy and other resources.

The complexities of stagflation are awesome. While Americans are just coming to grips with it, European and developing nations have long known what it is to live beyond one's means. Savers and investors have lost faith in the future—the very incentive for saving and investing. Industry avoids long-term capital investment in new plants, or in research and development, the condition of new opportunities. Yet effective answers to the energy crisis cannot be found in the growing dependence on short-term low-risk projects with quick returns. Stagflation engenders managerial attitudes incompatible with the long-term responses required to meet the energy problem.

Historically, both economic stagnation and inflation have proved to be only temporary problems, but the new economic climate may well be more deep-seated. For the energy problem, the persistence of stagflation could be especially serious. Energy-intense technologies historically have depended upon growth and progress for their future development. The effect of stagflation upon new investment in energy resources threatens to upset this interdependence.

Government Regulation and Intervention

A fourth new feature of the modern American social landscape is widespread government regulation and intervention in the economy. The growing role of central government has been a major aspect of American economic life beginning with the New Deal. It reached truly epic proportions in the 1960s and 1970s. For many economic actors it became a major axiom that success or failure begins and ends in Washington, due to the role of federal procurement, subsidy, and regulation. Nowhere is this more evident than in federal policy for energy and natural resources. Producers and consumers, organized interest groups and the military, ethnic minorities, the rich as well as the poor, all expect government to intervene at the first hint of trouble for any of them. The energy crisis has not hurt as much as it might have because government agencies have gone to great lengths to cushion its impact, on the nation as a whole and on particular regions and social groups. The result has sometimes been insulation from harsh reality. Buffered against otherwise "uncontrollable" forces, all groups tend to rush for protection to

government, however ready they are to denounce bureaucratic bunglin
legislative incompetence. Government energy policy "fixes" are view
substitutes for technological "fixes." It is said that the problem is not sc
but management. That is, policy decisions, court cases, legislation, and e
agency actions are the means to stimulate production of more oil and n
gas and solve the nuclear and solar debates and to guarantee the Am
way of life. Unfortunately, this attitude only makes the problems
because it shifts the burden of responsibility onto government agencie
politicians who are powerless to control market forces and foreign de
ments and who, in the last analysis, can only act decisively if there is a s
public consensus for a particular course of action. In the absence of s
consensus, reliance on paternalistic government is bound to lead t
appointment.

3 The Debate Over Energy Policy

While energy supplies were still plentiful and affordable, most Americans had no incentive to concern themselves with energy policy. As a result of recent shortages of oil and increased prices for all forms of energy, indifference has given way to apprehension, which has triggered a wide-ranging and sometimes highly charged debate over energy policy.

The issues raised in this debate are by no means all new. In 1918, for example, the brilliant mathematician and chief engineer of the General Electric Company, Charles Proteus Steinmetz, read a paper[1] to a professional society, the American Institute of Electrical Engineers, in which he surveyed the country's potential supply of hydroelectric power and fossil fuels. He concluded that for the foreseeable future, the best use of these primary sources of energy would be to produce electricity—not a surprising position for someone whose company had a keen interest in the marketing of electrical appliances. But Steinmetz was too good an engineer not to recognize that current practice was often profligate, especially insofar as "many millions of kilowatts of potential power are wasted by burning fuel and thereby degrading its energy." Most of these lost kilowatts could be recovered, he pointed out, "by interposing simple steam turbine induction generators between the boiler and the steam heating systems, and collecting their power electrically"—the technique now known as cogeneration and common in European countries but still rare in the United States.

In the same article, Steinmetz also discussed another source of energy that he believed would one day become essential: "A source of energy which is practically unlimited, if it could only be used, is solar energy." He calculated that the solar radiation falling on the United States was the equivalent of 800,000 million kilowatts, a thousand times as much as was contained in the chemical energy of the coal that would be consumed in 1918, and 800 times the country's hydroelectric potential. Assuming that land not suited for agricul-

ture could be set aside for collectors "and assuming that in some futu
and by inventions not yet made, half of the solar radiation could be co
this would give an energy production of 130,000 million kilowatts." I
tenth of solar radiation could be put to use, Steinmetz estimated, the
supplied "would be many times larger than all the potential energy of c
water. Here then would be the great source of energy for the future."

From time to time, other equally astute and prescient comment
the same sort appeared in the technical and popular literature. In 195€
a more recent example, the petroleum geologist M. King Hubbert ma
was then considered the overly pessimistic prediction that dome
production would peak between 1966 and 1971 and then decline sharp
peak was reached in November 1970.)[2] But like Steinmetz befo
Hubbert attracted little popular interest, and his warning had littl
political impact. In the federal executive and Congress, policy for ene
decided piecemeal under the heading of "fuels policy" rather than c
hensively, and with little regard for long-term trends. Each energy sou
treated separately within the Department of the Interior and in Cc
enabling clusters of regional, industrial, bureaucratic, and consumer i
with special concerns for coal, oil, natural gas, and electric power t
policy as major issues arose. For security reasons, responsibility for f
the development of atomic energy was placed in a special new agency,
decision to treat yet another energy source in isolation from all
conformed to the traditional pattern.

