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Resilience by Other Means: The Potential Benefits of Alternative Government Investments in U.S. Energy Security

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Chapter 7
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I. Introduction

U.S. incentives to use military force to maintain the flow of oil in the Persian Gulf revolve largely around the economic costs of an oil supply disruption. To an important extent, these costs depend, in turn, on baseline levels of U.S. petroleum supply and consumption and how quickly the United States could alter those levels in the event of a disruption. What measures could the United States take to reduce the economic consequences of an oil supply disruption, both in the short term and in the longer run? This book proceeds from the assumption that American policy should depend on a comparison of the potential costs and benefits of such measures with those of a comparable investment in U.S. military capabilities intended to reduce the likelihood, size, and/or duration of an oil supply disruption. Thus if the United States could limit its vulnerability to a major oil supply disruption, it might be able to cut commensurately its need for military forces.

This chapter explores ways that the U.S. government could potentially reduce the economic costs of a future oil supply disruption, thereby reducing the incentives to be politically and militarily involved in the Persian Gulf in order to prevent a future disruption or to restore the flow of oil as quickly as possible, should a disruption nevertheless occur. After briefly reviewing the potential direct economic costs to the United States of an oil supply disruption, which are examined in detail in Chapter 3, it identifies and evaluates some of the principal policy alternatives, on both the supply and demand sides, and both at home and abroad. On the supply side, the chapter emphasizes potential measures to ramp up domestic oil production and the size of the strategic petroleum reserve. On the demand side, it focuses on the transportation sector, which is responsible for some 70 percent of U.S. oil consumption. Here, leading options include raising taxes on petroleum products, raising fuel economy standards for cars and trucks, promoting the production and substitution of alternative fuels, and supporting the electrification of the transportation sector. The chapter also examines how – and to what extent – the United States could promote similar policies in other oil producing and consuming countries. Because oil is a global commodity, and because U.S. energy security is linked to the global price of oil, other countries' preparations for dealing with oil shocks also bear on U.S. security.

Could the United States increase its energy security or achieve an equal level of energy security at less cost by investing at home and abroad in such measures? This chapter finds that there is no panacea. The U.S. economy will be affected by oil supply disruptions as long as the United States consumes a substantial amount of petroleum and oil can be freely traded across U.S. borders, and no single policy by itself promises to reduce significantly the cost of a future oil supply disruption. In combination, however, these options could make a substantial difference, both by reducing the exposure of the U.S. economy to a jump in world oil prices and by damping the impact of a supply disruption on those prices. Indeed, the United States could arguably reduce its vulnerability eventually to the point where the biggest impact of an oil supply disruption would be felt indirectly, through its effects on the economies of other countries with which the United States is economically interdependent. In contrast, as the penultimate section of the chapter argues, the ability of the United States to help or ensure that other countries adopt similar measures seems highly limited.

Before proceeding, an important caveat is in order. This chapter does not evaluate the potential environmental consequences of various policy options. Of particular concern is the impact on levels of greenhouse gas emissions, which are implicated in global warming. Although a thorough cost-benefit analysis should consider such externalities, this chapter remains limited to examining the contributions to reducing U.S. vulnerability to oil supply disruptions in the Persian Gulf.

II. Incentives for Involvement in the Persian Gulf: The Potential Economic Costs of Oil Supply Disruptions

To lay the foundation for an analysis of measures that can reduce the cost of oil supply disruptions, we need to identify the key ways in which a disruption could hurt the U.S. economy. Frequently, concerns focus on shortages of petroleum products, which seemed to occur during the oil shocks of the 1970s, when long lines appeared at some U.S. gasoline stations. In fact, however, most of the shortages that did occur resulted from domestic policies, such as price controls, that created bottlenecks in the supply chain. And the prospects for physical shortages have further diminished as the international oil market has become more liquid, with prospective purchasers generally being able to meet their needs at some price. In any case, the U.S. received just 16.4 percent of its imports from the Middle East in 2011.[1]

Instead, the biggest impact of an oil supply disruption in the United States is likely to take the form of higher oil prices. Depending on the size and expected duration of a disruption, the world price of oil could rise substantially. Such an oil price shock would affect the US economy in three main ways.[2] First, it would result in increased outlays for oil imports, transferring wealth to oil producing countries and thereby reducing aggregate demand at home. Second, it would reduce the country's economic output as businesses cut back on energy use in response to the higher prices, causing production and productivity to decline. Both of these effects, however, are not unique to sudden supply disruptions; even a gradual increase in oil prices would produce similar results. Thus, the most distinctive cost of an oil price *shock* would be macroeconomic adjustment costs, which represent a temporary drop in output below the country's economic potential.

This summary of the potential economic costs of an oil supply disruption suggests four general strategies for reducing these costs: One is to lower the share of oil that is imported, which would limit the wealth transfer cost. Another is to cut the baseline level of oil consumption, which would limit the costs of lost economic output and reduce adjustment costs.

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[1] U.S. Energy Information Administration (EIA), *Annual Energy Review 2011* (Washington, DC: EIA, 2012), 127.

[2] John S. Duffield, *Over a Barrel: The Costs of U.S. Foreign Oil Dependence* (Stanford, CA: Stanford University Press, 2008). See also Kenneth R. Vincent, "The Economic Costs of Persian Gulf Oil Supply Disruptions," Chapter 3 in this volume.

Both of these strategies could also help to lower the average cost of oil, although such a reduction in price alone would not necessarily reduce the marginal cost of an oil price shock. Two other strategies would seek to reduce the economic costs by limiting the price increase caused by an oil supply disruption. The first of these is to increase temporarily the amount of oil on the market, thereby making up for some or all of the loss from the disruption. The other is to reduce quickly, if only temporarily, the demand for oil, which would also effectively compensate for some of the loss. The range of possible strategies can also be organized in terms of whether they concern the supply or demand side and whether they are designed to have sustained or short-term effects on supply and demand (see Table 1).

III. Possible Supply Side Solutions

We turn first to possible supply side solutions to the problem of oil supply disruptions. This area would seem to be the logical place to start, since it addresses most directly the potential problem of reduced supply. Here we find two main options. One is to increase U.S. oil production, which could reduce U.S. oil imports and bring down commensurately the amount of money sent abroad, both during a supply disruption and in normal periods. The other option is to increase U.S. oil reserves so that they could be released more quickly and/or for a longer period in the event of a supply disruption, which would help to moderate likely price increases.

