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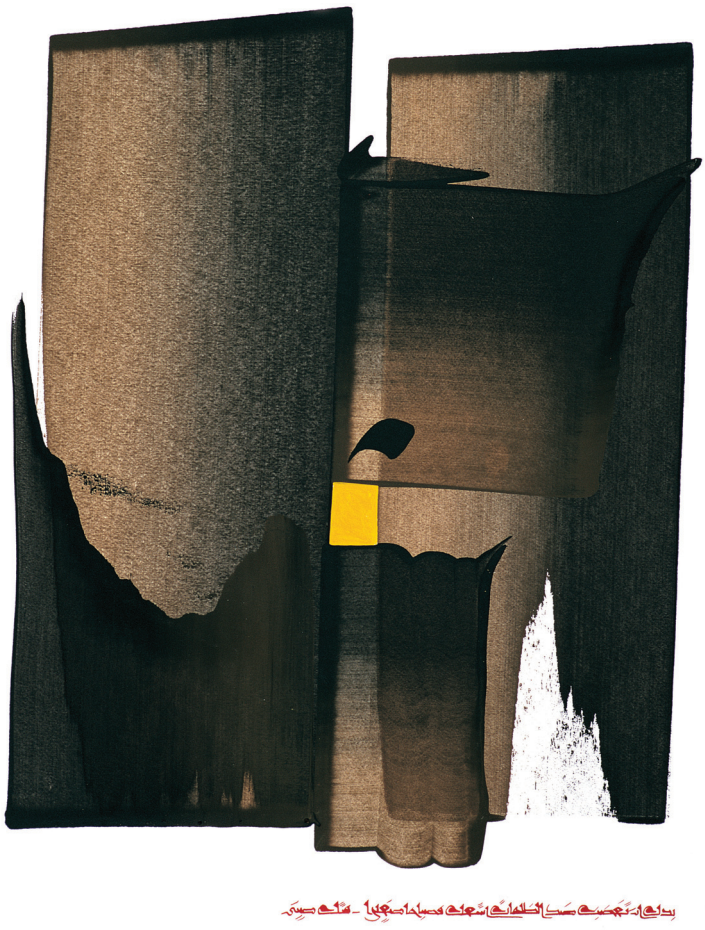
U.S. Energy Policy
The Need for Radical Departures

Dreams of a near-term transformation are illusory. The needed massive overhaul will take time and commitment.

Five years may be an entire era in politics, and as the recent global economic upheavals have shown, it is also a span long enough to hurl nations from complacent prosperity to panicky fears. Five years might also suffice to usher in, however belatedly, a sober recognition of the many realities that were previously dismissed or completely ignored. But five years is too short a period to expect any radical large-scale changes in the way in which affluent economies secure their energy supplies and use their fuels and electricity. Indeed, the same conclusion must apply to a span twice as long. This may be unwelcome news to all those who believe, as does a former U.S. vice president, that the United States can be repowered in a decade. Such a completely unrealistic claim is rooted in a fundamental misunderstanding of the nature of technical innovation.

Most notably, the process of accelerating innovation, habitually illustrated with Moore's famous graph of an ever-denser packing of transistors on a microchip, is an entirely invalid model for innovations in producing large amounts of commercial energies, bringing them reliably to diverse markets, and converting them in convenient and efficient ways. The principal reason for this difference is the highly inertial nature of energy infrastructure, a reality that is especially germane for the world's largest and exceptionally diversified energy market, which is also very dependent on imports. U.S. energy production, processing, transportation, and distribution—coal and uranium mines; oil and gas fields; pipelines; refineries; fossil fuel–fired, nuclear, and hydroelectric power plants; tanker terminals; uranium enrichment facilities; and transmission and distribution lines—constitute the country's (and the world's) most massive, most indispensable, most expensive, and most inertial infrastructure, with principal features that change on a time scale measured in decades, not years.

Similarly, as in any modern society, the United States relies on the ubiquitous services of enduring prime movers, some of which are only more efficient versions of convert-



HASSAN MASSOUDY, *Instead of damning the darkness, it is better to light a little lantern* (Chinese proverb), Ink and pigment on paper, 29.5 x 21.7 inches, 2002.

ers introduced more than 125 years ago. Parsons's steam engine, Benz and Maybach's and Daimler's Otto-cycle internal combustion engines, and Tesla's electric motor were all patented during the 1880s. Others have been with us for more than 100 years (Diesel's engine) or more than 60 years (gas turbines, both in their stationary form and as jet engines). And, of course, the entire system of electricity generation/transmission/distribution originated during the 1880s and had already matured by 1950. Even more remarkable than the persistence of these concepts and machines is the very low probability that they will be displaced during the next 20 to 25 years.

