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Moving beyond Alchemy with Demand Response

Electricity: If We Want It Clean, Firm, and Cheap, We're Going to Have to Pick Two

I. Engine of the World Economy and *Sine Qua Non* of the Ascendant Global Middle Class

Electricity is, with the possible exception of water,[1] the most critical commodity in the daily lives of the world's population with access to it. Just ask residents who endured several weeks of power outage after Hurricane Ike hit the U.S. Gulf Coast and Houston in September 2008.[2] Equally important, we use it to power the world economy, and we use lots of it. Global electricity consumption in 2006 was 18 trillion kilowatt hours; that figure is projected to increase to 31.8 trillion kWh by 2030.[3]

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Moderation or reduction in global electricity demand comes, as a practical matter, with unacceptable side effects.[4] The current recession has certainly yielded up some demand statistics that haven't been seen in two generations, if ever. The International Energy Agency (IEA) recently projected that global demand for electricity will decline in 2009 for the first time since records began to be kept in 1945, by about 3.5 percent compared with 2008. The IEA projects that 2009 demand will fall more than 2 percent in China, nearly 10 percent in Russia and nearly 5 percent in the OECD countries. Notably, about 75 percent of the reduction is in industrial rather than domestic demand.[5] And it is not impossible that reality will be worse than the IEA's projections. U.S. utility generation in the second quarter of 2009 was more than 10 percent below the same period of 2008, because of weaker demand by the manufacturing sector.[6]

Offsetting the recession's downward near-term effect on electricity demand is the rise of middle-class purchasing power in emerging economies such as the BRIC countries (Brazil, Russia, India, and China) and the Middle East – an undeniable demographic trend that will drive global electricity demand upward for decades. According to the National Intelligence Agency, a ''stunning'' 135 million people, more than live in Japan and almost the number living in Russia, escaped poverty between 1999 and 2004. Over the next several decades, the size of the global middle class is expected to swell from 440 million to 1.2 billion (from 7.6 percent of the world's population to 16.1 percent), according to the World Bank.[7] And, depending on how one defines middle class, some say it will increase by 2 billion people by 2030 (reaching 50 percent of the World's total population).[8] It's not unthinkable that this new, incremental middle class will have $10–20 trillion of annual purchasing power to spend on digital age goods and services that are made with, and operate on, electricity. Not surprisingly then, global electricity demand is forecast to increase 77

 1040-6190/$–see front matter doi:/10.1016/j.tej.2009.09.007

percent by 2030, according to the U.S. Department of Energy/Energy Information Administration (DOE/EIA).[9]

With this potential ascendancy of 2 billion people into the middle class, access to secure and clean energy sources (and management of chronic water shortages) will assume an elevated importance in a larger number of countries, even in the medium term between now and 2025.[10] Continued economic growth coupled with an increase in the global population of 1.2 billion by 2025 (a ''relative certainty'') will put pressure on energy resources, among others. And it is ''likely'' that ''all current technologies are inadequate for replacing traditional energy architecture on the scale needed.''[11] All of these are probably understatements.

A. Clean. World CO_2e[12] emissions stood at approximately 45 gigatons (Gt) in 2007 and are forecast to rise significantly. Under a business-as-usual scenario, CO_2e emissions will continue to rise at 1.5 percent per year, which could cause global temperature increases of up to 4 °C by 2030, and ''runaway global warming by 2050'' when CO_2e emissions would top 84 Gt per year.[13] What we do – both in the areas of science and technology and energy and environmental policy – will likely determine whether GHGs are sufficiently reduced over the next 15 years to prevent global warming in excess of 2 °C, the level above which the effects are generally no longer considered manageable.[14] The U.N. has recently noted that an energy transition is necessary if we are to implement an integrated multinational strategy for meeting climate change goals. Energy use is responsible for 60 percent of total GHG production and achieving the 2 °C scenario will require ''a huge share of emissions reductions, perhaps a much as 80 percent, . . . to come from the reshaping of energy systems.''[15]

Even though China is now the world's largest producer of GHGs, the U.S. still generates four times as much on a per capita basis.

