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PLUGGING CARS INTO THE GRID: WHY THE GOVERNMENT SHOULD MAKE A CHOICE

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Synopsis: Modern American life is premised on the assumption that inexpensive oil will be available forever to fuel our transportation system. The vehicles we drive, the jobs at which we work, and even the structure of our communities all depend on reliable supplies of affordable oil. Yet growing worldwide demand for oil and tightening supplies strongly suggest that the days of cheap, plentiful oil are over. Because we consume so much oil, which is so highly valued and for which we have virtually no substitutes in the short-term, the price volatility in the world oil market inflicts significant economic damage on the United States, with nearly every recession over the past forty years being preceded by or occurring concomitant with an oil price spike. Our dependence on oil has been equally damaging beyond our shores, constraining our conduct of foreign policy and placing significant operational demands on our military.

Oil price volatility is a result of highly inelastic short-term demand, geopolitical instability in oil producing nations, inadequate investment in production capacity, and surging demand in emerging market nations. It is exacerbated by a classic market failure—oligopolistic behavior by nations participating in an oil producers' cartel. Unfortunately, traditional antitrust remedies are not available because the conspirators are sovereign nations.

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Unable to address the supply side of the problem, we are left to examine the demand side of the equation.

In order to escape the economic consequences of oil price volatility, consequences that are quite severe, it is necessary to electrify the short-haul transportation system. Electrification offers at least six advantages over the status quo: using electricity promotes fuel diversity; electricity is generated from a domestic portfolio of fuels; electricity prices are less volatile than oil and gasoline prices; using electricity is more efficient and has a better emissions profile than gasoline; using electricity will facilitate reduction of greenhouse gas emissions; and electricity is a low-cost alternative. We also observe that electricity is superior to other practical alternatives to petroleum to fuel the short-haul transportation system—natural gas, hydrogen, and biofuels—for many reasons, both economic and scientific. Accordingly, the government should implement policies to actively promote the development and deployment of technology to electrify the short-haul transportation system as part of an effort to reduce the economy's petroleum intensity.

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I. INTRODUCTION: THE AMERICAN OIL ECONOMY

For over a century, plentiful cheap energy has driven American economic growth. In one sense, this does not differentiate our nation from almost any other in modern economic history. Since the early days of the Industrial Revolution, economic growth has been yoked to energy demand growth. As economic activity increases, including everything from manufacturing and agriculture to service delivery and consumption, the need for energy increases as well. After all, at its most basic level, energy is simply the ability to do work. And economic growth does not come without work.

Yet the United States is a special case. In 2006, Americans consumed on average 335 million British thermal units (BTUs) of energy, as compared to per capita energy consumption of 181 million BTUs in France, 177 million BTUs in Germany, 56 million BTUs in China, and 16 million BTUs in India.¹ The United States is responsible for twenty-three percent of the world's daily oil consumption, twenty-two percent of daily natural gas consumption and seventeen percent of daily coal consumption.² Of every 100 kilowatt hours of electricity generated each day in the world, twenty-three percent are generated in the United States.³ Our cities, our culture and our society were built on the assumption that energy—and the fuel to make it—would be practically limitless and indefinitely cheap. And for the most part, we continue to live that way today. This is particularly true in the case of petroleum.

Since 1908, when the first mass-produced Model Ts began rolling off of Henry Ford's assembly line at the Piquette Plant in Detroit, Michigan, Americans have enjoyed one of the most mobile, flexible, and prosperous societies in the world. It is often noted that Ford's great vision was to make owning a car more than just a novelty or status symbol. To be sure, the assembly line rapidly reduced production costs and opened the vehicle market to a broad cross-section of American society. It is less widely known that Ford's gasoline-propelled design emerged victorious over both steam and electricity in a

1. United States Department of Energy (DOE), Energy Information Administration (EIA), *World Per Capita Total Primary Energy Consumption* (2006), available at www.eia.doe.gov/emeu/international/energyconsumption.html (hyperlink "All Countries, 1980-2006 for the International Energy Annual 2006).

2. BP Statistical Review of World Energy 2009, at 41 (2009), available at www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/2009_downloads/statistical_review_of_world_energy_full_report_2009.pdf.

3. DOE, EIA, *World Total Net Electricity Generation, 1980-2006*, at Tbl. 6 (2006), available at www.eia.doe.gov/pub/international/iealf/table63.xls.

heated competition for how best to fuel motor cars.⁴ Whatever initial hesitations Ford may have had, his instincts were quickly proven right. Just as transportation was being revolutionized in the United States, the global market for oil was undergoing its own revolution.

By 1900, U.S. oil production had been ongoing for more than forty years, with “rock oil” largely used as a feedstock to produce kerosene for illumination. Early discoveries in Pennsylvania and Ohio launched the industry in America, and major commercial discoveries near the Caspian Sea in modern-day Azerbaijan (then Russia) and East Asia began to globalize competition shortly thereafter. It was in the early 1900s that many Americans got their first glimpse of the modern oil industry. In 1901, the gusher at Spindletop previewed the prolific future of Texas oil production, and soon thereafter prospectors discovered oil in California, Oklahoma, and Louisiana. At the turn of the century, annual U.S. oil production was roughly 63.6 million barrels.⁵ By 1905, it had more than doubled to 138 million barrels.⁶

The exponential growth of the oil industry laid the groundwork for what would eventually become its most reliable customers—transportation in general, and the internal combustion engine in particular. In the United States, vehicle registration rose from 8,000 in 1900 to 944,000 in 1912.⁷ In 1913, William Meriam Burton invented thermal cracking, a process that significantly increased the potential gasoline yield of crude oil from fifteen percent to forty-five percent.⁸ By 1929, there were more than 23 million vehicles registered in the United States, and more than 140,000 drive-in gasoline stations provided easy access to gasoline.⁹

Over the decades that followed, vehicle ownership soared ever higher as Americans endeavored to move away from overcrowded urban environments to enjoy the benefits of cleaner, less dense suburbs. Passage of the Servicemen’s Readjustment Act of 1944¹⁰—commonly known as the G.I. Bill of Rights—accelerated the growth of the suburbs (and the need for automobiles), with the Veterans Administration backing nearly 2.4 million home loans for World War II veterans between 1944 and 1952.¹¹ Then, beginning in the 1950s, the federal government built a national highway system¹² and Americans began to hit the roads en masse every summer to explore the vast nation. As of 2007, there were 844 vehicles for every 1,000 people in the United States compared to 426 in the

4. JILL JONNES, *EMPIRES OF LIGHT: EDISON, TESLA, WESTINGHOUSE, AND THE RACE TO ELECTRIFY THE WORLD* 352 (Random House, Inc. 2004) (2003).

5. DOE, EIA, *Petroleum Navigator*, <http://tonto.eia.doe.gov/dnav/pet/hist/mcrfpus1a.htm>, (last visited Sept. 16, 2009).

6. *Id.*

7. United States Department of Commerce, Bureau of the Census, Statistical Abstract of the United States (2009), available at www.allcountries.org/uscensus/1027_motor_vehicle_registrations.html.

8. DANIEL YERGIN, *THE PRIZE: THE EPIC QUEST FOR OIL, MONEY AND POWER* 95 (Simon and Schuster 2008) (1991).

9. *Id.* at 191-92.

10. Servicemen’s Readjustment Act, Pub. L. No. 78-346, 58 Stat. 284 (1944).

11. United States Dep’t of Veterans Affairs, *GI-Bill History, Born of Controversy: The GI Bill of Rights*, available at www.gibill.va.gov/GI_Bill_Info/history.htm (last visited Sept. 15, 2009).

12. National Interstate and Defense Highways Act, Pub. L. No. 84-627, 70 Stat. 374 (1956).

United Kingdom, 543 in Japan, and thirty in China.¹³ It is not surprising, therefore, that there are few recurring phenomena that influence global petroleum prices more heavily than the so-called “summer driving season” in the United States.¹⁴

To be sure, there were bumps along the road as the American oil economy expanded in size and scope. Most notably, the 1970s ushered in the rise of the Organization of the Petroleum Exporting Countries’ (OPEC) power, the Arab Oil Embargo, and the Iran-Iraq War. These geopolitical disruptions resulted in skyrocketing oil prices, and initial public policy responses in the United States often only served to exacerbate problems. Gas lines, rationing, stagflation, and “turning down the thermostat” were defining aspects of the 1970s that seemed to significantly—if not permanently—alter views about oil consumption, both in the halls of government and around the country.

The Energy Policy and Conservation Act of 1975 mandated an improvement in the efficiency of the American automotive fleet.¹⁵ And the Fuel Use Act of 1978 was primarily responsible for reducing petroleum use in the electric power sector from fifteen percent in 1975 to four percent in 1985.¹⁶ All told, the petroleum intensity of the U.S. economy fell by thirty-five percent between 1973 and 1985. Between 1973 and 1995, the difference was forty-five percent.¹⁷ But only a few years later, it was easy for most Americans to view the events of the 1970s as one-off perturbations. Disagreements among OPEC members led to an oil price collapse by 1985.¹⁸ Crude oil was discovered in Prudhoe Bay and the North Sea, adding a much-needed boost to global oil supplies and placing further downward pressure on prices.¹⁹

With lower prices and new discoveries, oil market volatility posed a minimal threat in most American’s minds by the end of the 1980s. Efforts to increase efficiency fell by the wayside.²⁰ And with oil prices at such low levels, most international oil companies scaled back their investments in developing new reserves, believing such efforts to be unprofitable in the short-term.^{21, 22} In

13. DOE, Office of Energy Efficiency and Renewable Energy (EERE), Vehicles Technology Program, *Changes in Vehicles per Capita Around the World* (June 29, 2009), available at www1.eere.energy.gov/vehiclesandfuels/facts/2009_fotw577.html.

14. DOE, EIA, *A Primer on Gasoline Prices*, at 2 (2006), available at www.eia.doe.gov/bookshelf/brochures/gasolinepricesprimer.

15. Energy Policy and Conservation Act, Pub. L. No. 94-163, 89 Stat. 871 § 301 (1975) (codified at 15 U.S.C. §§ 2001-12 (1975)).

16. DOE, EIA, *Annual Energy Review 2008*, at 230 (2009), available at www.eia.doe.gov/emeu/aer/pdf/pages/sec8_8.pdf [hereinafter, *Annual Energy Review 2008*].

17. Calculated by authors based on data from BP Statistical Review of World Energy 2009, Historical Data, www.bp.com/productlanding.do?categoryId=6929&contentId=7044622 (last visited Aug. 30, 2009); U.S. Bureau of Economic Analysis, National Economic Accounts, Gross Domestic Product, www.bea.gov/national/xls/gdplev.xls (last visited Aug. 30, 2009).

18. DOE, EIA, *Petroleum Chronology of Events 1970-2000* (2002), available at www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/chronology/petroleumchronology2000.htm.

19. DOE, EIA, *Report on Alaska Prudhoe Bay Crude Oil Shut-In* (Aug. 2006), available at tonto.eia.doe.gov/oog/special/eia_sr_alaska.html.

20. *Id.*

21. Jamal Saghir, *Upstream Oil and Gas: Securing Supply*, at 2 (2008) (background paper for the Energy Dialogue to Respond to the Global Challenges, 11th International Energy Forum, April 20-22, 2008), available at http://sitesources.worldbank.org/intogmc/resources/saghir_securing_supply_background.pdf.

many ways, the 1990s served to reinforce these beliefs. Of course, there were a handful of bumps in the road. Although the Iraqi invasion of Kuwait in 1990 and resulting collapse of Iraqi production capacity significantly eroded OPEC spare production capacity for several years,²³ for most of the period between 1993 and 2002 global oil production capacity stayed well above global oil demand, and prices were generally low and stable.^{24, 25}

Change, however, was on the horizon. Many of the efficiency gains of the 1980s were reversed with the explosion in popularity in the United States of sport utility vehicles, whose viability was premised, in significant part, on the availability of cheap oil.²⁶ But the 1990s were perhaps the last decade of “easy oil.” By 2008, almost 100 years to the date after Ford introduced “the car that put America on wheels,” Americans were confronted with the possibility that there was a limit to the seemingly endless flow of oil that had for close to a century supported our mobile lifestyle.

Today, the U.S. economy is dangerously exposed to a global oil market whose fundamental characteristics will ensure that, at least through the medium-term, it is likely to be increasingly volatile and unstable. Growing demand for oil from the developing world, limited access to the reserves owned by national oil companies, the higher cost of production of those fields that are available to international oil companies, and the inevitable fact that at some point in the future, production of conventional oil will peak and be replaced by more expensive unconventional oil, all suggest that the threat posed to our economy by our dependence on oil will continue to grow over time.

The importance of the oil industry to the U.S. and global economies is beyond dispute. Globally, oil provides far more energy on a Btu basis than any other fuel and is forecast to maintain its dominance beyond 2030 (the farthest out that EIA makes forecasts).²⁷ Eight of the ten largest global companies are either oil companies or car companies.²⁸ The combined revenue of those companies in 2008 was \$2.6 trillion,²⁹ an amount that exceeds the GDP of all but the six largest economies in the world.³⁰

22. According to the IEA, most of the world’s current fleet of roughly 600 offshore oil and gas rigs were built between 1970 and 1985 as a result of high demand and high prices. In the 12 years after global oil prices collapsed in 1985, just 40 offshore vessels were constructed. IEA, *World Energy Outlook 2008*, at 320 (2008) available at <http://www.worldenergyoutlook.org/2008.asp> [hereinafter, *World Energy Outlook*].

23. *Annual Energy Review 2008*, *supra* note 18, at 315 (2008).

24. *Drowning in Oil*, at 19, THE ECONOMIST, March 4, 1999, available at http://www.economist.com/opinion/displaystory.cfm?story_id=188131.

25. Dr Nimat B. Abu Al-Soof, slide presentation at Offshore Technology Conference 2007, *The Role of OPEC Spare Capacity*, at slide 2, (2007), available at <http://www.opec.org/opecna/Speeches/2007/attachments/OPEC%20Spare%20Capacity.pdf>.

26. Oak Ridge Nat’l Lab., *Transportation Energy Data Book 2008*, at 3-5 (2008), available at <http://cta.ornl.gov/data/chapter3.shtml> (hyperlink “U.S. Cars and Trucks in Use, 1970-2007”).

27. DOE, EIA, *Annual Energy Outlook 2009, Updated Reference Case* (April 2009), available at www.eia.doe.gov/oiaf/servicert/stimulus/aeostim.html [hereinafter, *Annual Energy Outlook 2009*].

28. *Global 500: Our Annual Ranking of the World’s Largest Corporations*, FORTUNE, 2009, available at http://money.cnn.com/magazines/fortune/global500/2009/full_list/ (last visited Aug. 19, 2009).

29. *Id.*

30. The World Bank, World Development Indicators, *Gross Domestic Product 2008*, available at <http://siteresources.worldbank.org/DATASTATISTICS/Resources/GDP.pdf> (last visited Aug. 19, 2009).

In the five years from 2004 to 2008, U.S. oil consumption averaged 20.46 million barrels per day (mbd).³¹ In 2008, total transportation was responsible for sixty-nine percent of oil consumption,³² with light-duty vehicles (LDVs) representing 8.6 mbd of that demand.³³ Perhaps more illustrative, the transportation sector as a whole is today ninety-five percent reliant on petroleum products for delivered energy³⁴—with no substitutes available at scale. This extraordinary reliance on a single fuel to power an indispensable sector of our economy has exposed the United States to a significant vulnerability, both for our economy and for our national security.

In Section I of this paper, we summarize the history of our use of oil to fuel our transportation system, and characterize our use of oil relative to the size of the U.S. economy and the economy of other nations.

In Section II of this paper, we explain in detail the manner in which our dependence on oil affects our nation, particularly our economy and national security. Most people believe that the high price of foreign oil is the primary source of our vulnerability. We believe that this is incorrect. High prices are certainly harmful, but it is price volatility that has constituted a much greater threat to our economy over the past thirty-five years. Moreover, while importing oil certainly creates great challenges with respect to the trade deficit, challenges that may grow over time, the fact that the majority of the oil we consume is imported is far from our greatest vulnerability.

Section III of this paper evaluates the efficacy of the measures that we can take within the existing transportation paradigm to reduce our dependence on oil.

Section IV states the case for electrification. It explains that: using electricity promotes fuel diversity; electricity is generated from a domestic portfolio of fuels; electricity prices are less volatile than oil and gasoline prices; using electricity is more efficient and has a better emissions profile than gasoline; using electricity will facilitate a reduction in greenhouse gas emissions; and electricity is a low-cost alternative.

Finally, in Section V of this paper, we examine the viability of the primary alternatives to electrification—natural gas and hydrogen—and explain why electrification is superior to each. We then conclude in Sections VI and VII that transformative, effective public policy is necessary to accelerate the shift from petroleum to electricity.

II. THE EFFECTS OF OIL DEPENDENCE

A. *A Different Kind of Price Spike*

If the oil price spike of 2008 felt different from prior episodes of oil market volatility, it was for good reason. On July 3rd, when oil prices reached their inflation adjusted all-time high of more than \$147 per barrel,³⁵ it was not just a

31. BP Statistical Review of World Energy 2009, *supra* note 2, at 11.

32. *Annual Energy Review 2008*, *supra* note 18, at v.

33. *Annual Energy Outlook 2009*, *supra* note 32.

34. *Annual Energy Review 2008*, *supra* note 18, at v.

35. Rebecca Kebede, *Oil Hits Record Above \$147*, REUTERS, July 11, 2008, available at www.reuters.com/article/topNews/idUST14048520080711.

bump in the road. It was, instead, largely the result of a set of fundamental factors that increasingly appear inherent to the global oil market: rising demand for energy in developing countries, stagnant growth in OPEC oil production capacity, and increasingly complex and costly development outside of OPEC.

Between 2003 and 2008, oil prices climbed steadily—almost relentlessly—higher. Economic growth in developing countries like China and India added a new component to the world oil demand picture.³⁶ In total, world demand for oil increased by eleven percent between 2000 and 2008, but fully 100 percent of this growth occurred in non-Organisation for Economic Co-Operation and Development (OECD) countries.³⁷ In 2004 alone, Chinese oil demand increased by 16.7 percent, an unexpected and unprecedented great leap forward.³⁸

At the same time that demand was increasing, new oil supplies struggled to keep pace. Within OPEC, decades of underinvestment left total production capacity in 2008 at 34 mbd, slightly less than its 37 mbd level 35 years earlier in 1973.³⁹ This was true despite the fact that the cartel's proved reserves more than doubled between 1980 and 2008.⁴⁰ Outside of OPEC, oil supplies also struggled to grow, but for different reasons. In mature petroleum provinces like the United States, the United Kingdom, and Norway, new supplies became more geologically difficult and costly to access. In other high-potential regions like the Caspian Sea area, Latin America, and West Africa, a wide range of geopolitical factors combined to stymie investment.⁴¹

As a result of these factors, the global oil market operated with minimal spare capacity—less than three percent of daily demand—throughout most of the period from 2005 to 2008.⁴² In such a market environment, even small events around the world can have dramatic effects on oil prices. A hurricane in the Gulf of Mexico, violence in the Niger Delta, or an oil worker strike in Venezuela can lead to sudden and potentially calamitous swings in the price of oil as markets adjust their expectations about the supply-demand balance and about risks to future deliveries of crude oil.

36. Robert Pirog, *World Oil Demand and its Effect on Oil Prices*, at 8, 16, 17, 20, CONGRESSIONAL RESEARCH SERV. (2005), available at <http://www.fas.org/sgp/crs/misc/RL32530.pdf>.

37. BP Statistical Review of World Energy 2009, *supra* note 2, at 11.

38. *Id.*

39. M.A. Adelman, *Prospects for OPEC Capacity*, 23 ENERGY POLICY 3, 235-241 (1995), available at <http://www.sciencedirect.com/science/article/b6v2w-3ycmtvc-36/2/06684dc518bcd65fe97dab107292e7fe>; IEA, *Medium-Term Oil Market Report*, at 58 (June 2009), available at http://www.iea.org/textbase/speech/2009/Fyfe_mtomr2009_launch.pdf.

40. BP Statistical Review of World Energy 2009, Historical Data, Workbook, *Oil—Proved Reserves History*, available at www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/2009_downloads/statistical_review_of_world_energy_full_report_2009.xls.

41. See, e.g., IEA, Working Paper Series, *Perspectives on Caspian Oil and Gas Development* (Dec. 2008), available at www.iea.org/textbase/papers/2008/caspian_perspectives.pdf.

42. Spare production capacity is defined by the IEA as idle oil production capacity that could reasonably be brought online within 30 days. IEA, *Oil Market Report*, at 18 (Aug. 12, 2009), available at <http://omrpublic.iea.org/currentissues/full.pdf>. During normal market conditions, all spare capacity resides within OPEC member states. Spare capacity can alternatively be thought of as that amount of sustainable production capacity that exists in excess of OPEC's production quota at any point in time.

In 2003, real oil prices averaged \$33.75 per barrel.⁴³ The annual average price rose each year afterward, reaching \$75.14 in 2007 and \$97.26 in 2008.⁴⁴ By July 2008, oil prices reached a level that was simply unsustainable—the point of demand destruction. In general, oil consumption is highly inelastic, but only to a point. As gasoline prices soared past \$4.00 per gallon in the United States, household budgets fell apart.⁴⁵ In the third quarter of 2008, oil consumption was down more than 8.5 percent compared to the same period in 2007, the largest annual decline since the first quarter of 1980.⁴⁶ Consumer spending began to fall, business activity slowed, and the economy was shocked to a stall.

And yet, despite the current economic environment, the underlying factors that led to record oil prices in 2008 have not substantially altered. Demand growth for oil products—particularly in the industrialized world—has temporarily subsided, to be sure.⁴⁷ But this reduction is not the result of any fundamental change in technology, policy, or infrastructure. Rather, it is simply the result of reduced economic activity during the current downturn. As economic activity resumes, demand for all energy—including petroleum—will also increase, particularly in emerging economies that will continue to require high rates of economic growth to accommodate population growth and higher standards of living. Assuming no changes in government policies, by 2030, the International Energy Agency (IEA) expects that world demand for petroleum will increase by 21.2 mbd, or roughly twenty-five percent compared to 2007 levels.⁴⁸ Of this growth, fully 100 percent is forecast to occur in the developing world, with sixty-three percent expected in China and India alone.⁴⁹

On the supply side, the picture is also less than encouraging. In its 2008 World Energy Outlook, the IEA conducted a field-by-field analysis of 798 of the world's largest oil fields, which collectively account for three-quarters of all initial reserves ever discovered. Out of these initial reserves of 1,306 billion barrels, only 697 billion barrels remain. This latter figure, however, makes up seventy-nine percent of remaining conventional oil reserves. Five-hundred and eighty of the 798 fields are post-peak production and declining at a rate of 5.1 percent per year.⁵⁰ The report was careful to note that observed decline rates are

43. BP Statistical Review of World Energy 2009, Historical Data, *supra* note 39.

44. *Id.*

45. See, e.g., Jad Mouawad, *Gas Prices Soar, Posing a Threat to Family Budget*, N.Y. TIMES, Feb. 27, 2008, available at <http://www.nytimes.com/2008/02/27/business/27gas.html>; Rock Newman, *The Repercussions of \$4 Gas*, USNEWS.COM, Mar. 7, 2008, available at www.usnews.com/blogs/flowchart/2008/03/07/the-repercussions-of-4-gas.html; Richard S. Chang, *Fueling 1,000 Stories*, N.Y. TIMES, June 27, 2008, available at wheels.blogs.nytimes.com/2008/06/27/fueling-1000-stories/?scp=30&sq=gas%20prices%20%244%20budget&st=cse; John Branch, *At Small Tracks, High Fuel Prices Put Racers in a Pinch*, N.Y. TIMES, June 3, 2008, available at <http://www.nytimes.com/2008/06/03/sports/othersports/03fuel.html>.