A new awareness of the need to define an energy policy did emer
time, but without much effect, in the years immediately following th
the Second World War. It was keenly recognized by many at high l
policy making that resource scarcity had played a considerable rol
Japanese decision to initiate war and in the breakdown of the German
machine in the last months of the war. Out of concern for the reliat
America's energy resources in the event of a future emergency, Pr
Truman ordered a major study to be made of the future availability of
supplies by a commission chaired by broadcasting executive William S
In 1952, the commission produced its report, *Resources for Freedom*
warned that at current and expected rates of depletion, domestic fos
would rapidly become scarcer and more expensive. Noting that '
nature over 500 million years to store in the ground these stockpiles c
fuels' which civilization is now consuming in a flash of geological tir
report proposed that "such unconventional sources as solar and
energy" be developed to replace fossil fuels in the near future. The rep
recommended that the United States assist other, poorer countries to
for new sources of fossil fuels, but warned against overdependency on
East oil. Greater emphasis was urged on encouraging technological ir
ments, in order to make it easier to substitute fuel sources and to recov

oil and gas from known deposits. A gradual shift in patterns of consumption was forecast back to coal from oil and gas. More attention was urged to the commercial development of synthetic liquid fuels from shale and eventually coal. Although the report did not press the government to take a major role in implementing these proposals, it did recommend the formulation of a "comprehensive energy policy" and a single focus for administrative review of energy issues in a single department.[3]

By the time the Paley Report was issued, however, the Korean War had diverted the attention of the policy makers to short-term needs, and before the report's proposals could be digested politically, a new Republican administration had come into office strongly averse to anything that smacked of government planning and equally strongly committed to allowing the price mechanism to determine rates of resource extraction and patterns of allocation. In practice, the Eisenhower administration was sometimes much more activistic than its ideological professions allowed for. The president and his Secretary of State, John Foster Dulles, intervened to assure continued access to Iranian oil for American companies and to resist Iran's effort to nationalize foreign holdings. Eisenhower's "atoms for peace" plan stimulated domestic and foreign business for the fledgling atomic energy industry. Contrary to the recommendations of the Paley Commission, however, no steps were taken to formulate a comprehensive policy or to reorganize the administration of energy issues to provide greater coordination of policy.

With the Paley Report's recommendations largely ignored, the emphasis of private and public efforts for the next two decades was concentrated on expanding supply by drilling for oil and gas and increasing imports of oil and on building new generating capacity to meet existing and expected growth in demand for electricity. Coal production declined as coal became less competitive with oil and natural gas. Price controls kept the price of natural gas low and oil use was stimulated by a variety of incentives to producers, including the oil depletion allowance and a provision enabling oil importing companies to offset foreign royalty payments against domestic tax liabilities. The policies adopted were often contradictory in their purposes and effects. While some encouraged importation, others sought to limit imports in order to protect small domestic "independents." One agency sought to foster atomic energy while another set pollution standards that delayed construction and imposed severe economic hardships on the industry. The net result, however, was that far from experiencing the shortages predicted by the Paley Report for the near future, the country actually experienced a glut of energy supplies, accompanied by declining prices.

With the benefit of hindsight, it is clear that this era of plenty was the result of anomalous and temporary conditions. Especially in the earlier years of the postwar period, while other industrial countries were still struggling to

recover, American consumers faced only weak foreign competition markets. Policy decisions that effectively raised consumption and de supplies domestically, while increasing dependence on foreign sources served to postpone the advent, and increase the severity, of exact problems to which the Paley Report tried to draw attention. As cons grew more and more dependent on declining domestic reserves and inc imports, the nation became more and more vulnerable to shortage cutoffs of supply.

Misgivings about the long-term effects of growing reliance on (ishing fossil fuel reserves were often allayed by rosy predictions impending benefits of atomic energy. In due course, it was thought, a energy would come to the rescue of consumers used to relying on fossil Gradually, more and more nuclear plants would replace conven generating facilities and provide even cheaper energy that would soon to be virtually inexhaustible, especially once breeder reactors and, even fusion systems became commercially feasible. Neither corporate- managers, driven by concern for short-run profitability, nor gover overseers, concerned with maintaining orderly and competitive marke protecting consumers against monopolistic practices, saw a need to re the appetite for increased consumption. In the executive, this compla reached its nadir in what has been called the policy of "benign ne followed in the early years of the Nixon administration before the 1973 embargo.[4]

As this complacency was rudely shattered by the oil shortage res from the embargo and the steep increases in prices resulting from subse decisions by the oil-exporting companies organized in OPEC, belated were finally made to develop national policy and the questions at issue to be widely debated.

THE NATURE OF THE DEBATE

The energy debate of recent years has been many-sided and comple brief overview of the actors, goals, policies, and implications will he indicate.

Actors

Among the principle participants in the debate are such interested p as the oil companies (both the large multinational companies and the sr independents); investor-owned, publicly regulated electric utilities; mining companies (some of which are now part of larger energy con erates); states and regions with actual or potential fuel resources; comp

that produce nuclear and other power-generating facilities; the various federal agencies with supervisory and regulatory functions pertaining to energy; experts in various technologies, in the economics of energy supply and demand, and in foreign policy; organized groups of citizens in favor of certain options and opposed to others; and of course also countless concerned citizens and their official and unofficial spokesmen in politics and the media.

Goals

To some of the participants, perhaps most, the goal of a national energy policy must be to seek to assure continued supply of energy services, whether by conventional or unconventional means. To others, however, the goal is to adjust patterns of consumption, and with them patterns of expectation, in order to manage the transition from reliance on fossil fuels to reliance on renewable resources. There are grounds of agreement between these two views, but more often it is the differences that tend to receive the most emphasis in the debate, as is nowhere more evident than in the argument over the rate of economic growth that is to guide energy planning. Those who hold the first view tend to favor relatively high rates of growth; those who hold the second tend to favor relatively lower rates of growth, or if not to favor them, then to argue that they are all but dictated by energy constraints.