Coal, of course, is not clean, but it is plentiful and cheap. Even though use of natural gas is expected by DOE/EIA projections to grow 60 percent by 2025 (and with it dependence on Russia, Iran, and Qatar, which hold collectively 57 percent of global natural gas reserves), it's coal that is the worst problem to tame, from a greenhouse gas emissions standpoint, particularly when viewed on a global basis. The U.S., Russia, India, and China possess the four largest recoverable coal reserves, enough to last 100 years or more.[16]

The international challenges of reducing global production of GHGs cannot be overestimated. As observed by Bales and Duke, preventing global warming in excess of 2 °C will require reducing the current levels of greenhouse gas emissions (which will mean reducing dependence on coal-fired electricity) in both developed and developing countries. Even though China is now the world's largest producer of GHGs, the U.S. still generates four times as much on a *per capita* basis (and 10 times India's *per capita* contribution to the problem). If the developed nations were to reduce total greenhouse gas emissions by 80 percent by mid-century, that would help. But there is consensus that aggregate emissions from the developing countries cannot be permitted to continue without unmanageable consequences to the global climate and, consequently, to global politics and the security of nations.[17] In these regards, science is telling the world one singular truth: not opting for clean is not an option.

Wind can be part of the clean solution. Investment in U.S. wind generation has taken off, spurred by the production tax credit.[18] Wind generation capacity in the U.S. has grown, on average, 29 percent per year since 2001.[19] Over 8,500 MW of new wind generation capacity was added and $16.4 billion invested in 2008, more than triple the 2006 total.[20] The U.S.'s 25,000 MW of installed wind generation capacity is now the most in the world.[21]

All of that said, wind power is still a small fraction of the total energy consumed in the U.S.

 1040-6190/$–see front matter doi:/10.1016/j.tej.2009.09.007

Because of its inherently low capacity factor, wind generated less than 2 percent of U.S. electricity consumption in 2008.[22] The DOE has suggested that wind, though a small contributor to clean electricity today, could, under favorable policy conditions and with large investments, produce as much as 20 percent of U.S. electricity consumption by 2030.[23]

Even if one subscribes to the DOE's 20 percent wind scenario, we cannot be clean without nuclear, and lots of it. It is our ''only existing, proven and scalable low carbon baseload generation technology.''[24] But building more nuclear units will be a challenge from a financial, regulatory, and construction standpoint. As the Business Roundtable notes, ''the urgency of this challenge is highlighted by the advanced age of the existing electric power generation fleet and the expected retirement of the vast majority of the nation's baseload capacity in the first half of this century.''[25] The current U.S. nuclear fleet of 104 reactors produces about 20 percent of all MWh, which constitutes about 70 percent of all of our low- or non-carbon generation.[26] Our Generation II reactors will end up operating for about 50 years, after all the license extensions are given effect. It's reasonable to think the Generation III plants will last longer, which should ameliorate their high capital cost. The problem is that we need an enormous number of them by 2050, at the latest, just to replace the 20 percent nuclear share of our current generation, let alone respond to demand growth or replace coal. This realization has yet to achieve universal acceptance in Washington, where support is essential. So far, only Republican Sens. Lamar Alexander, Bob Bennett, John McCain, and Jeff Bingaman have suggested a large re-build of nuclear infrastructure – 100 new units by 2030.[27] On the global scale, the challenge is magnified enormously, 15- or 20-fold. As pointed out by Oliver Morton, the British science writer, construction of enough new nuclear capacity to supply 10 percent of the needed GHG-free energy by 2050 – 2 terawatts[28] – equates to building a new nuclear unit every week for the next 40 years. That's 50 per year, which is somewhat more than the current rate of about five per year.[29]

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From a cost perspective, Generation III nuclear units may be built for a cost ''comparable to or slightly higher than those of modern coal or natural gas'' units.[30] Carbon prices or high fossil fuel prices should make Generation III nuclear units even more attractive, cost-wise. The main cost (and therefore financing) uncertainty is a function of two unknowns: (1) whether the combined operating license (COL) procedure really will eliminate litigation risk and the attendant licensing delays, and (2) whether, in light of the fact that there have been no new U.S. nuclear units built since the 1980s, we have the construction industry resources and the human infrastructure to build Generation III units on time and on budget. Until these risks are substantially lowered, governmental support of new nuclear will be necessary.[31] Development of nuclear power generation needs to, and will, expand, but not rapidly enough unless we streamline licensing processes, develop enhanced construction resources, and invest in the necessary human infrastructure, as outlined below. Otherwise, nuclear won't ''cover anywhere near'' the increase in demand for electricity in the next 15 years.[32]