Increase U.S. Oil Production?

After a long period of decline, production of hydrocarbon liquids in the United States has grown substantially in recent years. This positive trend has had three main causes. One has been increased offshore production of crude oil, which has been rising since 2008.[3] Another has been a rise in the output of natural gas plant liquids (NGPL) since 2005 as a byproduct of increased natural gas production.[4] But the most important cause has been increased production of so-called "tight" oil from shale and other underground rock formations through the use of hydraulic fracturing (fracking) and horizontal drilling.

Considerable uncertainty attends estimates of future U.S. oil production, in part because of the recent drop in world oil prices. For example, the most recent U.S. Energy Information Administration (EIA) projections show U.S. crude oil production in 2040 ranging from 7.1 million barrels per day (mbd) to 16.6 mbd, depending on oil prices and the ultimate size of U.S. oil resources.[5] Given these wide ranges, a promising place to begin an analysis is with the EIA's reference case, which assumes no change in current laws and regulations. The central trend in the EIA's reference case is generally positive, with total liquids production (crude oil plus NGPL) rising more or less steadily from 10.05 mbd in 2013 to 14.6 mbd in 2020, and then declining slowly thereafter. Largely as a result of this increase, the EIA projects that net oil imports will drop from 6.2 mbd in 2013 to 2.7 mbd, or just 14 percent of liquid fuels consumption, in 2020 and then rise slowly.[6] This trend marks a dramatic improvement over the

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[3] EIA, *Annual Energy Review 2011*, 123.
[4] EIA, *Annual Energy Review 2011*, 121, 139.
[5] U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2015* (Washington, DC: EIA, 2015), C-9 and D-9.
[6] EIA, *Annual Energy Outlook 2015*, A-23. These figures assume the implementation of some of the policies to reduce U.S. oil consumption described below.

high point of U.S. import dependence in the middle of the last decade, when oil from abroad accounted for more than 60 percent of petroleum consumption.[7]

What steps could the United States take to increase further domestic petroleum production? The federal government currently provides about $500 million dollars a year in subsidies to the domestic petroleum industry. Presumably, additional subsidies could incentivize even more production, but these would seem to be politically infeasible in view of the low price of oil and current fiscal constraints.[8] Instead, the most common recent policy proposals for increasing production have involved opening up the Arctic National Wildlife Refuge (ANWR) and hitherto restricted areas in the Outer Continental Shelf (OCS) to exploration and production. According to the most detailed government estimates, however, the potential for raising U.S. oil output through these measures is relatively modest. In 2008, the EIA estimated that the coastal plain region of ANWR contained between 5.7 and 16.0 billion barrels of oil that could be produced using current technology, with a mean estimate of 10.4 billion barrels. Assuming that production would begin in 2018, ten years after approval to develop the area was given, output would peak in the mean case at 780,000 barrels per day in 2027 and decline slowly thereafter.[9] A 2009 EIA analysis noted that the undeveloped areas of the OCS contained approximately 18 billion barrels of technically recoverable oil, although that estimate was highly uncertain given the absence of previous exploration and development activity. Assuming that those areas were

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[7] EIA, *Annual Energy Review 2011*, 121.
[8] Organization for Economic Cooperation and Development (OECD), *Inventory of Estimated Budgetary Support and Tax Expenditures for Fossil Fuels 2013* (Paris: OECD Publishing 2012), 429.
[9] U.S. Energy Information Administration (EIA), *Analysis of Crude Oil Production in the Arctic National Wildlife Refuge* (Washington, DC: EIA, 2008).

open for development, the EIA estimated that U.S. crude oil production would be 270,000 barrels per day higher in 2020 and 540,000 barrels per day higher in 2030.[10] In the longer term, there may be other steps that the U.S. government can take to promote higher levels of domestic oil production. The injection of carbon dioxide into depleted wells in order to boost their pressure and the exploitation of America's vast reserves of oil shale are thought to hold particular promise. But the widespread use of these techniques is currently constrained by a number of technical, economic, and environmental factors.[11]

Increased domestic production would cause net U.S. imports to decline by a roughly equivalent amount. Thus it would bring down the U.S. import bill for oil by an amount equal to the number of barrels times the world price of oil, especially if U.S. consumption stayed roughly constant, and that benefit would be magnified in the event of a sharp increase in world oil prices following an oil supply disruption in the Persian Gulf. Higher U.S. output could also exert downward pressure on world oil prices. But exactly what impact it would have would depend critically on the responses of consumers and other producers. Lower prices would promote both greater consumption and production cuts, causing prices to rise again. Thus the 2008 EIA analysis estimated that opening ANWR would reduce oil prices by just 75 cents per barrel in 2025, or just over one percent, and by less in subsequent years in the mean resource case.[12] As perhaps the most thorough recent analysis of the subject concludes, "Letting U.S. production rise

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[10] U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2009* (Washington, DC: EIA, 2009), 35-37.
[11] Michael Levi, *The Power Surge: Energy, Opportunity, and the Battle for America's Future* (New York: Oxford University Press, 2013).
[12] EIA, *Analysis of Crude Oil Production,* 11.

would help keep a lid on prices, which might otherwise rise more. Anything much beyond that, though, seems unlikely, at least in the long run."[13]

Higher production levels alone, moreover, would not provide protection against the other economic costs of oil shocks. For that, the United States would need the ability to increase domestic production quickly in response to unanticipated supply disruptions elsewhere. This is precisely what occurred during the Suez crisis of 1956 and the unsuccessful Arab oil embargo of 1967. Since about 1970, however, oilfields in the United States have been producing at 100 percent of their capacity, eliminating their ability to provide a supply cushion in the event of an emergency. In theory, the government could require producers to hold some of their production capacity in reserve, similar to the state-regulated prorationing system that prevailed from the 1930s through the 1960s, but such an arrangement would likely prove highly unpopular among both producers and consumers, since it would involve keeping oil off the market.

Increase the Strategic Petroleum Reserve?

Instead, this limitation has been addressed since the 1970s by the maintenance of strategic stocks of oil. In 1975, following the first oil shock, Congress mandated the creation of a Strategic Petroleum Reserve (SPR) with a capacity equivalent to ninety days of crude oil imports, or about 500 million barrels at the time. Two years later, the Carter administration increased the planned capacity to one million barrels, to be achieved by 1985. For various reasons, the filling of the SPR proceeded more slowly than originally planned and stalled at just under 600 million barrels in the early 1990s. Following the September 11 attacks, however,

[13] Levi, *Power Surge*, pp. 65-70, at 69-70.