Policies

The approach to policy favored by the participants in the debate is often shaped by attitudes toward government intervention in the economy. Those who favor a significant degree of intervention sometimes advocate the nationalization of major energy companies or at least efforts to increase regulatory control of their behavior, by strict application of antitrust laws and safety and pollution regulations. They are also apt to favor active measures by government to cushion hardships suffered by the least advantaged sectors of society because of efforts to curb energy use by allowing prices to rise. On the other side of this divide are those who argue that government intervention in the energy area has only made matters worse, and that the best way to handle the problem now is to remove price controls and subsidies and lighten the burden of regulation consistent with necessary standards of public safety. In their view, the best course is to make it possible for the private sector to adjust to new demands both for new supplies of energy and for more efficient use of the supplies available. This issue is also raised in the controversy over nuclear power, but attitudes toward the relative safety and need for nuclear power are also in play.

Implications

Domestically, the energy debate touches on many aspects of Americ social structure, including standards of living, the democratic process, degr of confidence and civility, and other similar issues, both tangible a intangible. In terms of foreign policy, the implications range from concern the impact of energy policy on America's role in the world, on relations w allies, adversaries, and the developing countries, and on the dang associated both with the proliferation of nuclear weapons and the tensic that might arise as a result of energy scarcity.

If there is a single set of questions about which the debate may be said focus, it is probably the dispute over whether to encourage a broad range efforts to curb consumption and at the same time promote all possible mea of supply, or whether to institute more fundamental changes in consumpti and technology in order to move as rapidly as possible away from reliance fossil fuels and nuclear energy toward the use of small-scale systems rely largely on solar energy.

To understand this central debate, it is useful to consider its ideologi implications, which have brought to mind an older American debate betwe Jeffersonians and Hamiltonians.[5] While this parallel is far from perfect, it useful way of thinking about the current debate. The new Jeffersonia advocate an energy policy designed to inhibit the growth of corporate pov and big government, and instead to promote decentralization and part patory democracy. They urge the adoption of technologies that minim dependence on fossil fuels and rely instead on renewable sources, or so energy. They tend to oppose nuclear power on a variety of grounds, includ its potential for promoting proliferation of nuclear weapons. They tend sympathize with the demand of the developing countries for self-deter nation and for a global redistribution of wealth and political control of mar forces, as envisioned in the call for a New International Economic Ord They stress the need for the advanced countries to assist the less develop countries in learning how to avoid high-technology, fossil-based ene solutions and to pursue ecologically sound, village-based schemes of ene development emphasizing the use of renewable and other small-scale sourc

The new Hamiltonians generally view most or all of these proposals unrealistic because such proposals reflect a mistaken view that large-sc conventional technologies can easily be dispensed with in favor of new t untried alternatives that have yet to be shown to be feasible in act operation. They argue that the advocacy of exclusive reliance on solar ene reflects a bias against continued economic growth and against the system individual opportunity and free choice that such growth makes possible. In place, they contend, those who urge a policy of low-growth or no grov would impose penury in place of affluence, mass conformity in place

individual choice and diversity. They also argue that a failure to maintain productivity by developing all possible sources of energy will weaken this nation's power to protect itself and its allies and will prevent it from providing the levels of assistance the developing countries will need to cope with the added burdens imposed by shortages of energy.

JEFFERSONIANS AND HAMILTONIANS: AMORY LOVINS AND HIS CRITICS

One of the most prominent and articulate participants in the public debate over energy policy has been Amory Lovins, a consulting physicist associated with the environmental organization, Friends of the Earth. His article, "Energy Strategy: The Road Not Taken?", in *Foreign Affairs* magazine,[6] attracted both enthusiastic support and impassioned criticism. In subsequent writings, Lovins has openly declared that his bias is "in essence, Jeffersonian,"[7] but he has also contended that while "nobody can make a completely value-free analysis."[8] the validity of his arguments does not depend upon acceptance of his value premises. This is certainly true insofar as his analysis concerns calculations of the costs, vulnerability, and other technical characteristics of different options. Nevertheless, his diagnosis of the energy problem aims to be comprehensive, and to this end he deliberately invokes social and political criteria of acceptability along with technical criteria. The "soft path" he advocates is not justified solely on the ground that small-scale systems using renewable sources of energy are less expensive, more efficient, and less vulnerable than the "hard path" alternatives, but also on the ground that they are more socially desirable. The "hard path" is opposed because it requires more centralization and is therefore Hamiltonian rather than Jeffersonian, in the sense in which Lovins understands the difference, as when he writes that "although humanity and human institutions are not perfectable, legitimacy and the nearest we can get to wisdom both flow, as Jefferson believed, from the people, whereas pragmatic Hamiltonian concepts of central government by a cynical elite are unworthy of the people, increase the likelihood of major errors, and are ultimately tyrannical."[9]

The link between this political belief and energy policy is established in a general way by the advocacy of decentralized systems, which diminish the economic and political power of large corporations, government bureaucracies, and technocratic elites in favor of small-scale enterprise and individual and community autonomy. In particular, it supports such statements as this comment on the human unacceptability of centrally generated electricity: "In an electrical world, your lifeline comes not from an understandable neighborhood technology run by people you know who are at your own socia but rather from an alien, remote, and perhaps humiliatingly uncontr technology run by a faraway, bureaucratized, technical elite who probably never heard of you."[10]