46. DOE, EIA, Petroleum Navigator, *U.S. Product Supplied of Crude Oil and Petroleum Products*, available at tonto.eia.doe.gov/dnav/pet/hist/mtupus2m.htm (last visited Aug. 25, 2009).

47. *Annual Energy Review 2008*, *supra* note 18, at 152-57 (2009), available at <http://www.eia.doe.gov/emeu/aer/pdf/aer.pdf>.

48. *World Energy Outlook*, *supra* note 22, at 93 (2008).

49. *Id.* at 97.

50. According to the IEA, the average size of the fields analyzed was substantially larger than the global average, as the IEA data set includes all super-giant fields and the majority of the giant fields. Because decline rates tend to be lower in larger fields, IEA assumes that the global data set (which would include a much larger

affected by field maintenance and ongoing investment by oil producers. In the absence of such investment, the decline rate nearly doubled to nine percent per year—a figure which is expected to increase in the coming decades.⁵¹ In total, the IEA estimated that crude oil output from existing fields will decline from roughly 70 mbd in 2007 to just 27 mbd in 2030.⁵² In other words, the world's oil producers will need to add 64 mbd of *new* capacity (including unconventional fuels, biofuels, and natural gas liquids) between 2007 and 2030 to replace lost reserves and meet incremental demand growth from emerging markets.⁵³ All told, the IEA estimated that total upstream investment of at least \$5 trillion is required to meet oil demand over the next twenty years.⁵⁴

Initial evidence suggests that maintaining the current oil field investment pace will be a formidable challenge. Roughly eighty-eight percent of global oil and gas reserves are controlled by national oil companies (NOCs), which are typically accountable to central governments.⁵⁵ In countries like China, Iran, Venezuela, Mexico, Saudi Arabia and even Norway, the vast majority of revenue from oil and gas development is essentially incorporated into the national budget.⁵⁶ In some countries, particularly Norway, much of this revenue is carefully reinvested in oil and gas development for the future.⁵⁷ But for many governments with vast oil and gas reserves, production revenue from NOCs is diverted to finance social spending programs, with reduced shares being reinvested in oil and gas production.⁵⁸ The drawbacks and limitations to such an approach were made all the more obvious as oil prices fell from record highs to five-year lows in the closing months of 2008. Social spending promises made in mid-summer by many governments in oil-producing nations became much less viable with revenues reduced by as much as seventy percent by mid-autumn.⁵⁹

For international oil companies (IOCs), the investment challenge is somewhat different, though no less daunting. First, IOCs are typically restricted from accessing the most promising conventional reserves. For example, Saudi

share of smaller fields) has a significantly higher average decline rate. IEA calculates this figure to be 6.7 percent. *Id.* at 43.

51. *Id.* at 221, 244.

52. *Id.* at 255.

53. *Id.* at 250, 255.

54. *Id.* at 323, 324.

55. DOE, EIA, *Energy in Brief: Who Are the Major Players Supplying the World Oil Market?* (2009), available at tonto.eia.doe.gov/energy_in_brief/world_oil_market.cfm.

56. Ministry of Finance, Norway, *Budget 2009*, Oct. 7, 2008, available at www.statsbudsjetten.dep.no/upload/Statsbudsjett_2009/dokumenter/pdf/budget_2009.pdf; Erik Sperling, *Venezuela's National Assembly Approves 2009 Budget*, VENEZUELANALYSIS.COM, Dec. 13, 2008, available at www.venezuelanalysis.com/news/4037; United States Dep't of State, *Background Note: Saudi Arabia* (Jan. 2009), available at www.state.gov/r/pa/ei/bgn/3584.htm#econ (last visited Sept. 15, 2009).

57. The Norwegian Ministry of Foreign Affairs, *Norway, an Oil Nation*, available at www.norway.org.uk/policy/trade/oil/oil.htm (last visited Aug. 20, 2009).

58. See, e.g. International Monetary Fund, *Islamic Republic of Iran: Selected Issues*, at 36-44 (2008), available at <http://www.imf.org/external/pubs/ft/scr/2008/cr08285.pdf>.

59. Associated Foreign Press, *Iran's Oil Party Over, Economists Warn* (Oct. 23, 2008), available at http://afp.google.com/article/ALeqM5ieZwfY_AnXMWsH_g32jABqdDtv2Q; Juan Forero, *Lower Oil Prices Hurt Venezuela's Budget*, NATIONAL PUBLIC RADIO (Oct. 21, 2008), available at www.npr.org/templates/story/story.php?storyId=95924814 (last visited Sept. 15, 2009); Voice of America, *Cheap Oil May Spark Russian Budget Crisis*, (Dec. 15, 2008), available at <http://www.voanews.com/english/archive/2008-12/2008-12-15-voa55.cfm?moddate=2008-12-15>.

Arabia, home to twenty-one percent of the world's conventional proved oil reserves, generally does not grant access to IOCs for upstream oil projects⁶⁰—though a number of joint ventures exist for upstream natural gas production.⁶¹ Second, those oil reserves that are accessible to most IOCs are growing increasingly complex and costly to produce.⁶² In other words, in addition to the typical costs for pipelines, tankers, and refineries, IOCs must now invest significant additional capital per barrel of oil produced. The additional capital pays for new necessities, including specialized drilling equipment, oversized offshore platforms, and advanced upgrading facilities. As a result, the marginal cost of production for a barrel of non-OPEC oil has increased rapidly in recent years.⁶³ Currently, the break-even price for Canadian oil sands is estimated at between \$50 and \$80 per barrel.⁶⁴ For projects in the Gulf of Mexico, marginal costs are estimated to be \$60 per barrel.⁶⁵ Promising basins off the coast of Brazil and in the North Caspian near Kazakhstan are also complex and costly.⁶⁶

Finally, both private companies and NOCs investing in oil and gas projects must have access to capital and financing. Healthy debt and capital markets are typically a requirement for committing billions of dollars to long-term projects that will only pay off years in the future and only as long as oil prices remain stable. In 2009, as the financial crisis widened, the recession deepened and oil prices plummeted, the IEA estimated that 6.2 mbd of planned capacity additions had either been cancelled or postponed for more than eighteen months.⁶⁷ The IEA report further noted that 2009 upstream investment was at least twenty-one percent below 2008 levels.⁶⁸

Viewed as a whole, these various data points indicate that as world demand grows and supplies are constricted, medium-term and long-term oil prices will increase until meaningful substitutes are deployed. More importantly, prices can be expected to retain a substantial level of volatility as uncontrollable events around the world continue to rattle markets. Given U.S. dependence on petroleum, this volatility can be expected to exact a heavy toll on long run economic growth. To understand why, it is useful to examine the economic effects of oil dependence in greater detail.

60. *World Energy Outlook*, *supra* note 22, at 335-36.

61. See, e.g., Rig Zone, *SRAK Begins Drilling for Gas in Saudi Arabia's Empty Quarter* (Sept. 6, 2006), available at www.rigzone.com/news/article.asp?a_id=35885; DOE, EIA, *Country Analysis Briefs: Saudi Arabia*, at 12 (2008), available at http://www.eia.doe.gov/cabs/Saudi_Arabia/pdf.pdf.

62. *World Energy Outlook*, *supra* note 22, at 343-53; Bernstein Research, *Global Integrated Oils: Breaking Down the Cost Curves of the Majors, and Developing a Global Cost Curve for 2008*, at 14 - 34 (Feb. 2, 2009).

63. *Id.* at 34.

64. Jeffrey Jones, *UPDATE 1-Suncor CEO Says Oil Sands Profitable at \$50 Crude*, REUTERS, Apr. 1, 2009, available at www.reuters.com/article/mnaNewsEnergy/idUSN0133604420090401.

65. DOE, EIA, *Performance Profiles of Major Energy Producers 2007*, at 26 (Dec. 2008), available at www.eia.doe.gov/emeu/perpro/020607.pdf, (last visited Aug. 28, 2009).

66. See, e.g., Bernstein Research, *Global Integrated Oils: Kashagan – Better Late Than Never - Our Annual Update & Implications For The Owners* (Oct. 1, 2008).

67. IEA, *Impact of the Financial and Economic Crisis on Global Energy Investment*, at 3 (May 24-25 2009) (Background paper for the G8 Energy Ministerial Meeting), available at www.iea.org/Textbase/Papers/2009/G8_investment_ExecSum.pdf.

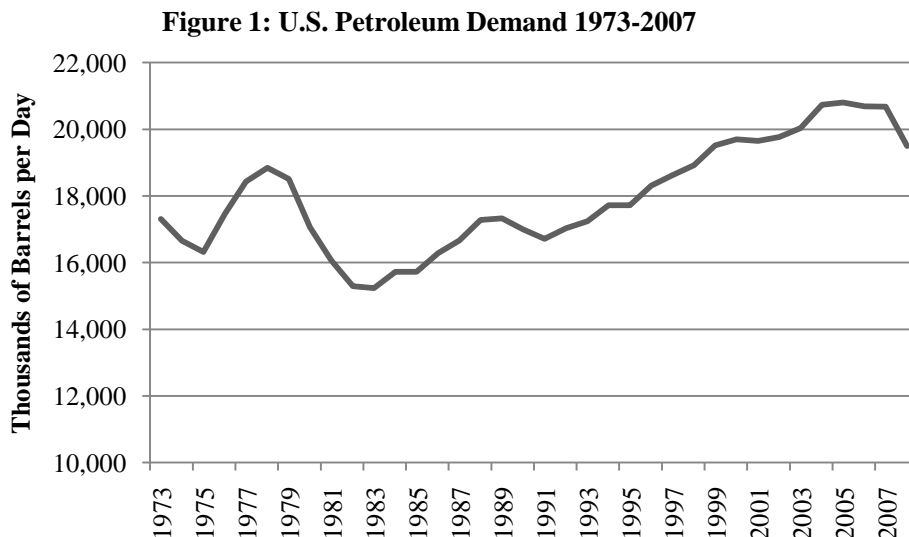
68. *Id.*

B. *The Characteristics of Oil That Underlie Its Economic Power*

We believe that the volatility of oil prices is the primary manner in which our dependence on oil threatens our economic and national security. Yet, if the price volatility occurred alone, it would not represent a more significant threat than that posed by our use of any other commodity. Instead, it is the combination of price volatility with three other characteristics that make our petroleum dependence unique: the volume of oil that we consume, the value of oil that we consume in any given time period, and the inelasticity of short-term demand for oil.

1. Volume of Oil Consumed

The United States consumed 19.5 mbd of oil in 2008,⁶⁹ twenty-three percent of global consumption.⁷⁰ As seen in Figure 1, for at least the past twenty-five years, the demand for oil has generally risen at a relatively steady rate, although it has fallen on a few occasions in response to sustained periods of high prices and recession (including the current one). It is possible that this long-term trend may change. The small decline in demand that resulted from the current recession, followed by stagnant demand as tightened fuel economy standards that were enacted in 2007 begin to affect average fuel economy in 2011, may mean that U.S. oil demand is finally nearing a peak.⁷¹ Nevertheless, even if U.S. oil consumption remains completely flat, we will still consume an enormous volume of oil.



69. DOE, EIA, International Petroleum Monthly, *World Oil Balance, 2005-2009*, Tbl 2.1 (July 2009), available at www.eia.doe.gov/emeu/ipstr/t21.xls.

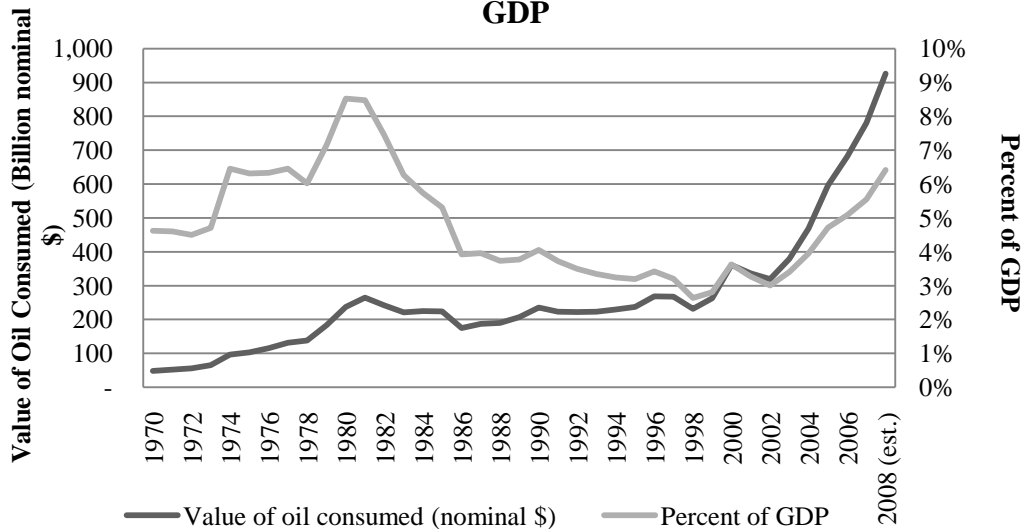
70. *Id.*

71. Energy Independence and Security Act (EISA), Pub. L. No. 110-140, 121 Stat. 1492 at § 102(b)(1)(A) (2007).

2. Value of Oil Consumed

The volume of oil that we consume might not be important in its own right except that oil is relatively expensive. The total value of oil consumed by the United States represents a significant portion of all economic activity in the nation. Even when oil prices are low, the value of our total consumption remains large. As seen in Figure 2, the value of oil and oil products consumed in the United States has ranged from \$48 billion to \$925 billion over the past three decades, representing between 2.6 and 8.5 percent of the GDP.⁷²

Figure 2: Value of Annual Oil Consumption and Percent of GDP



Demand for gasoline is highly inelastic in the short-term; the price of oil and gasoline can fluctuate significantly over periods of time that are too short for most people to adjust their consumption. There are few (if any) substitutes for oil, at least and especially in the short-term. Most consumers cannot simply stop using gasoline on short notice in response to rising prices. We intuitively understand that people still have to get to work and get children to school. While some consumers can make adjustments in the short-term by taking public transportation, combining trips, or simply reducing travel, much of the day-to-day driving we do is necessary, at least given the current structure of our communities and our current lifestyle. Simply stated, we have long established patterns of places to go, people to see, and things to do, and few people are going to move closer to public transport, take a new job, or buy a new, more efficient car simply in response to gas prices that rise by a \$1.50 per gallon. As damaging as such a price increase might be, the costs of those alternatives are generally greater, especially if the price spike is perceived by consumers to be transient, a perception that nearly always exists and has, thus far, always proven correct. Moreover, even when the alternative is superior when amortized over the

72. *Annual Energy Review 2008*, *supra* note 18, at 77 (2009); BEA, National Economic Accounts, available at www.bea.gov/national/index.htm#gdp (last visited Sept. 15 2009).

lifetime of, for example, a new car, people have great difficulty psychologically comparing the amortized daily cost of capital goods to daily expenditures.

Our intuitive understanding that the short-term demand for oil is relatively inelastic is confirmed by economic data. The short-term inelasticity of demand can be seen in Figures 3 and 4. Although demand for oil has responded to changes in price, the response is weak, indicating that price has a relatively small effect on demand, particularly in the price ranges that we have seen in recent years.

As depicted in Figure 3, from January 2007 through July 2008, the price of gasoline rose from \$2.38 per gallon to \$4.17 per gallon.⁷³ Yet during this time period, gasoline demand actually increased by 1.6 percent,⁷⁴ even though prices rose by seventy-five percent. Similarly, as depicted in Figure 4, from mid-February 1999 through September 2000 the price of gasoline rose from \$0.96 to \$1.58 per gallon.⁷⁵ Yet during that time period, gasoline demand remained essentially flat, averaging about 8.5 mbd.⁷⁶

These particular examples are supported by research at the Institute of Transportation Studies, University of California, Davis, which examined the short-term price and income elasticity of gasoline demand between 2001 and 2006. The researchers concluded that short-term demand was highly inelastic between 2001 and 2006, with the price elasticity of gasoline demand ranging from -0.034 to -0.077.⁷⁷ That means that if the price of gasoline doubled during that time period, demand would have fallen by between just 3.4 and 7.7 percent. Given the short-term inelasticity of demand for oil demonstrated both anecdotally and quantitatively, it is clear that when the price of oil moves sharply, it must affect disposable income and business budgets, with significant economic ramifications.⁷⁸

73. DOE, EIA, Petroleum Navigator, *Weekly U.S. All Grades, All Formulations Retail Gasoline Prices*, available at http://tonto.eia.doe.gov/dnav/pet/pet_sum_top.asp, (last visited Aug. 28, 2009) [hereinafter, *Petroleum Navigator*].

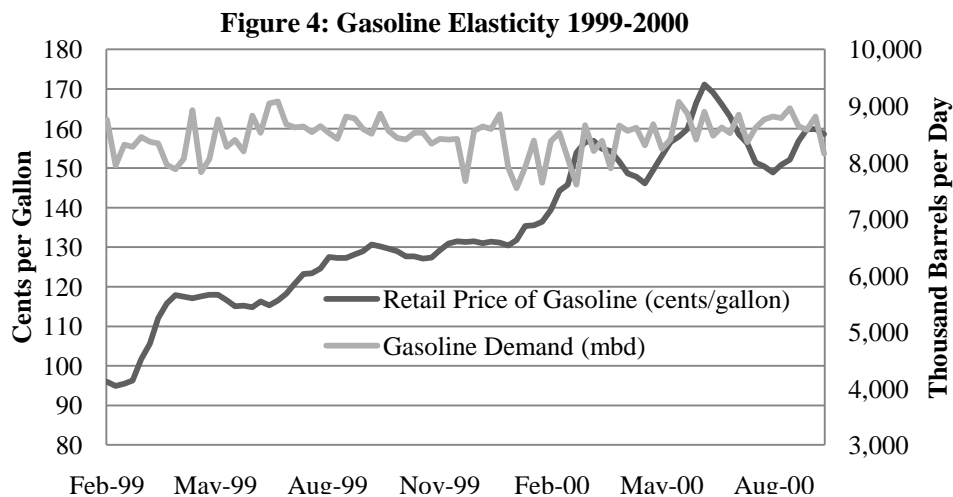
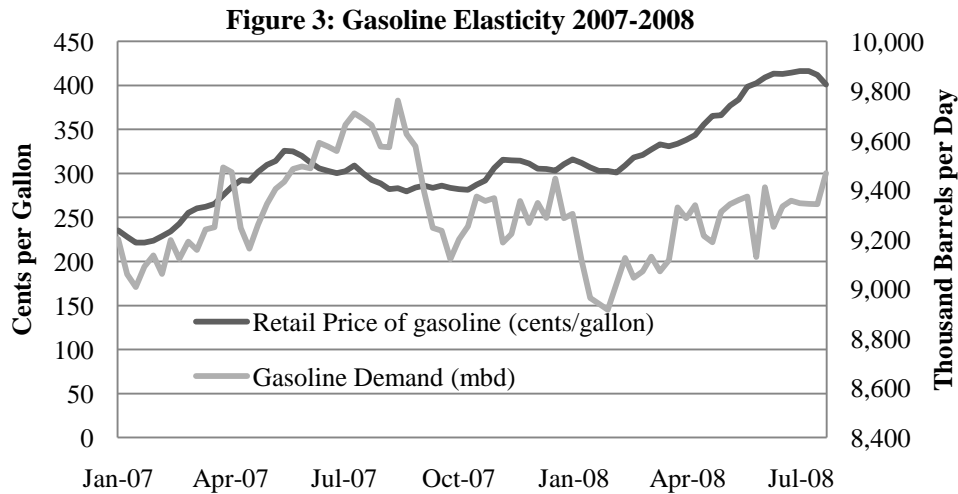
74. DOE, EIA, Petroleum Navigator, *Weekly U.S. Finished Motor Gasoline Product Supplied*, available at tonto.eia.doe.gov/dnav/pet/hist/wgfupus2w.htm, (last visited Aug. 28, 2009).

75. *Petroleum Navigator*, *supra* note 72.

76. *Id.*

77. Jonathan Hughes, et al., *Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand* (Feb. 14, 2007), available at www.econ.ucdavis.edu/faculty/knittel/papers/gas_demand_083006.pdf.

78. As part of the study, researchers also compared elasticities between 1975-1980 to those between 2001-2006. They concluded that not only was short-term demand price inelastic between 2001 and 2006, but that it was significantly more inelastic than during the earlier period, estimating that the price elasticity of gasoline demand for the period from 1975 to 1980 ranged from -0.21 and -0.34 while the price elasticity for the more recent period ranged from -0.034 to -0.077. *Id.*



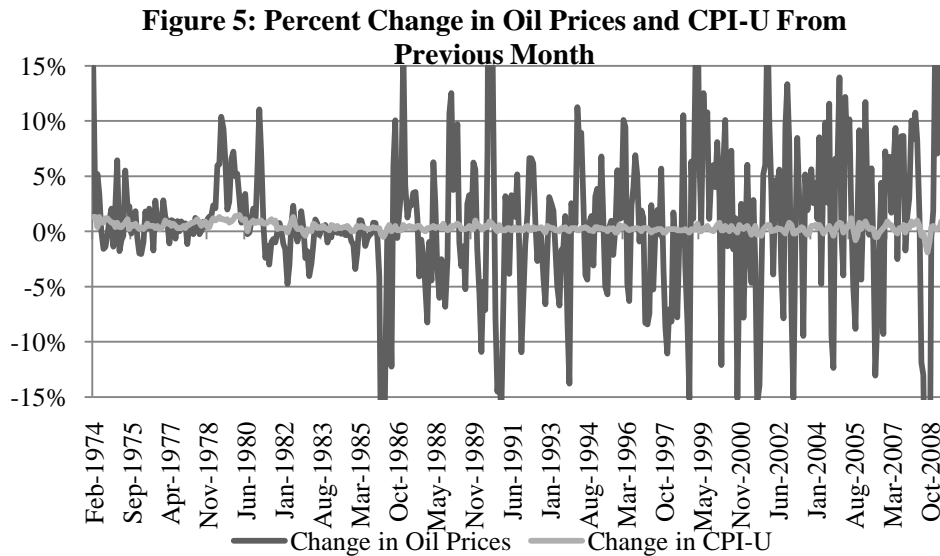
4. Oil Price Volatility

We intuitively know that the price of gasoline, the major component of which is the price of oil,⁷⁹ is highly volatile, as we have all seen the price of gasoline move sharply higher and sharply lower many times in recent years. Our intuition is supported by the facts, as demonstrated in Figures 5, 6, and 7 below. Figure 5 shows the percent change in the price of oil over the previous month. Since 1974, the average price of oil has either risen or fallen by more than ten percent from the previous month fifty-four times,⁸⁰ while over that same time period, the consumer price index has never risen or fallen by more than 1.9

79. This is certainly the case in the United States, but varies by region. In most of Europe for example, government taxes represent the largest component of retail gasoline prices, which contributes to lower overall gasoline price volatility.