1. Streamline licensing processes

The COL procedure[33] remains untested. Clearly intended to eliminate regulatory uncertainty associated with licensing of new reactors, the extent to which the new COL procedures (including the inspections, tests, analyses, and acceptance criteria, or ITAAC) and the required NEPA review are immune from, or even resistant to, intervenor litigation attack and consequent licensing delay is an unknown. Environmental

 1040-6190/$–see front matter doi:/10.1016/j.tej.2009.09.007

contentions have been among the easiest to raise, rarely require technical expertise or significant financial resources, and are difficult to dismiss. All of this has meant asymmetrical power for intervenors at this stage of the hearing process. So, until the first half dozen COL applications have been prosecuted through to completion (issuance of an operating license), licensing delay will remain an uncertainty for providers of equity and debt capital. Continued effort on the part of the NRC to streamline and standardize the licensing process – consistent with safety and reliability considerations – is needed. Deviations from approved designs should be discouraged – or even outright prohibited – if the effect would be to introduce uncertainty as to the fact or timing of licensure.

2. *Develop enhanced construction resources*

The U.S. engineering and construction industry needs to break out of its historical boom-bust cycle, become willing to stick to realistic pricing during times when business is bad (*i.e.*, periods of intense competition), and commit to the delivery of jobs on time and on budget without resorting to the usual large-scale horse-trading of claims at completion. Without this, owners (whether utility or merchant) and their financing providers will find new nuclear reactors difficult, or impossible, undertakings. While some price contingencies are inevitable and manageable, large uncertainties in total delivered cost will simply, in many situations, render projects unfinanceable. This will require a new level of enhanced owner-contractor attention and cooperation during the construction phase of the first four-to-six new reactors. And until owners and contractors demonstrate that new reactors can be delivered within the up-front estimate of their cost (and are thus capable of delivering MWh at the up-front estimated cost – important for both merchant and utility units), financing without the support of government guarantees is going to be tough, to say the least.

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3. *Invest in the necessary human infrastructure*

Standardized design will certainly help. But a new generation of design, engineering, construction management, and craft labor professionals, just to name a few, will need to be identified, educated, and trained (or re-trained). There will be plenty of good-paying engineering and construction jobs, likely for decades, if we are to even make a dent in our dependence on fossil fuels for powering our baseload units. And there will be ripple effects through the job markets. University professors capable of teaching nuclear engineering, technical school instructors capable of imparting field skills, like welding, with the degree of competence and repeatability that passes nuclear plant QA/QC muster, and teachers of cost accounting, just to name a few, will all see an enormous uptick in demand. The next generation of nuclear plant construction could have a substantial effect on U.S. employment statistics. And that ignores the potential for employment of U.S. engineering and construction personnel at nuclear plants being constructed in India and China and in other global locations.

B. Firm. U.S. electricity demand, though down in 2009, is forecast by the North American Electric Reliability Corporation (NERC) to increase nearly 20 percent by 2020. In contrast, the nation's transmission grid[34] capacity is projected to increase by less than half the forecast increase in demand,[35] for a variety of reasons, not the least of which is the fact that more than 3,000 different utilities exercise decision-making authority over transmission system facilities and service, including investor-owned utilities, federal, state, and municipal government agencies, rural electric cooperatives, and independent transmission companies.

Renewable sources of electric energy – particularly wind and solar – will contribute even

 1040-6190/$–see front matter doi:/10.1016/j.tej.2009.09.007

more to an increase in green generation once a carbon cap or tax is instituted. These resources, unfortunately, are not located in, or even near, load centers. In fact, the opposite is true. The best locations for solar and wind generation are in the remote Upper Midwest and Southwest. The existing transmission system was not designed to transmit large quantities of electricity over the long distances from these remote areas to urban loads.

Accordingly, investments in new transmission capacity and technologies will be essential to transport wind- and solar-generated electricity from resource-rich locations to the centers of heaviest demand, a necessary step before wind and solar power can become economically competitive on a large scale.[36] Building new transmission capacity poses difficult siting and cost allocation issues, and the intermittent nature of wind and solar generation might make it more difficult to economically justify the building of new, high-voltage transmission capacity solely for renewable energy. That being said, one knowledgeable consultant says the bottom line is simple: ''If we want renewables, let's support transmission: siting, cost allocation, and regional planning in support of it.''[37]

And President Obama's on board: ''We'll fund a better, smarter electricity grid and train workers to build it – a grid that will help us ship wind and solar power from one end of this country to another. Think about it. The grid that powers the tools of modern life – computers, appliances, even BlackBerrys.''[38]

The cost to modernize the U.S. electric grid and make it ''smart'' to enable the integration of intermittent energy sources like solar and wind could be very significant. Former Vice President Gore's Alliance for Climate Protection set the cost of updating grid infrastructure over the next 10 years at $400 billion.[39] That's more than $1,000 for every American.