In arguing against the "hard path," Lovins contends against the vie he takes to be the conventional wisdom, or the attitude that has helc until now and that continues to be supported by industrial interests an supporters within the technical community. This path, he argues, invol effort to expand supply indefinitely by finding more and more fossil fue supplementing these fuels with nuclear power, in ever more costly, cor centralized, and gigantic systems. He calls this policy one of "strength th exhaustion." It requires that "in essence, more and more remote and places are to be ransacked, at ever greater risk and cost, for increa elusive fuels, which are then to be converted into premium fuels—fluic electricity—in ever more costly, complex, gigantic and centralized pla The use of energy would double, even treble, over the next several decac the process, privately owned energy companies would prosper and stronger politically. Regulatory requirements would also reenforce tend toward greater bureaucratization in government and toward a more po role for technocrats. Public subsidies for large-scale energy projects, Lovins estimates have reached an annual size of ten billion dollars, continue and probably grow even larger.

The most obvious problem with an effort to continue along this path," according to Lovins, is that it is simply "unworkable" economical politically. Huge, unsupportable investments of capital would be req Even if such investments could be made, moreover, they would aggr unemployment because they produce fewer jobs than any other compa investment. Politically, such a course is bound to meet with resistance those directly affected by the pollution and safety risks large-scale sy inevitably entail. Opposition would also be aroused because of the " tural" implications of hard path solutions, including centrism, vulnera technocracy, alienation, repression, and other stresses and conflicts, incl tensions between regions and income groups. Centralized system vulnerable because power lines can be severed by a single riflem disconnected by a few strikers, while nuclear facilities invite sabotage a diversion of dangerous materials. They would therefore require "stri social controls" as well as repression of "dissent against the energy systen more and more people became unwilling to accept decisions ma established authorities, political alienation would grow and threate legitimacy of government.[12]

To this list of dire domestic consequences, Lovins adds an even threatening chain of potential international consequences:

> We use the apparently cheap energy wastefully, and continue to increase our dependence on imported oil, to the detriment of the Third World, Europe, Japan, and our own independence. We earn foreign exchange to pay for the oil by runing down domestic stocks of commodities, which is inflationary; by exporting weapons, which is inflationary, destabilizing, and immoral; and by exporting wheat and soy beans, which inverts midwestern real estate markets, makes us mine groundwater unsustainably in Kansas, and raises our own food prices. Exported American wheat diverts Soviet investment from agriculture into defense, making us increase our own inflationary defense budget, which we have to raise anyhow to defend the sea lanes to bring in the oil and to defend the Israelis from the arms we sold to the Arabs.[13]

To the argument that only by maintaining high levels of energy supply will the advanced countries be able to aid the developing countries, he argues both that it is possible to decouple growth in output from growth in energy consumption and that "high growth in overdeveloped countries is inimical to development in poor countries."[14] He does not explain how this is so, but he seems to be suggesting that the "trickle down" theory works as poorly internationally as its critics say it does domestically. Presumably, the growing economic strength of the advanced countries makes them even better able to dictate the terms of trade to the developing countries and to prevent them from adopting measures to promote self-sufficiency.

Fortunately, there is an alternative—the so-called soft path. By this term Lovins means those energy technologies that are not complex and overcentralized but that match scale and end use to purpose. Instead of using hydroelectric dams to provide electricity for heating water—"cutting butter with a chain saw"[15]—this power would be used for industrial processes like steel making that require large amounts of power. Homes and hot water, however, would be heated exclusively by solar technology. Instead of trying in vain to build new generating capacity, at ever increasing marginal cost, the soft path would rely on conservation to reduce the need for energy by improving the efficiency with which it is used. The soft path would eventually lead to a lower ratio between energy consumption and production, without lowering expectations. Existing centralized power stations would be used as a bridge to a sustainable future, but they would not be replaced as they run down. In theory, at least, by the use of soft technologies "an affluent industrial economy could advantageously operate with no central power stations at all!"[16]

In a soft path strategy, development of many types of solar technology would be encouraged, including the use of agricultural wastes as biomass for conversion to liquid fuel but not large-scale systems such as those that require huge arrays of collectors in the desert or giant satellite receivers. These are classified as "hard" technologies. Similarly, the effort to generate electricity by

fusion is deplored. Fusion would be more complex and difficult than even fa
breeders, and it might produce fast neutrons that would be used for bon
material. Even if it turns out to be a clean way of developing energy, "we sh
so overuse (it) that the resulting heat release will alter global climate. V
should prefer energy sources that give us enough for our own needs wh
denying us the excesses of concentrated energy with which we might
mischief to the earth or to each other."[17] (Curiously, however, this se
denying ordinance is applied only to the production of electricity. Since the
is no objection to the development of biomass liquid fuels, there would
nothing to prevent overproduction of these fuels, even though they too m
lead us to do mischief.)