80. See United States Dep't of Labor, Bureau of Labor Statistics, *Consumer Price Index Databases*, www.bls.gov/cpi/data.htm (last visited Sept. 15, 2009).

percent in a month (and has only risen or fallen by more than 1.5 percent in a month only once).⁸¹ Oil prices, then, are highly volatile relative to the economy overall. Figure 6 describes the percent change in the price of gasoline from week to week, showing that the price of gasoline has become increasingly volatile in recent years. That is further demonstrated in Figure 7, which plots the difference between the high and low price of gasoline over the previous fifty-two weeks.⁸² In fact, one recent study concluded that crude oil prices are currently more volatile than about sixty-five percent of other commodities, and more than ninety-five percent of products sold in the U.S. economy.⁸³



81. *Id.* (Authors' calculation based on data available at United States Department of Labor, Bureau of Labor Statistics, Consumer Price Index Databases).

82. DOE, EIA, *U.S. Gasoline and Diesel Retail Prices*, available at tonto.eia.doe.gov/dnav/pet/xls/PET_PRI_GND_DCUS_NUS_W.xls.

83. Eva Regnier, *Oil and Energy Price Volatility*, 29 *Energy Economics* 3, 405-427 (2007). See also Amanda Logan & Christian E. Weller, *Signals on the Fritz: Energy Price Volatility Impedes Investment by Creating Uncertainty*, CENTER FOR AMERICAN PROGRESS (June 2009), available at http://www.americanprogress.org/issues/2009/06/energy_price_volatility.html.

Figure 6: Percent Change in Price of Gasoline From Previous Week

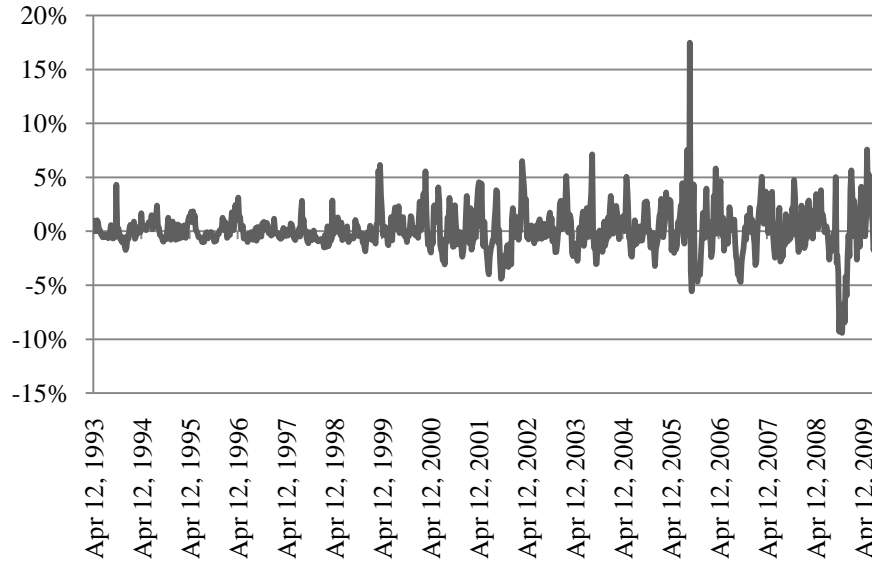
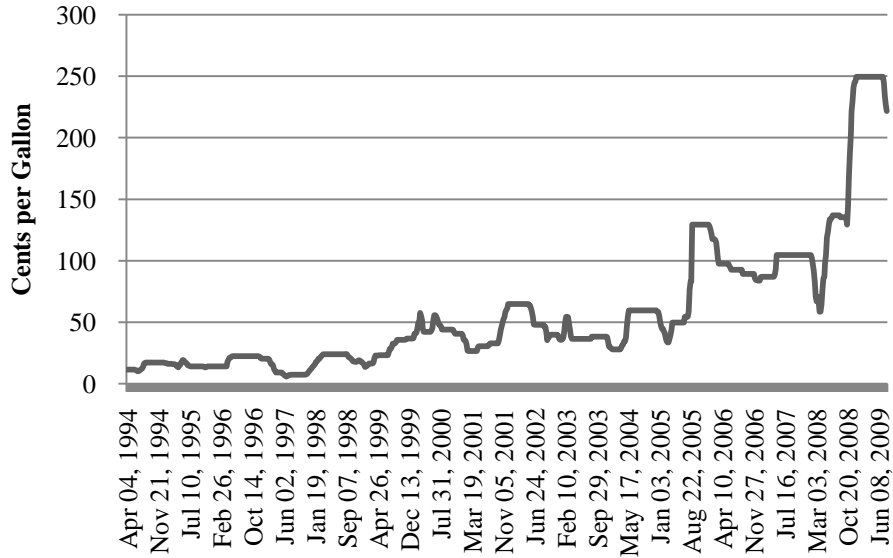


Figure 7: Difference Between Min and Max Gas Price Over Previous 52 Weeks



5. All Characteristics Are Equal, But Some Are More Equal Than Others

It is the unique combination of these four characteristics of our use of oil and the world oil market that creates economic vulnerability. If any three

characteristics existed without the fourth, then our vulnerability would be significantly reduced or perhaps eliminated. If, for example, the price of oil were high and volatile and demand were inelastic, but the volume we consumed were small, then the cumulative cost of a price spike would still be small relative to individual budgets or the overall economy. If we consumed a large volume, our demand were inelastic, and the price were volatile, but the price were also low, again the cumulative cost of a price spike would still be small, and would be unlikely to pose a meaningful threat to our economy. If prices were high and volatile, and we generally consumed a large volume, but our demand were elastic in the short-term, we would be able to quickly reduce demand, perhaps by substituting other products for oil. And, finally, if the price of oil were high, we consumed a large volume and our demand were inelastic, but the price were stable, we could adjust to higher prices over time. After all, there are components of our budgets and sectors of the economy that are larger than energy; it is simply that we have already planned for those higher expenses.

But though our dependence is a function of all four of these characteristics, we believe that the volatility of oil prices is a particularly damaging characteristic because it thwarts the possibility of a sustainable, market-driven effort to use oil more efficiently throughout our economy.

If we could predict future oil prices, and knew that they would simply be higher, we could mitigate much of the damage through planning. If we knew oil prices would rise to particular price levels, we would make investments in efficiency that would save oil and have positive paybacks. Manufacturers could then develop and sell more efficient capital stock. Consumers would have a greater incentive to invest in efficiency because it would be possible to calculate a reasonably reliable payback period.

In fact, not only can we not predict future oil prices with any degree of accuracy, the one thing that experience has shown in the past is that prices are highly volatile and that at some point after the prices rise sharply, they will fall almost as far as they rose—if not further. Therefore, not only do volatile prices hurt us when prices rise by eroding our purchasing power, but they also harm us when prices fall, by undermining our ability to make investments in efficiency and other alternatives.

We therefore find ourselves in a situation where a year-long oil price spike is sufficient to do significant economic harm, but is insufficient to induce significant investment in efficiency and alternatives. The lack of such investments then increases the likelihood of further price volatility and its attendant economic harm. In other words, price volatility appears to have, thus far, condemned us to a world in which we are subject to a cycle of oil-driven economic boom and bust.

We also believe that price volatility is oil's most misunderstood characteristic. People understand that we consume a lot of oil and that consumption represents a large expenditure. They also understand that we have no alternatives to oil to fuel our vehicles. What is misunderstood, however, is that it is the change in price that is more harmful than a high price because while one can adjust to a high price, it is hard to adjust to a volatile one. Nevertheless, the combination of these four characteristics, which do not exist anywhere else in the economy, makes oil like no other product (or service) that we consume.

C. *The Economic Consequences of Our Dependence on Oil*

There are at least three mechanisms through which U.S. oil dependence weakens our economy: the economic adjustment costs that result in misallocated resources and reduced GDP, the transfer of wealth to foreigners, and additional means of foregone GDP.⁸⁴

1. Economic Adjustment Costs and Loss of GDP

Economic adjustment costs are the additional reductions of GDP, beyond that which would occur simply as a result of higher prices, which are caused by the temporary misallocation of resources as the result of sudden price changes. This is perhaps the most noticeable category of costs that our dependence on oil imposes on our economy because these accompany price spikes, whereas the other categories discussed below are more likely to exist, though possibly in less potent form, even in the absence of a price spike.

There are at least three categories of economic adjustment costs. First, changes in oil prices alter the budgets of households, businesses and governmental entities, generally resulting in a loss of economic output as the optimal mix of inputs shifts. Second, and closely related to the first category, price spikes can shift consumer demand for products and services, both because consumers may have less disposable income as a result of higher spending on oil and because goods or services may be more expensive if oil (or products derived from oil) was among their inputs. Third, ongoing uncertainty about the future price of oil reduces economic output below what it would be otherwise.

The consumption of gasoline is the primary means through which oil prices filter down to the average American family, although home heating oil and diesel prices have an impact on some households as well. American households consume an average of about 1,100 gallons of gasoline each year,⁸⁵ at an average cost of \$3,597 in 2008,⁸⁶ a level of consumption that is, as described above, inelastic, particularly in the short-term. This represents an important part of the 2007 median household's income of \$50,233.⁸⁷ Each one dollar increase in the annual average price of a gallon of gasoline reduces average American household discretionary spending by about ten percent,⁸⁸ effectively acting as a tax increase with the value of the tax accruing to oil producers (most of which are foreign) instead of the U.S. government.⁸⁹

84. David L. Greene & Sanjana Ahmad, Oak Ridge Nat'l Lab., *Costs of U.S. Oil Dependence: 2005 Update* (Jan. 2005), available at http://cta.ornl.gov/cta/publications/reports/ornl_tm2005_45.pdf.

85. DOE, EIA, *Household Vehicles Energy Use: Latest Data & Trends 2001*, at 57 (2005), available at [www.eia.doe.gov/emeu/rtecs/nhts_survey/2001/tablefiles/es0464\(2005\).pdf](http://www.eia.doe.gov/emeu/rtecs/nhts_survey/2001/tablefiles/es0464(2005).pdf) (This estimate for travel in 2001 was published in 2005).

86. Authors' calculation based on data from DOE, EIA, *Annual Energy Review 2008*, at 181 (2009).

87. Press Release, Dep't of Commerce, United States Census Bureau, Household Income Rises, Poverty Rate Unchanged, Number of Uninsured Down (Aug. 26, 2008), http://www.census.gov/Press-Release/www/releases/archives/income_wealth/012528.html.

88. Scott Crawford, *Cutting Back on Discretionary Spending* (2009), available at www.debtgoal.com/blog/cutting-back-on-discretionary-spending, (last visited Sept. 15, 2009) (calculation based on data drawn from the United States Department of Labor, Bureau of Labor Statistics 2006 Consumer Expenditure Survey).

89. Of the 8.4 million households that used fuel oil, average consumption was 663 gallons per year for space heating and 228 gallons per year for heating water at an average cost of \$2,870 in 2008, imposing on

Between 2001 and 2008, the average retail price of gasoline rose \$1.81 per gallon, from \$1.46 to \$3.27,⁹⁰ increasing the average household's annual gasoline bill by \$1,991. By way of comparison, all changes to the federal tax code during that same period decreased annual federal income and estate taxes by about \$1,900 for the median household.⁹¹ In other words, every penny that the typical household saved due to federal income and estate tax cuts was spent on higher gasoline bills. These increased energy costs reduced nearly every family's discretionary income, diminishing their ability to spend and contributing to a weakening of our consumer spending-driven economy.

Businesses that consume oil face similar challenges, as rising prices undermine their budgets as well. Volatile fuel prices hit airlines particularly hard, for example, because fuel makes up a high percentage of their costs.⁹² The airline industry has recently held the dubious distinction of being both vital to our nation's economy and in a persistent near-death state. A primary reason for its recent troubles was rising fuel prices between 2002 and 2006.⁹³ Airlines can hedge against price spikes by buying large amounts of oil futures, securing oil at a specific price at a future date certain. Southwest Airlines guessed right and hedged against the 2005-09 price spike, giving it an edge against its competitors, but most airlines lacked the balance sheet to support such hedging.⁹⁴ The U.S. airline industry lost more than \$35 billion between 2001 and 2005, almost entirely because of expensive jet fuel for which they had not been able to predict or plan.⁹⁵ Worldwide estimated net losses for 2008 were roughly \$10.4 billion,⁹⁶ and the International Air Transport Association (IATA) recently forecast net 2009 losses for the industry at \$9 billion.⁹⁷ An airline industry that is perpetually on the precipice of bankruptcy does not promote economic security.

them burdens similar to their consumption of gasoline. (Based on authors' calculations based on data supplied by EIA, *2005 Residential Energy Consumption Survey*, at Tbls US2, SH7, WH (Sept. 2008), available at www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html; *Annual Energy Review 2008*, *supra* note 18, at 179).

90. *Annual Energy Review 2008*, *supra* note 18, at 181.

91. Tax Policy Center, Urban Inst. and Brookings Inst., *Individual Income and Estate Tax Provision in the 2001-08 Tax Cuts*, at Tbl T08-0147 (2008), available at www.taxpolicycenter.org/numbers/displayatab.cfm?DocID=1856&topic2ID=150&topic3ID=157&DocTypeID=2.

92. According to the Air Transport Association of America, Passenger Airline Cost Index First Quarter 2009, fuel represented 21.3% of operating expenses during the first quarter of 2009. One can appreciate that fuel will represent a higher percentage of overall costs when oil prices are higher than they were at the beginning of the year. See Air Transport Ass'n of America, *Passenger Airline Cost Index First Quarter 2009*, available at www.airlines.org/economics/finance/Cost+Index.htm.

93. Total passenger airline fuel costs rose from \$7.1 billion in 1st Quarter '06 to as high as \$14.6 billion in 3rd Quarter '08, or from 23.4% to 35.6% of operating expenses respectively. See *id.*

94. Moira Herbst, *Hedging Against \$200 Oil*, BUSINESSWEEK, May 7, 2008, available at www.businessweek.com/bwdaily/dnflash/content/may2008/db2008056_075377.htm.

95. Christopher J. Goodman, *Takeoff and Descent of Airline Employment*, MONTHLY LABOR REVIEW, at 8 (Oct. 2008), available at www.bls.gov/opub/mlr/2008/10/art1full.pdf.

96. International Air Transport Ass'n, *Annual Report*, at 13 (2009), available at www.airlines.org/NR/rdonlyres/83BC223A-6855-4257-B74C-209A43C70F65/0/2009AnnualReport.pdf.

97. International Air Transport Ass'n, *Financial Forecast Green Shoots Face Severe Headwinds*, at 1 (2009), available at <https://www.iata.org/NR/rdonlyres/70FF7D0D-392E-46C5-8AAB-965902435457/0/FinancialForecastJune2009.pdf>.

Sustained high gasoline prices, which effectively exist through very high tax rates in much of Europe, might cause U.S. families to reorient their lifestyles around reducing fuel expenditures. Homeowners, for instance, might be less inclined to move out of urban areas to less expensive suburban housing that will require increased driving. And drivers might be inclined to purchase more fuel-efficient vehicles. This has not yet occurred, however, because persistent opposition to increasing the tax on gasoline keeps taxes low, allowing prices to fall as well as rise, and to fall to levels near which most consumers are not concerned about fuel economy. When gas prices are low, it is rational to move to the suburbs or to purchase a cheaper car that gets fewer miles per gallon. Moreover, the prospect that prices may fall in the future provides a fig leaf that enables households to make economically irrational decisions to favor perceived quality of life over low energy consumption: even if prices are high now, they may fall in the future.

2. Transfer of Wealth

It is easy to understand how our dependence on oil imports constitutes a significant transfer of wealth from U.S. consumers to foreign producers. The value of that transfer is equal to the product of the volume of oil and refined products that the United States imports from foreign producers and the average cost of imports.⁹⁸ According to the U.S. Department of Energy, the nation imported \$450 billion of petroleum in 2008 alone.⁹⁹

The transfer of wealth abroad directly increases our trade deficit. As oil prices have steadily increased in recent years, petroleum imports have exacted a heavy toll on the nation's current account balance. In 2008 alone, net trade in petroleum and petroleum products cost the American economy \$388 billion.¹⁰⁰ ¹⁰¹ This staggering total represented fifty-seven percent of our total trade deficit of \$681 billion.¹⁰² Our 2008 petroleum deficit was greater than the deficit with China, NAFTA, or the European Union,¹⁰³ and it exceeded the combined 2008 cost of wars in Iraq and Afghanistan.¹⁰⁴

In some circumstances, this transfer of wealth contributes to a global economic environment in which rising oil prices, the declining value of the dollar, and the increasing trade deficit feed off of each other in a self-reinforcing phenomenon, pushing oil prices higher. While not a rigid cycle in which each step occurs in lockstep fashion, these factors work together to support higher prices and further weaken the economy. The phenomenon begins within the

98. While it is true that the United States also exports a small amount of refined product, transfer of wealth is intended simply to measure the amount of capital exchanged for fuel.

99. *Annual Energy Review 2008*, *supra* note 18, at 81.

100. Our net trade in petroleum is lower than our gross import of petroleum because although the United States exports little if any crude oil, we do export finished products, largely, but not exclusively, to our Western Hemisphere trading partners.

101. *Annual Energy Review 2008*, *supra* note 18, at 77.

102. U.S. Dept. of Commerce, Bureau of Economic Analysis, 89 SURVEY OF CURRENT BUSINESS 4, 28, Tbl 1 (Apr. 2009), available at www.bea.gov/scb/pdf/2009/04%20April/0409_ita-tables.pdf.

103. *Id.* at 46, 47, 48 Tbl 12.

104. Amy Belasco, *The Cost of Iraq, Afghanistan, and Other Global War on Terror Operations Since 9/11*, CONG. RESEARCH SERV., at 13 (2009), available at <http://www.fas.org/sgp/crs/natsec/RL33110.pdf>.

traditional supply and demand model, but a combination of other factors reinforces upward price pressure:

The price of oil rises in response to ongoing concerns about demand growth and supply availability; the higher price of oil causes the United States to spend more money on oil and to export more dollars to pay for imported oil and petroleum products; spending more money on imported oil increases the trade deficit, which along with a weakened economy, caused in part by higher oil prices, further erodes the value of the dollar; the further weakening of the dollar places additional upward pressure on oil prices, so that oil producers do not lose purchasing power as measured in Euros and other currencies.¹⁰⁵

This transfer of wealth has the potential to reduce our GDP because money spent abroad on oil and petroleum products may not be recycled to be spent on goods and services in the United States. Moreover, to the extent that we cannot finance our imports with exports, we must finance our imports with foreign borrowing, which imposes a drag on the U.S. economy through significant interest charges. It also is worth observing that our level of imports has grown significantly over the years. In fact, oil imports reached a new ceiling in thirty-four of the last sixty years.¹⁰⁶ The trend of increased imports should be expected to continue as long as domestic oil production continues to decline and oil consumption remains at least at current levels.¹⁰⁷

3. Additional Foregone GDP

Researchers at the Oak Ridge National Laboratory (ORNL) have studied a third category of economic losses that results in additional foregone GDP beyond that resulting from transfer of wealth or the reallocation of resources. Its calculation is somewhat less straightforward to measure than other economic losses. Dr. David Greene of ORNL defines this category of loss as the loss of ability of an economy to produce GDP as a result of increased scarcity of oil.¹⁰⁸ In other words, when there is less oil available to an economy because supply is constrained by monopolistic or oligopolistic behavior, the economy is less able to produce goods and services. The source of this loss is the decline in consumer and producer surplus which results from the exercise of monopoly power by oil producers, and the lost consumer and producer surplus in other product markets whose prices have been affected by the price of oil.¹⁰⁹ This loss occurs whenever prices are higher than they would be in a competitive market (an occurrence that can usually be attributed to OPEC action), whether or not they have recently spiked.

105. See *Securing America's Future Energy, A Different Type of Price Spike* (2008), available at www.secureenergy.org/files/files/760_Research%20Paper.pdf.

106. *Annual Energy Review 2008*, *supra* note 18, at 129.

107. Whereas we have calculated the magnitude of the transfer of wealth based on our use of oil, Greene et al. have calculated the magnitude of the loss based on the exercise of monopoly power by foreign oil producers. Rather than categorize the value of all imports as imposing a cost on our economy by increasing the trade deficit, Greene has calculated the increase in our foreign debt resulting from the exercise of monopoly power by oil exporters. He calculates the value of the transfer as the total value of all crude oil and petroleum product imports, as the volume of imports multiplied by the difference between the price of oil and the estimated price of oil in a competitive market and the price of oil in the actual market.

108. Greene & Ahmad, *supra* note 83, at 9.

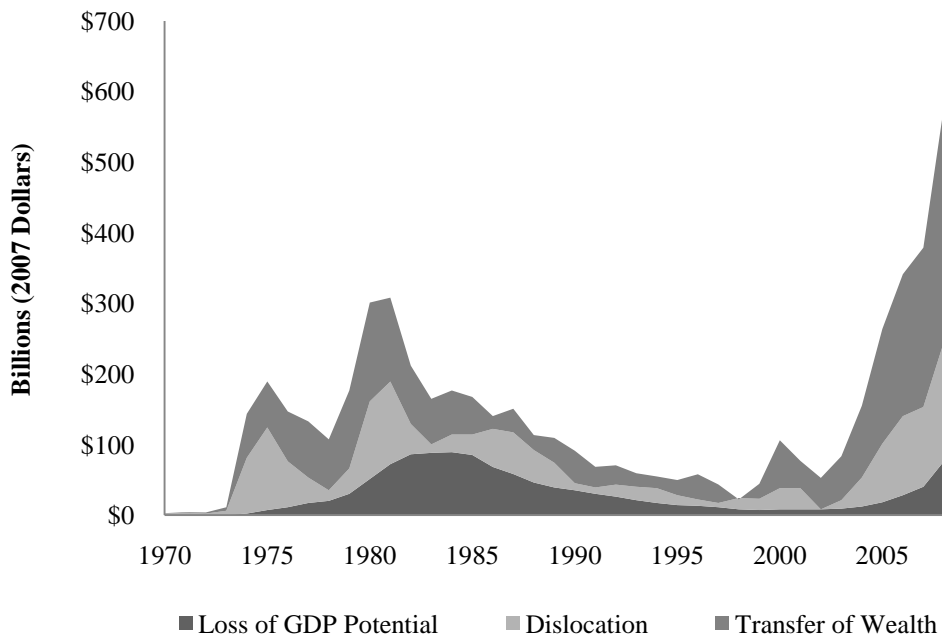
109. *Id.*

Consumer surplus is the difference between what a consumer is willing to pay for a good or service and what that consumer actually pays based on the established market clearing price.¹¹⁰ When demand for a product is inelastic, consumer surplus is typically larger than it would be if demand were unit elastic or elastic because consumers are willing to pay more for the product that the seller is charging.¹¹¹ Oligopolists exploit their power by raising prices to maximize their profits while reducing output, which reduces consumer surplus.¹¹²

Greene explains that when OPEC is able to exercise monopoly power in oil markets, its actions reduce GDP by decreasing consumer surplus.¹¹³ According to his research, this category of losses represents a significant portion of the overall economic cost of the exercise of monopoly power by oil producers.¹¹⁴

The magnitude of the costs of oil dependence across these three categories clearly varies over time. When oil prices are steady and low, the economic impact of our dependence on oil is also relatively low. When oil prices are high and volatile, the economic costs are generally high and damaging. According to Greene's analysis, the costs to the economy, depicted in Figure 8 below, reached \$600 billion in 2008.