But for scientists and engineers with an urgent need to engage in public matters and for policymakers responsible for charting a new course, the next five years should be a period long enough to accomplish three essential steps:

- Create a broad consensus on the need for embarking on the protracted process of phasing out fossil fuels.
- Engage in an intensive education effort that would make clear the transition's true nature and requirements as a complex, protracted, and nonlinear process that is unpredictable in its eventual technical and managerial details; will last for decades; and will require sustained attention, continuous R&D support, and enormous capital expense for new infrastructure.
- Offer a minimalist agenda for deliberate long-term action that would combine a no-regrets approach with bold departures from the existing policy prescriptions. This means that the agenda's success would not be contingent on a single major variable influencing long-term energy actions, such as the actual progress and intensity of global warming or the future state of the Middle East, and that its eventual goals would envisage a system radically different from anything that would result from marginal tweaking of the existing arrangements.

What follows is a brief outline of an approach that I would advocate based on more than 40 years of interdisciplinary energy studies. Although it rests on first principles and on indisputable biophysical realities, it has a stamp of personal convictions, and its ultimate goal calls for a fundamental rethinking of basic positions and propositions.

Although the first of the three just-outlined near-term tasks has no formal policy standing, few would disagree that, as with all other affluent societies, the United States must reduce its overwhelming dependence on fossil fuels. The most common conviction is that the coming energy transition must rest on increasing the share of fuel and electricity derived from renewable energy flows, although no unbiased policymaker should exclude nuclear fission. It must be under-

stood that the magnitude of U.S. energy needs, the diversified nature of its fuel and electricity consumption, and the inherent limits on the use of renewable energy flows will make this coming transition extraordinarily difficult. The public interest is not served by portraying it as just another instance of technological innovation or by asserting that it could be accomplished by a concentrated, government-sponsored effort in a short period of time. Calling for the energy equivalent of the Manhattan Project is utterly misguided and inevitably counterproductive.

It is also imperative to make clear that this transition should not be driven primarily by fears of the imminent exhaustion of fossil fuels (Earth's crust contains ample resources) or by the near-term prospects of extraordinarily high energy prices (market adjustments have been fairly effective), but rather by a number of economic, strategic, and environmental factors. Energy trade has been creating large regional payment imbalances, including the now perennial U.S. deficits. Strategic concerns range from the future role of the Organization of Petroleum Exporting Countries and the stability of the Middle East to Russia's designs. The foremost environmental justification for reducing dependence on fossil fuels is the need to minimize risk by reducing the emissions of carbon dioxide (CO_2) from coal and hydrocarbon combustion.

And although all of the above factors apply equally well to the U.S., European, or Japanese situations, it is necessary that Americans understand the extraordinary nature of their energy consumption. In per-capita terms, Americans now consume energy at a rate that is more than twice the average in the European Union (EU)—almost 8.5 tons of oil equivalent (TOE) a year per capita as compared to about 3.7 TOE for the EU—and almost twice the level in the largest and the most affluent EU nations (Germany and France) or in Japan (all of which average about 4.2 TOE per capita). Normalizations taking into account differences in the size of territory and climate reduce this gross disparity, but the net difference remains large, particularly considering that the United States has been deindustrializing, whereas energy-intensive manufacturing remains much stronger in Germany and Japan.

Yet this energy profligacy has not translated into any real benefits for the country. The overall U.S. quality of life is obviously not twice as high as in the EU or Japan. Measured by a number of critical socioeconomic indicators, it actually falls behind that of Europe and Japan. Maintaining this exceptionally high energy consumption in an increasingly globalized economy is both untenable and highly undesirable. Indeed, the greatest challenge for responsible leadership in the years ahead will be making it clear to the public that a deliberate, gradual, long-term reduction in energy use is both desirable and achievable.

A farsighted long-range energy policy would replace the standard call for a combination of increased energy production and improved efficiency of energy conversion with a new quest for gradually declining levels of per-capita energy use, a goal to be achieved by a simultaneous pursuit of two key long-term strategies.

