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# Chapter 16

## Conclusion: Final Thoughts on New Beginnings

*Cities phosphorescent*

*On the riverbank…*

*the murmur*

*Of the millionfold…*

W.G. Sebald, "After Nature"

*We cannot absolutely prove that those are in error who tell us that society has reached a turning point, that we have seen our best days. But so said all who came before us, and with just as much apparent reason…On what principle is it that, when we see nothing but improvement behind us, we are to expect nothing but deterioration before us?*

Thomas Macauley, "Critical and Historical Essays," 1830

In the first few years of the new millennium, after decades of relative stability, our energy landscape has been rocked by deep changes and uncertainties. Supply problems, volatile economics, political turmoil, global recession, war itself—old horsemen, we might say, from a generation past, but now given new life, longevity, and an added, companion. Not since the 1970s, before climate change arrived, has energy been such a focus of concern. A major difference is the scale involved. No longer is the topic a core worry for a dozen wealthy countries; it is global in every sense.

If we stick to rich countries, those of the North, we find an especially high level of anxiety, openly expressed. "Today," a typical example reads,

> America faces grave challenges in the field of energy—from the gathering storm of global warming to a dangerous addiction to oil that jeopardizes our national and economic security. We must meet these twin threats… head-on, with that same spirit of hope and optimism that has characterized our finest hours. We, as a nation, have the ingenuity, know-how, and determination necessary to create an energy-secure America.(1)

Such is not, we might observe, the speech of smiling confidence. It is more an attempt to rally the troops before the moment of final peril. Threat and the edge of despair lie waiting, no less than the vision of victory. All the more significant, then, that these words introduce a report on the need for a "fresh and innovative approach" to U.S. energy policy, based on "green optimism."

It pays to see things as they are, free of clouds dark or bright. Fossil fuels do run our world—not entirely, but dominantly and unquestionably. They will continue to do so for decades, also without doubt. Oil, gas, and coal will not merely remain indispensable; they will expand. Whatever the outcome of any financial crisis, however serious it may prove to be, civilization will recover and begin to call for more energy. Together, fossil sources account for eight out of every ten Btus humanity employs and form the nexus of a system representing tens of trillions of dollars and 150 years of investment, innovation, and cultural adaptation. This system is not going away anytime soon. On the contrary, it can't help but get bigger, as more of the world clamors for economic growth and industrial advance, before it changes course. Green longings, however potent in a time of high oil prices and climate consciousness, will not make it possible to power the vast new cities of Asia with wind and solar energy by 2020. Carbon energy has not yet completely matured. Attempts at changing the global system succeed from the margins inward.

Yet, as the saying goes, peripheral vision is often the sharpest. Deeply dependent on the same fuels that powered the last century, our energy landscape is nonetheless in the midst of many efforts to transform what now exists. Some of these efforts can appear in conflict with one another—why develop hydrogen if all-electric vehicles are closer to fruition? Why advance nuclear power at the same time as competitors like clean coal and natural gas? Why sink billions into fusion that could go to solar power? And so on. But every such question returns to a single answer: the world needs a more diverse, adaptable energy future—less vulnerable to crisis, more reliant on variable sources—and it is rich enough and knowledgeable enough to pursue many options together.

The work being done to amend our energy landscape therefore reflects not only worry, but dissatisfaction and hope. We understand that, despite its providence to this point in so many aspects of life, our energy system also has profound flaws and frailties, and decided limits too, that are embedded in chemistry, geology, and geography, as well as politics, economics, and behavior. We know this system is temporary. It cannot last a great deal longer in its current form. Nearly half of humanity, billions of people, will enter the ranks of the modern energy consumer in the next 30-50 years. Global resources of oil, gas, and coal are not infinite, and the effects of using them, without big changes, are too dire and too well-understood for things to remain the same. The fossil fuel era, which really began in 17$^{th}$ century London, center of the Scientific Revolution, will not come to a sudden or crashing end. It may plateau, in whole or part, within the lifetime of many people now breathing. But it will continue thereafter for many years, merging into a new order, propelled not by some miracle yet unknown, but by science and technology backed by vision and ideas: the Energy Revolution, gradual and inevitable, will be a result of human capital supported by the society it serves.