President George W. Bush ordered that the SPR be filled to its then full capacity of some 727 million barrels, a goal that was achieved in 2009.[14]

In the event of an oil supply disruption, oil could be released from the SPR at a rate of as much as 4.4 mbd for 90 days. Over the next 90 days, the withdrawal rate would decline steadily, to approximately just one-third of the maximum amount.[15] A 2006 GAO study found that use of the SPR, especially in combination with other existing international reserves, could neutralize the economic impact of all but the largest supply disruptions. A larger combination of reserves, however, would be needed to compensate for a three month-long closure of the Strait of Hormuz or a multi-year loss of Saudi Arabian oil production because of the volumes of oil required.[16]

The last decade has seen two unsuccessful efforts to increase the size of the SPR. The 2005 Energy Policy Act (EPACT), the first major U.S. energy legislation since the early 1990s, directed the government to expand the SPR to its authorized capacity of one billion barrels, which would require enlarging the existing storage sites and/or adding at least one new facility. And in his 2007 State of the Union address, President Bush called for doubling the size of the SPR, to 1.5 billion barrels by 2027. This proposal, however, was not included in that year's energy bill, and in 2011, the process of adding new capacity was canceled.[17]

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[14] Duffield, *Over a Barrel*, 81-82; EIA, *Annual Energy Review 2011*, 157. In 2011, 30 million barrels were sold as part of a coordinated release in response to oil supply disruptions in Libya and elsewhere, leaving a total of just under 700 million barrels in the SPR.
[15] U.S. Government Accountability Office (GAO), *Strategic Petroleum Reserve: Available Oil Can Provide Significant Benefits, but Many Factors Should Influence Future Decisions about Fill, Use, and Expansion* (Washington, DC: GAO, 2006), 25.
[16] GAO, *Strategic Petroleum Reserve.*
[17] See U.S. Department of Energy, "Strategic Petroleum Reserve - Profile," available at (accessed March 30, 2013).

Nevertheless, expanding the SPR remains a policy option. What is unclear is the optimal size, which depends in turn on the likely size and duration of a potential oil supply disruption. It also depends on the size of the strategic reserves maintained by other countries. The International Energy Agency (IEA) mandates that its members hold reserves equal to 90 days of imports, and several developing countries, notably China, have recently created their own reserves. A unilateral increase in the size of the SPR, however, might encourage other states as well as private actors to limit or even to reduce their own stockpiling efforts.[18] Thus the success of such a move might require participation of and cooperation by other states and perhaps increased regulation of private stockpile obligations. Whether and how the United States could encourage other states to increase the size of their reserves will be discussed below.

Another question is cost. The DOE recently put the capital cost of expanding the capacity of the SPR by 273 million barrels at $3.7 billion and estimated the cost of operating and maintaining the expanded portion of the SPR at $35 to $40 million per year.[19] Thus, the bulk of the cost of expanding the SPR would come from the acquisition of crude oil. Even with the price of oil running at roughly $60 per barrel, adding 300 million barrels, to reach a total capacity of one billion, would carry a price tag of roughly $18 billion. Creating a reserve of 1.5 billion barrels would require the purchase of approximately $48 billion worth of oil plus capital costs of about $10 billion and an additional $100 million per year for operation and maintenance. This would be a substantial investment, but in comparison with the level of military spending

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[18] The buildup of the SPR was accompanied by a decline in privately held stocks of crude oil and pretroleum products in the United States. See EIA, *Annual Energy Review 2011*, 157.
[19] U.S. Government Accountability Office (GAO), *Strategic Petroleum Reserve: the Cost Effectiveness of Filling the Reserve* (Washington, DC: GAO, 2008), 2.

intended to maintain the flow of oil, expanding the SPR might still be a cost-effective move in terms of potential economic damage avoided in the event of a major oil supply disruption. For example, an SPR of 1.5 billion barrels, supplemented by existing international reserves and assuming a proportionate increase in the maximum drawdown rate, would be sufficient to compensate for all but the most extreme scenario considered in the GAO analysis.

IV. Possible Demand-Side Solutions

We now turn to possible demand-side solutions for reducing oil consumption. In 2014, the United States consumed an average of 18.0 mbd of petroleum products, down from a peak of 20.8 mbd in 2005.[20] The EIA projects that, assuming no change in current laws and legislation, total petroleum consumption remain at roughly the same level, rising to 18.6 mbd in 2020 and then gradually declining to 18.1 mbd in 2040.[21]

This section will focus on what could be done to further reduce petroleum consumption in the transportation sector. In 2013, that sector alone accounted for 70.5 percent of petroleum consumption, with most (24.7 percent) of the rest being used in industry, and the EIA projects that the share of liquid fuels consumed by transportation will decline only slowly, remaining at least 65 percent through 2040.[22] Another reason for this focus is that transportation is the sector

[20] The 18.0 mbd figure comes from estimated consumption of liquid fuels less renewable fuels in EIA, *Monthly Energy Review* (May 2015), 45.
[21] EIA, *Annual Energy Outlook 2015,* A-23. These figures assume implementation of the increased fuel economy standards adopted in 2007 and 2009 and the Renewable Fuel Standard (RFS) adopted in 2007. For further discussion of these measures, see below.
[22] EIA, *Annual Energy Outlook 2015,* A-23.

most dependent on oil. Despite a noteworthy increase in the use of biofuels over the past decade, 92 percent of the energy used in transportation is still derived from petroleum.[23] Hence the sector is especially vulnerable to the consequences of oil supply disruptions.

There are two broad approaches for cutting petroleum consumption in the transportation sector. One is to reduce total fuel demand. The other is to displace petroleum with alternative fuels and energy sources, especially those whose prices are not determined by the price of oil. Over the years, the United States has tried both approaches, although it has not come close to exploiting fully the potential of either.