The first should be a more vigorous quest for efficiency gains by established converters in order to achieve substantial efficiency gains in every sector of the economy. This approach must mix diffusing well-established superior techniques and introducing bold innovations. Fortunately, the potential for such gains remains in many ways as promising today as it was at the time of the first energy crisis in 1973 and 1974, with opportunities ranging from mandatory reliance on the best commercially available methods to a targeted introduction of innovative solutions. Adopting new DiesOtto engines (grafting the advantages of the inherently higher efficiency of Diesel's machines onto standard gasoline-fueled engines), installing high-efficiency (in excess of 95%) natural gas furnaces in all new buildings, using power factor correction for electronic devices, switching to LED lighting, and recovering low-temperature waste heat for electricity generation are just a few prominent examples of this vast potential.

But better conversion efficiencies are not enough. Pursuing them must be combined with relentless enhancement of overall system performance. Above all, we must avoid consuming more energy more efficiently. Thus, the second component of an effective long-range energy policy must be a quest for significant overall reductions in energy use, a goal to be achieved by a gradual adoption of measures leading to a fundamental reshaping of consumption patterns and a redesign of energy-consuming infrastructures.

This would necessarily be a prolonged process, and its success would be impossible without redefining many long-established ways of measuring and judging fundamental realities and policies. For example, one of its key preconditions would be to move away from the existing incomplete and misleading ways of pricing goods and valuing services without examining their real cost, including environmental, strategic, and health costs, and without subjecting them to life cycle analyses. Although these ideas have yet to capture the economic mainstream, a considerable intellectual foundation for a transition to more inclusive valuations is already in place. Pursuing this course would be infinitely more rewarding than bizarre methods of producing more energy

with hardly any net energy return (such as the cultivation of energy crops without taking into account the energy inputs and environmental burdens), hiding the emissions of CO_2 (as favored by powerful carbon capture and sequestration lobbies), or making impossible claims for nonfossil forms of electricity generation (perhaps most notably, various exaggerated goals concerning the near-term contributions of wind turbines to national and continental electricity generation).

The goal of reduced energy use is actually less forbidding than it appears at first sight. Not only is U.S. energy consumption substantially higher than in any other affluent nation (making reductions without any loss of quality of life easier than in, say, France), but despite profligate use of fuels and electricity, the average per-capita energy use in the United States has increased only marginally during the past two generations (from about 8.3 TOE in 1970 to 8.4 TOE in 2007). Clearly, if more rational regulations (ranging from responsible residential zoning to steadily tightening vehicle mileage standards) had been in place between 1975 and 2005, the country would have avoided the enormous infrastructural burden of exurbia and of 20-mile-per-gallon SUVs, and average per-capita energy use might have already declined by an encouraging margin.

I believe that having in mind an ultimate—distant, perhaps unattainable, but clearly inspirational—goal would be helpful. Years ago, I formulated it as a quest for an economy of 60 gigajoules (GJ) per capita, or roughly 1.5 TOE. This amount is now the approximate global per-capita mean consumption of all fossil fuels. A European initiative led by the Swiss Federal Institute of Technology and coordinated by Eberhard Jochem ended up with a similar ultimate goal of a 2,000-watt society (an annual energy consumption of 60 GJ per capita corresponds to the power of 1,900 watts).

If the United States is to maintain its prosperity and its prominent role in world affairs, it must lead, not follow, and it must provide a globally appealing example of a policy that would simultaneously promote its capacity to innovate, strengthen its economy by putting it on sounder fiscal foundations, and help to improve Earth's environment. Its excessively high per-capita energy use has done the very opposite, and it has been a bad bargain because its consumption overindulgence has created an enormous economic drain on the country's increasingly limited financial resources without making the nation more safe and without delivering a quality of life superior to that of other affluent nations.

However, if grasped properly and used effectively, this very weakness contains a promise of new beginnings, but only if the United States' traditional creativity and innovative drive are combined with a serious commitment to reduce its energy use. I realize that such a call will be seen as a nonstarter in the U.S. energy policy debate and that its rejection will be supported by voices extending across most of the country's political spectrum. Changing long-established precepts is always hard, but the current concatenation of economic, environmental, and strategic concerns offers an excellent opportunity for new departures.

Energy transitions are inherently prolonged affairs, and in large nations with massive and costly infrastructures, their pace cannot be dramatically speeded up even by the most effective interventions. Five or 10 years from now, the U.S. pattern of energy supply and the dominant modes of its conversion will be very similar to today's arrangements, but the coming years offer an uncommon opportunity to turn the country's policy in a more sensible direction and to lead along a difficult but rewarding path of global energy transition.

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