Modernizing the grid to deliver energy from solar and wind resources to loads, and to reduce the intermittency of these generating resources, is not without substantial cost.

More data points: American Electric Power and the American Wind Energy Association recently collaborated on a study analyzing transmission needs associated with allowing wind energy to supply 20 percent of the nation's electricity needs by 2030.[40] According to the study, approximately 19,000 miles of extra-high-voltage (765 kV) lines would provide a robust interstate overlay grid to accomplish this goal at a cost of about $60 billion.[41] To put this into perspective, current estimates suggest that the utility industry will invest about $31.5 billion in transmission facilities from 2007 to 2010.[42] More recently, the U.S. Eastern Interconnection's Joint Coordinated System Plan 2008 projected $80 billion of needed transmission investments to support a 20 percent wind energy scenario in the U.S. Eastern Interconnection, excluding Florida, against a base (5 percent wind) case of $50 billion of investment, all by 2024.[43]

All of this underscores the fact that modernizing the grid to deliver energy from solar and wind resources to loads, and to reduce the intermittency of (*i.e.*, firm up) these generating resources, is not without substantial cost. And this doesn't count, *e.g.*, the $650 billion that the Joint Coordinated System Plan 2008 says will be needed to build new wind capacity between now and 2024 to achieve the 20 percent wind scenario in the Eastern Interconnection.[44]

C. Cheap. Power is not going to be cheap. Old paradigms of long-term delivered cost being predominantly a function of the cost of fuel go away. Meeting baseline energy demand over the next 20 years is estimated to require $3 trillion of investment in hydrocarbon (coal, oil, and gas) production.[45] Doing so with clean technologies that produce no (or lower) GHGs will require a lot more than that. Infrastructure (*i.e.*, capital) and carbon costs[46] are going to be significant going forward, raising the cost of clean electricity. For example, the IEA estimates that it will cost roughly

 1040-6190/$–see front matter doi:/10.1016/j.tej.2009.09.007

$45 trillion to cut GHGs in half by 2050 and thereby hold expected warming below the 2 °C target.[47] In a June 12, 2009, letter, the Congressional Budget Office estimated that the cost to achieve a hypothetical 15 percent reduction in domestic CO_2 emissions would be $1,600 per year for the average household.[48] That's around $160 billion – per year, which is about $7 trillion through 2050. The National Intelligence Council has said that by 2025 ''the most likely occurrence [in the energy space] is a technological break-through that will provide an alternative to oil and natural gas, but implementation will lag because of necessary infrastructure costs.''[49] Hope springs eternal.

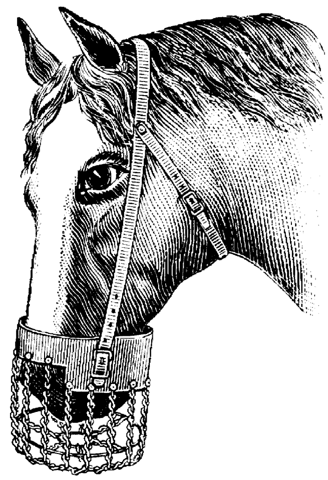
II. Conclusion

If we want our electricity clean, we have to solve the carbon problem, which means phasing out global reliance on coal-fired generation. Global limits on CO_2 emissions, whether imposed by direct tax, cap and trade, or otherwise, are necessary, they are necessary now, and they will have a cost.

If we want it firm, we have to solve the locational problem for renewables. That means investment in grid infrastructure and technology, and that will have a cost.

If we want it cheap, we will have to solve the demand problem, which is not likely solvable given global demographics. Efforts to address inevitable demand growth, whether by increasing efficiencies or building more capacity or both, will have a cost.