In this book, we have looked briefly at (flown over) many of the major forms and shapes that constitute our energy landscape and that will influence its future. Which among them are especially compelling? Here is a selection to contemplate:

1. In the last 150 years, our energy system has multiplied in every way—not only in scale and capability, but also in sources and technologies. In every sector—power, transport, industry, etc.—the range of fuels has grown and the uses for them have diversified. Before WWII, electricity came from coal and hydropower,

and cars had gasoline engines; today natural gas, uranium, biomass, solar, wind, and geothermal energy all provide power, and millions of diesel, hybrid, and flex-fuel vehicles roam the roads, with plug-in and all-electric species in waiting. Multiplicity has its limit; some technologies will likely cancel out. Yet the grand pattern is clear: no single wonder-source lies in our future, but instead a portfolio of options demanding thoughtful balance. Progress in energy is tied directly to technological diversity.

2. Such progress, in rich nations particularly, has been headed in a clear direction: greater, more varied use of electricity. Electrical power has grown at a higher rate than any other form of energy consumption, aided by development in emerging nations and by the "information revolution," affecting all areas of life. This will not change; the Digital Age has only begun. Since WWII, meanwhile, nearly every new source—nuclear, solar, wind, biomass, plus future options like fuel cells and fusion—is aimed at expanding electricity. Even in transport, kingdom of oil, a threshold has been crossed, with hybrids bringing electric propulsion into the mainstream. This has major implications for future infrastructure planning. Increasing access to electricity, primary basis for modern life, is a core energy focus in developing countries, where nearly 1.5 billion people live without it today. They, plus the billion more who will be born over the next three decades, will form new e-consumers. For many reasons, then, electricity (not oil) sits at the true center of our global energy system

3. There is no single "energy crisis." Instead, the world faces a number of different, partly interrelated, energy challenges, all pressing. Solving oil supply will not eliminate the global demand for non-carbon sources and more electricity. Finding a way to make solar cells half as expensive or nuclear power palatable to western (non-French) audiences won't suddenly render transport more emissions free. Capturing carbon from coal power plants, meantime, can't itself make buildings less wasteful in their lighting and heating/cooling. Convincing China to use more natural gas, or India more renewables, won't cause Iran to abandon its nuclear enrichment program or the Kremlin to be more gentle in its policies. The complexity of our energy geography means that these and other challenges have to be tackled all at the same time—no single, miracle solutions exist. If there be one overriding conundrum, it would have to be this: future rises in the global demand for energy will be huge, yet climate/pollution concerns are arguing for reduced dependence on fossil sources even as alternatives are not yet ready to take their place.

4. Much progress can come from improving how energy is produced and consumed. Making our system more efficient—from power plants to cars—affects supply, use, and emissions at every level and is thus like adding a new, "clean" energy source. Developing nations could especially benefit, since they are growing far more rapidly, sinking money into long-lived capital stock (e.g. power plants). Improving efficiency is a continual, long-term endeavor that can't be achieved by market forces alone: significant R&D and government support are essential. It is,

however, no panacea. Making energy cheaper and easier to use affects the demand side of the equation, having led to higher levels of consumption (the "paradox of plenty") in the past. Other incentives to conserve are needed; government policy has a role to play here too. Though efficiency is likely the cheapest, most effective way to advance energy use in the near-term, it cannot satisfy future needs for more transport, power, and industry as the world continues to urbanize and economically develop.

5. This situation emphasizes that the future of energy belongs to nations (and firms) who invest deeply in human and technological capital—the mind. Long-term, energy will move from a commodity resource base (coal, oil, etc.) to a knowledge base (e.g. advanced conversion technologies), making R&D crucial. Rich countries are where new technological options, including ways to deal with climate change, will first emerge, but nations like China and India could contribute a great deal if they continue to invest in human capital. From this perspective—and energy's importance to every aspect of national well-being (public health, defense, the economy, etc.)—strong government support for R&D, including both fossil and non-fossil sources, will prove essential. Though in decline for decades, such support has had real benefits, not least in fossil energy. Given the scale of future energy challenges, nations who do not invest in this way will become less competitive, parasitic on advances by others.