Reducing Transportation Fuel Demand

Transportation fuel demand can be reduced in two general ways. One is to change behavior. For example, people might be encouraged or required to drive less frequently and shorter distances, to use public transportation, or to operate their vehicles in a more energy efficient manner. The other is to make vehicles more energy efficient. For example, a 2008 National Research Council report estimated that if future improvements to gasoline-powered engines were used exclusively for fuel economy gains, then oil consumption per mile traveled could be reduced by almost 30 percent by 2020, more than 40 percent by 2035, and about 50 percent by 2050. Likewise, evolutionary improvements in hybrid-electric vehicles could reduce

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[23] EIA, *Monthly Energy Review* (May 2015), 35.

fuel consumption for new vehicles by about 50 percent by 2020, more than 60 percent by 2035, and nearly 70 percent by 2050 compared to current conventional gasoline engines.[24]

Governments have pursued two main strategies for reducing transportation fuel demand: various types of taxes intended to alter consumer incentives and regulations, primarily in the form of fuel economy standards. U.S. policy has emphasized the latter, but the former has even greater potential to bring about reductions in petroleum consumption.

Increased Fuel Economy

In the United States, light-duty vehicles (LDV) in the form of passenger cars and light trucks account for 60 percent of total transportation energy use. Thus it is not surprising that U.S. efforts to improve energy efficiency have focused on this important segment of the sector. In 1975, Congress established the Corporate Average Fuel Economy (CAFE) standards for LDVs, which were phased in between the late 1970s and the mid-1980s. During the following two decades, the standards remained at approximately 27.5 miles per gallon (mpg) for passenger cars and 20.5 mpg for light trucks. Because of the increasing popularity of minivans and SUVs, which qualified under the lower light truck standard, and the fact that on-road fuel economy is about 20 percent lower than test results, the actual fuel economy of the entire light vehicle fleet stood at just 20 mpg in 2005.[25]

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[24] National Research Council (NRC), *Transitions to Alternative Transportation Technologies: A Focus on Hydrogen* (Washington, D.C.: National Academies Press, 2008), 15.
[25] U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2008* (Washington, DC: EIA, 2008), 129.

Since the mid-2000s, U.S. fuel economy standards have been rising. In 2003, the Bush administration issued a rule that would boost the fuel economy of light trucks to 22.2 mpg, by 2007.[26] Much more significantly, the 2007 Energy Independence and Security Act (EISA) mandated an effective 40 percent increase in the tested fuel economy for all LDVs, from an average 25 mpg to 35 mpg, by 2020. It also established for the first time a fuel economy program for work trucks and commercial medium and heavy-duty trucks.[27] Then, after taking office in 2009, the Obama administration accelerated the introduction of the new standards and raised them slightly, setting a new target of 35.5 mpg by 2016.[28] Because of the discrepancy between on-road and tested fuel economy, however, the EIA projected that actual average fuel economy of new light vehicles would reach only around 30 mpg, and because of the relatively slow replacement rate, the actual fuel economy of the entire LDV stock was projected to rise much more slowly than the standards, reaching only 25.6 mpg in 2025 and 28.2 mpg in 2035.[29] Thus, according to various estimates, the higher standards introduced by EISA would reduce US

[26] Robert L. Bamberger, "Energy Policy: The Continuing Debate and Omnibus Energy Legislation," CRS Issue Brief for Congress (Washington, DC: Congressional Research Service, 2004), 11.
[27] Jay Hakes, *A Declaration of Energy Independence* (Hoboken, NJ: John Wiley & Sons, 2008), 87-88; Fred Sissine, "Energy Independence and Security Act of 2007: A Summary of Major Provisions," CRS Report for Congress (Washington, DC: Congressional Research Service, 2007).
[28] According to Christopher R. Knittel, "Reducing Petroleum Consumption from Transportation," *Journal of Economic Perspectives* 26, no. 1 (2012), 99, the effective increase will be to 34.1 mpg.
[29] U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2012* (Washington, DC: EIA, 2012), 146.

oil consumption by 1.1 to 1.2 mbd by 2020 and total liquid fuel use (including biofuels) by 2.1 mbd by 2030 as the U.S. LDV fleet gradually turned over.[30]

In 2012, after intensive negotiations with automakers, the Obama administration announced an even more dramatic increase in fuel economy, to 54.5 mpg on an average fleet-wide basis by 2025. Because of various credits, the actual fuel economy of new vehicles was expected to be about 49 mpg on average, but this figure would still represent a rough doubling of recent levels.[31] To be sure, the overall fuel economy of the entire LDV fleet would not increase nearly as much, given the large number of older vehicles still on the road. Nevertheless, the EIA projects that actual on-road fuel economy for all vehicles in use will increase from an average of 21.9 mpg in 2013 to 28.5 mpg in 2025 and then 37.0 mpg in 2040, or 75 percent. In addition, thanks to these newest standards, total consumption of liquids in the transportation sector would be an additional 0.6 mbd lower in 2025 and 1.5 mbd lower in 2040, and about 90 percent of the reduction would be in petroleum.[32]

One attraction of fuel economy standards is that the cost to the federal government is minimal. Instead, the direct costs of raising fuel efficiency are borne by auto manufacturers and, especially, consumers, who must pay more for new vehicles, although the additional cost to the average consumer may be offset by future savings on outlays for fuel. Nevertheless, fuel economy standards do nothing to reduce the fuel consumption of existing vehicles and, indeed, by making driving less costly in new vehicles, they may actually encourage more driving, a

[30] Nancy Pelosi, *A New Direction for Energy Security: A Detailed Summary* (Washington, DC: U.S. House of Representatives, 2007); Edmund L. Andrews, "Senate Adopts Energy Bill Raising Mileage for Cars," *New York Times*, June 22, 2007; EIA, *Annual Energy Outlook 2008*, 3.
[31] Bill Vlasic, "U.S. Sets Higher Fuel Efficiency Standard," *New York Times*, August 28, 2012.
[32] EIA, *Annual Energy Outlook 2012*, 30 and 146; EIA, *Annual Energy Outlook 2054* , A-16.

phenomenon known as the "rebound" effect. In addition, projected efficiency gains have been not nearly as great for heavy trucks and commercial aircraft, which have lacked fuel economy standards, yet these will account for an increasing share of transportation energy use – from 27.2 percent in 2013 to 36.0 percent in 2040 – as the fuel economy of LDVs rises.[33] Thus the rate at which overall petroleum use in the transportation sector can decline will be limited, especially until fuel economy standards are broadened to include other important categories of vehicles.