Figure 8: Economic Costs of U.S. Oil Dependence



110. ROBERT A. SAMUELSON & WILLIAM D. NORDHAUS, *ECONOMICS* 97 (McGraw Hill 2001) (1948).

111. *Id.* at 78.

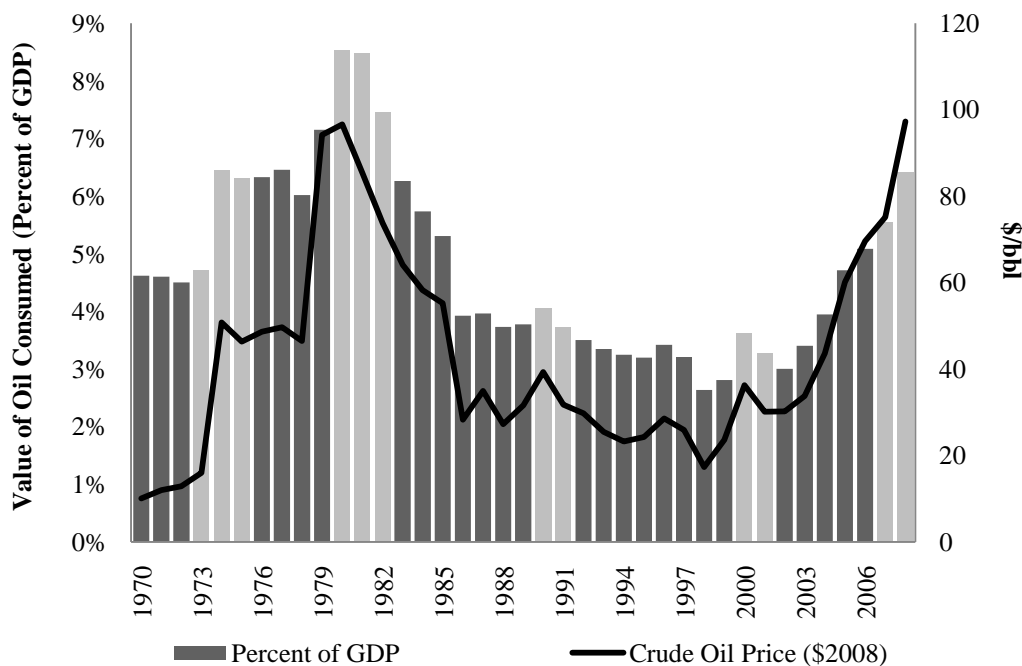
112. *Id.* at 197.

113. Producer's surplus is the difference between what producers are willing to supply goods to market and the price that they actually receive for their goods. *Id.* at 1589. When demand for a product is inelastic a producer with monopoly power can increase its profits at the expense of consumer surplus.

114. David L. Greene & Sanjana Ahmad, *supra* note 107.

There can be no doubt that the characteristics of our oil consumption and oil markets described above have led to periods in which the loss of GDP was sufficient to throw the economy into recession, with all of its attendant damage, including a reduced standard of living, job losses, and a larger trade deficit. (It should be noted that this is not only a problem that faces the United States. The 2008 oil price spike affected all consuming countries, feeding a global recession.) As demonstrated in Figure 9, oil price spikes have either preceded or concurred with every U.S. recession since 1970, including the current one. Although there obviously are numerous factors that contributed to the current recession, recent research has demonstrated that the oil price spike in 2008 caused the recession to begin six to nine months earlier (in December 2007) than would have occurred otherwise.¹¹⁵ Although the correlation between oil prices and the onset of recessions does not necessarily imply causation, we believe that there is a strong negative correlation between oil price spikes and the strength of the economy, a view that is acknowledged in the economics literature.¹¹⁶

Figure 9: U.S. Oil Expenditures and Economic Recessions



Note: Recessionary periods are in light gray

115. James D. Hamilton, *Causes and Consequences of the Oil Shock of 2007-08* (Apr. 2009) available at dss.ucsd.edu/~jhamilto/Hamilton_oil_shock_08.pdf (Working Paper).

116. See, e.g., REBECA JIMÉNEZ-RODRÍGUEZ & MARCELO SÁNCHEZ, WORKING PAPER SERIES NO. 362 – OIL PRICE SHOCKS EMPIRICAL EVIDENCE FOR SOME OECD COUNTRIES (European Central Bank 2004), available at <http://cta.ornl.gov/cta/publications/reports/ornl>.

D. National Security Consequences of Our Dependence on Oil

While the economic costs of U.S. oil dependence—transfer of wealth, foregone GDP, and macroeconomic disruption—are quantifiable and somewhat well understood, the national security costs are much less so. In general, there are at least two primary consequences of America’s heavy reliance on petroleum. The first is that U.S. foreign policy is constrained in dealing with a range of foreign policy priorities in oil-producing countries and regions. Second, and closely related, is that the U.S. military is overburdened and overexposed by our need to maintain secure transit routes for global oil supplies. The United States is not alone in facing these challenges, which constrain the foreign policy of our allies as much as they constrain our foreign policy, further endangering national security by reducing the value of America’s chief alliances, particularly NATO.

1. Foreign Policy

At a general level, one needs to look no farther than the so-called Carter Doctrine to summarize the impact of U.S. oil dependence on our foreign policy. On January 23, 1980, in his State of the Union address to Congress, President Carter declared,

[l]et our position be absolutely clear: An attempt by any outside force to gain control of the Persian Gulf region will be regarded as an assault on the vital interests of the United States of America, and such an assault will be repelled by any means necessary, including military force.¹¹⁷

Of course, the United States may have had a number of reasons for intervening in any invasion of Middle East countries. The Carter Doctrine was largely directed at the Soviet Union in response to its invasion of Afghanistan in the last days of December 1979. While stemming the Soviet tide was a driving concern of the day, adventurism in the heart of the Persian Gulf had a special significance because of American dependence on a stable global oil market. Our willingness to respond “by any means necessary” might not have held true in many other places.

The statements and policies of successive administrations generally confirm this notion. After taking office in 1981, President Carter’s successor—President Ronald Reagan—extended the Carter Doctrine to cover not just external but regional threats to Persian Gulf oil supplies.¹¹⁸ In articulating his corollary to the Carter Doctrine, President Reagan stated “there is no way that we could stand by and see [Saudi Arabia] taken over by anyone that would shut off [the] oil.”¹¹⁹ And in 1989, National Security Directive (NSD) 26, issued by President George H. W. Bush, stated

[a]ccess to Persian Gulf oil and the security of key friendly states in the area are vital to U.S. national security. The United States remains committed to defend its vital interests in the region, if necessary and appropriate through the use of U.S.

117. The State of the Union Address Delivered Before a Joint Session of the Congress, 1 Pub. Papers 114 (Jan. 23, 1980).

118. KEITH CRANE, ANDREAS GOLDTHAU, ET AL., IMPORTED OIL AND U.S. NATIONAL SECURITY 61 (RAND 2009).

119. The President’s News Conference, 1 Pub. Papers 873 (Oct. 1, 1981).

military force, against the Soviet Union or any other regional power with interests inimical to our own.¹²⁰

More recently, the National Defense Strategy issued by Secretary of Defense Robert Gates in June 2008 notes that

[t]he United States requires freedom of action in the global commons and strategic access to important regions of the world to meet our national security needs. The well-being of the global economy is contingent on ready access to energy resources. . . . The United States will continue to foster access to and flow of energy resources vital to the world economy.¹²¹

For a brief but more detailed case study in the foreign policy impacts of oil dependence, consider U.S.-Iran policy since the 1950s. In 1951, Mohammed Mosaddeq came to power in Iran intent on nationalizing the domestic petroleum industry, which had long been dominated by a British company, the Anglo-Persian Oil Company (APOC).¹²² The industry had nearly been nationalized decades earlier in 1933, but a last minute agreement between Anglo-Persian and Shah Reza Pahlavi averted the seizure. In 1935 APOC was renamed the Anglo-Iranian Oil Company (AIOC) and continued to develop Iranian oil reserves under an agreement that allotted Iran a guaranteed fixed royalty of four shillings per ton, twenty percent of AIOC's profits above a certain minimum, and a £750,000 annual minimum payment.¹²³ But in 1950, a U.S. company, Aramco, agreed to a fifty percent production sharing agreement with the monarchy in Saudi Arabia,¹²⁴ and many Iranians were infuriated that such an agreement had not been negotiated with AIOC. So shortly after gaining power, Mosaddeq nationalized AIOC's operations in Iran, much to the chagrin of the British government.

The details of what transpired over the following years are now well known. The British government lobbied hard in Washington to enlist American support for the overthrow of Mosaddeq. By convincing the Eisenhower administration that Mosaddeq was a Communist intent on selling Iranian oil to the Soviet Union, the British eventually gained American support: the coup that overthrew Mosaddeq in 1953 and installed Reza Shah was partially orchestrated by American intelligence organs.¹²⁵ Reza Shah's governance left most Iranians impoverished and created an anti-American backlash that took the form of Ayatollah Khomeini's militantly religious revolution in 1979.

Leaving aside the merits of U.S. policy choices in decades past, it is clear that a central policy driver when it comes to Iran—perhaps one among a handful, but an important one nevertheless—has often been the urgent desire to keep Iranian oil flowing into Western markets. The situation today is of course far more complex, with U.S. sanctions ranking among the top factors preventing

120. George H.W. Bush, National Security Directive 26, at 1 (Oct. 2, 1989) available at www.fas.org/irp/offdocs/nsd/nsd26.pdf.

121. Crane, *supra* note 117, at 62.

122. Yergin, *supra* note 8, at 437-38.

123. *Id.* at 253-254.

124. *Id.* at 429.

125. SCOTT A. KOCH, "ZENDEBAD, SHAH!": THE CENTRAL INTELLIGENCE AGENCY AND THE FALL OF IRANIAN PRIME MINISTER MOHAMMED MOSSADEQ 23-26 (Central Intelligence Agency (CIA) Aug. 1998), available at www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB126/iran980600.pdf; MARK GASIOROWSKI, MOHAMMAD MOSADDEQ AND THE 1953 COUP IN IRAN (Syracuse University Press 2004).

Iran from maximizing its production potential. And yet, the United States' option set in dealing with Iran is likely sharply limited by Iran's important role in the global oil market. Over the past five years (2004-2008), Iranian oil production averaged 4.3 mbd, about five percent of the global oil supply.¹²⁶ Throughout that same period, effective OPEC spare production capacity averaged just 1.5 mbd.¹²⁷ In other words, any substantial disruption of Iranian oil production could have easily overwhelmed the global oil supply buffer and sent oil prices surging higher. But Iran's influence in the world oil markets is not based solely on its production capacity. Of potentially greater concern is Iran's proximity to key transit points for oil shipments. The Strait of Hormuz, which connects the Persian Gulf with the Gulf of Oman and the Arabian Sea, is arguably the world's most important strategic chokepoint. On a typical day, fifteen crude oil tankers carrying 17 million barrels (or forty percent of seaborne oil trade) pass through Hormuz, which includes a two-mile wide shipping channel at its narrowest point.¹²⁸

During the Iran-Iraq War, Iran mined the Strait and even interfered with oil shipments, particularly Kuwaiti tankers carrying Iraqi oil. Only when the U.S. Navy agreed to escort tankers through the Strait, at the expense of the individual governments and great risk to both cargo and personnel, could the oil shipments resume. Today, according to one recent analysis, Iran possesses a larger stockpile of missiles and mines ten times as powerful as those used to sabotage the Strait during the Iran-Iraq War.¹²⁹ The analysis goes on to suggest that even if Iran managed to lay only a relatively small number of mines, the United States would surely be compelled to clear the area. However, the experience of past mine-warfare campaigns suggests that it could take many weeks, even months, to restore the full flow of commerce, and more time still for the oil markets to be convinced that stability had returned. Saudi Arabia, well aware of the possibility of this sort of interference, maintains substantial spare capacity in the Petrolina pipeline, which links its Persian Gulf refining complex at Abqaiq to an export terminal, Yanbu', on the Red Sea.

No doubt, as U.S. policymakers consider expanding sanctions on Iran or even endorsing targeted air strikes on suspected nuclear facilities, the ability of the Iranian government to damage the U.S. economy by interrupting oil flows through the Strait of Hormuz remains a persistent worry. That is to say, the American foreign policy apparatus is not fully in the driver seat in constructing its option set in the Middle East. Instead, American diplomats find their hands tied and their options limited in dealing with Iran as the regime in Tehran accelerates its uranium enrichment, continues to support a disruptive Hizb'allah in Lebanon, and plays a decidedly unhelpful role in Iraq.

All of these foreign and military challenges are born at least in part out of our need for a steady global supply of oil. And yet Iran is only one of many

126. Authors' calculations based on data at: BP Statistical Review, *supra* note 2, at 8.

127. Authors' calculations based on data from: DOE, EIA, *Short Term Energy Outlook Custom Table Builder*, available at tonto.eia.doe.gov/cfapps/STEO_TableBuilder/index.cfm (last visited Aug. 21, 2009).

128. DOE, EIA, *Country Analysis Brief: World Oil Transit Chokepoints*, 2-3 (2008), www.eia.doe.gov/cabs/World_Oil_Transit_Chokepoints/pdf.pdf.

129. Caitlin Talmadge, *Closing Time: Assessing the Iranian Threat to the Strait of Hormuz*, INTERNATIONAL SECURITY, at 82-117 (Summer 2008).

examples across the world of the manner in which our dependence on oil has constrained our conduct of foreign policy.

2. The World's (Oil) Police

The example of the Iran-Iraq War demonstrates that the United States has periodically endured a unique burden as the guarantor of the world's oil supplies. In the decades since that particular conflict, a number of observers and defense analysts have pointed to other specific large-scale military decisions as having been directly tied to protecting oil flows. The two most frequently cited examples are Operation Desert Storm and Operation Iraqi Freedom. In assessing the military burden associated with oil dependence—the “policing” effect—it might be useful to assign a specific value to such operations. Indeed, several attempts have been made to quantify the military externality costs associated with oil dependence.¹³⁰ In our view, however, it is simply impossible to quantify the American response to the Iraqi invasion of Kuwait based on oil dependence versus other *causae belli*, such as defense of Kuwaiti sovereignty. It is similarly imprecise to assign the full cost of Operation Iraqi Freedom to oil dependence versus, for example, democracy building. No doubt, oil dependence and oil politics played a strong role in both actions, but assigning a precise monetary cost seems an exercise in futility.

In addition to large scale deployments, other, more routine U.S. military activities occur on an ongoing basis that are also closely associated with energy security and protecting oil flows. For example, U.S. naval assets routinely patrol key shipping chokepoints, including the Straits of Malacca in the Far East, and American forces are currently training security forces to guard critical energy infrastructure in the South Caucasus, West Africa, and the Middle East—almost exclusively at the expense of the U.S. taxpayer. These kinds of routine security functions are often explicitly tied to the preservation of shipping lanes for oil and other goods. More broadly, providing general security training is often aimed at improving the overall security and stability of a region, which is a prerequisite for expanded and secure oil production. Ultimately, the U.S. military helps to provide long-term security—which is a prerequisite for oil production—and oil is a factor in choosing where it should focus on providing that security.

In 2007, for example, the Department of Defense launched its Africa Partnership Station (APS) initiative, designed to provide professional training and support to West African security and maritime forces without requiring a permanent basing presence onshore.¹³¹ In 2007 and 2008, the *USS Fort McHenry* spent time in Senegal, Ghana, Liberia, Gabon, Cameroon, and São Tomé.¹³² During that same time period, the U.S. naval presence off of Africa was also augmented by the Los Angeles-class nuclear-powered attack submarine *USS Annapolis*, which became the first U.S. submarine ever to make a visit to

130. ANITA DANCS, ET. AL., *THE MILITARY COSTS OF SECURING ENERGY* 4 (National Priorities Project 2008), available at www.nationalpriorities.org/auxiliary/energy_security/full_report.pdf; KEITH CRANE, ET. AL., *IMPORTED OIL AND U.S. NATIONAL SECURITY* 59-74 (Rand 2009), available at www.rand.org/pubs/monographs/2009/RAND_MG838.pdf.

131. Matthew Green, *U.S. Launches Good Boat Diplomacy in Africa*, FINANCIAL TIMES, Apr. 14, 2008, available at http://us.ft.com/ftgateway/superpage.ft?news_id=fto041420081243128720&page=2.

132. Daniel Flynn, *U.S. to Woo Africans with Naval Diplomacy*, REUTERS, Nov. 12, 2007, available at <http://www.reuters.com/article/politicsNews/idUSL1259159520071112>.

Sub-Saharan Africa, and the Ticonderoga-class guided missile cruiser *USS San Jacinto*. Altogether, the first APS voyages included visits to Angola, Benin, Cameroon, Cape Verde, Equatorial Guinea, Gabon, Ghana, Liberia, Nigeria, São Tomé and Príncipe, Senegal, and Togo.¹³³

The range of exercises conducted by the APS deployments certainly implies a broad scope, but the focus in the Gulf of Guinea clearly ties in closely with U.S. oil interests in the region. States adjacent to the Gulf will supply roughly twenty-five percent of U.S. oil imports in 2015, and U.S. companies including Exxon-Mobil and Chevron operate in the area. At the same time, the Gulf of Guinea is generally regarded as one of the most dangerous, pirate-riddled waterways in the world. Moreover, in mid-2009, it was estimated that approximately twenty percent of Nigerian oil production capacity was offline due to violence and instability, largely generated by militants engaging in sabotage of oil pipelines and other infrastructure, including offshore platforms.¹³⁴ As a result, specific training exercises carried out by APS include repelling takeovers of offshore oil facilities.

3. Military Dependence on Oil

Perhaps the great irony of military operations in defense of oil supplies is that the military itself is wholly dependent on petroleum to carry out such operations. Since First Lord of the Admiralty Winston Churchill converted the Royal Navy from coal to petroleum in 1912-1914, the world's most advanced naval forces have relied heavily on petroleum to conduct warfare. The advent of modern air forces ushered in a new era of fuel dependence for large-scale military operations, and in no nation is this vulnerability more acute than the United States. In 2006, the Department of Defense (DOD) spent \$10 billion on mobility fuel (as opposed to fuel for stationary installations), which accounts for roughly three-fourths of DOD fuel consumption.¹³⁵ Jet fuel is by far the military's largest fuel requirement, accounting for fifty-three percent of DOD energy consumption.¹³⁶ Diesel for marine and auto transport and fuel oil for generators accounted for another twenty-five percent.¹³⁷

As depicted in Figure 10, U.S. defense fuel costs have skyrocketed in recent years as deployments have increased in Iraq and Afghanistan amid rising petroleum prices. According to the Congressional Research Service,

[i]n FY1997 fuel represented 1.2% of the total DOD budget authority, and by 2007 fuel represented 1.9%. While the total defense budget authority increased 233% over the period of FY1997-FY2007 (in current dollars), fuel costs increased 373%.¹³⁸

133. J. Peter Pham, *Engaging Maritime Africa*, WORLD DEFENSE REVIEW, Sept. 16, 2008, available at www.worlddefensereview.com/pham091608.shtml.

134. Joe Brock, Factbox, *Nigeria's Oil Production Outages*, REUTERS, Aug. 14, 2009, available at www.reuters.com/article/rbssIntegratedOilGas/idUSLB12285320090814.

135. Thomas D. Crowley, et. al., *Transforming the Way DOD Looks at Energy*, LMI, Apr. 2007, available at <http://www.acq.osd.mil/dsb/resports/2008-02-ESTF.pdf>.

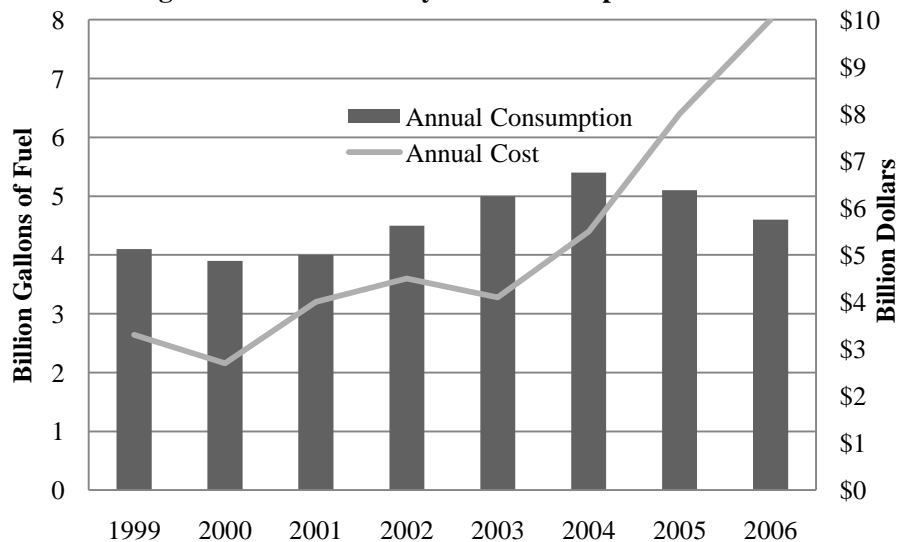
136. U.S. Dep't of Defense, Defense Science Board Task Force, *More Flight, Less Fuel* (Feb. 2008), available at <http://www.acq.osd.mil/dsb/resports/2008-02-ESTF.pdf>.

137. *Id.*

138. Anthony Andrews, *Department of Defense Fuel Spending, Supply, Acquisition, and Policy*, CONG. RESEARCH SERV., Mar. 20, 2009, at 2, available at <http://ftp.fas.org/sgp/crs/natsec/R40459.pdf>.

In 2007, the military spent roughly \$2.23 a gallon for fuel, but that figure rose to over \$20 a gallon when the cost of shipping fuel to the Middle East was factored in.¹³⁹ In FY 2007, DOD spent in excess of \$7 billion on jet fuel alone.¹⁴⁰ These skyrocketing costs have wreaked havoc on defense budgeting and have ultimately reduced the flexibility of the Department's decision-makers to invest in other line items, including R&D and procurement.

Figure 10: DOD Mobility Fuel Consumption 1999-2006



Finally, the strategic vulnerability of supply lines for fuel in the field has become one of the greatest threats to U.S. troops. According to some estimates, up to half of U.S. military casualties in Iraq and Afghanistan through 2008 were associated with convoys that transported fuel and equipment.¹⁴¹ Approximately seventy percent of the tonnage moved when the Army deploys is fuel.¹⁴² This simple fact has driven DOD to rethink the way it uses energy, both in combat and at home. Nearly ten percent of electricity used on DOD installations came from renewable sources in 2005, and as of 2007, the Air Force was the number one purchaser of renewable energy in the United States.¹⁴³ In 2006, DOD launched the Power Surety Task Force specifically to address these difficult issues and to transition the Services away from heavy petroleum reliance wherever possible.¹⁴⁴

139. Rebekah Kebede, *U.S. Military Conserving Fuel to Save Lives, Money*, REUTERS, Dec. 7, 2007, available at <http://www.alertnet.org/thenews/newsdesk/N07332362.htm>.

140. Andrews, *supra* note 137, at 3.

141. Amory Lovins, *How DOD Can Win the Oil Endgame: More Fight, Less Fuel, Lower Cost, Safer World*, ROCKY MT. INST., at 16, available at http://www.ndia.lorg/Divisions/Divisions/EnvironmentAndEnergy/Documents/Content/ContentGroups/Divisions1/Environment/Energy_PDFs/Rocky%20Mountain%20Institute.pdf.