So, even though we want electricity clean, firm, and cheap, we are going to have to pick two, which means conceding one. No rational argument can be made against clean, *i.e.*, for ignoring our intergenerational responsibility for stewardship of the environment. Firm energy is the foundation for



economic growth, not to mention the hallmark of the developed world. That leaves cheap as the loser. It reminds me of Jim Steinman's great lyric, ''Two Out of Three Ain't Bad.'' And in this case it's probably quite good.■

Endnotes:

1. Just as the industrialized world's addiction to energy from hydrocarbons is rapidly damaging the atmosphere, the state of the world's water resources is being similarly affected by ill-advised, even reckless, behavior. For a sobering introduction, *see* FRED PEARCE, WHEN THE RIVERS RUN DRY: WATER – THE DEFINING CRISIS OF THE TWENTY-FIRST CENTURY (Beacon, 2006). Today, according to the U.S. National Intelligence Council, 21 countries with a combined population of 600 million are cropland- or freshwater-scarce. Just 15 years from now, 36 countries and 1.4 billion people will be in this category. U.S. National Intelligence Council, *Global Trends 2025: A Transformed World*, Nov. 2008 (''Global Trends 2025''), at 51.

2. *See ''Ike's Growing Toll: When the Lights Go Out, What Does It Cost Us?''* HOUSTON CHRONICLE, Oct. 5, 2008, at A1, at http://www.chron.com/CDA/archives/archive.mpl?id=2008_4645620; *TNMO Completes Power Restoration After Hurricane Ike*, Thomson Reuters, Sept. 28, 2008, at http://www.reuters.com/article/pressRelease/idUS14956+28-Sep-2008+PRN20080928.

3. Energy Information Administration, *International Energy Outlook 2009*, May 27, 2009, at 64.

4. Actually, it's probably *vice versa*. Demand decline is really a function of depressed global economic activity.

5. Reported by IEA at Group of Eight meeting in Rome, May 24, 2009 (as reported in INT'L. BUSINESS TIMES, May 22, 2009, at http://www.ibtimes.com/articles/20090522/iea-forecasts-first-electricity-use-decline-since-1945.htm).

6. Genscape, Inc.'s Quarterly Review and Outlook, July 6, 2009 (as reported by GAS DAILY, July 7, 2009, at 3).

7. Global Trends 2025, at 8. The World Bank defines middle class as those with $4,000–17,000 of annual income.

8. Goldman Sachs, *The Expanding Middle: The Exploding World Middle Class and Falling Global Inequality*, July 7, 2008, at 5, 10. The study defines middle class as those with $6,000–30,000 of annual income.

9. EIA, *supra* note 3, at 63.

10. Global Trends 2025, at 41.

11. *Id.* at iv. By 2025, India will grow by 240 million and China by 100 million, each reaching about 1.4 billion people, and totaling more than one-third of the global population. *Id.* at 19.

12. CO_2e is a measure of all greenhouse gases (such as CO_2, methane, and nitrous oxides) on a CO_2-equivalent basis.

13. Carter F. Bales, *Countdown to Climate Disaster*, 2009 (''Bales''), at 3–4. ''To put the root cause of climate change in graspable terms, the average per-

person CO_2e emissions rate for 2007 is 20 tons in the United States; in Europe, 10 tons; and in India, 2.2 tons. The global rate must be reduced to India's current level if we are to avert disruptive climate change. But even if the world rate were reduced to India's rates, the increase in world population alone – from, say, 6.5 to 9.5 billion by 2050 – would contribute approximately 7 Gt of CO_2e to the atmosphere.'' *Id*.

14. Global Trends 2025, at 41.

15. United Nations Dept. of Economic & Social Affairs, *World Economic and Social Survey 2009 Promoting Development, Saving the Planet*, June 2009 (hereinafter, ''WESS 2009'').

16. *Id*. at 42.

17. Carter F. Bales and Richard D. Duke, *Containing Climate Change: An Opportunity for U.S. Leadership*, FOREIGN AFFAIRS, Sept./Oct. 2008 (''Bales and Duke''), at 79.

18. 26 U.S.C. § 48 (2008).

19. U.S. Dept. of Energy, *2008 Wind Technologies Market Report* (July 2009), at 6.

20. *Id*. at 3.

21. *Id*. at ii.

22. *Id*. at 9.

23. U.S. Dept. of Energy, *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply*, July 2008.

24. Business Roundtable, *The Balancing Act: Climate Change, Energy Security and the U.S. Economy*, June 2009 (''BR''), at 32.