Taxes

The principal alternative way to reduce transportation fuel consumption is through the use of taxes. Indeed, economists argue that the most efficient way to do so is by imposing taxes on oil and/or petroleum products. Rather than favoring particular technologies, such taxes allow manufacturers and consumers to decide how to reduce the use of petroleum in the most cost-effective manner. As a result, higher taxes would probably reduce consumption through a variety of mechanisms. In the short run, they would prompt consumers to drive fewer miles and in ways that were more fuel efficient. They would encourage drivers to live closer to their work places or use alternative forms of transportation. And they would provide incentives for consumers to demand -- and manufacturers to provide -- vehicles with better fuel economy or that employed other forms of technology, such as all-electric or natural gas-powered vehicles, even in the absence of other government mandates or incentives.[34] According to various estimates, the overall economic cost of reducing gasoline consumption by raising fuel economy

[33] EIA, *Annual Energy Outlook 2015*, A-17.
[34] Duffield, *Over a Barrel*.

standards can be 2.4 to 13 times as expensive as using a gasoline tax, and a tax could produce greater immediate savings, because it would affect all vehicles rather than just new ones.[35]

Most other advanced industrialized countries have used taxes on gasoline and diesel to reduce fuel consumption in the transportation sector. Indeed, in many countries, such as Britain, France, and Germany, taxes accounted for more than half of the cost of gasoline in 2011, even with oil at nearly $100 a barrel.[36] So far, however, the United States has not tried this approach. The federal government has imposed an excise tax on gasoline (and subsequently diesel) since 1932, but the purpose has never been to discourage consumption. Rather, the proceeds have been used to fund the federal highway program and, since 1983, mass transit as well as to raise general revenues for the government. As a result, U.S. fuel taxes have been among the lowest in the industrialized world. Indeed, the real value of the federal gasoline tax—fixed at 18.4 cents per gallon since 1997—has been generally at or below where it stood before the first oil shock in 1973.[37]

Nevertheless, increasing taxes on petroleum products could potentially yield large dividends in terms of lower use. According to one commonly used rule of thumb, a 10 percent

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[35] Andrew Kleit, "Impacts of Long-Range Increases in the Fuel Economy (CAFE) Standard," *Economic Inquiry* 42, no. 2 (2004), 279-94; David Austin and Terry Dinan, "Clearing the Air: The Costs and Consequences of Higher CAFE Standards and Increased Gasoline Taxes," *Journal of Environmental Economics and Management* 50 (2005), 562-82; Keith Crane, et. al., *Imported Oil and National Security* (Santa Monica, CA: RAND, 2009), 87; Eduardo Porter, "Taxes Show One Way to Save Fuel," *New York Times*, September 11, 2012; and Valerie J. Karplus, et. al, "Should a Vehicle Fuel Economy Standard Be Combined with an Economy-Wide Greenhouse Gas Emissions Constraint? Implications for Energy and Climate Policy in the United States," *Energy Economics* 36 (2013), 322-33.
[36] Stacy C. Davis, Susan W. Diegel, and Robert G. Boundy, *Transportation Energy Databook: Edition33* (Oak Ridge, TN: Oak Ridge National Laboratory, 2014), 10-1.
[37] Duffield, *Over a Barrel*, 64-65.

increase in the price of gasoline could eventually reduce consumption by six to nine percent.[38] Other estimates by economists are more conservative, but still suggest that a 10 percent increase in the price of gasoline would reduce consumption by roughly three to five percent over a range of prices.[39] Thus, in 2004, both the Congressional Budget Office (CBO) and the Department of Energy (DOE) estimated that an increase on the order of 50 cents per gallon, when gasoline prices were fluctuating between $1.50 and $2 per gallon, would cut gasoline use by 10 to 15 percent.[40]

Consequently, the last decade has seen proposals for raising the federal tax on gasoline by one to two dollars over five to 10 years. The cost to the government would be limited to collecting the tax. Indeed, a tax could raise substantial revenue, given that U.S. gasoline consumption is well over 100 billion gallons per year. One problem is that such a tax would be regressive, hitting harder poorer consumers who spend a higher proportion of their income on

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[38] Steven E. Plotkin and David L. Greene, "Prospects for Improving the Fuel Economy of Light-duty Vehicles," *Energy* 25 (14-15); 1179-88; Congressional Budget Office, *Reducing Gasoline Consumption: Three Options* (Washington, DC: Congressional Budget Office, 2002); and Uchitelle and Megan Thee, "Americans Are Cautiously Open to Gas Tax Rise," *New York Times*, February 28, 2006.

[39] Sarah E. West and Robert C. Williams, III, "Empirical Estimates for Environmental Policy Making in a Second-Best Setting," NBER Working Papers Series (Cambridge, MA: National Bureau of Economic Research, 2004); Christopher W. Evans, "Putting Policy in Drive: Coordinating Measures to Reduce Fuel Use and Greenhouse Gas Emissions from U.S. Light-Duty Vehicles" (Cambridge, MA: Massachusetts Institute of Technology, Engineering Systems, 2008); Lucas W. Davis and Lutz Killian, "Estimating the Effects of a Gasoline Tax on Carbon Emissions," NBER Working Paper Series (Cambridge, MA: National Bureau of Economic Research, 2009); and John Heywood et al., "An Action Plan for Cars: The Policies Needed to Reduce U.S. Petroleum Consumption and Greenhouse Gas Emissions," in *An MIT Energy Initiative Report* (Cambridge, MA: MIT, 2009).

[40] Terry Dinan and David Austin, "Fuel Economy Standards Versus a Gasoline Tax," Economic and Budget Issue Brief (Washington, D.C.: Congressional Budget Office, 2004); and Robert N. Stavins, "A Tale of Two Taxes, A Challenge to Hill," *The Environmental Forum* (November/December 2004), 12.

transportation fuel. Thus most proposals involve returning the revenues to consumers through reductions in income and/or payroll taxes and through financing improvements in transportation infrastructure.[41]

Another type of tax, widely known as a "feebate," provides an on-going incentive for consumers to place greater emphasis on fuel economy in their vehicle purchasing decisions. Under such a system, the government would impose a tax or fee on vehicles that fall below a certain fuel economy benchmark and offer a rebate for vehicles above that point. The size of the feebate would be proportional to the difference between the expected fuel consumption and the benchmark. Currently, the United States maintains a truncated feebate system in the form of the "gas guzzler" tax. This system involves a tax on vehicles rated at less than 22.5 mpg that starts at $1000 and rises as high as $7700. But there is no rebate for more efficient vehicles, and the tax applies only to passenger cars and not the many other LDVs.[42]