142. *Id.*

143. Crowley, *supra* note 134, at 4-9.

144. See Power Surety Task Force Vision, www.ref.army.mil/powersurety/default.asp (last visited Sept. 14, 2009).

III. OPERATING WITHIN THE EXISTING PARADIGM

We believe that U.S. oil dependence overburdens our military while undermining both our economic stability and our foreign policy priorities. So long as we fail to address this vulnerability we will continue to risk the continuance of an oil-driven boom and bust economic cycle. High prices will weaken our economy and initiate economic slowdowns which cost us jobs and undermine our standard of living, while volatility undermines the incentive to engage in efforts to reduce our dependence on oil, thus continuing the cycle. In addition to weakening our economy, it will continue to undermine our foreign policy and impose significant burdens on our military, including the need to put American lives in harm's way, a cost that we believe is intolerable.

The challenge we face is how best to break this dependence while ensuring that the U.S. economy retains the mobility and flexibility it needs in order to grow.

This is not necessarily a new question. Since the 1970s, Congress has established the Department of Energy¹⁴⁵ and passed a slew of legislation to enhance our energy and economic security. In 1975, Congress passed the Energy Policy and Conservation Act¹⁴⁶ (which, among other things, established the first CAFE standards)¹⁴⁷ and created the Strategic Petroleum Reserve.¹⁴⁸ Congress also passed the Energy Reorganization Act of 1974,¹⁴⁹ the Energy Supply and Environmental Coordination Act of 1974,¹⁵⁰ the Emergency Natural Gas Act of 1977,¹⁵¹ the Public Utilities Regulatory Policy Act,¹⁵² the Energy Tax Act of 1978,¹⁵³ the National Energy Conservation Policy Act,¹⁵⁴ the Power Plant and Industrial Fuel Use Act of 1978,¹⁵⁵ the Natural Gas Policy Act of 1978,¹⁵⁶ the Energy Security Act,¹⁵⁷ the Energy Policy Act of 1992,¹⁵⁸ the Energy Act of 2000,¹⁵⁹ the Energy Policy Act of 2005,¹⁶⁰ the Energy Independence and Security Act of 2007,¹⁶¹ and the Energy Improvement and Extension Act of 2008¹⁶² with each law intended to enhance our energy security.

This library of legislation has provided assistance to a wide range of technologies to fuel vehicles, including synthetic fuels,¹⁶³ natural gas,¹⁶⁴

145. Department of Energy Organization Act, Pub. L. No. 95-91, 91 Stat. 565 (1977).

146. Energy Policy and Conservation Act (EPCA), Pub. L. No. 94-163, 89 Stat. 871 (1975).

147. *Id.* at § 301, codified at 15 U.S.C. §§ 2001-12 (1975).

148. *See* EPCA §§ 151-66, codified at 42 U.S.C. §§ 6231-46 (1975).

149. Energy Reorganization Act, Pub. L. No. 93-438, 88 Stat. 1233 (1974).

150. Energy Supply and Environmental Coordination Act, Pub. L. No. 93-319, 88 Stat. 246 (1974).

151. Emergency Natural Gas Act, Pub. L. No. 95-2, 91 Stat. 4 (1977).

152. Public Utilities Regulatory Policies Act, Pub. L. No. 95-617, 92 Stat. 3117 (1978).

153. Energy Tax Act, Pub. L. No. 95-618, 92 Stat. 3174 (1978).

154. National Energy Conservation Policy Act, Pub. L. No. 95-619, 92 Stat. 3206 (1978).

155. Power Plant and Industrial Fuel Use Act, Pub. L. No. 95-620, 92 Stat. 3289 (1978).

156. Natural Gas Policy Act, Pub. L. No. 95-621, 92 Stat. 3350 (1978).

157. Energy Security Act (ESA 80), Pub. L. No. 96-294, 94 Stat. 611 (1980).

158. Energy Policy Act, Pub. L. No. 102-486, 106 Stat. 2776 (1992).

159. Energy Act, Pub. L. No. 106-469, 114 Stat. 2029 (2000).

160. Energy Policy Act (EPAAct 2005), Pub. L. No. 109-58, 119 Stat. 594 (2005).

161. EISA, *supra* note 70.

162. Energy Improvement and Extension Act, Pub. L. No. 110-343, 122 Stat. 3807 (2008).

163. *See, e.g.,* ESA80, *supra* note 156, at §§ 100-95.

biofuels,¹⁶⁵ hydrogen,¹⁶⁶ and electricity.¹⁶⁷ The range of assistance, however, is not the result of a national energy policy to determine the best and most efficient outcome, but instead is the product of a haphazard, politicized, and inconsistent approach, with policymakers at times unwilling to interfere with industry and at other times mandating or subsidizing various technologies. The former is problematic because it has meant that the market has not been consistently required to incorporate the cost of the externalities of oil dependence. The latter is problematic primarily because support for technology has been highly politicized, with subsidies, mandates, and demonstration projects starting and ending based on factors other than the viability or deployment of the technology. Policy has been led by favoritism of particular technologies (e.g., fuel cell vehicles) rather than technology-neutral incentives to achieve a particular goal (e.g., low carbon transport). A current example is tax credits for wind energy, which have expired and been extended several times based solely on the vagaries of Congressional horse-trading.¹⁶⁸ Another example is the FutureGen carbon capture and sequestration project, which was unexpectedly buried by the Bush Administration after billions of dollars and years of carefully wrought international cooperation,¹⁶⁹ and which the Obama administration is apparently committed to revive.¹⁷⁰ Command and control energy policy is not desirable because it is inherently inefficient—the government is unlikely to be better at picking the best technological solution than the market—but to the extent that government does try to shape the way we use and develop energy technology, it should at least be consistent and somewhat predictable. Instead, we have no long-term national energy strategy. It is perhaps ironic that the challenge of transforming our energy sector is compared to the Apollo project. The Apollo project had a clearly defined goal: to send a man to the moon and bring him safely back to earth by the end of the 1960s. Our energy policies, however, are not similarly focused, or even focused at all. We do a little of many things—such as biofuels, natural gas vehicles, hydrogen vehicles, electric vehicles, and more efficient gasoline vehicles—without a clearly focused commitment to achieve any positively stated goal. The result is mixed messaging to the industrial sector, producing little or no progress.

We believe that significant oil consumption reduction must come from the transportation sector, which is responsible for more than seventy percent of American oil demand. We also believe that the approach of most policymakers to date—increase domestic supply of oil, reduce demand—while laudable and necessary, will never provide true security for the U.S. economy.

164. See, e.g., EPA92, *supra* note 157, at §§ 201-514, 1913; 26 U.S.C. § 179A (2006).

165. See, e.g., ESA80, *supra* note 156, at §§ 201-514; 26 U.S.C. § 30C (2006).

166. See, e.g., EPA92, *supra* note 157, at §§ 201-514, 1913; 26 U.S.C. §§ 30C, 40A, 179A (2006).

167. See, e.g., *Id.* at §§ 201-514, 1913; 26 U.S.C. §§ 30B, 30C (2006).

168. See, e.g., *Id.* at §§ 201-514, 601-626, 1913; 26 U.S.C. §§ 30, 30B, 30C (2006).

169. Steven Ashley, *U.S. Cancels Clean Coal Plant*, SCIENTIFIC AMERICAN, February 4, 2008, available at, <http://www.scientificamerican.com/article.cfm?id=us-cancels-clean-coal-plant>.

170. Ben Geman, *DOE Revives FutureGen, Reversing Bush-Era Decision*, N.Y. TIMES, June 12, 2009.

A. Domestic Oil Production

Increasing domestic oil production can improve the U.S. trade deficit, reduce the magnitude of the wealth transfer, and increase reinvestment of oil revenue into the United States. All of those benefits represent legitimate reasons to maximize domestic oil production. Increased supply cannot, however, meaningfully reduce oil price volatility or the economic damage that volatility wreaks on U.S. households and businesses. If for no other reason, this is true simply because the United States does not possess enough oil to meaningfully alter the global supply-demand balance. U.S. proved reserves currently stand at just 30.5 billion barrels, or about 2.4 percent of the global total.¹⁷¹

Admittedly, proved reserves do not present a complete picture of potential resources. Factoring undiscovered technically recoverable reserves (UTRR)—including those resources held off-limits on public lands, onshore and offshore—total U.S. reserves could be in excess of 160 billion barrels of oil.¹⁷² Including unconventional sources of liquid fuel such as oil shale and liquefied coal (CTL), the resource estimates spiral into the trillions of barrels.¹⁷³ And yet each of these resource categories is beset by uncertainty. In the case of UTRR, much of the resource base is highly speculative and extremely costly. For example, UTRR figures commonly include offshore acreage adjacent to the East and West coasts that has not been surveyed in decades.¹⁷⁴ Unconventional sources—like oil shale and CTL—come with capital costs as high as \$1 billion for 10,000 barrels per day of capacity.¹⁷⁵ This says nothing of the carbon intensity of these fuels, which can be up to double that of conventional petroleum unless carbon capture and storage is deployed.¹⁷⁶

Based on these and other factors, the Department of Energy currently forecasts U.S. crude oil production to be 5.79 mbd in 2020 and 7.14 mbd in 2030.¹⁷⁷ This rise of just 1.35 mbd is itself highly questionable given the steady decline in U.S. crude oil output over the past thirty years. Moreover, the entire forecasted increase derives from fields in the lower forty-eight contiguous states, which leads us to believe that DOE has assumed new production from the

171. BP Statistical Review of World Energy, *supra* note 2, at 6.

172. DOI, MMS, USGS National Assessment of Oil and Gas Resources Update, Total Oil and Gas Resources (November 2007), *available at* certmapper.cr.usgs.gov/data/noga00/natl/tabular/2007/summary_07.pdf, (last visited Aug. 30, 2009); DOI, MMS, Offshore Federal UTRR: USGS, *Assessment of Undiscovered Technically Recoverable Oil and Gas Resources of the Nation's Outer Continental Shelf* (February 2006), *available at* www.mms.gov/revaldiv/PDFs/2006NationalAssessmentBrochure.pdf; BP Statistical Review of World Energy, *supra* note 2, at 6.

173. NPC GLOBAL OIL & GAS STUDY, TOPIC PAPER #27: OIL SHALES 1 (National Petroleum Council, July 18, 2007).

174. DOI, MMS, *Survey of Available Data on OCS Resources and Identification of Data Gaps*, at II-22, II-32 (2009).

175. Lee R. Raymond, *Hard Truths: Facing Hard Truths About Energy*, NAT'L PETROLEUM COUNCIL, July, 2007 at 206, <http://www.npchartruthsreport.org>; JAMES T. BARTIS, ET. AL., OIL SHALE DEVELOPMENT IN THE UNITED STATES: PROSPECTS AND POLICY ISSUES 15 (Rand 2005).

176. Natural Resources Defense Council (NRDC), *Why Liquid Coal is Not a Viable Option to Move America Beyond Oil*, Feb. 2007, at 2, *available at* www.nrdc.org/globalWarming/coal/liquids.pdf.

177. DOE, EIA, *An Updated Annual Energy Outlook 2009 Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in the Economic Outlook*, Apr. 2009, at TbleA.11, *available at* <http://www.eia.doe.gov/oiaf/sercierpt/stimulus/pdf/stimulus.pdf>.

Atlantic and Pacific offshore regions, which, as mentioned, is highly speculative in nature.¹⁷⁸

Leaving aside domestic production potential, it is important to note that basic characteristics of the global oil market completely undermine the ability of domestic oil production to insulate the U.S. economy from the most damaging consequence of oil dependence—oil price volatility. While it is true that oil is produced, transported, refined, and consumed at all corners of the globe, it is also true that there is a single world market for oil. All variations from that price represent adjustments to account for the location of the oil (prices are lower near producers and higher near markets, to account for transportation costs) and the oil's quality (lighter oil and lower sulfur oil, each of which require less refining to produce gasoline, diesel, or other products, are more expensive than heavier oil and oil with higher sulfur content), international variations in demand between regions, and changes in the balance of demand for different oil products (e.g., diesel, gasoline, jet fuel, heating oil). Professional traders quickly arbitrage out any unsupported price differentials.

Price formation in the global oil market implicitly accounts for all of the oil production and all of the oil consumption in the world. Because there is a single market for oil, all consumers of oil are dependent on all producers of oil to get their supply to market. Often, isolated variances from this process result in dramatic price swings, particularly in times of low spare capacity. For instance, in late 2002 and early 2003, an oil worker strike in Venezuela resulted in a sharp reduction of oil production.¹⁷⁹ The result was not simply higher prices for the United States, which is the main customer for Venezuela's oil; it was instead a higher *global* price for oil.¹⁸⁰ In other words, consuming nations are dependent on every supplier in the world—those from whom they purchase and those from whom they do not—to ensure a stable supply and price of oil. Calls to eliminate imports of Middle Eastern oil, therefore, reflect inaccurate reasoning. Whether or not we import oil from Saudi Arabia, a reduction or disruption in oil production or exports from Saudi Arabia will affect the price of oil all over the world. This dynamic also explains why increasing domestic oil production will not insulate the United States from oil price volatility.

Ultimately, even if the United States produced 100 percent of the oil it consumed, the price of oil would still be subject to volatility based on the output of other producers, including OPEC countries, as well as the demand from oil consuming nations. The only means to address volatility directly through supply would be to build sufficient spare production and refining capacity to serve as buffers that could quickly increase or decrease production in response to exogenous events to maintain price stability. The last time that the United States was able to do this was in the 1960s, when the Texas Railroad Commission could meaningfully manage global supply. We believe, however, that such an undertaking would be impossible. The volume of spare capacity required would

178. Indeed, in its online supplemental tables, DOE shows crude oil production from the Atlantic and Pacific increasing from roughly 100,000 b/d today to 700,000 b/d by 2030. DOE, EIA, *Annual Outlook 2009 Updated Annual Energy Outlook 2009 Reference Case with ARRA*, Apr. 2009, available at www.eia.doe.gov/oiaf/aeo/index.html.

179. IEA, *Oil Market Report*, Jan. 17, 2003, at 17-18, available at <http://omrpublic.iea.org/omrarchive/17jan03full.pdf>.

180. *Id.* at 38.

be enormous and in a market economy there is no incentive for anyone to invest in spare capacity that will be underutilized and will not generate a return on capital. Even OPEC itself lacks the resources to manage the market on this scale. Moreover, in a world of growing demand for oil, a willingness to pay for such capacity could in effect lead to its incorporation into base capacity, at which point it would no longer be serving its intended purpose. In short, while there is an important role for domestic production, we cannot drill our way out of this problem.

B. Biofuels

Biofuels are largely produced domestically, a fact that is widely perceived to enhance our security relative to the use of imported oil.¹⁸¹ Biofuels proponents generally call for establishment of an open fuel standard, which would effectively require that any vehicle be a flex-fuel vehicle, capable of operating on nearly any mixture of traditional gasoline and biofuels.¹⁸² They argue that displacing some portion of petroleum derived fuel with domestic biofuels will improve our energy and economic security. These arguments were compelling enough that Congress responded in 2005 by creating the Renewable Fuel Standard (RFS), a requirement that a certain percentage of all motor fuel sold be biofuels.¹⁸³

We fully appreciate that the increased use of biofuels may be useful in many respects: it could lower the trade deficit, create jobs, enhance the environment (particularly with respect to carbon emissions), stimulate the development of new technologies, and perhaps, lower the baseline price of oil. Therefore, we believe that no matter what progress is made towards the deployment of grid-enabled vehicles (GEVs) in the next several decades, biofuels will have an important role to play in helping meet our demand for liquid motor fuels.

We do not, however, believe that displacing some portion of petroleum derived fuel with domestic biofuels will substantially improve our energy and economic security. Biofuels' primary difference from petroleum-based fuels is that they are derived from biomass instead of crude oil. While their source may differ, their use is nearly identical. They are liquid fuels that are distributed, at least in part, through the same distribution system as gasoline and diesel fuel, and are blended with fuel derived from crude oil to burn in an internal combustion engine. Thus, a broad expansion of biofuel production, concomitant with the establishment of a policy that all vehicles operate on a wide range of liquid fuels, would essentially convert the domestic gasoline market into a market for liquid motor fuel in which consumers would generally be indifferent to the particular mixture of gasoline and other liquid fuels, so long as price was adjusted to account for the fuel's actual energy content. Once the markets for the two fuels—gasoline and biofuel—effectively merge, a merger that already

181. Oxford Analytica, *Biofuel Benefits Go Beyond Environment*, FORBES, Apr. 10, 2006, available at www.forbes.com/2006/04/07/biofuel-benefit-ethanol-cx_0410oxford.html; DOE, EERE, Alternative Fuels and Advanced Vehicles Data Center (AFAVDC), *Ethanol Benefits*, July 10, 2009, available at <http://www.afdc.energy.gov/afdc/ethanol/benefits.html>.

182. DOE, EERE, AFAVDC, *Ethanol Market Penetration* (July 10, 2009).

183. EPAAct 2005, *supra* note 159, at § 1501.

has occurred to some extent though the production of fuel with up to ten percent ethanol and of E85, the problems that plague gasoline would also affect biofuels. For instance, the price of domestically-produced biofuels will be a function of the price of gasoline. This happens because the market price is determined by the incremental or marginal price of adding another barrel of liquid fuel. Since the extra barrel comes from the global oil market, that market's volatility will be directly tracked in biofuel prices. Therefore, when gas rises to four dollars a gallon, so will ethanol (adjusted to account for its lower energy content);¹⁸⁴ when gasoline falls to two dollars a gallon, so will ethanol. And when the price of gasoline falls below the marginal cost of producing ethanol, production of ethanol will decline. We have, in fact, already witnessed this effect. Last year, many ethanol companies were booming. However, when oil prices collapsed, so did ethanol prices.¹⁸⁵ Many of the largest U.S. biofuel companies have since declared bankruptcy, closed plants, or merged with their competitors.

The ultimate result is that, from an energy security perspective, domestic production of biofuels is functionally equivalent to domestic production of oil; it improves the U.S. trade deficit, reduces the magnitude of the wealth transfer, and increases investment into the United States, but does not address price volatility. As with domestic production of oil, the only means for biofuels to meaningfully reduce price volatility would be to build a substantial amount of spare production capacity that could be used to offset short-term changes in either supply or demand to help stabilize prices. But there is no incentive for anyone to build spare ethanol production capacity (just as there is no incentive for any non-cartelized party to build spare oil production capacity).

There are three other noteworthy points regarding the use of biofuels. First, biofuels currently represent only five percent of all motor fuel sold in the United States,¹⁸⁶ and even the level of production required by the last year of the renewable fuel standard, which many experts consider impossible to achieve without foreign ethanol imports, will represent only 10.4 percent of forecast demand for motor fuel.¹⁸⁷ Second, there is a growing concern that corn-based ethanol is at best equivalent to gasoline in life-cycle emissions of greenhouse gases.¹⁸⁸ Biofuel crops in their present form are water-intensive, erode the soil, raise food prices, and by some estimates, consume about as much fossil fuel energy in their production as they provide to a vehicle's engine.¹⁸⁹ The EPA

184. In fact, biofuels may sell at a slight discount even after adjustment for its lower energy content, to account for the fact that drivers using biofuels will have to refill their tanks more frequently, imposing some degree of inconvenience on the driver. See Roger Blanchard, *Then & Now*, ENERGY BULLETIN, July 13, 2009, available at <http://www.energybulletin.net/node/49550>.

185. Daniel O'Brien and Mike Woolverton, *The Relationship of Ethanol, Gasoline and Oil Prices*, AGMRC RENEWABLE ENERGY NEWSLETTER, July 2009, available at www.agmrc.org/renewable_energy/ethanol/the_relationship_of_ethanol_gasoline_and_oil_prices.cfm.

186. DOE, EIA, *U. S. Energy Consumption by Energy Source 2004-2008*, July 2009, available at www.eia.doe.gov/cneaf/alternate/page/renew_energy_consump/table1.html.

187. Authors' calculations based on data available at EISA 2007, *supra* note 160, at § 202; *Annual Energy Outlook 2009*, *supra* note 32, at Tbl. 7.

188. Congressional Budget Office (CBO), *The Impact of Ethanol Use on Food Prices and Greenhouse Gas Emissions*, Apr. 2009, at 12-16, available at www.cbo.gov/ftpdocs/100xx/doc10057/04-08-Ethanol.pdf.

189. R. Dominguez-Faus, *et al.*, *The Water Footprint of Biofuels: A Drink or Drive Issue?*, 43 ENVIRONMENTAL SCIENCE AND TECHNOLOGY 3005-10 (2009), available at <http://cohesion.rice.edu/engineering/pedroalvarez/emplibrary/103.pdf>.

recently announced new carbon content measurements, which determined that greenhouse gas emissions from biofuels were five percent worse than gasoline over a thirty year period.¹⁹⁰ Third, it was widely reported last year that as ethanol production grew to meet the legal requirement, food prices began to rise.¹⁹¹ Part of the blame was placed squarely at the step of the biofuels industry, as corn, which was previously used for food and feed, increasingly was being used for fuel.¹⁹² Some observers have argued that this resulted in a global chain reaction in land use changes, causing significant food shortages in the world's poorest countries.¹⁹³ But setting these points aside, so long as the production of biofuels is unable to reduce the volatility of liquid motor fuel prices in the United States, they remain unable to help us address the economic and national security challenges that are the focus of our concern no matter what other benefits they may provide to the nation.

C. Fuel Efficiency

One of the few meaningful steps we can take to enhance our energy and economic security while continuing to use oil to power our cars is to increase the fuel efficiency of those vehicles. Doing so can reduce the petroleum intensity of the economy—the amount of oil that the economy consumes to produce a specified level of economic output. As mentioned earlier, the petroleum intensity of the U.S. economy fell by forty-five percent between 1973 and 1995, chiefly due to improved fuel economy of passenger cars, the virtual elimination of oil as a fuel for electric power generation, and a shift to less energy-intensive economic sectors for growth (services). That improvement has reduced the importance of oil in the economy and mitigated some of the effects of higher and volatile oil prices. Yet much of that improvement was achieved prior to 1990 and due to increased automotive efficiency in response to the establishment of Corporate Average Fuel Economy (CAFÉ) standards in 1975.¹⁹⁴

CAFE standards were introduced as a regulatory response to U.S. dependence on oil, and over the following ten years the miles-per-gallon (mpg) performance of new LDVs (both cars and trucks) improved by sixty-two percent without any loss in performance.¹⁹⁵ Between 1987 and 2007, however, fuel economy for America's LDVs remained essentially unchanged,¹⁹⁶ while average

190. Steven Mufson & Juliet Eilperin, *EPA Proposes Changes To Biofuel Regulations*, WASHINGTON POST, May 6, 2009, available at www.washingtonpost.com/wp-dyn/content/article/2009/05/05/AR2009050503731.html.

191. International Monetary Fund, *World Economic Outlook October 2008: Financial Stress, Downturns, and Recoveries*, at 96-99, available at www.imf.org/external/pubs/ft/weo/2008/02/pdf/text.pdf.

192. CBO, *supra* note 187, at 6.

193. Keith Bradsher, *The Other Oil Shock: Vegetable Oil Prices Soar*, N. Y. TIMES, Jan. 19, 2008, available at www.nytimes.com/2008/01/19/business/worldbusiness/19iht-palmoil.1.9339824.html.