Nuclear power is objectionable not only because it is dangerous a
promotes overcentralization but also because it makes proliferation
nuclear weapons much more likely. Lovins argues that a U.S. decision
forego nuclear power and to stop its own sales of nuclear power facilities
other countries would have an inhibiting effect on other suppliers and th
dramatically reduce the likelihood of proliferation.[18]

In order to reverse the present course, barriers in the way of conservatic
and more rational supply technologies would need to be removed. This wou
require, above all, revision of building codes that inhibit construction of mo
energy efficient buildings. Subsidies for conventional fuel and power systen
would be reduced and eventually eliminated, and antitrust laws would
vigorously enforced, to prevent giant corporations using profits from risir
energy prices to acquire control over a variety of energy sources. Mark
forces would be used to bring energy prices to the level of margin
replacement costs. To speed the process, an energy tax—in effect a "severan
royalty"—might be imposed on all fuels, according to their energy content,
they come out of the ground or into the country.[19]

Measures aimed at conservation would include retrofits on existin
buildings and new designs for energy efficient buildings, as well as an increa
in the use of cogeneration. Soft technology aims to rely on renewable forms
energy—on "income rather than capital," on a diverse mix of sources, o
flexible and relatively low technology systems, matched in scale an
geographic distribution to end use needs, and in energy quality. For th
purpose, the use of electricity for low-grade purposes is to be avoided, in fav
of an "elegant frugality," marked by such values as thrift, simplicity, diversit
neighborliness, humility, craftsmanship...."[20] According to Lovins, so
technologies are "inherently more participatory" and less coercive than har
technologies: no one can opt out of nuclear risk, and in an electrified societ
everyone's lifestyle is shaped by the homogenizing infrastructure an
economic incentives of the system. Anyone anxious to live in an uninsulate
house or drive a gas guzzler would be free to do so, provided he pays the soci
costs they entail.[21]

The viewpoint expounded by Lovins has been criticized by many commentators on various grounds. Many of the objections refer to technical and economic estimates related to different technologies. Lovins has frequently been accused of overestimating the costs and underestimating the benefits of conventional power while grossly minimizing the problems of introducing unproven alternate technologies. One industry critic argued that Lovins is not so much proposing a new course of action as trying to inhibit all action, by urging that we stop doing what we know how to do "in order to do something better that we don't yet know how to do."[22] Advocacy of soft technology, he has observed, is in effect a rationale for opposing everything with a realistic chance of alleviating the energy problem, such as Alaskan oil, western coal, hydroelectric dams, offshore oil, geothermal energy, nuclear energy, and shale conversion and other synthetics.

Another industry critic, Sheldon Butt, president of the Solar Energy Industries Association, has denied Lovins's claim that all the heat required for most buildings can almost always be supplied by solar systems at a cost that compares favorably with the marginal cost of power generated by other means. "This," according to Butt, "is simply not true." Solar energy "cannot reasonably be a 100% source of heating energy." Lovins has cited Danish data to show that with systems designed to store heat in water, 100 percent solar heating is economical. Butt has contended that the capital costs of storage facilities would be higher than storing an amount of coal equivalent in energy in a central power station. He predicts that no more than 12 percent of the energy budget could possibly be solar by 2025,[23] in contrast to Lovins's contention that with an adequate effort to develop the technology and a removal of subsidies to other sources, solar would account for much more by that time.

Two energy economists have charged that Lovins's economic assumptions ignore the likely effect on demand of relatively stable prices. Theoretically, at least, efforts to hold energy consumption constant while providing relatively inexpensive energy are likely to be frustrated by increased demand.[24]

Other critics have charged that Lovins is trying to use energy policy as a lever of social change. Although he responds by claiming that he is simply following the logic to which his analysis leads,[25] they argue that the analysis proceeds from a predetermined conclusion. A social theorist has suggested that Lovins seems to think that by making the right technological choices, people can solve certain long-standing social and political problems, free themselves from the domination of corporate interests, bureaucracy, and experts, and in the process restore power to local communities and neighborhoods and render complex problems more intelligible and more manageable at the local level. Lovins has replied that while he does not suppose that the soft path will solve such problems, "at least it should prevent

such problems, in the context of energy policy, from getting worse."[26] Tl critic contends that Lovins's prescriptions fall in the same category as oth earlier efforts to promote settlement houses and community self-he movements—efforts that cannot solve large problems and tend to be replac or absorbed by more efficient, more professionalized, and large-scale soci systems.

While many of the critics agree with Lovins's stress on the desirability energy conservation, they question whether conservation alone can allow f continued economic growth at a high enough rate to satisfy aspirations ar enable the nation to maintain its power in the world. They suspect that Lovi views conservation as a way to force a change in habits of consumption and impose limits on American power—on the ground that energy surplus tempt people to do harm to the earth and to themselves. Although Lovi argues that he favors using market forces to encourage conservation and stimulate the development of soft path technologies, his critique of b business and oligopoly is interpreted by some critics as a veiled attack c industrial capitalism. One of them sees in Lovins's preferred new socie nothing but "a society of peasants and craftsmen."[27] Although he ridicul such charges, Lovins lends credence to them in such cryptic remarks as h claim that under modern conditions the Jeffersonian and the Maoi philosophies merge in pointing to the underlying economic problem of whic the energy problem is presumably an outgrowth:

> As we learn to question the ability of present policy to serve both public and private ends, the legitimacy of those ends themselves comes up for review. Our know-how has far outstripped our know-why; and as we seek to redress the balance, old political concepts begin to reassert themselves. Grassroots democracy acquires a more concrete meaning. Jefferson and Mao gain a curious affinity.[28]

Is this merely traditional American populism joined to a once fashionab view of Maoism as nothing but Chinese "agrarian reform"? Or does it sugge something more radical, such as the idea that social reform must be aimed a undermining the structure of corporate capitalism in favor of experimen with backyard smelters and communal enterprise, and perhaps also redistribution of wealth? Does the participatory democracy Lovins calls f include a tacit encouragement of acts of civil disobedience against nuclea power facilities, and perhaps against all other "hard path" technologies? that why Lovins—who is normally careful about his choice of words—fea that "dissent" against the energy system may be repressed?