One recent study proposes a feebate of $120 for each incremental change in fuel consumption of one gallon per thousand miles. The benchmark would initially be set at slightly lower than the current model year average mpg (e.g., 30 mpg is equivalent to 33 gallons per thousand miles), but would steadily increase over time. Approximately 98 percent of all vehicles would fall somewhere between receiving a $2000 rebate and paying a $2000 fee, with the average consumer receiving a $240 rebate. Such a feebate system would cost the federal

[41] For example, Heywood et al., "An Action Plan for Cars," 3.
[42] Heywood et al., "An Action Plan for Cars," 3, 7.

government several billion dollars per year, but it could drive improvements in fuel economy by 20-30 percent in the absence of other measures.[43]

In this regard, the feebate bears comparison with fuel economy standards. The latter provide certainty of increases in fuel economy, but the former is generally regarded as more cost-effective. A feebate is viewed as especially effective when adopted in conjunction with a fuel tax, because consumers do not fully value the lifetime fuel expenses associated with a vehicle purchase.[44] But like fuel economy standards, it does nothing to reduce fuel consumption by the existing vehicle fleet

All of these measures, including fuel taxes, have one further limitation. Although they would reduce the economic costs of a future oil supply disruption by lowering the baseline level of U.S. oil demand and possibly the baseline price of oil, they would not increase the ability of the United States to mitigate the impact of a disruption by quickly reducing consumption an additional amount for the duration of the disruption. Indeed, higher taxes would reduce the impact of a rise in oil prices on behavior, since the price of oil would represent a smaller share of a gallon of gasoline. For such short-term flexibility in consumption, we must look at the potential to substitute other energy sources for petroleum.

Displacing Petroleum with Alternative Fuels and Energy Sources

[43] Heywood et al., "An Action Plan for Cars," 8. See also David L. Greene et al., " Feebates, Rebates and Gas-guzzler Taxes: A Study of Incentives for Increased Fuel Economy," *Energy Policy* 33 (2005), 757-75.
[44] Heywood et al., "An Action Plan for Cars," 8.

The other general approach for reducing U.S. oil consumption in the transportation sector is to replace petroleum with alternative fuels and energy sources. Here we find three main options: alternative liquid fuels, especially biofuels, that have many of the same properties as petroleum products; other on-board fuels, such as natural gas and hydrogen; and electricity from the electric power grid.[45] In evaluating each approach, we must consider three issues: the production of the alternative fuel or energy source in question, the means of distributing it, and the modifications required in vehicles in order to use it.[46]

Thus far, U.S. policy has emphasized the first option, promoting the production of biofuels, which have been most readily substitutable for petroleum-based fuels. But recent years have seen increasing numbers of opportunities and proposals for making more radical changes in the way the American transportation fleet is powered.

Biofuels

Federal government support for biofuels dates back to the late 1970s, but they only reached one percent of transportation energy use in 2004.[47] It was not until the U.S. government established a renewable fuel standard (RFS) in the 2005 EPACT and then greatly expanded it in the 2007 EISA that the production and use of biofuels took off. The EPACT mandated that the amount of ethanol and biodiesel in the nation's fuel supply rise to 7.5 billion gallons per year by 2012, after which the share of renewables would be held constant. The EISA raised the standard

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[45] From an economic standpoint, alternative liquid fuels can be regarded as having an effect similar to that of an increase in the supply of oil rather than a reduction in oil consumption.
[46] Heywood et al., "An Action Plan for Cars," 4.
[47] Duffield, *Over a Barrel*, 74-75; EIA, *Annual Energy Review 2011*, 44.

to 36 billion gallons by 2022 while capping the amount of ethanol that could be derived from corn starch at 15 billion gallons. This limit was meant to ensure that a growing share – and eventually the majority – would consist of advanced biofuels, especially ethanol derived from cellulose.[48] When fully implemented, the RFS would provide the equivalent of about 1.6 mbd of gasoline, thereby reducing U.S. petroleum demand by an equivalent amount. And recent studies have put the country's long-term sustainable ethanol production potential at as much as 90 billion gallons per year, or the equivalent of 4 mbd of gasoline.[49]

Implementation of the RFS proceeded quickly at first but has encountered obstacles of late. By 2011, production had plateaued at around 14 billion gallons, or less than 40 percent of the ultimate goal, because of difficulties with scaling up the production of advanced biofuels, especially cellulosic ethanol. Since 2010, the government has been forced to cut the target for cellulosic ethanol substantially. There has also been much criticism of the extensive use of corn for ethanol production, which consumes as much as 40 percent of the U.S. corn crop, especially during times of drought and high corn prices. Thus the EIA projected in 2012 that biofuel consumption would reach only 22.1 billion gallons in 2022 and not meet the standard of 36

[48] Sissine, "Energy Independence and Security Act of 2007"; Randy Schnepf and Brent D. Yacobucci," Renewable Fuel Standard (RFS): Overview and Issues," CRS Report for Congress (Washington, DC: Congressional Research Service, 2012).
[49] Sandia National Laboratories, "90-Billion Gallon Biofuel Deployment Study: Executive Summary" (February 2009), available at http://www.ascension-publishing.com/BIZ/HD19-90bl.pdf (accessed June 21, 2013); Gal Luft and Anne Korin, *Turning Oil Into Salt: Energy Independence Through Fuel Choice* (BookSurge Publishing, 2009), 85; and NRC, *A Focus on Hydrogen*, 15. A gallon of ethanol contains only about 68 percent as much energy as does a gallon of gasoline.

billion gallons until sometime in the early 2030s,[50] and in 2013 and 2014, the EIA dramatically cut its projection of renewable biofuel consumption in 2035 to less than 16 billion gallons.[51]

In the longer term, moreover, full implementation of the RFS and the increased production of biofuels more generally may depend on investments in new vehicles and infrastructure. Although ethanol is very similar to gasoline, there is widespread concern that most gasoline-powered cars and trucks currently on the road cannot use concentrations of ethanol greater than 10 or 15 percent (E10 and E15), the so-called "blend wall," because of its corrosive properties. As a result, the EIA projects that the volume of blended ethanol will peak at 13 billion gallons per year in 2025 before rising again in the late 2030s.[52] Thus, especially as gasoline consumption declines because of fuel efficiency increases, full exploitation of the RFS will require greater use of much higher concentrations of ethanol, most commonly E85, in so-called flexible fuel or flex-fuel vehicles (FFVs) that can run on almost any combination of gasoline and alcohol.