194. See EPCA § 301, codified at 15 U.S.C. §§ 2001-12 (2006).

195. NAT'L ACAD. OF SCI., COMM. ON THE EFFECTIVENESS AND IMPACT OF CAFE STANDARDS, EFFECTIVENESS AND IMPACT OF CORPORATE AVERAGE FUEL ECONOMY (CAFE) STANDARDS, 3 (Nat'l Academies Press 2002), available at <http://www.nap.edu/openbook.php?isbn=0309076013>.

196. Environmental Protection Agency (EPA), *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2007 – Executive Summary*, at ii (September 2007), available at <http://www.epa.gov/oms/cert/mpg/fetrends/420s08003.pdf>.

horsepower increased by eighty-five percent,¹⁹⁷ average weight rose by nearly thirty percent,¹⁹⁸ and average acceleration times were enhanced by over twenty-five percent.¹⁹⁹ Not coincidentally, fuel-economy improvements ceased at the same time as the initial CAFE targets were attained. For cars, these initial targets have remained unaltered for decades, even as technological advances made substantial efficiency improvements, all of which the automakers directed to improve vehicle performance and size instead of fuel economy.

CAFE worked in part because it accelerated U.S. automakers' implementation of industry-best practices and technological advancements in fuel economy. Prior to CAFE, neither foreign competition nor fluctuating fuel prices generated the significant gains in fuel economy that regulation ultimately did.

In December, 2007, Congress passed the Energy Independence and Security Act of 2007 (EISA), which increased fuel-economy standards for the first time in nearly two decades.²⁰⁰ In May 2009 President Obama announced a tightening of this standard, ultimately requiring an average fuel-economy standard of 35.5 mpg in 2016.²⁰¹

While EISA represents important progress and will result in substantial fuel savings, it does not address the underlying problem represented by our transportation network's nearly complete dependence on oil. Tighter fuel standards in the range contemplated by EISA can reduce, but not eliminate the effects of volatility, because new business and governmental budgets will assume increased efficiency. Nor would they insulate us from price spikes brought on by, for example, a new military conflict in the Middle East. Of course, greater efficiency can help by reducing the magnitude of the economic effects of price spikes when they do occur. We have seen, however, that merely reducing the fuel intensity of the economy will not eliminate the effects of high and volatile prices, which can in fact, be quite severe.

IV. TRANSFORMATIONAL CHANGE FOR THE LONG-TERM: ELECTRIFICATION

We suggest that working within the traditional paradigms, though useful on a limited scale, cannot and will not offer the transformative change required to end our nation's dependence on petroleum. What is required is a new model. We believe that model should be electrification of our nation's short-haul ground transportation system.

Today, GEVs are offering the potential to address the two primary problems that electric vehicles (EVs) have faced in the past. The viability of

197. David L. Greene, Testimony to the United States Senate Committee on Energy and Natural Resources *Policies to Increase Passenger Car and Light Truck Fuel Economy* (Jan. 30, 2007), available at http://www.cta.ornl.gov/cta/Publications/Reports/Testimony_PoliciesToIncreaseFuelEconomy_Greene.pdf.

198. EPA, *supra* note 195.

199. NAS, *supra* note 194.

200. See EISA, *supra* note 70, at § 102; KELLY SIMS GALLAGHER & GUSTAVO COLLANTES, ANALYSIS OF POLICIES TO REDUCE OIL CONSUMPTION AND GREENHOUSE-GAS EMISSIONS FROM THE U.S. TRANSPORTATION SECTOR 4 (Harvard University, Belfer Ctr. for Sci. and Int'l Affairs 2008), available at http://belfercenter.ksg.harvard.edu/files/2008_Gallagher_Collantes_AutoPolicyModelingResults.pdf.

201. White House Office of the Press Sec'y, President Obama Announces National Fuel Efficiency Policy (May 19, 2009), http://www.whitehouse.gov/the_press_office/President-Obama-Announces-National-Fuel-Efficiency-Policy.

EVs has long been limited by their range and the time needed to recharge their batteries. By combining an electric motor and gasoline engine into a single drive-train in a hybrid-electric vehicle (HEV), automakers were able to significantly improve gasoline mileage. Now that it is clear that an HEV can be modified to operate as a plug-in hybrid electric vehicle (PHEV), a vehicle that operates in part (or exclusively) as an electric car until its battery reaches its discharge limit, and then as a traditional hybrid until it can be recharged, the possibility of an ultra-efficient car is more attainable than ever before. Because the majority of vehicles travel fewer than forty miles a day, such a vehicle offers the opportunity for much of the oil savings possible from EVs without their restriction on range. The deployment of PHEVs, therefore, represents an opportunity to radically improve the fuel efficiency of the short haul transportation fleet, even prior to the deployment of EVs, thereby significantly reducing the petroleum intensity of the U.S. economy in the short-run. In doing so, they can offer a step towards the deployment of battery EVs, while improving our economic and national security.

Given our relatively recent discovery of the new opportunities provided by GEVs, one can reasonably ask why we should deliberately choose the path of electrification. After all, eight years ago hydrogen was the fuel of the future with everyone talking about the development of a hydrogen economy. Four years ago biofuels were viewed as the answer to our oil problems. Today, electrification is clearly the favored technology. Given that we have emphasized different approaches to our energy security at different times, including three distinct phases this decade alone, why should we focus our effort, energy and investments in one particular technology that itself remains unproven? Does it not seem likely that five years from now we will believe that some other technology holds more promise than electrification, and that this too was just a phase?

A. *Why the Government Should Choose*

Government intervention in the marketplace should generally be limited to those instances in which there is a market failure. There is a clear market failure in the world oil market. OPEC members engage in oligopolistic behavior by withholding oil supplies from the market. Generally speaking, in a competitive market all producers would produce at maximum output when their marginal cost of production is below the market price for a product. But several OPEC members, as a matter of practice, have withheld production from the market despite the fact that due to favorable geology their marginal cost of production was far below the market price of oil.²⁰² Since the short-term demand curve is so inelastic, all revenue they lose by withholding volume is more than made up for with higher prices.²⁰³ They choose to engage in this behavior because the state-

202. See, e.g., CBS News, Transcript of 60 Minutes (Dec. 7, 2008), www.scribd.com/doc/8743779/60-Minutes-Transcript-on-Saudi-Arabia-Bullish-Oil-Future-12708, (last visited Sept. 15, 2009).

203. See, e.g., James L. Williams, *Oil Price History and Analysis*, WTRG Economics, www.wtrg.com/prices.htm (last visited Sept. 15, 2009); See also, Martin Seiff, *OPEC Oil Price Push May Threaten World Recovery*, UPI, May 28, 2009, available at www.upi.com/news/issueoftheday/2009/05/28/OPEC-oil-price-push-may-threaten-world-recovery/UPI-7358124354589/ (For most non-OPEC producers, although the fixed costs of oil production may be very high, the cash costs are quite low, meaning that they always have an incentive to produce at or near maximum

owned oil companies in most OPEC-member countries are serving national political interests rather than seeking profit maximization.

If OPEC-like behavior were to occur within our borders, the government would intervene. Colluding with competitors to withhold product from the market is a clear violation of U.S. antitrust laws. Those laws, however, do not and cannot apply to sovereign nations. Geopolitical factors, violence, and instability represent additional factors within the global oil market over which the United States has no practical control, but that directly threaten our economy.

Unable to address supply, the government is left with no option but to address the demand side of the equation. The policy question is whether the government should take unprecedented measures to address this market failure. We believe that it must for all of the reasons above. This is not a classic antitrust case where parties were colluding to increase the price of legal services or even gasoline.²⁰⁴ Oil is a strategic commodity. Its role in the economy is both unique and enormous, and the anticompetitive behavior undertaken by OPEC members significantly damages our national security, our foreign policy, and our economy. A policy that would penalize the oligopolistic behavior might seem the best policy, but even if it were available it would fail to address either the myriad of supply side problems outside of OPEC or the climate change problems associated with petroleum. Moreover, policies undertaken over the past thirty-five years to this point have largely failed. Our conclusion is that the government should adopt a policy to affirmatively promote electrification of the short-haul transportation sector of the economy not because we generally support government intervention in the market, but because, to paraphrase Winston Churchill, doing so may be the worst policy choice available, except for every other one.²⁰⁵ Unlike hydrogen fuel cells and cellulosic ethanol policy, we are proposing the government support the large-scale deployment of an existing technology that has been proven in the market rather than pin its hopes on the future potential of a new technology that is far from commercialization.

B. Balancing Energy, Economic and National Security

Electrification represents the best opportunity in the foreseeable future to enhance our energy, economic, and national security while reducing our nation's dependence on oil. EVs, which are powered by batteries that are charged by connecting them to the electrical grid either at home, work, or elsewhere, operate without using oil. However, the viability of EVs has been constrained by the high cost of batteries, vehicle range and recharging time. Perhaps consumers are

capacity. They cannot, therefore, counteract OPEC production cuts. OPEC members have therefore had the ability to exercise oligopoly power over the market even though they controlled less than half of all production).

204. See, e.g., *FTC v. Superior Court Trial Lawyers Ass'n*, 493 U.S. 411, 421-23 (1990) (holding it to be illegal for a group of lawyers to refuse to represent indigent defendants unless lawyers' fees were raised); *United States v. Socony-Vacuum*, 310 U.S. 150, 223 (1940) (holding competitors' agreement to buy excess gasoline on spot market to stabilize prices to be illegal).

205. See The Official Report, House of Commons, 444 Parl. Deb., H.C. (5th ser.) (1947) 206-07, available at <http://hansard.millbanksystems.com/commons/1947/nov/11/parliament-bill>.

simply unwilling to purchase cars whose range is limited to 100 miles, and the required recharging that could take many hours.²⁰⁶

While we await the development of affordable electric vehicles, the combination of high oil costs, concerns about oil security and availability, and air quality issues related to vehicle emissions are driving interest in “plug-in” PHEVs. Similar to today’s familiar hybrids, PHEVs incorporate both an internal combustion engine and an electric motor. With a hybrid drive-train, batteries charge off the internal combustion engine either directly or by recapturing energy normally lost in braking. This recapture combined with the torque advantage of the electric motor at low speeds, and consuming little or no energy when the vehicle is stopped, allows hybrid vehicles to use the energy contained in fossil fuels more efficiently than vehicles powered solely by internal combustion engines (ICEs).

PHEVs feature a larger battery and a plug-in charger that allows the driver to charge the battery by connecting it directly to the power grid. When the battery is sufficiently charged, the vehicle may operate in a battery-depleting all-electric or blended mode. Once the battery is depleted to the point that it can no longer power the vehicle, the vehicle may then operate as a traditional HEV, powered by its gasoline-fueled engine and its electric motor, a mode of operation during which it would still generally achieve far greater fuel economy than a gasoline-powered vehicle. Therefore, PHEVs may derive a substantial fraction of their miles from grid-derived electricity, but without the range restrictions of pure battery EVs.

The average LDV’s trip is less than ten miles, and average households log less than thirty-five miles per day.²⁰⁷ According to data assembled by the U.S. Department of Transportation, vehicles driven forty or fewer miles per day log an estimated seventy percent of all vehicle miles traveled on weekdays and eighty percent of all vehicle miles traveled on weekends.²⁰⁸ Because the majority of Americans drive only relatively short distances each day, electric cars should be able to satisfy most driving needs even if they need to recharge more often than gasoline-powered vehicles need to be refueled.

In 2006, the Bush administration announced the U.S. Advanced Energy Initiative, which sought to develop a PHEV capable of traveling up to forty miles on a single electric charge (a PHEV-40).²⁰⁹ Such a vehicle could cut many drivers’ gasoline consumption in half.²¹⁰ Research by engineers from General Motors concluded that a PHEV with an 8 kWh battery charged only at home could reduce fuel consumption by fifty-five percent.²¹¹ If the driver had the capability to charge at work and elsewhere, fuel consumption could be reduced

206. Darryl Siry, *The Problem With Electric Car Range Figures*, THE BUSINESS INSIDER GREEN SHEET, May 14, 2009, available at <http://www.businessinsider.com/the-problem-with-ev-range-figures-2009-5>.

207. Oak Ridge Nat’l Lab, *supra* note 26, at Figs 8.3, 8.5.

208. *Id.*

209. DOE, EERE, *Plug-In Hybrid Electric Vehicle R&D Plan*, at 1, 4, 5, 7 (2007), available at http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/phev_rd_plan_02-28-07.pdf.

210. ELECTRIC POWER RESEARCH INSTITUTE (EPRI), *COMPARING THE BENEFITS AND IMPACT OF HYBRID ELECTRIC VEHICLE OPTIONS*, at 2-5 (2001), available at <http://mydocs.epri.com/docs/public/00000000001006892.pdf>.

211. E.D. TATE & PETER SAVAGIAN, *THE CO2 BENEFITS OF ELECTRIFICATION: E-REVS, PHEVS, AND CHARGING SCENARIOS 10* (General Motors Corp. 2009).

by nearly eighty percent.²¹² Analysis conducted by the National Renewable Energy Laboratory concluded that a PHEV-40 could use upwards of seventy percent less gasoline than a base conventional vehicle. That study found that a car powered by an ICE uses around 535 gallons of gasoline a year, and a HEV uses 386 gallons. A PHEV would use between 145 and 237 gallons, depending on driving patterns.²¹³ Deployed at scale, this technology would provide significant oil savings, reducing the petroleum intensity of the economy and enhancing our economic and national security. Based on the result of these analyses, it is clear that while pure EVs might represent complete freedom from petroleum, PHEVs can constitute a first step towards that goal, a step that will support the development of common infrastructure and technology, and which can, even as an interim step, significantly reduce the petroleum dependence of the U.S. economy. As of 2009, production of PHEVs is essentially limited to demonstration vehicles and prototypes. However, the technology is the subject of considerable interest and research.

Even as PHEVs are showing signs of promise, other technological improvements are coming to the forefront. In August 2009, General Motors announced that its Volt may achieve 230 miles per gallon of gasoline based on the EPA's preliminary guidelines for calculating the fuel efficiency of HEVs.²¹⁴ GM is calling the Volt an extended range EV with a pure electric drive-train and gasoline powered engines that can be used to generate electricity to power the drive-train and recharge the battery after it is discharged. Although it differs from PHEVs in that the gasoline engine only generates electricity and does not provide physical power to the drive-train, it is similar to PHEVs in that the drive-train is powered at least in part by electricity drawn from the grid, yet is not limited in range as is a pure EV. Nissan has also stated that its new battery electric vehicle will achieve triple digit fuel economy once it is deployed.²¹⁵

A path towards electrification is also supported by the fact that a substantial portion of the LDV fleet could be recharged using the existing electric infrastructure with important, but practical, upgrades.²¹⁶ While the grid currently is capable of recharging the first PHEVs to hit the consumer market, as their numbers grow over time, it will be necessary to upgrade the infrastructure. But that investment is both manageable in cost and sound in policy. Most of the upgrades to the grid are either in the last few feet of wire (connecting existing wires to recharging devices), or related to technological upgrades to transform the existing grid into a "smart grid," upgrades that will likely occur whether or not GEVs are deployed because of the myriad of advantages that a smart grid

212. *Id.*

213. K. PARKS, P. DENHOLM & T. MARKEL, COSTS AND EMISSIONS ASSOCIATED WITH PLUG-IN HYBRID ELECTRIC VEHICLE CHARGING IN THE XCEL ENERGY COLORADO SERVICE TERRITORY 12 Tbl 3 (Nat'l Renewable Energy Lab. 2007), available at <http://www.nrel.gov/docs/fy07osti/41410.pdf>.

214. Sharon Terlep, *GM Hopes Volt Juices Its Future*, WALL ST. J. (Aug. 12, 2009), available at http://asia.wsj.com/documents/print/WSJ_B001-20090812.pdf.

215. Chris Woodward, *Nissan Claims 367 mpg For its Electric Leaf - Even Though it Doesn't Use Gas*, USA TODAY (Aug. 12, 2009), available at <http://content.usatoday.com/communities/driveon/post/2009/08/68496729/1>.

216. MICHAEL KINTNER-MEYER, KEVIN SCHNEIDER, & ROBERT PRATT, *IMPACTS ASSESSMENT OF PLUG-IN HYBRID VEHICLES ON ELECTRIC UTILITIES AND REGIONAL U.S. POWER GRIDS* 1-6 (Pac.Nw. Nat'l Lab. 2007), available at www.ferc.gov/about/com-mem/wellinghoff/5-24-07-technical-analy-wellinghoff.pdf.

offers to utilities and their customers. Moreover, the transformation will take place over time, creating an opportunity to explore the best way to fund any necessary upgrades, based, at least in part, on the business models that develop to support GEVs.

For the reasons stated above, we believe that the development of PHEVs represents a transformative event that signals the first step towards the wider deployment of a range of GEVs that will have radical implications for energy security. For those drivers who want the benefits of an electric vehicle without restricted range, a PHEV should meet their needs, almost immediately. In doing so, they can represent a cornerstone of our transportation future, one which will strengthen our economy and national security while enhancing our environment.

C. Why Electrification is the Best Approach

We believe that electrifying the light-duty fleet is the best approach to reducing our dependence on oil for the following six reasons: using electricity promotes fuel diversity; electricity is generated from a domestic portfolio of fuels; electricity prices are less volatile than oil and gasoline prices; using electricity is more efficient than gasoline; using electricity will facilitate reduction of greenhouse gas emissions; and electricity is a low-cost alternative. Moreover, we believe that when it comes to powering the LDV fleet, electricity is superior to all other alternative fuels.

1. Using Electricity Promotes Fuel Diversity

America's vehicles currently are powered almost exclusively by fuel derived from crude oil.²¹⁷ Electricity, in contrast, is generated by a diverse set of fuels, including coal, uranium, natural gas, flowing water, wind, geothermal heat, the sun, landfill gas, and others.²¹⁸ An electrically-powered transportation system, therefore, is one in which an interruption of the supply of one fuel can be made up for by others, even in the short-term, at least to the extent that there is spare capacity in generators fueled by other fuels, which is generally the case.²¹⁹ Similarly, price volatility for one fuel is dampened by price stability in others. Lastly, the ability to use different fuels as a source of power increases the flexibility of an electrified light duty vehicle fleet. As our national goals and resources change over time, we can shift transportation fuels without overhauling our transportation infrastructure. In short, an electrified transport system would give us back the reins, offering much greater control over the fuels we use to support the transportation sector of our economy.

2. Domestic Fuels Generate Electricity

While oil supplies are subject to a wide range of geopolitical risks, the fuels that we use to generate electricity are generally sourced domestically. All renewable energy is generated using domestic resources. We are a net exporter

217. *Annual Energy Review 2008*, *supra* note 18, at v.

218. DOE, EIA, *Electric Power Annual 2007*, at 2 (2009) available at www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html. [hereinafter, *Electric Annual 2007*]

219. *Id.* at 102.

of coal,²²⁰ from which we generate about half our electricity.²²¹ Although we currently import approximately sixteen percent of the natural gas we consume,²²² over ninety percent of those imports were from North American sources (Canada and Mexico) in 2008.²²³ More importantly, perhaps, is that we do not rely, yet, on a global natural gas market, which could expose us to the same types of vulnerabilities with respect to our natural gas supplies that we currently face with our oil supplies.²²⁴ Because a single global market like that for oil does not exist for natural gas, domestic production does more to insulate natural gas prices from shocks than in the case of oil. Vast shale resources currently in development may also give us the option to avoid imports entirely.

We do import a substantial portion of the uranium we use for civilian nuclear power reactors. Forty-two percent of those imports, however, are from Canada and Australia.²²⁵ Moreover, although we rely more on imported uranium than other fuels in the electric power sector, over half of uranium purchases are pursuant to medium-term or long-term contracts that contain fixed price or base-escalated pricing provisions.²²⁶ These contractual features help limit the effects of uranium price volatility. Further, the cost of fuel represents a much smaller portion of overall costs at nuclear plants than at other non-renewable energy power generating stations.²²⁷ Therefore, even when uranium prices are volatile, that volatility is not reflected in the price of power generated at nuclear plants.

3. Electricity Prices Are Less Volatile Than Oil and Gasoline Prices

Electricity prices are significantly less volatile than oil or gasoline prices. As depicted in Figure 10, over the past twenty-five years, electricity prices have risen steadily but slowly. Since 1983, the average retail price of electricity delivered in the United States has risen by an average of less than two percent per year.²²⁸ Moreover, prices have risen by more than five percent per year only three times in that same time period.²²⁹ This price stability, which is in sharp contrast to the price of oil or gasoline, exists for at least two reasons.

220. Fred Freme, DOE EIA, *U.S. Coal Supply and Demand 2008 Review*, at 11-13 (2009) available at www.eia.doe.gov/cneaf/coal/page/special/article_dc.pdf.

221. *Electric Annual 2007*, *supra* note 217, at 2.

222. *Annual Energy Outlook 2009*, *supra* note 32, at 78.

223. *Annual Energy Review 2008*, *supra* note 18, at 191.

224. See, e.g., Monika Ehrman, *Competition Is A Sin: An Evaluation of the Formation and Effects of a Natural Gas OPEC*, 27 ENERGY L. J. 175 (2006).

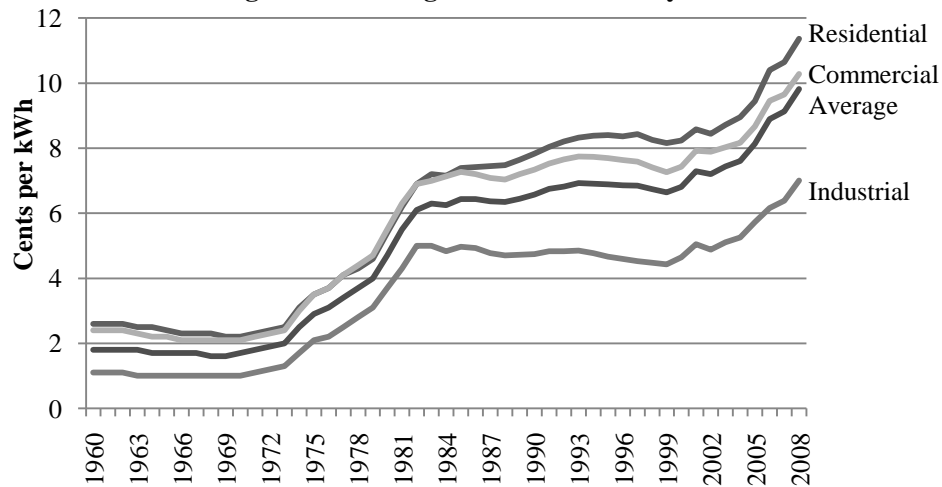
225. DOE, EIA, *2008 Uranium Marketing Annual Report*, at 1 (2009), available at <http://www.eia.doe.gov/cneaf/nuclear/umar/umar.html> [hereinafter, *Uranium Report*].

226. *Id.*

227. Nuclear Energy Inst., *Costs: Fuel, Operation and Waste Disposal*, www.nei.org/resourcesandstats/nuclear_statistics/costs/ (last visited Sept. 11, 2009).

228. *Annual Energy Review 2008*, *supra* note 18, at 261.