His critics sense that Lovins speaks not only for alternate technologi but for an alternate set of values. Butt voices a common concern amor Lovins's critics when he suggests that "the basic justification for ou

technological society, as it has evolved over a period of somewhat less than two centuries, lies in the exceptionally broad opportunity which it has provided to the citizens for individual expression and for the expression of political initiative."[29] While Lovins cannot fairly be accused of wanting to restrict citizens' political initiative, at least one critic wonders whether the policies he advocates would not require the restriction of economic initiative. "At no time in history," Butt observes, "have more individuals had the opportunity to devote a large proportion of their labor to those things which they individually elect as expressing their own desires, after first having satisfied their own needs." This opportunity, he adds, depends upon a system of "individual rewards."[30] It is interesting that in commenting on this criticism, Lovins avoids committing himself either for or against the belief in equal opportunity for unequal reward. Instead, he criticizes Butt's view as an instance of the chauvinism of people in industrially advanced societies, and observes that anthropological studies show that so-called primitive peoples "have considerably more leisure and more surplus resources to devote to their highly developed arts than do typical members of the most affluent Western societies today."[31]

In international terms, Lovins claims that he is merely urging an effort to minimize the dangers of nuclear proliferation and to improve the prospects for international equity, cooperation, and development in the poorer countries. Although he seems to imply no wish to promote fundamental changes in socioeconomic systems or in the balance of power, his strong advocacy of the New International Economic Order proposed by the bloc of developing nations suggests that he would be ready to countenance the replacement of market mechanisms and the role of multinational corporations by a more political, more bureaucratic system, and to require a redistribution of wealth among nations.

The argument between Lovins and his critics, then, is evidence that the general public debate over energy policy in this country can in some respects be thought of as a revival of the argument between Jeffersonians and Hamiltonians. Inevitably, however, historical changes make the simple repetition of old arguments in new circumstances awkward at best and worse when they lead to self-deception. Jefferson and Hamilton were arguing about whether the United States should move on an agrarian or an industrial path. Jefferson was not calling for the "repeal" of an industrialization that had already taken place. Would he have wanted to undo an industrial society created under the aegis of democracy and providing for the pursuit of happiness on a scale even he could scarcely have imagined? Would he have wished to limit individual choice so that people would not be free to harm themselves or others? We can be sure that he would have sympathized with efforts to preserve local autonomy and "grassroots" democracy. We can be much less certain whether he would have found large-scale industrial

capitalism an enemy of individual autonomy, whether he would have favor of strong government to counterbalance the strength of large ec interests. We can only be sure that he would have wished to prese fundamental principles of private ownership and exchange, for Jeffer no communist, neither Marxist nor Maoist.

As to Hamilton, is it really true that he was in favor of a "cynical e as Lovins claims? Hamilton certainly feared mob rule and believ society should be guided by its most able men—those in whom the s civic virtue could be nurtured into the capacity for statesmanship an service. He was content to allow the best to achieve a privileged status he believed, in company with others nurtured in eighteenth-century ide the best way to assure the common good was to allow for the free talents and interests. Jefferson also believed in the need to nurture a ' aristocracy" as the governing class of a free society—an aristocracy tha be "raked from the rubbish"[32] by a system of public education. Both were thinkers of a democratic tendency—republicans, in the then pı usage; they differed in the confidence they had in the capacity of the c man to regulate his own affairs and contribute constructively to affairs and in the role they were prepared to give to central public authorit

What either of them would make of a society as populous, comp highly organized as the United States has become, and with its role i affairs, is anyone's guess. Would they have differed as Lovins as his cı over energy policy? Perhaps, but it is hard to envision either of t apprised of the modern choices, turning his back on the comple dependence of modern civilization in favor of a return to a simpler e each subcommunity could aim to provide for its own needs from resources and to make itself as independent as possible of all others.

Whatever happens to America's energy systems—whether pres phasis on central generation of power persists or is replaced by small relying on renewable sources—we can hardly suppose that techn changes will automatically bring profound alterations in social va some respects the choice of energy technologies does, as Lovins poi either serve or disserve particular values. It does not follow, however, best test of the linkage is whether the technology is close or remote, s large, and whether the resources used are exhaustible or renewable. industry spokesmen are fond of pointing out, the nutritional cor processed food is often as high or higher than that of organically grow To the domestic consumer of energy it may not matter how the electro his home, or whether they are produced by the burning of fossils or from solar radiation. What matters most to him—and to the stabilit social system—is that the energy services he depends upon contin available. It is arguable that insofar as large-scale energy systems variety of resources, provide abundant energy, they help make pc

degree of individual autonomy and stable self-government that both Jefferson and Hamilton sought to assure. Only to the extent that these systems have offsetting disadvantages is there a basis for serious concern.

ENERGY AND IDEOLOGY: THE PUBLIC DEBATE OVER POLICY OPTIONS

The controversy sparked by Amory Lovins brought ideological considerations to the surface of the public debate over the energy crisis. For the most part, however, this debate has been preoccupied with arguments over policy in which ideologies are entangled with economic interests and technical judgments. Nevertheless, a review of the policy debates will show that ideological considerations play at least as important a role as these other factors in shaping and constraining policy decisions.