6. Does the world face scarcity in the resources it now uses? In absolute terms, no. There are many decades of coal left, trillions of bbls of petroleum (all forms), vast volumes of natural gas and nuclear fuels (uranium, thorium). The world is in greater danger of running low on clean water than fossil fuels. Humanity *may* be approaching a limit in its ability to extract cheap, conventional oil. Yet "proven conventional reserves" is a dynamic, evolving, inexact category and does not measure what the world has, but what it thinks it can deliver. The best studies suggest that a plateau (not peak) in world oil production will begin before 2040—but as the recent oil shock showed, this would most likely come not from scarcity but from insufficient development of new reserves, high prices, and new vehicle technologies that over time bring a shift away from petro-fuels.

7. Energy wealth and poverty divide today's world, as they have throughout the modern era, but this will gradually change. High levels of per-capita use are a given in rich societies, due to technology penetration, yet the era of rapid increases in energy use by these nations may well be over, as their economies are mature and their populations are stabilizing and even declining. Per-capita energy consumption will progressively (if fitfully) grow in Asia, Latin America, and eventually Africa as well. Rich nations have moved away from heavy industry, slowing the rise in their energy demand, while such industry has shifted to emerging and developing countries. In Africa and Asia, where population growth is high, over a billion people still live without electricity, fundament of modern life. Rapid modernizers like China, India, and Brazil are performing a great

historical experiment. In a few decades, they are building, simultaneously, heavy industrial and service (knowledge) societies on a scale vastly greater than what the West achieved in a century. This is a profound change in the dynamic of the modern world—nothing less. Emergent nations have become the core of global energy demand; they already control the fossil fuel system in terms of resource transfer. A major concern is that pollution control has not yet found a stable home in these states.

8. There will be future shocks to the global energy system. Unforeseen events are inevitable, and, as the recent (2006-2008) "oil crisis" showed, the system is both robust and fragile. Exaggerated commodity cycles are certain if oil/gas markets are bound by capacity limitations in production and refining, and if resources are highly politicized, thus tied to political events and psychological winds. Policies that support fuel subsidies or reduce foreign investment add to market deformations and uncertainty. Exporters control supply; importers have power to control demand. Ultimately, the latter is more determining, but the former will persist. National oil companies, who own over 80% of global oil/gas, are conservative in developing new reserves, yet often do not have the expertise to maximize recovery, and thus may be forced to accept foreign investment over time. Simultaneous oil and gas cartels would render the global system even more vulnerable to shocks, and would make the search for substitutes more urgent.

9. The invasion of Iraq was a gamble of the highest order in the geopolitics of oil. The goals of bringing democracy to the Persian Gulf, turning an enemy petro-state (with huge reserves) into an ally, and inspiring reform in nearby oil nations—thus enhancing the flow of peace and petroleum both—were largely turned into their deadly opposites. Democratic reform has not spread and Iraq's oil industry has been stymied by violence, corruption, lack of stability, and sabotage. With peace restored, this industry could recover and double its production within 5-7 years, though internal politics could complicate matters, too. Yet the goal of transforming the Persian Gulf, politically and socially, was a naïve and terrible failure. Vast amounts of money to fund the struggle in Iraq have essentially doubled the loss of U.S. wealth during an era of high prices and lowered America's financial ability to pursue other paths to a more secure energy future. At some level, it is fair to view the Iraq invasion as a substitute for government investment in other forms of energy advancement. Such does not quite capture the horrible toll in human lives and suffering, nor the truth that the conflict has added a new element of instability to the region that will continue to act as a primary source of the world's dominant fuels.

10. Natural gas is poised for a bright yet possibly troubled future, also for geopolitical reasons. Globally abundant, a likely "bridge" to a new energy era, gas has durable environmental advantages over coal. Greatly preferred in rich nations, it has been less so in Asia, where coal is cheap and plentiful. The global market for gas, very young at present, will expand significantly even as regional markets

endure, aided by climate worries, growing power demands, rising supply (Middle East especially), and new LNG technology. Yet concern over a future cartel, led by gas giants Russia, Iran, and Qatar, and including most OPEC members, is legitimate. Recent problems involving Russian supply to Europe, where gas dependence is high and growing, suggest the global market will subject to geopolitical difficulties. In the U.S., huge progress in unconventional gas recovery has helped relieve domestic supply problems and raised potential global reserves considerably (example of technological leadership), but likely won't end the need for future imports. The main uses for gas, in power generation, industry, and home heating, could be added to significantly if natural gas vehicles become more popular.