229. *Id.*

Figure 10: Average Price of Electricity 1960-2008

First, the retail price of electricity reflects a wide range of costs, only a small portion of which is the underlying cost of the fuel. The remaining costs are largely fixed.²³⁰ In most instances, the cost of power plant fuel represents a smaller percentage of the overall cost of delivered electricity than the cost of crude oil represents as a percentage of the overall cost of retail gasoline.²³¹ For instance, although fossil fuel prices rose twenty-one percent between 2004 and 2006 (as measured on a cents per Btu basis),²³² and the price of uranium delivered in 2006 rose forty-eight percent over the cost of uranium delivered in 2004,²³³ the national average retail price of all electricity sales increased only seventeen percent (from 7.6 cents per kWh in 2004 to 8.9 cents per kWh in 2006);²³⁴ the average price of residential electricity rose only sixteen percent (from 8.95 to 10.4 cents per kWh).²³⁵ This cost structure promotes price stability with respect to the final retail price of electricity.

Second, although real-time electricity prices are volatile, sometimes highly volatile on an hour-to-hour or day-to-day basis,²³⁶ they are nevertheless relatively stable over the medium-term and long-term. Therefore, in setting retail rates, utilities or power marketers use formulas that will allow them to recover their costs, including the occasionally high real-time prices for electricity, but which effectively isolate the retail consumer from the hour-to-

230. DOE, EIA, *Energy in Brief-What Everyone Should Know: How is my Electricity Generated, Delivered, and Priced?*, tonto.eia.doe.gov/energy_in_brief/electricity.cfm (last visited, Sept. 11, 2009) [hereinafter, *Energy Brief*].

231. See DOE, EIA, *A Primer on Gasoline Prices*, (2008), available at www.eia.doe.gov/bookshelf/brochures/gasolinepricesprimer/; *Electric Annual 2007*, *supra* note 217, at 69.

232. *Electric Annual 2007*, *supra* note 217, at 48.

233. *Uranium Report*, *supra* note 224, at 3.

234. *Annual Energy Review 2008*, *supra* note 18, at 261.

235. *Id.*

236. SUSTAINABLE ENERGY ADVANTAGE, L.L.C., USING WIND POWER TO HEDGE VOLATILE ELECTRICITY PRICES FOR COMMERCIAL AND INDUSTRIAL CUSTOMERS IN NEW YORK at 2-3 (2003), available at www.powernaturally.org/About/documents/WindHedgeExSumm.pdf.

hour and day-to-day volatility of the real-time power markets.²³⁷ By isolating the consumer from the price volatility of the underlying fuel costs, electric utilities would be providing to drivers of GEVs the very stability that oil companies cannot provide to consumers of gasoline.

4. Use of Grid-Enabled Vehicles Reduces Carbon Emissions and Energy Consumption

Using GEVs reduces carbon emissions as compared to petroleum-fueled vehicles. While emission reductions are greater if the GEV is recharged using electricity generated from a renewable resource, several well-to-wheels analyses conclude that even vehicles powered by the current mix of fuel sources in the United States will produce substantially lower carbon emissions than conventional vehicles.

Well-to-wheels analyses examine the energy use and carbon emissions attributable to a vehicle from the time an energy source is extracted until it is consumed.²³⁸ In 2007, the Natural Resources Defense Council (NRDC) and the Electric Power Research Institute (EPRI) published a well-to-wheels analysis of several different automotive technologies fueled by a range of fuels commonly used to generate power.²³⁹ Its analysis concluded that using a PHEV would reduce carbon emissions as compared to a petroleum-fueled vehicle, even if all of the exogenous electricity used to recharge the PHEV was generated at an old (relatively dirty) coal power plant. Whereas a conventional gasoline vehicle would be responsible for emissions, on average, of 450 grams of CO₂ per mile, a PHEV that was recharged with power generated at an old coal plant would be responsible for emissions of about 325 grams of CO₂ per mile, a reduction of about twenty-five percent.²⁴⁰ Emissions attributable to the vehicle could be reduced to as low as 150 grams of CO₂ per mile if the exogenous power was generated at a plant without carbon emissions and ranged between 200 and 300 grams of CO₂ per mile if the power used were generated using any other fossil fuels and generation technologies.²⁴¹ Therefore, the NRDC study demonstrated that no matter how the exogenous power consumed by a PHEV was generated, the overall level of emissions attributable to its operation would be lower compared to a conventional vehicle.²⁴²

The results of the NRDC/EPRI study were consistent with an MIT study that examined the same issue.²⁴³ That study included an integrated well-to-wheels analysis of the different vehicle technologies to determine their relative level of carbon emissions and energy usage. The study concluded that PHEV-10s, PHEV-30s, PHEV-60s, and EVs use less energy on a well-to-wheels basis

237. *Energy Brief*, *supra* note 229.

238. MATTHEW A. KROMER & JOHN B. HEYWOOD, ELECTRIC POWERTRAINS: OPPORTUNITIES AND CHALLENGES IN THE U.S. LIGHT-DUTY VEHICLE FLEET at 24 (MIT 2007), *available at* web.mit.edu/sloan-auto-lab/research/beforeh2/files/kromer_electric_powertrains.pdf.

239. NRDC & CHARLES CLARK GROUP, ENVIRONMENTAL ASSESSMENT OF PLUG-IN HYBRID ELECTRIC VEHICLES: VOLUME 1: NATIONWIDE GREENHOUSE GAS EMISSIONS (EPRI 2007), *available at* mydocs.epri.com/docs/public/00000000001015325.pdf.

240. *Id.* at 7.

241. *Id.*

242. *Id.*

243. Kromer & Heywood, *supra* note 237.

than petroleum-fueled conventional vehicles.²⁴⁴ While a conventional vehicle consumes 3.35 MJ/km of energy, the various types of PHEVs and the EV consume 1.16, 1.24, 1.32, and 1.79 MJ/km respectively.²⁴⁵ Their increased efficiency is reflected in their reduced level of carbon emissions, with the PHEVs and EVs emitting 84.3, 86.2, 89.8, and 115.6 grams of CO₂/km as compared to a conventional vehicle's emission of 251.8 grams of CO₂/km.²⁴⁶ These two studies are consistent with the results of numerous other analyses that have examined this issue and found that the emissions profile of PHEVs and EVs is always superior to an ICE-powered vehicle.²⁴⁷ Accordingly, even if one powers a PHEV or EV with electricity generated at an old coal plant, overall carbon emissions will be lower than emissions from a traditional internal combustion engine. And to the extent that the electricity used to power the vehicle is generated at a power plant with fewer carbon emissions than an old coal plant, the carbon emissions profile of the PHEV or EV will improve as well.

5. Using Electricity Will Further Facilitate Reduction of Greenhouse Gas Emissions

The light-duty fleet is responsible for about 17.5 percent of U.S. greenhouse gas emissions.²⁴⁸ Running cars on electricity offers advantages in dealing with greenhouse gas emissions both at the demand (vehicle) level and at the supply (generation) level. In the absence of greenhouse gas emission regulation, the extent to which the use of GEVs reduces greenhouse gas emissions will be a function of the marginal generation fuel used by the utility generating the electricity. But as just explained in Section IV.C.4 above, no matter what fuel is used to generate the power consumed by GEVs, the vehicle is responsible for lower carbon emissions even if the power it uses is generated from coal.

But perhaps of greater importance is that once GEVs are in place, their emissions profile will continue to improve without any additional changes to the vehicle, as the emissions profile of our power generating plants improve. At the moment, there are over 250 million LDVs on the road, each burning fuel and emitting carbon dioxide.²⁴⁹ To achieve improvements in their cumulative emissions profile, improvements must be made in the emissions profile of each vehicle, one at a time. An electric-powered vehicle fleet, however, would circumscribe the challenge of reducing those carbon emissions to roughly 6,900 coal and natural gas generation plants that comprise over eighty percent of the

244. *Id.* at 115

245. *Id.*

246. *Id.*

247. See, e.g., Constantine Samaras & Kyle Meisterling, *Life Cycle Assessment of Greenhouse Gas Emissions from Plug-in Hybrid Vehicles: Implications for Policy*, 42 ENV'T. SCI. TECH. 3170–3176 (2008); Tate & Savagian, *supra* note 210; Christopher Yang & Ryan McCarthy, *Electricity Grid Impacts of Plug-In Electric Vehicle Charging*, available at pubs.its.ucdavis.edu/download_pdf.php?id=1290 (last visited Sept. 11, 2009).

248. Raymond J. Kopp, *Issue Brief 12: Transport Policies to Reduce CO2 Emissions from the Light-Duty Vehicle Fleet*, at 163 available at www.rff.org/rff/Publications/upload/31815_1.pdf.

249. RESEARCH & INNOVATIVE TECH. ADMIN., BUREAU OF TRANSP. STATISTICS, TBL 1-11: NUMBER OF U.S. AIRCRAFT, VEHICLES, VESSELS, AND OTHER CONVEYANCES (U.S. Dep't of Transp. 2009), available at www.bts.gov/publications/national_transportation_statistics/html/table_01_11.html.

nation's power generating capacity.²⁵⁰ It is far simpler to sequester carbon or employ renewable energy at the power plant than the tailpipe. Indeed, analyses of the cost of greenhouse gas emission reductions routinely find that it is more expensive to reduce emissions from vehicles than from power plants. Therefore, proportionately more emission reductions will come from power plants than from vehicles.²⁵¹ By shifting the emissions stream created by vehicles from their tailpipes to central power stations, we will both facilitate and lower the costs of combating climate change.

6. Electric Miles Are Cheaper Than Gasoline Miles

Operating a vehicle on electricity in the United States is considerably less expensive than operating a vehicle on gasoline. The Electric Power Research Institute has determined that a compact size PHEV will use only 160 gallons of gasoline a year, compared 300 in a hybrid and 400 in a conventional ICE compact car. They calculate that with gasoline at only \$3 a gallon, a PHEV-20 would, over the course of the vehicle's lifetime, save \$10,000 in gasoline compared to a base ICE vehicle.²⁵² (However, the lower operating costs contrast with the significantly higher cost of the vehicle, due, in large part, to the cost of the battery.)

That GEVs have lower operating costs was confirmed by a National Renewable Energy Laboratory (NREL) study which examined the effects of replacing thirty percent of the vehicle fleet in the Xcel Energy Colorado service area with PHEVs.²⁵³ Using utility system modeling tools, NREL simulated expected electricity demand under four charging scenarios. One was uncontrolled charging, where individuals charged only at home using normal, low-voltage outlets. This results in a great deal of charging during what is otherwise peak, or near peak, demand for the utility. A second scenario, delayed charging, ensures that people charge the vehicle after the early evening peak. The third approach, off-peak charging, allows utilities to control vehicle charging and thus match it to the "valley" of low demand in the middle of the night. The fourth is a scenario of widely available charging stations, a continuous charging scenario in which people could charge whenever they parked during the day, or chose to "top off" their batteries.²⁵⁴

The uncontrolled and continuous charging cases result in vehicle charging during periods of high electricity demand, and thus add to utilities' peak capacity requirements. The delayed charging case is substantially better. The off-peak charging scenario is beneficial to the utility because it fills the valley, increasing the minimum load.²⁵⁵ The analysis concluded that the annual fuel cost of a PHEV in the first three cases, based on a 2006 gasoline prices of \$2.57 a gallon

250. *Electric Power Annual 2007*, *supra* note 217, at 25.

251. See, e.g., DOE, EIA, *Energy Market Impacts of Alternative Greenhouse Gas Intensity Reduction Goals*, at 18 (2006), available at [www.eia.doe.gov/oiaf/servicerpt/agg/pdf/sroiaf\(2006\)01.pdf](http://www.eia.doe.gov/oiaf/servicerpt/agg/pdf/sroiaf(2006)01.pdf).

252. Tom Reddoch, Elec. Transp. and Energy Efficiency, EPRI Briefing to the Energy Task Force, State of Tennessee, Franklin, Tennessee (Sept. 19, 2008), at 8, available at bree.mnanytime.org/energy/sites/default/files/EPRI%20Final%2009-19-08.pdf.

253. Parks, Denholm & Markel, *supra* note 212.

254. *Id.* at 7-11.

255. *Id.* at 13, 14.

and average electricity retail price of 8.64 cents/kWh, would be about \$778.²⁵⁶ An HEV, with a hybrid drive-train that cannot charge its battery exogenously, would have annual fuel costs of \$993,²⁵⁷ and a conventional vehicle powered solely by gasoline would have annual operational costs of \$1,375.²⁵⁸

As mentioned earlier, vehicle electrification also would enable the more efficient use of existing power plants, creating savings that over time should accrue to consumers. It is not possible to cost-effectively store electricity in meaningful quantities, so all power must be generated at the moment it is demanded. Utilities must be able to meet peak demand on the hottest day of the year, so most of the time a significant portion of the nation's generating capacity sits idle.²⁵⁹ If grid-connected vehicles are recharged overnight, generators' utilization factors should increase. The average price of a kilowatt-hour should then decrease as the same fixed cost is spread over a greater volume of generated power.

V. EVALUATING THE COMPETITION

The perils of relying on fuel derived from crude oil are well known. Yet, there are only a limited number of possible alternatives to gasoline or diesel, including alternative liquid fuels, hydrogen, natural gas, and electricity. In addition to the six reasons stated in Section IV.C, we believe that the nation should pursue a path of electrification because every other alternative fails to meet several critical objectives. We discussed the shortcomings of biofuels in Section III.B. As with domestic oil production, we should maximize cost-effective biofuel production, but we should also understand that it will not fundamentally solve our oil dependence. There are at least two other potential 'next-generation' alternatives: natural gas and hydrogen. Neither is a compelling alternative to electrification.

A. Natural Gas

A growing chorus of analysts and observers point to natural gas as a potential game-changer in transportation because of its ability to satisfy multiple constraints, such as sustainability, affordability, and security.²⁶⁰ We believe that natural gas has a critical role to play in the United States' energy future, but not as an alternative to petroleum in short-haul transport via compressed natural gas vehicles (NGVs). Instead, natural gas makes the most sense in the electric power sector and, perhaps, in fleet vehicles with central refueling stations: buses, taxicabs, and others. To understand why, it is useful to review the pros and cons of natural gas as an energy source.

256. *Id.* at 12.

257. *Id.*

258. *Id.*

259. *Electric Annual 2007*, *supra* note 217, at 102.

260. See, e.g., T. Boone Pickens & Ted Turner, *New Priorities For Our Energy Future*, WALL ST. J., Aug. 17, 2009, available at <http://online.wsj.com/article/SB20001424052970203863204574348432504983734.html>.

First, consuming natural gas emits about thirty percent less CO₂ than oil and forty percent less CO₂ than coal on an energy equivalent basis,²⁶¹ a calculation that does not take into account the platform in which the fuel is consumed. There is a world of difference between an inefficient internal combustion engine, a pulverized coal power plant and a natural gas power plant. On average, internal combustion engines currently achieve an efficiency rating of just twenty to thirty percent.²⁶² Meanwhile, the fleet of U.S. coal power plants currently rates at thirty percent.²⁶³ The current gas fleet reaches roughly forty-three percent, and has been improving substantially as combined cycle gas plants are deployed in greater numbers.²⁶⁴ Current generation combined cycle plants reach efficiency levels of sixty percent,²⁶⁵ which, when combined with the lower carbon profile of gas, results in an emissions reduction of about seventy percent per unit of electricity generated versus the coal fleet.²⁶⁶

Second, natural gas is currently a largely domestic fuel. In 2008, dry domestic natural gas production equated to eighty-nine percent of total natural gas consumed in the United States.²⁶⁷ In addition, fully ninety percent of U.S. gross natural gas imports came from Canada.²⁶⁸ Only a small fraction—about 1.5 percent—of U.S. gas supplies came from the global liquefied natural gas (LNG) market in 2008.²⁶⁹ This was just below the all-time high in 2007 of about three percent.²⁷⁰ It is important to note, however, that domestic natural gas prices have historically tracked international oil prices, which raises concerns about price volatility. During the summer of 2008, U.S. natural gas futures prices spiked as high as \$13.58 per million Btu on the New York Mercantile Exchange (NYMEX).²⁷¹ Figure 11 plots NYMEX oil prices versus natural gas prices on a Btu equivalent basis since 1994.²⁷²

261. DOE, EIA, *Natural Gas Issues and Trends*, at 58 (1999), available at http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_trends/pdf/cha-pter2.pdf.

262. DOE, EERE, *Advanced Combustion and Emissions Control Technical Roadmap for Light-Duty Powertrains*, at 8 (2006), available at http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/acec_roadmap.pdf.

263. János M. Beér, *Higher Efficiency Power Generation Reduces Emissions: National Coal Council Issue Paper*, at 2 (2009), available at <http://web.mit.edu/mitei/docs/reports/beer-emissions.pdf>.

264. *Annual Energy Outlook 2009*, *supra* note 32, at 126, 135 (2009) (assumes natural gas heat content of 1,028 Btu per cubic foot and 3,412 Btu per kilo-watt hour).

265. GE Energy, *Gas Turbine and Combined Cycle Products*, at 4, available at www.gepower.com/prod_serv/products/gas_turbines_cc/en/downloads/gasturbine_cc_products.pdf.

266. Authors' calculations assuming natural gas contains 45% less carbon than coal and comparing a combined cycle gas turbine (60% efficiency) to the existing coal fleet (32% efficiency).

267. *Annual Energy Review 2008*, *supra* note 18, at 187.

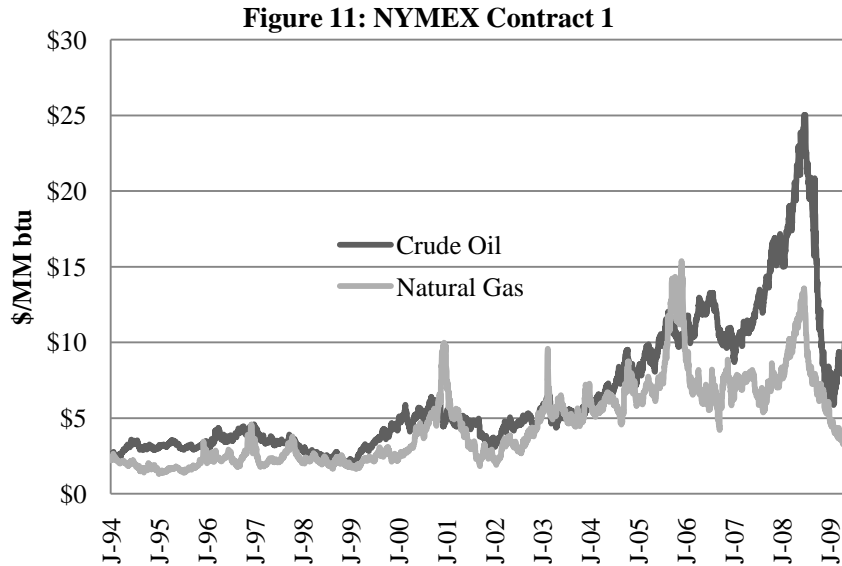
268. *Id.* at 191.

269. DOE, EIA, *Natural Gas Monthly, July 2009*, Tbls 1 & 4 (2009) (for author's calculations).

270. *Annual Energy Outlook 2009*, *supra* note 32, at 135.

271. DOE, EIA, *Natural Gas Navigator: Daily Natural Gas Futures: Contract 1*, tonto.eia.doe.gov/dnav/ng/hist/ngc1d.htm (last visited, Sept. 11, 2009) [hereinafter, *Natural Gas Navigator*].

272. *Id.*; DOE, EIA, *Petroleum Navigator: NYMEX Futures Prices*, available at tonto.eia.doe.gov/dnav/pet/pet_pri_fut_s1_d.htm (last visited Sept. 11, 2009).



Still, the price picture has been growing less clear for natural gas. End use natural gas prices in the United States generally trended well below prices in European and Asian economies beginning in late 2007 and continuing through most of 2008 and 2009.²⁷³ In part, this reflects the fact that there is relatively little fuel-switching between gas and oil in the United States. It also reflects our insulation against the often fierce competition for access to spot LNG cargoes. In Asian economies in particular, where LNG imports account for a more substantial share of gas consumption, high demand has led to large price swings. LNG cargoes fetched prices above \$23 per million Btu in the third and fourth quarters of 2008.²⁷⁴

Finally, mounting evidence suggests that the United States may have an abundance of domestic natural gas. Just a few years ago, most analysts had concluded that U.S. gas production was in an irrevocable free-fall.²⁷⁵ Gulf of Mexico production, which in 1990 met nearly fifty percent of U.S. demand, was in a state of rapid decline.²⁷⁶ By 2007, gross Gulf withdrawals provided just twelve percent of U.S. natural gas consumption,²⁷⁷ and new discoveries were in short supply. According to DOE, 2007 federal offshore reserves of both dry and wet natural gas were at roughly fifty percent their 1992 levels.²⁷⁸ Onshore conventional reservoirs were also experiencing slow growth, and discussion of

273. IEA, *NATURAL GAS INFORMATION: 2009 EDITION*, at III-29-30, Tbl. 18, Tbl. 19, Tbl. 20 (IEA 2009).

274. *Id.* at III-20 Tbl. 12.

275. See e.g., ROBERT L. HIRSCH, *PEAKING OF WORLD OIL PRODUCTION: IMPACTS, MITIGATION, AND RISK MANAGEMENT* 33-36 (National Energy Tech. Lab. 2005).

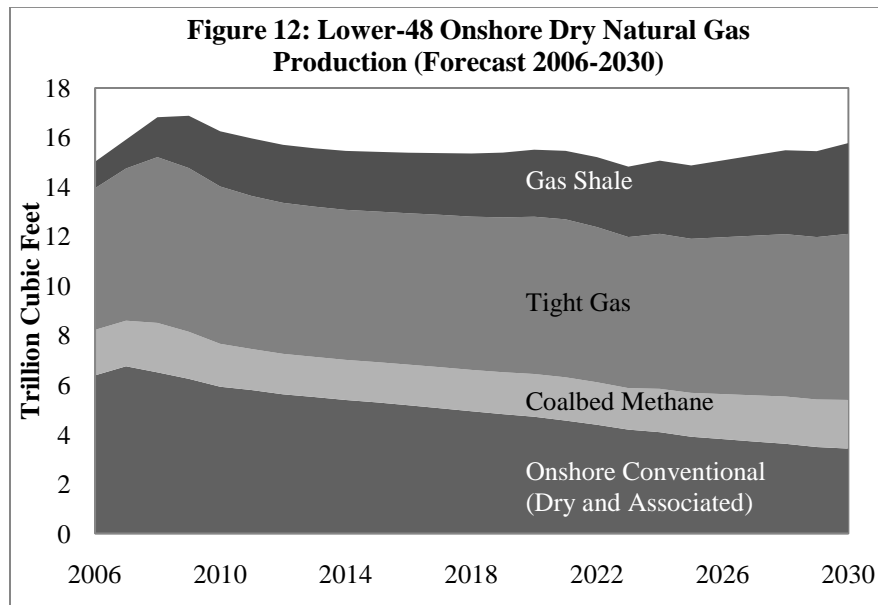
276. *Annual Energy Review 2008*, *supra* note 23, at 193, 195.