Although Americans are not as overtly committed to ideological doctrines as people often are in other political cultures, their views of the aims of social life and government have been profoundly influenced by the ideological principles invoked originally to justify the American Revolution and subsequently institutionalized in public law and the political system.[33] Appeals to these principles are sometimes only of symbolic significance, as in the case of Fourth of July oratory, when the intention is to reenforce patriotic sentiment. At other times, however, especially when the aim is to mobilize support for political parties, politicians, and policies, the appeal to ideological principles is much more meaningful, because these principles can shape electoral behavior and constrain the choice of policies.

Traditionally, the ideological principle most frequently identified as the cardinal element of the American political creed has been the belief in the liberty of the individual. Except during wartime, this belief has manifested itself in an aversion to centralized, concentrated, and comprehensive authority. The generally accepted view has been that in order to protect the liberty of the individual, the power of government must be held in check. During the Progressive era, and still more during the New Deal, this traditional belief was challenged by those who contended that in view of the growing concentration of economic power and the need to coordinate an increasingly complex society, it was necessary to assign to government a positive responsibility for economic management and for the promotion of social welfare. In a number of respects, their efforts to modify the traditional suspicion of strong government succeeded in bringing about important changes.

In the case of energy resources, one result was to strengthen the bargaining power of coal mine workers against owners. Another was to make provision for public works projects designed to provide affordable energy in

rural areas and in regions where energy might promote economic d
ment, notably in the area served by the Tennessee Valley Authority.
aftermath of World War II, the reforms of the New Deal period w
extended further, and a kind of equilibrium seemed to have been estat
Government agencies came to play a significant role in stimulati
regulating development, but the actual provision of energy services wa
private industry and regulated public utilities. Thus, the Atomic
Commission was established to supervise the production of atomic w
and to encourage the application of nuclear energy for civil purposes. I
agencies also acquired responsibilities for assuring mine safety, for reg
prices of oil and natural gas, and for setting import quotas for oil. Ta
was adjusted to provide incentives for oil drillers in the form of de
allowances. Foreign policy was also brought into play to protect ac
foreign sources of oil on favorable terms.

This combination of government oversight and private enterpr
two important results. Energy prices were kept relatively low, with th
that economic growth was given a powerful stimulus, and the nation
more and more dependent on oil and natural gas. Because much of the
imported, the nation became vulnerable to precisely the kind of actio
by the Arab oil-producing states in 1973. The embargo, coupled w
strengthening of OPEC, succeeded in imposing a dramatically higher p
oil, with repercussions not only for the American economy but for n
security as well. Among many Americans, however, the initial impu
not to see the crisis as the result of imprudent public policies but instea
to pin the blame on the oil companies, for creating a supposedly a
shortage, or on the federal government, for interfering with market f
keep energy prices artificially low, or on the OPEC countries, for colle
control supply and price. (The leaders of the oil-producing countries,
turn, blamed the profligacy of western consumers and sanctimo
asserted that they were merely righting old wrongs and compelling th
to value its finite supplies of fossil fuels more realistically.) Considerab
was expended in these recriminations, before public attention came t
on practical proposals for dealing with the problem.

Although some of the proposals sought to address the prob
nationalizing or breaking the power of the giant energy companie
made no headway, partly because it was not obvious that they would h
positive effect on the immediate problem, but also because they cut aga
grain of conventional ideological conviction. More in keeping with i
ical convention, though scarcely more realistic, was President
announcement of a plan to achieve "energy independence." The pla
for the adoption of policies aimed at making the nation potentia
sufficient by the end of the decade. This was to be accomplished by a

prices to rise—which would lead to decreased consumption and increased domestic production—and by expanding nuclear power capacity to replace reliance on oil and natural gas. The Ford administration sought to continue in the same direction, envisaging the construction in ten years of 200 nuclear power stations, 250 new coal mines, 150 coal-fired plants, 30 new refineries, and 20 new synthetic fuel plants, all large-scale.

This strategy presupposed that the conventional way of providing for energy needs that had seemed to work in the past—combining government support and regulation with industrial initiative—could be made to work again. The prospect was particularly appealing because this proposal did not call for radically lowered expectations but instead promised an economic boom resulting in an ability to rely on domestic resources. The trouble was that it rested on highly optimistic projections of what could be accomplished in a short time and on equally optimistic estimates of what such massive efforts would cost—not only in economic terms but also in terms of the social and political costs that would be entailed by efforts to override concern for preserving strict environmental and safety standards.

As the sense of crisis deepened, a very different view gathered increasing support. Articulate critics charged that the effort to increase supply to meet ever-growing expectations had brought about the energy problem and was hardly an adequate prescription for dealing with it at a time when conventional resources were being rapidly depleted. Instead, the critics called for a policy aimed at curbing growth in energy consumption—one that would be sensitive to environmental considerations and appropriate to an "era of limits," even if it did not satisfy all expectations of continuous improvements in material standards of living.[34]

This point of view had considerable influence in shaping the energy program advanced by President Jimmy Carter. In declaring the energy problem "the moral equivalent of war," he used a formula designed both to arouse public support and to justify a departure from previous policies. In the first place, the Carter "National Energy Plan" stressed conservation. The assumption behind it was that "the most effective way to 'produce' new energy was by saving it."[35] The plan also rested on the belief that in the long run it was essential to move from nearly exclusive reliance on fossil fuels to a much greater reliance on "renewables."