11. Coal will likely remain the most abundant, cheap, and polluting fuel, thus a source of fervid debate. With over 70% of all fossil Btus, it is itself a diverse resource, able to yield natural gas, low-sulfur fuels, and $H_2$. Large reserves in Russia, China, and India, plus per-Btu costs less than half those for gas, suggest that coal will continue to be a strong factor in energy security. In the U.S., the world's coal colossus, there is much pressure to put this source to work more fully but environmental and climate concerns restrain its expansion. This is not true for China, which views its coal (60% of total energy use in 2008) in conflicted fashion—as an origin of economic growth, thus political legitimacy, but also environmental degradation, public unrest, and highest carbon emissions in the world (global image problem). Pressure will continue, from within and without

China, for the government to diversify energy sources. As with oil, the market price of coal does not include the social costs of using it. Carbon taxes or emissions trading would put back some of these costs, and carbon capture and storage, now at an early stage, could greatly reduce climate impacts. It is not clear how rapidly such measures might be implemented or whether CSS technology will eventually be successful. The geopolitics of coal are linked in the long-run to the geopolitics of climate.

12. Nuclear power is entering a new era of expansion, due to growing power needs in the developing world and climate concerns. This source remains, for now, the only non-fossil option able to generate uninterrupted power on a mass scale. Growth will be concentrated in Asia; more than 150 new plants could be built there by 2040. More modest construction will occur in the West, where legacy fears still hold nuclear to a standard of near-perfection (no risk) and "what if" scenarios. Yet pro-nuclear arguments will continue to gain from the "competing threat" of climate change, lack of recent major accidents, safer, more efficient reactors, and new generations of voters. Economics and technology are factors: plants are capital-intensive but competitive over time due to low operating costs, while technology has advanced to a new generation of safer, more modular, and efficient reactors. Globally, proliferation is by far the greatest concern. Securing all weapons and highly-enriched fuel, reducing the current stockpile of warheads, and preventing new "tactical" weapons are crucial objectives. The examples of Iran and North Korea suggest that if nuclear is to expand worldwide, it is

necessary to restrict enrichment/reprocessing, perhaps using a small number of tightly guarded fuel banks under multilateral control. Nuclear will be a vulnerable option: a single large accident or terrorist attack would bring panic; advanced renewables could make nuclear less socially viable.

13. Renewables, fastest growing domain of energy production in the 2000s, offer vast but for now measured hope for the future. At present, they provide major socio-environmental benefits, yet inferior sources of power and fuel. After a decade of subsidized growth, solar et al. account for <2% of global energy; technologically, economically, they won't run the world any time soon. Yet the overall increase is impressive; for some countries the figure is >10%, implying future use will be nation-specific. Limitations are intermittency (need for power storage), land/water use, high cost, and geography. Few of these apply to geothermal, which remains hugely under-utilized. As a global source to replace petroleum, biofuels have an uncertain future, due to direct and indirect environmental effects, water use, lower energy content, and the fact that they are carbon sources. Solar energy has the largest array of uses and offers new potential through concentrated thermal technology, yet power densities are still low. Advances in PV efficiency could have a major positive impact, if costs are reduced. Distributed generation may prevail in many areas, with implications for localized energy autonomy. Past history implies that support for solar, wind et al. in the West is a servant to oil prices. However, climate concerns and the hope for new "green industries" may alter this calculus. Renewables, if more affordable, could be a significant force in

the developing world, bringing modern energy to the world's poor. These forms of energy production make clear two points: advanced technology is key, and "green" depends on the consumption of resources, including water, land, and materials.

14. The role of technology in our energy system is complex. Western leaders stress it as a solution, yet for decades failed to match such faith with support. Funding for U.S. energy R&D was lower in 2007 than in 1978 and has been trivial compared to health and defense, due to the idea that energy innovation is best left to the free market. With economic crisis (market failure), there has been renewed interest in high-level government support for energy R&D. Most of this interest is focused on non-fossil options, which are indeed important. But fossil and nuclear energy remain the basis for socio-economic reality and should not be ignored. Advancing all options and carbon mitigation will likely be most successful in an environment of high oil/gas prices, with government, academic, and private sector involvement and international cooperation. Overall, however, technology is no fix. Promoting a "Manhattan Project" for energy solutions draws on a false analogy: this was purely a government project, with no cost limits or commercial demands. Technology also has limited power to alter geopolitics. It will not erase problems in natural resource states; indeed, the Iranian nuclear situation shows technology can add to conflict. Finally, innovation is not destiny: belief that some "game changer" breakthrough, e.g. in solar cell efficiency, will rapidly

reorient our entire energy geography is, at best, naïve. Major infrastructure changes are difficult, disruptive, and take time.