277. *Id.*

278. DOE, EIA, *Federal Offshore Gulf of Mexico Proved Reserves*, available at tonto.eia.doe.gov/dnav/ng/ng_enr_deep_s1_a.htm.

the need for a trans-continental pipeline that would access stranded gas resources in Alaska's North Slope, perhaps 100 trillion cubic feet (tcf), grew intense despite the fact that the cost of the project was estimated at more than \$19.4 billion.²⁷⁹

By early 2008, however, U.S. gas markets were being completely reshaped. The change stemmed from advancements in the recovery of gas resources from unconventional reservoirs like shale gas, coal bed methane, and tight gas. The estimates vary widely, but consensus seems to be settling on undiscovered technical recoverable reserves well in excess of 1,000 tcf. In June of 2009, the Potential Gas Committee at the University of Colorado estimated that total U.S. reserves—proved, probable, possible, and speculative—were in excess of 2,000 trillion cubic feet.²⁸⁰ By way of comparison, BP reports that current U.S. proved gas reserves are just over 200 tcf.²⁸¹ One look at Figure 12 tells the story.



With conventional production in rapid decline, shales, coal bed methane, and tight gas are expected to keep lower forty-eight onshore production steady for the next two decades. Shallow water Gulf of Mexico production continues to decline through 2030 in DOE forecasts, while advances in technology provide a steady increase in deepwater production.²⁸² No doubt, expanded offshore development in the Atlantic and Pacific regions of the United States could boost overall offshore output, but expectations are growing that onshore

279. DOE, EIA, Annual Energy Outlook 2007, *Issues in Focus: Alaska Natural Gas Pipeline Developments*, at 52-54, available at <http://www.eia.doe.gov/oiaf/aeo/otheranalysis/angpd.html>.

280. Potential Gas Comm., *Potential Supply of Natural Gas in the United States*, at Slide 4, Dec. 31, 2008, available at <http://www.aga.org/NR/rdonlyres/D4CFEBEB-81B3-4219-9800-6FFDDC7FCD1D/0/0906PGC.pdf>.

281. BP, *Statistical Review of World Energy 2009*, *supra* note 2, at 22.

282. *Annual Outlook 2009*, *supra* note 32.

unconventional production could provide the United States with a scalable, affordable, secure, and clean source of energy for everything from electric power generation to home heating and industrial processes.

At least two significant question marks exist regarding the future of unconventional gas. Only time and experience will ultimately provide answers to both. But two years into the great U.S. gas boom, some signs are pointing to a less rosy outlook than many observers have suggested.

First, what makes shale, coal bed methane, and tight gas ‘unconventional’ is rock property. In essence, unconventional reservoirs are defined by reduced porosity vis-à-vis conventional reservoirs.²⁸³ In order to extract natural gas from these reservoirs, producers must over-pressurize the source rock, creating multiple fractures in which gas supplies can accumulate. The fracturing process is typically achieved using fluids like water under high pressure along with viscosity-enhancing chemical agents. In addition, producers typically inject a proppant, or propping agent, into the well in order to keep the fractures from closing when pressure is reduced.²⁸⁴

As unconventional gas production grows more common, some externalities of hydraulic fracturing may be coming into focus. Concerns about the impact on water wells spurred debate in Congress in 2009, and there is a growing call for EPA to start regulating hydraulic fracturing at the national level under the Underground Injection Control Program and the Safe Drinking Water Act.²⁸⁵ Congress exempted the practice from federal regulation as part of EPAct 2005.²⁸⁶ Of course, in addition to drinking water safety, the broader issue of freshwater access is likely to emerge as a challenge for the industry, particularly in the Western United States. Lifecycle water use for unconventional gas recovery is significant—a typical shale well using hydraulic fracturing consumes 3.4 million gallons of fresh water.²⁸⁷ Water treatment options certainly exist, but recycling is not currently the norm.²⁸⁸

The second question mark for unconventional gas is the cost of production—or perhaps more importantly, the price of natural gas required to support ongoing capital expenses in unconventional production. Natural gas production wells have steep decline rates. According to published company reports, the first year decline rate for a typical well in the Haynesville shale play is eighty-one percent; the second year rate is thirty-four percent and the third

283. DOE, Office of Fossil Energy and Nat'l Energy Tech. Lab., *Modern Shale Gas Development in the United States: A Primer*, at 14 (Apr. 2009), available at http://fossil.energy.gov/programs/oilgas/publications/naturalgas_general/Shale_Gas_Primer_2009.pdf.

284. EPA, Underground Injection Control Program, *Hydraulic Fracturing*, available at www.epa.gov/ogwdw000/uic/wells_hydrofrac.html.

285. See e.g., National Public Radio Press, *Face Off Over Fracking: Water Battle Brews on Hill*, May 27, 2009, available at www.npr.org/templates/story/story.php?storyId=104565793.

286. EPAct 2005 *supra* note 159, at § 322.

287. See Chesapeake Energy, *Natural Gas Production*, available at www.askchesapeake.com/Barnett/Multimedia/Brochures/Water%20Use%20in%20Barnett%20Deep%20Shale%20Gas%20Exploration%20May%202009_Rev%201.pdf (for Chesapeake Energy's discussion of water recycling).

288. See Chesapeake Energy, *Natural Gas Production*, available at www.askchesapeake.com/Barnett/Production/Pages/WaterManagement.aspx, (last visited Aug. 25, 2009) (for a second Chesapeake Energy discussion on water recycling).

year rate is twenty-two percent.²⁸⁹ In other words, steady production requires steady capital investment in new wells. Factoring in these costs, along with taxes and operating costs, Bernstein Research report recently estimated that Haynesville operators needed a natural gas price of nearly \$8 per million Btu to earn a nine percent return on average capital employed (a modest return for a mid-sized operator in the natural gas business).²⁹⁰ This is equivalent to an oil price of roughly \$50 per barrel.²⁹¹ Throughout 2009, natural gas prices have been far below this, and the pressure on shale operators to postpone new drilling has been immense. Of course, increased demand from adding transportation as a major gas consumer would also arguably drive up equipment and service costs, ultimately buoying natural gas prices at higher levels.

Setting aside these challenges, the real dilemma seems to be how best to use natural gas. Some, like T. Boone Pickens, have proposed displacing gas from the power sector and deploying it in transportation.²⁹² This seems counterproductive. It would be illogical to take natural gas out of combined cycle gas plants and burn it in internal combustion engines. As noted above, current generation combined cycle gas plants achieve efficiency levels of sixty percent, which, when combined with the lower carbon profile of gas, results in an emissions reduction of about seventy percent per unit of electricity generated versus the existing coal fleet.²⁹³ Comparatively, CNG vehicles offer just a forty-five percent benefit compared to the existing passenger car stock (even factoring in the slight fuel-economy advantages of new CNG cars versus the existing ICE stock).²⁹⁴

A more straightforward proposal might be to simply incentivize the rapid expansion of U.S. natural gas production to meet some fraction of transportation demand. To get a sense of the magnitude of such a proposition, consider that the U.S. transportation sector used roughly 14.4 mbd of U.S. liquid fuels in 2008.²⁹⁵ Of this total, ethanol and biodiesel provided approximately 670,000 b/d,²⁹⁶ leaving oil consumption in the U.S. transportation sector at about 13.6 mbd. Converted to a Btu basis, U.S. transportation sector demand equaled roughly 27.9 quadrillion Btu, with on-road transport amounting to 22.3 quadrillion Btu.²⁹⁷ By comparison, total domestic production of dry natural gas totaled

289. Goodrich Petroleum Corp., Haynesville Shale Overview, Presentation at EnerCom Oil & Services Conference VII (Feb. 18-19, 2009) at 19, available at www.doodrichpetroleum.com/presentations/20090213_EnerCom.pdf.

290. Bernstein Research, *Why the Haynesville (and Other Plays) Won't Work at \$4, \$5, or \$6/mcf Gas*, BERNSTEIN COMMODITIES AND POWER, Mar. 27, 2009.

291. See DOE, EIA, *Energy Calculator* (2008) www.eia.doe.gov/kids/energyfacts/science/energy_calculator.html (last visited Sept. 12, 2009) (analysis performed by the authors assumes 5.8 million Btu per barrel of crude oil and 1,028 Btu per cubic foot of natural gas).

292. Pickens Plan, *The Plan: America is Addicted to Foreign Oil*, available at www.pickensplan.com/theplan/ (last visited Sept. 12, 2009).

293. Authors' calculations assuming natural gas contains 45% less carbon than coal, and comparing a combined cycle gas turbine (60% efficiency) to the existing coal fleet (32% efficiency).

294. *Annual Energy Outlook 2009*, *supra* note 32.

295. *Id.* at 125.

296. *Id.* at 131.

297. *Id.* at 125.

roughly 21 quadrillion Btu in 2008.²⁹⁸ In other words, the United States would need to more than double domestic gas production to offset all on-road use of oil (assuming that no currently-produced natural gas would move to the transportation sector). Alternatively, all of the natural gas used for power generation in 2008—approximately 6.58 quadrillion Btu—would displace just 3.43 mbd of oil.²⁹⁹

Thus far, we have focused largely on the supply-side issues associated with natural gas as a transport fuel. But there are also substantial drawbacks in distribution of natural gas for NGVs and in the demand side—vehicles—as well.

Use of natural gas for surface transportation would require the development of significant new infrastructure that is difficult to justify. To be sure, both NGVs and GEVs will require new infrastructure for refueling or recharging. The two technologies, however, face different barriers when it comes to refueling. The electric grid already reaches nearly every building in the United States. Although some grid upgrades and the provision of public charging infrastructure would be necessary, the underlying infrastructure is already in place, and a substantial portion of grid improvements will be made in any event as part of the evolution of the smart grid. In contrast, creating a refueling infrastructure for natural gas powered cars would be a significant undertaking, especially in those regions of the United States that do not already have networks for delivery of natural gas to residences and businesses.

Even in areas with a developed gas infrastructure, new gas lines would have to be laid to serve refueling stations. Furthermore, refueling stations might be needed more than gas stations for a similar number of vehicles (NGVs tend to have a shorter range than gasoline or diesel fueled vehicles because at ambient temperature, methane is not a dense fuel).³⁰⁰ Automobiles must carry their fuel on board, so it must both fit in a small space and power the vehicle for long periods—in other words, possess high energy density. Natural gas is expensive and somewhat dangerous to compress. Vehicle range, therefore, will always be a challenge for natural gas, which is much better suited to combustion in stationary power plants. Batteries also face a storage challenge, but their capabilities are limited by our failure to invest in innovative technology rather than thermodynamics and molecular physics. As the incentives begin to align, battery technology is advancing rapidly in order to produce stored power suitable for LDVs.

Home refueling stations are also available for homes with natural gas service, but they have two critical drawbacks. First, they are quite expensive (over \$8,500 installed in the Washington, D.C. area).³⁰¹ Second, they are slow, taking up to eighteen hours to fill a completely empty tank (or about four hours to pump sufficient fuel to travel fifty miles) in the Honda Civic GX, the only NGV currently available for sale in the United States.³⁰² The prospect of a new

298. *Id.* at 135-36.

299. *Id.* at 111-13, 131-32.

300. *Annual Energy Outlook 2009*, *supra* note 3, at 43.

301. Telephone Interview with a local Phil device distributor, Jan. 2009 (Price obtained by author for the Washington D.C. area).

302. Metropolitan Utilities District Omaha, Nebraska, Natural Gas Vehicle Frequently Asked Questions, mudnebr.net/naturalgas/pdfs/cng.faq.pdf (last visited Sept. 12, 2009).

refueling infrastructure to supplement the existing one for a fuel that is not even capable of replacing oil seems like a significant obstacle that NGV promoters are unlikely to overcome.

Finally, using natural gas means investing significant resources while remaining reliant on a single fuel. Setting aside all other propositions, this simple fact disadvantages NGVs to electrification. Investing in a technology that allows for the diversification of fuels instead of the concentration of risk in another fuel is a better way to enhance our energy and economic security.

Given those challenges, NGV promoters now appear to have recognized that NGVs may present a viable option for some fleets but are unlikely to be practical for personal vehicles. T. Boone Pickens' original energy plan in the summer of 2008 proposed to shift all of the natural gas used for power generation to vehicles, and to replace the natural gas used for power generation with wind.³⁰³ Over the months that followed, however, as the challenges of using NGVs became more apparent, Mr. Pickens shifted his focus to the use of NGVs for medium- and heavy-duty trucks, which we would argue have similar infrastructure challenges for long-distance transport as they exist for short-haul transport.³⁰⁴ Natural gas may, however, prove to be a cost-effective fuel for some centrally-fueled fleets, such as public metropolitan buses, whose vehicles would travel no further than the range of an NGV and which are fueled at a central facility, where fleet owners could install the refueling infrastructure. Nevertheless, fleet vehicle energy consumption represents just 8.4 percent of on-road transportation energy usage today.³⁰⁵

B. Hydrogen

In the early part of this decade, there was a sense that hydrogen-fueled vehicles would provide the answer to our energy security problems. In his 2003 State of the Union address, President Bush announced a \$1.2 billion research initiative to develop hydrogen-powered automobiles, stating that, "the first car driven by a child born today could be powered by hydrogen, and pollution-free."³⁰⁶ Shortly thereafter, California Governor Arnold Schwarzenegger established his Hydrogen Highway Network Action Plan, whose stated goal was "to ensure that by the end of the decade every Californian has access to hydrogen fuel along the State's major highways, with a significant and increasing percentage of that hydrogen produced from clean, renewable sources."³⁰⁷ He then worked with General Motors to build a prototype

303. Kate Galbraith, *Pickens Plan Stirs Debate, and Qualms*, N.Y. TIMES, Aug. 5, 2008, available at <http://www.nytimes.com/2008/08/05/business/05pickens.html>; Editorial, *T. Boone Pickens Rides the Wind*, N. Y. TIMES, July 22, 2008, available at <http://www.nytimes.com/2008/07/22/opinion/22tue3.html>.

304. T. Boone Pickens, *One Year Later, We Still Import Too Much Oil*, POLITICO, July 8, 2009, available at <http://www.politico.com/news/stories/0709/24652.html>.

305. *Annual Energy Outlook 2009*, *supra* note 32, at Tbls 45 & 62.

306. State of the Union Address of the President to the Joint Session of Congress (2003), available at www.c-span.org/executive/transcript.asp?cat=current&code=bush_admin&year=2003.

307. Governor Arnold Schwarzenegger's California Hydrogen Highway Network Action Plan, www.hydrogenhighway.ca.gov/vision/vision.pdf (last visited Sept. 12, 2009).

hydrogen-fueled Hummer, which was used by his office.³⁰⁸ There was public discussion and excitement about the development of a hydrogen economy.

Hydrogen-powered vehicles are electric drive-train vehicles (just as battery-powered electric vehicles) whose electricity is obtained from a fuel-cell instead of a battery. In the sense that both vehicles use electric drive-trains, they share many components. In fact, we recognize that at some point in the future, as fuel cell technology progresses and the cost of fuel cells fall, hydrogen vehicles may be a successor or supplement to battery-powered electric vehicles. Given the commonality between the vehicle designs, and the possibility of converting grid-connected electric vehicles to hydrogen fuel cell vehicles by replacing batteries with fuel cells, we do not view electrification of the LDV fleet as incompatible with the deployment of hydrogen fuel cell vehicles in the future. At the present time, however, electrification is a more viable and cost-effective proposition.

Commercialization of hydrogen-fueled vehicles faces several challenges that are greater obstacles than those facing battery-powered, grid-connected vehicles.

First, there is no clear ability to manufacture sufficient quantities of hydrogen to fuel the automotive fleet. The United States currently manufactures about 9 million metric tons of hydrogen per year for industrial use, primarily for fertilizer production and refining oil.³⁰⁹ That volume is the energy equivalent of about 190 million barrels of oil, less than a ten day supply for the nation.³¹⁰ To replace just the portion of oil that is used for short-haul transportation, the nation would have to increase its production of hydrogen by over thirty times. Moreover, most of the hydrogen produced in the United States is produced from natural gas,^{311, 312} and we believe that rather than diverting a substantial portion of the nation's natural gas to produce hydrogen for vehicles, the gas resources should be dedicated to power generation, which is a more efficient use of the fuel. While hydrogen can be produced by electrolyzing water, that process is particularly expensive, and the faster you make the hydrogen, the more energy the process consumes.³¹³ In fact, to produce enough hydrogen to replace the gasoline we consume today would take more electricity than is currently generated in the entire nation.³¹⁴

Second, reliance on hydrogen would require the construction of an entirely new infrastructure to distribute it to consumers. Hydrogen can be produced on board a vehicle from gasoline, but doing so would not resolve our dependence on oil. It could be produced at refueling stations from natural gas, but that again raises questions regarding the availability of sufficient supplies of natural gas. It

308. Press Release, Governor Schwarzenegger Drives Hydrogen Hummer to the First Retail Hydrogen Fueling Station in California (Oct. 22, 2004), available at gov.ca.gov/press-release/2717.

309. DOE, EERE, *U.S. Dep't of Energy Hydrogen Program*, at 2 (2009), available at www1.eere.energy.gov/hydrogenandfuelcells/pdfs/doe_h2_program.pdf.

310. JOSEPH J. ROMM, *THE HYPE ABOUT HYDROGEN 72* (Island Press 2004) (calculation by authors based on conversion ratio).

311. DOE, *National Hydrogen Energy Roadmap*, at 7 (2002), available at www1.eere.energy.gov/hydrogenandfuelcells/pdfs/national_h2_roadmap.pdf.

312. Worldwide, approximately 48% of hydrogen is produced from natural gas, 30% from oil, 18% from coal and the remainder from electrolysis. Romm, *supra* note 309, at 72.

313. *Id.* at 75.

314. *Id.* at 76.

could be produced in central plants, but that would require development of a trucking network to distribute it to refueling stations, an expensive endeavor at large-scale volumes. Building pipelines would be difficult because hydrogen can make pipeline materials brittle and prone to failure.³¹⁵

Third, the use of hydrogen raises several safety issues. Hydrogen is highly flammable and easily ignitable.³¹⁶ Also, because hydrogen molecules are so small, they leak easily.³¹⁷ Moreover, the gas is clear and burns invisibly, making it difficult to tell if it has leaked or is on fire.³¹⁸ One approach to enhance safety issues would be to add an odorant, as we currently do to natural gas so that leaks in homes may be detected. The addition of an odorant, however, would likely be incompatible with use in a fuel cell.³¹⁹ Finally, to the extent that hydrogen is stored and transported at high pressures in order to make transport more cost effective, it increases the risk of tank or pipeline failure, which again raises the risk of fire.

Fourth, hydrogen fuel cells are significantly more expensive than petroleum or GEVs. While batteries currently make GEVs more expensive than conventional gasoline-powered ones, fuel cells are understood to be significantly more expensive, though how much so is unclear because having never been produced at scale it is difficult to estimate manufacturing costs. Nevertheless, most experts agree that hydrogen fuel cells seem to be much further away from commercialization than batteries.³²⁰

Finally, perhaps the largest obstacle to the development of a hydrogen-fueled light-duty fleet is the fact that hydrogen itself is much more expensive than electricity, and likely always will be. Hydrogen is not a source of new energy, but a carrier of energy processed from either natural gas or with the use of electricity. The process of producing hydrogen, preparing it for transport, distributing it, and converting it back into electricity is itself energy intensive and can consume as much as seventy-five percent of the initially available energy.³²¹ In contrast, transmission losses from the distribution of electricity, the same electricity that can be used to either make hydrogen or power cars directly, have averaged just below ten percent in recent years.³²² While it is difficult to predict the nature of future technological developments, it may prove to be very difficult for hydrogen to overcome this price disparity.

VI. THE PATH FORWARD

Given the diverse interests of many participants in the electric and automotive industries, we believe it is unlikely that they will come together to develop an efficient deployment strategy for GEVs. Because this issue is of

315. *Id.* at 101.

316. *Id.* at 105.

317. *Id.* at 105.

318. *Id.* at 106.

319. *Id.* at 106.

320. *Id.*; Stephen Power, *Energy Secretary, Congress Collide Over Hydrogen Car Funds*, WALL ST. J., July 28, 2009, at A6; Ulf Bossel, Presentation at "Intelec '05" at Berlin, *On the Way to a Sustainable Energy Future*, at 6 (Sept. 18 -22, 2005), available at www.efcf.com/reports/E15.pdf.

321. *Id.*

322. *Annual Energy Review 2008*, *supra* note 18, at 66.

such great importance to the nation, we believe that the government must facilitate this process.

It is beyond the scope of this paper to identify at any level of detail the policies that will be necessary to implement a research, development and deployment strategy for GEVs. Suffice it to say that there are two major challenges to address. First, battery technology must be improved to reduce the cost, improve the energy density, and extend the life of existing batteries. We have long advocated the dedication of significant government resources to reduce battery costs.³²³ Congress and President Obama took significant steps forward in this regard with the American Recovery and Reinvestment Act of 2009.³²⁴ Yet we do not believe that this one time expenditure is enough. Reducing the cost of batteries is the most critical step to make the total cost of ownership of a GEV competitive with a traditional internal combustion engine powered vehicle. Therefore, it may be necessary to dedicate more funds to this effort.

Second, recharging infrastructure must be deployed. Doing so will require the development of a business model that will fund that infrastructure. It will also require policymakers to address the infrastructure chicken and egg problem. Consumers will not purchase cars on a wide scale until recharging infrastructure is in place, but there is little incentive to invest in such infrastructure until it is clear that sufficient cars will be deployed to help recapture the cost of the infrastructure. The government should dedicate significant funds to the development of recharging infrastructure, at least in a set number of communities in which the government would seek to facilitate the development of GEV ecosystems. In such localized ecosystems, a sufficient concentration of vehicles would reduce the cost of sales, repair, and recharging infrastructure to support significant deployment of GEVs. That deployment, in turn, could be used to test both consumer acceptance and different business models that would attract consumers.

By helping to bring down the total cost of owning a GEV and defining and funding large scale pilot demonstrations, the government can help move the ball forward. At a later point in time, as the shape of the technology and business models come into sharper focus, the government will have to address regulatory issues, such as who, if anyone, will regulate sellers other than traditional utilities of electricity to GEV owners and subject to what rates, terms and conditions they can sell electricity for GEV charging. There will undoubtedly be other regulatory issues which are not yet even apparent. At this point, however, we believe that government must first adopt the goal of electrification as a national priority.

VII. CONCLUSION

Transportation electrification offers the most promising pathway to a more secure energy future, but there should be no mistaking the magnitude of this undertaking. The existing oil infrastructure spans the globe, was created over the course of a century, and is worth trillions of dollars. Replacing it with an alternate infrastructure that delivers similar functionality will take decades,

323. Energy Security Leadership Council, *Recommendations to the Nation on Reducing U.S. Oil Dependence*, at 40 (2008), available at http://secureenergy.org/reports/ESLC_Oil_Report.pdf.

324. American Recovery and Reinvestment Act, Pub. L. No. 111-5, 123 Stat. 115 (2009).

which should not be surprising given that new cars routinely last for fifteen years and new power plants are built to operate for fifty years.

Without committing to electrify at least parts of our transportation system, the burdens of oil dependence on our economy and our national security are only likely to grow. In the past, we have failed to commit to a particular technology path, whether because of uncertainty as to the correct path or discomfort about the government making such critical decisions instead of the marketplace. That approach has not worked.

A careful examination of the relative merits and pitfalls of each technology has demonstrated not only that electrification offers numerous advantages over oil, and that it has many advantages over the other most promising alternatives, but that none of the other alternatives even offers the promise of a viable solution. We have chosen electrification of the vehicle fleet because we believe that it will work and because we are certain that the alternatives, including maintaining the status quo, will not.

Once this is understood, the nation can commit itself to solving those challenges that must be addressed for electrification to work and to ultimately connecting the nation's light-duty fleet to the electrical power grid. In our estimation only this can close the chapter of U.S. dependence on foreign oil.