Although FFVs made up several percent (7.1 million) of the light-duty vehicles on the road in 2010, only about one percent of ethanol was used in E85 that year.[53] One reason is the lack of dedicated refueling infrastructure. Again, because it causes corrosion, ethanol cannot be readily transported through the existing extensive network of pipelines for petroleum products and may require its own distribution system as well as dedicated storage tanks and fuel pumps. Thus in 2012, the number of publicly accessible E85 refueling sites in the United States

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[50] EIA, *Annual Energy Outlook 2012*, 97, 153.
[51] EIA, *Annual Energy Outlook 2015*, A-23.
[52] EIA, *Annual Energy Outlook 2015*, A-23.
[53] Davis, Diegel, and Boundy, *Transportation Energy Databook*, 2-5, 6-3.

amounted to just 2500, compared with about 160,000 conventional refueling stations, and the former were heavily concentrated in the upper Midwest.[54]

One possible solution to these bottlenecks is the substitution for ethanol of so-called "drop-in" biofuels that are largely compatible with existing fuel infrastructure. Of particular interest in this regard is butanol, which can be produced by virtually the same process as is ethanol, but whose chemical properties are more similar to those of petroleum products. As a result, it can be blended with gasoline in higher concentrations and shipped via pipeline. In addition, butanol's energy content per gallon is almost the same as that of gasoline. Thus several companies are currently exploring the conversion of ethanol plants to produce butanol.[55]

Greater penetration of biofuels would also be facilitated if the government were to require or strongly incentivize auto manufacturers to produce a much higher percentage of FFVs. According to a number of estimates, the cost of building new gasoline-powered vehicles to be able to use alcohol fuels is on the order of just $100 to $200, and existing vehicles can be retrofitted to be FFVs for less than $500. Legislation to establish such an Open Fuel Standard has been pending before Congress since 2005, but has not yet passed. Alternatively, an annual government subsidy of $1-2 billion could finance the production of 10 million new FFVs per

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[54] Davis, Diegel, and Boundy, *Transportation Energy Databook*, 6-10; 4-19. See also the statement of Howard Gruenspecht, Deputy Administrator of the Energy Information Administration, before the Subcommittee on Energy and Power, Committee on Energy and Commerce, U.S. House of Representatives, July 17, 2012, 8, available at http://energycommerce.house.gov/sites/republicans.energycommerce.house.gov/files/Hearings/EP/20120717/HHRG-112-IF03-WState-GruenspechtH-20120717.pdf (accessed March 21, 2013).

[55] Henry Fountain, "Corn Ethanol Makers Weigh Switch to Butanol," *New York Times*, October 23, 2012.

year, or the majority of the light duty vehicles produced each year.[56] Each additional 10 million FFVs on the road, if consistently fueled with E85, could reduce gasoline consumption by an additional 2.7 billion gallons per year or 0.2 mbd.

If the number of FFVs increased substantially and larger amounts of cellulosic and other second-generation forms of ethanol became available, transport fuel distributors and retailers would have a greater financial incentive to invest in dedicated E85 refueling infrastructure, such as storage tanks and fuel pumps. Here, too, however, the federal government could accelerate the process by mandating the necessary investments or offering subsidies. Indeed, the 2005 EPACT provided a 30 percent tax credit (up to $30,000) for investments in alternative fueling equipment.[57] At this rate, the cost to the government of subsidizing the installation of E85 equipment at 100,000 fueling stations, or roughly two-thirds the number of conventional refueling stations, would be about $3 billion.

In the absence of any major change in U.S. policy, however, the EIA projects that FFV sales will amount to just 11 percent of new vehicle sales in 2035.[58] This level of production would represent an improvement, but it would fall well short of the potential for increasing biofuel use in the United States. Thus, biofuels would contribute to reducing U.S. petroleum consumption over the long term, but quite possibly not to the same extent as will planned

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[56] Luft and Korin, *Turning Oil Into Salt*, 58-59. See also the testimony of Don Althoff, CEO of Flex Fuel USA, before the Energy and Commerce Committee of the U.S. House of Representatives, July 10, 2012, available at http://energycommerce.house.gov/sites/republicans.energycommerce.house.gov/files/Hearings/EP/20120710/HHRG-112-IF03-WState-AlthoffD-20120710.pdf (accessed March 21, 2013).

[57] Alternative Fuels Data Center, "Energy Policy Act of 2005," available at http://www.afdc.energy.gov/laws/epact_2005 (accessed June 18, 2014).

[58] U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2014* (Washington, DC: EIA, 2014), MT-15.

increases in fuel economy standards. Certainly, the prospects for phasing in the RFS on schedule, not to mention raising the target for biofuels even further, are dim.

One potential advantage of biofuels over fuel economy standards and taxes is that they could give the United States some fuel switching capability in the event of an oil supply disruption, thereby helping to moderate an oil price shock. As the price of gasoline rose, consumers could use gasoline blends with a higher proportion of ethanol. For this to make a significant difference, however, the United States would have to maintain either substantial stocks of ethanol or substantial excess capacity in ethanol production. For example, it would take an increase in the supply of ethanol of about 60 million gallons per day – a rate equivalent to 22 billion gallons per year – to bring down oil consumption by just 1 mbd, and that calculation assumes that sufficient flex-fuel capacity existed in the transportation fleet to take advantage of the increase. Nor could the United States count on being able to benefit from a surge in biofuel imports from other countries, since it is now, and is likely to remain for some time, the world's largest producer of biofuels.[59] Given that ethanol is likely to be much more expensive to stockpile than oil, the most cost-effective approach is likely to be for the government to pay for the creation of excess ethanol production capacity, assuming the availability of sufficient feedstocks and FFVs to consume the additional ethanol. Assuming that the cost of producing cellulosic ethanol can be brought in line with that of corn-based ethanol, the cost of building sufficient production capacity to replace 1 mbd of oil would be roughly $20 billion, and the exploitation of that capacity would depend on the availability of sufficient feedstocks on short

[59] *BP Statistical Review of World Energy 2012*; U.S. Energy Information Administration, *International Energy Outlook 2011* (Washington, DC: EIA, 2011), 244.

notice. One would also have to compare the cost-effectiveness of such a policy with that of increasing the withdrawal rate and overall capacity of the SPR by a comparable amount.