15. The world is on track to double the fleet of personal vehicles to ~1.2 billion by 2040. This is due to pent-up demand, road building, and future economic growth in developing nations, aligned with domestic auto companies creating low-cost options matched to local incomes (car buying has a demonstrated "take off" point at per-capita income of $3,500-$5,000). The impact on oil demand will depend greatly on fuel economy standards, which are set to rise over 70% (to a global average of ~40 mpg) in the West and China. New types of cars, built of lighter materials, achieving higher mileage through a combination of advanced internal combustion, plug-in hybrid, all-electric, and possibly fuel-cell engines, appear inevitable. Yet auto fleets to date have turned over slowly (about 8%/yr). A big question is how long it will take for such innovation, which raises costs, to succeed in developing countries. Battery advances will greatly aid electric vehicles, which will compete with advanced hybrids and require new power generation infrastructure.

16. The U.S. is the biggest player in world energy, and this will likely continue for decades. Importance is due not only to consumption levels (which may be surpassed by China before 2020), but a larger geopolitical role as financial, global, and technological superpower. Yet the U.S. faces several energy dilemmas. By not controlling oil demand, it has increased imports from

tyrannical regimes, thereby making U.S. calls for reform and human rights seem hypocritical. It is also facing infrastructure constraints: no new refineries have been built in 30 years; new coal-fired power plants as well as LNG ports have been largely forbidden by local governments; public resistance remains against new nuclear facilities and transmission lines. Off limits to oil/gas development are large federal and state areas, onshore and offshore, curtailing the U.S. resource base by many billions of bbls and Tcf. Clashes of values are involved in all of this—desire for cheap, reliable energy but an unwillingness to accept what this requires. Lack of serious policy to control demand has aided public misunderstanding and placed the U.S. in contrast to Europe and Japan. Politicians have long feared angering the consumer-voter, who has been coddled into a lack of awareness about the consequences of energy choices. The call to eliminate "foreign oil" from "problem suppliers" suggests energy isolationism, posing major questions for U.S. influence (no involvement in the Persian Gulf, Caspian area, West Africa, etc.?), and is not a possibility without enormous decline in demand, aided by changeover to new vehicle technologies.

17. Turning again to the U.S., it is apparent that various myths hold a high seat in public discussion. Examples include: "energy independence" (impossible for oil and gas, given U.S. resources); Big Oil as cause for high prices (it controls less than 8% of global reserves); excessive fear over LNG tankers (when more explosive gasoline cargoes come and go daily); worry over nuclear plants exploding like bombs (they can't); belief that renewables can rapidly replace

fossil fuels (they are far from ready for this); that "peak oil" is now upon us (it isn't); that the free market will solve our energy problems (except, perhaps, the political, social, and environmental ones). Such misconceptions waste a great deal of well-intentioned interest and commitment. Better education in energy matters and consistently responsible reporting from the media seem necessary goals for any effective energy policy.

18. Three challenges stand out as overriding concerns for the future of global energy. First is the need for *investment*—in new supply for existing fuels, and in innovation to improve technology and planning (ways of thinking, conceiving, imagining) future energy sources. Second, *climate change*—which casts a new frame around all energy use and will help drive change while also challenging the world's ability to act as a community. Third, the prospect that *developing nations everywhere will follow the path of the West*—building huge systems for coal and oil, thinking pollution controls and efficient technology can be applied later. Leaders of the global South appear to believe that economic growth, based on energy growth, is the only anti-poverty program that works. But the Earth does not possess, at affordable prices, enough coal and oil to bring all the world's people equal to the wealth that the West enjoys. Thus, all three challenges converge: investment is deeply needed to better advance all nations, environmentally, economically, socially, personally.