25. *Id*.

26. *Id*. at 32–33.

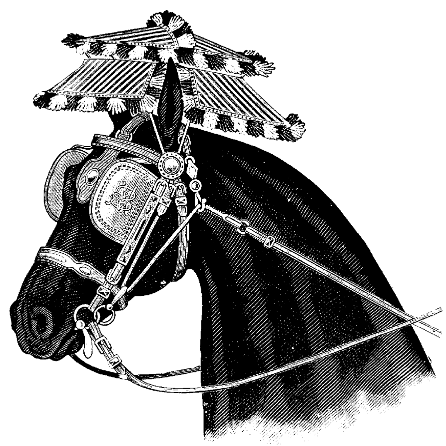
27. *See* Sen. Lamar Alexander, Speech at the National Press Club, July 13, 2009; *see also Bennett: U.S. Needs 100 More Nuclear Power Plants*, SALT LAKE TRIBUNE, June 22, 2009, at http://www.sltrib.com/news/ci_12666571.

28. 20,000 GW, or 2,000 new 1,000 MW reactors.

29. Oliver Morton, as quoted by Gideon Rachman, *Climate Activists Are Also in Denial*, FINANCIAL TIMES, July 28, 2009, at 7.

30. BR, at 34.

31. *Id*. at 37. The Business Roundtable advocates increasing the current DOE loan guarantee program from $18.5 billion to $100 billion. And that elevated amount should remain available to the industry on a revolving basis to support a long-term program of development of Generation III reactors. In addition, the Business Roundtable also correctly points out that there must be a ''credible federal program outside of DOE for long-term management of



nuclear waste.'' *Id*. at 39. The development of reprocessing technologies is essential, along with facilities for medium-term and permanent storage. *Id*. at 40.

32. Global Trends 2025, at 45.

33. 10 C.F.R. § 52 (2007).

34. The grid consists of more than 300,000 miles of transmission lines connecting over 9,200 electric generating units, with more than 950,000 MW of generating capacity. Congressional Research Service, Smart Grid Provisions in H.R. 6, 110th Congress, updated Dec. 20, 2007, at 1.

35. Bales, at 6.

36. BR, at 23.

37. Susan F. Tierney, presentation at Utilities Commissioners – Wall Street Dialogue, June 4, 2009.

38. President Barack Obama, address to members of the DOE, Feb. 5, 2009.

39. Bales, at 18.

40. Hearing before the United States Senate Committee on Energy & Natural Resources, S. Hrg. 110-598 (Jul. 31, 2008), testimony of American Electric Power President Susan Tomasky, at 84.

41. *Id*. at 113.

42. *Id*. at 83.

43. Joint Coordinated System Plan 2008: Executive Summary (2008), at 9.

44. *Id*. at 6.

45. Global Trends 2025, at 44.

46. Controlling carbon will have some positive economic side effects. Carbon trading could easily become the world's largest futures market. CFTC Commissioner Bart Chilton recently estimated that the market could reach $2 billion, or 60–180 million contracts traded annually. To put that in context, in 2008, Light Sweet Crude Oil traded 135 million contracts on the NYMEX, Natural Gas 30 million and all metals combined, 53 million. Bart Chilton, speech before Chicago Climate Exchange & Chicago Climate Futures Exchange, June 11, 2009.

47. Bales and Duke, at 81. This estimate is consistent with recent U.N. Dept. of Economic & Social Affairs thinking. According to the *World Economic and Social Survey 2009*, current investments in the global energy system are about $500 billion per year, and that would need to be doubled in order to broadly employ non-carbon-based resources to achieve the 2 °C scenario by 2050. WESS 2009, at xiii.

48. Letter from CBO Director Douglas W. Elmendorf to Sen. John F. Kerry, June 12, 2009. Other estimates range from $125 to $3,100 in annual household costs. The Business Roundtable's estimate is $800–1,500 per year (in 2008 dollars), or 0.7–1.2 percent of average annual household consumption, over the 2010–50 period. BR, at vi. At the other end of the spectrum is McKinsey & Co.'s recent study suggesting the cost of reducing U.S. emissions by nearly 30 percent by 2030 could be close to zero if certain federal policies are implemented. McKinsey & Co., *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?* Dec. 2007, at ix.

49. Global Trends 2025, at 46.

 , doi:/10.1016/j.tej.2009.09.007