In foreign policy, the Carter program also reflected a rejection of the counsel of those who saw the energy crisis as a challenge to American power, which would require vigorous assertion of that power. The Carter program did not aim at breaking the power of OPEC either by threatening or using military force or by forming a countervailing alliance of consumer nations, or by using any of the other methods that were being suggested for that purpose. Instead, its aim was to hold OPEC in check by negotiating emergency oil-

sharing agreements with America's allies, by building a strategic petrol reserve, and by agreeing with other user nations to set targets for achie lower imports of oil. The policy also included an effort to co-opt the lea Arab oil-producing state, Saudi Arabia, into a closer alliance with the wes nations.

This program, although it was by no means radical enough to satisf harshest critics on the political left, combined overtones of the New Deal (its emphasis on comprehensive planning and on mandatory conserva measures) with a recognition of the new concerns for a more frugal way of protection of the environment, and the maintenance of peaceful relations developing countries, which were important to certain elements of Democratic electoral constituency.

Although the full Carter program was not enacted into law, some o most important elements were put in place by a combination of legislative executive action. As a result, steps were taken to bring U.S. oil pricing u world levels, to control the price of newly discovered natural gas, to impos excise tax on newly discovered oil, to mandate conservation (by stipula improvements in average automobile fleet mileage, establishing a nati 55-mile-per-hour speed limit, and prescribing thermostat settings in fec buildings). Great emphasis was placed on the development of alterna energy sources, notably solar sources, and a Synthetic Fuels Corporation created to channel public investment into private efforts to produce li fuels, as well as gas from unconventional sources. Some of the Ca proposals were rejected. The proposal for an Energy Mobilization Board rejected by Congress, as was a request for standby authority to impc gasoline tax. Certain of the other proposals were considerably modified, as the windfall profits tax, which was originally intended to apply t domestic oil, whether already or newly discovered.

Enough of the Carter program was adopted, however, to make it c that there was considerable public recognition that the energy problem not just a temporary emergency caused by private greed or governr mismanagement, but that it reflected a long-term exhaustion of relati inexpensive forms of fossil energy. It was also an indication of pu acceptance of a basic strategy for dealing with the problem by making r efficient use of domestic resources and preparing for an eventual transitic greater reliance on renewable sources. The Carter approach to nuclear pc reflected the public ambivalence on that subject. Nuclear power was not t abandoned, but neither would it receive the same emphasis it was to under the Nixon-Ford proposals. Safety standards would not be rela more effort would be put into finding an acceptable way of storing nu wastes, and the development of the breeder reactor and the expor reprocessing facilities would be foregone in an effort to curb the threat o

international proliferation of nuclear weapons. The importance of developing and implementing a comprehensive strategy was recognized in the creation of the new Department of Energy.

The results of the 1980 election were interpreted by the victor, Ronald Reagan, to indicate that a majority of the voters agreed with his contention that freedom and prosperity would best be served by curtailing rather than continuing to expand the role of the federal government. Accordingly, he pledged to deal with the energy problem by encouraging private initiatives to discover and make available more sources of energy of all types. The new Energy Department was to be dismantled, and the burden of over regulation lifted from all segments of the energy industry, including the nuclear power sector. Oil prices were fully decontrolled ahead of schedule, federal lands were opened to drilling, and offshore oil and gas exploration was encouraged. Funds for the Synthetic Fuels Corporation were sharply curtailed. As oil consumption dropped and prices for oil declined, the Reagan administration took some of the credit, noting that market forces had been far more effective than government intervention. (It was not yet clear, however, to what extent these results were a temporary by-product of the global recession, and in any case, some of the decline in consumption must be attributed to mandatory conservation measures.) Although the Reagan program has yet to be fully implemented, it is already abundantly clear that the thrust of the program is closer to that advanced by presidents Nixon and Ford. Although it does not aim to make the nation independent of foreign supplies, it puts the same emphasis as earlier Republican programs on the effort to satisfy expected increases in demand by encouraging private industry to develop new supplies. To the extent that conservation is to occur, it will be as a result of higher prices rather than mandatory requirement, or as a result of initiatives on the part of state and local governments and public utility commissions.

Clearly this debate over energy policy is not simply a reflection of the economic interests of the different groups and regions, or of a rational response to new developments. It has also been influenced by considerations of political ideology. Republicans have addressed the energy problem as Republicans tend to address all other socioeconomic problems, emphasizing the need to maintain economic growth by stimulating market forces and curbing the role of government and bureaucracy. Democrats tend to address the same problem by emphasizing the need for planning and government initiative, for protecting the disadvantaged from the hardships inflicted by the play of market forces, and—lately—for adjusting expectations of continued improvements in standards of living and consumer choice to the growing constraints upon the possibility of economic growth.

The debate over energy policy is therefore only in part a debate about external realities and technical questions. It is, at the same time, a debate about the principles by which policy should be guided. There is an important

difference, however, between relying on ideologies to define these princ and relying on fresh reflection. Ideologies are by definition simplificatio complex ideas. Often, they have been formulated in earlier times, conditions were quite different. Sometimes, they contain internal contr tions, which become evident only when they are critically examined. more often than not, they can be invoked to rationalize or disguise a sp interest by making it appear to be associated with some lofty principl appreciate more fully what is at stake in the debate over energy policy therefore necessary to set ideologies aside and to try to identify and an the values in question and their implications for policy, as well a dilemmas that arise in the effort to apply them in practice.