19. In this vein, one can't talk about the future of global energy without special mention of China. This nation, soon to be the world's largest energy consumer, will drive many changes in decades to come. What the U.S. has been to the West—leader, protector, economic imperialist, self-obsessed provincialist, resource glutton, and crucial innovator, China may well be to Asia. It is common today (and this book does some of it) to list China's energy failings—from coal use and emissions to oil demand—as if reading a liturgy of failed modernism and imminent disaster. Yet the eager, often numbingly fatal diagnosis misses something critical. China's leaders recognize the problems they face. They are moving toward important measures—greater energy efficiency, liberalized energy markets, use of the most advanced technology, diversified energy sources (including renewables), and more. To achieve all this, China will need to evolve its political-economic system, and it will need much help and technology from the West and from its own ingenuity. Condemning China (or India, for that matter), isolating it strategically, will not advance the world. We will not get to the end of the present century without these pivotal nations becoming more successful stewards of their own growth.
20. In the end, concepts need to evolve too. It is important to understand that "energy" is not merely a matter of resources and markets. It is also a domain of ideas and beliefs about the nature of society, progress and its costs, and where civilization should be headed. Because so visible (gas prices on big signs), so inescapable and socially penetrative, "energy" is itself a reservoir for the hopes, ambitions, fears, and confusions that many feel about the state of the world and its

future. We should not be surprised therefore if, as an issue, it attracts a great deal of passion, whether well- or ill-informed. Such is no less true for government leaders. “Energy security,” a guiding precept today in political circles, speaks an embattled sense of stability. Needed in the short-term, it seems a dubious guide for building a better long-term system. More helpful is “energy sustainability,” a well-used term perhaps, but valuable if aptly defined. “Sustainable” shouldn’t mean a final, beatific state, but dynamic and unending improvement. There has never been, and there will never be, a system that brings all our worries, doubts, and appetites to an end. Shifts in geopolitics, breakthroughs in R&D, descents into ideology, economic vicissitudes, create an eternally shifting context. Humanity thus requires the imagination, technical mastery, and incentives to adapt to such changing circumstances, even to be prepared for them as they occur. Such capabilities are underway, haphazardly to be sure, but underway nonetheless and needful of systematic support. Energy can be—and definitely should be—a platform for cooperation among nations, not only conflict. “Sustainable” thus returns to the idea of a system that nourishes life and impels it to flourish, socially, communally, and personally.

Readers will perhaps lament that from these points no final, integrated picture emerges, no unified portrait and what lies clicking behind it. Yet the absence of such an image reflects another reality. Our energy system is an enormous historical patchwork, a gigantic mosaic of elements—pipelines, solar panels, power plants, dams, drill rigs, mines, stock futures, transmission lines, batteries, vehicles, sugar cane fields, and a

thousand other pieces, some as old as the Civil War, others as new as yesterday. Dealing with this mosaic requires applying vision to the details. It also means understanding the long view and where it is pointed.

More than a century ago, in an essay titled "Wealth," Ralph Waldo Emerson saw the force and direction of the modern era, embodied in a rock:

> Coal lay in ledges under the ground since the Flood, until a laborer with pick and windlass brings it to the surface...Every basket is power and civilization. For coal is a portable climate…Watt and Stephenson whispered in the ear of mankind their secret, that *a half-ounce of coal will draw two tons a mile*, and coal carries coal, by rail and by boat, to make Canada as warm as Calcutta, and with its comfort brings its industrial power.(3)

The mingle of literal truth and ironic burden in these words should not leave us stunned or wondering. Emerson is himself a compass; his enthusiasm for his own time might help excite us about what could exist by the end of our own century. As much as any thinker of that first industrial era, Emerson is a reminder too. Transformation is the essence of energy use. Now in its second great era of industrialization, the world will be altered yet again. It can be allowed to rumble forward, under its own blind power, or it can be directed to still higher means and ends by knowledge, foresight, and will.

- End -

Notes

1. Worldwatch Institute, 2006. *American Energy: The Renewable Path to Energy Security*. Washington, D.C.: Worldwatch Institute. Available online at: http://www.worldwatch.org/node/4405

2. Soddy, F., 1920. *Science and Life: Aberdeen Addresses*. New York: E.P. Dutton, p. vii.

3. Soddy, *Science and Life*, p. 6