Natural Gas

Another potential substitute for the use of petroleum in the U.S. transportation sector is natural gas. Indeed, the attractiveness of natural gas as a transportation fuel has grown substantially in recent years, thanks to the widespread application of hydraulic fracturing and horizontal drilling technology and the resulting boom in U.S. natural gas production. In addition, natural gas-powered vehicles already exist. Indeed, natural gas accounts for nearly 25 percent of the energy used by city transit buses. Nevertheless, its share of all the energy consumed in the transportation sector has actually declined over the last four decades, from 4.0 percent in 1973 to just 2.9 percent in 2013.[60]

There are two main options for the employment of natural gas as a transportation fuel. One is to use it directly in properly designed internal combustion engines, in the form of either compressed natural gas (CNG) or liquefied natural gas (LNG). The other is to convert it into methanol, which can be blended like ethanol with gasoline and used in standard engines.

A big advantage of natural gas is that it is already widely available. Thus the main additional costs of using CNG on a large scale would be manufacturing vehicles that can run on it and building the necessary refueling infrastructure, primarily in the form of compressing facilities. CNG-powered cars are already widely used in several countries, including Iran, Pakistan, and Argentina. Most gasoline-engines can be modified relatively inexpensively to use

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[60] Davis, Diegel, and Boundy, *Transportation Energy Databook*, 2-7, 2-4.

natural gas. Instead, the principal cost – and disadvantage – associated with CNG LDVs is the high pressure storage tank, which takes up more room than a typical gas tank and, even then, can provide only roughly half the range. Currently, CNG passenger cars, such as the Honda Civic GX, sell for roughly $4000 more than gasoline-powered versions.[61] Meanwhile, the cost of building an adequate refueling infrastructure is likely to be several billion dollars, assuming that the cost would be similar to that of deploying a comparable infrastructure for E85 or hydrogen (see below). Assuming that each new CNG vehicle replaced a gasoline-powered car that used roughly 400 gallons per year (10,000 miles per year divided by 25 mpg), it would require 40 million CNG vehicles to reduce U.S. gasoline consumption by 1 mbd. Although the vehicle price differential is likely to decline over time with growing production volumes, the cost of a full government subsidy for achieving this goal could be on the order of $100 billion. Alternatively, the federal government could require that automakers produce a certain number of CNG vehicles each year, similar to the fuel economy mandate contained in the CAFE standards.

Because of the higher cost of natural-gas powered vehicles, they are most cost-effective when the average vehicle is used extensively, especially when the price of natural gas is relatively low compared with petroleum products. In addition, natural-gas engines burn cleaner and tend to require less maintenance. Thus some companies with numerous delivery vehicles, such as FedEx, are experimenting with the use of CNG in their fleets.

Even greater potential for replacing oil lies with the use of natural gas in heavy (class 7 and 8) freight trucks, especially those involved in long-haul traffic. In 2012, those trucks accounted for 17.2 percent of transportation energy use and 27.9 billion gallons of fuel

[61] Knittel, "Reducing Petroleum Consumption," 104.

consumption.[62] The EIA projects that in 2040 they will be responsible for 26.4 percent of all energy used in the sector.[63] In the case of long-haul trucks, however, most attention is focused on the use of LNG, which because of its greater energy density, requires no sacrifice of range.

The challenge with this approach is that both LNG-powered trucks and the necessary refueling structure will have to be built largely from scratch, and both will be expensive. According to various estimates, the additional cost of outfitting a long-haul truck to use LNG is about $50,00-$70,000.[64] Meanwhile, LNG refueling stations can cost up to several million dollars. These high up-front costs have not prevented businesses from finding the LNG market attractive, however. Several companies are building LNG plants and refueling stations, and at least four major truck manufacturers are introducing optimally-sized LNG engines.[65] As a result, the EIA recently projected that natural gas use in heavy trucks will increase to 1 trillion cubic feet in 2040, displacing about 0.5 mbd of liquid fuels per day.[66]

Obviously, this process could be accelerated and broadened if the federal government were to provide financial incentives for the purchase of LNG-power vehicles and the construction of LNG refueling stations. In 2011, for example, bills were introduced in Congress that would have provided an income tax credit of $64,000 for heavy trucks and a refueling

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[62] Davis, Diegel, and Boundy, *Transportation Energy Databook*, 2-7, 5-3.
[63] EIA, *Annual Energy Outlook 2015,* A-16.
[64] MIT, *The Future of Natural Gas: An Interdisciplinary MIT Study* (Cambridge, MA: MIT, 2011), 26; Bob Tita, "Slow Going for Natural-Gas Powered Trucks," *The Wall Street Journal* (August 25, 2014).
[65] Josie Garthwaite, "The New Truck Stop: Filling Up With Natural Gas for the Long-Haul," *National Geographic Daily News 2013,* available at http://news.nationalgeographic.com/news/energy/2013/03/130318-natural-gas-truck-stops/ (accessed June 21, 2013).
[66] U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2013* (Washington, DC: EIA, 2013), 36.

infrastructure tax credit of up to $100,000 for an LNG station.[67] Given the fluidity of the situation, it is difficult to estimate how much, if any, support would be need to make large-scale use of LNG self–sustaining. But assuming tax credits of $50,000 for the first 100,000 long-haul trucks and $100,000 for the first one thousand refueling stations, the total cost to the government would be about $5 billion. And if this, in combination with sustained low natural gas prices led to a 50 percent share of the long-haul trucking market by 2035, the total savings would amount to roughly 15 billion gallons per year, or about 1 mbd.

Natural gas can also be converted into methanol, a liquid fuel, which, like ethanol, can be substituted for gasoline. And at recent natural gas prices, methanol can be produced with existing technology at a cost that is comparable to that of gasoline on an energy equivalent basis.[68] Like ethanol, however, methanol is more corrosive than gasoline and absorbs water and thus requires modest changes to engines and the fueling infrastructure. But, methanol could be used in tri-flexible-fuel vehicles (TFFVs) that could operate on any combination of methanol, ethanol, and gasoline.

Thus federal policies intended to promote the use of methanol in the transportation sector would look similar to those for ethanol. They might include an Open Fuel Standard, subsidies for the production and conversion of vehicles to run on methanol and for methanol refueling structure, and the inclusion of natural-gas derived methanol in the RFS. Providing a methanol

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[67] See http://www.ngvamerica.org/pdfs/2011_NatGas_SidebySide_111511.pdf.
[68] Methanol Institute, "Methanol: The Clean Alternative for Transportation," available at http://www.methanol.org/energy/resources/alternative-fuel/methanol-flexible-fuel-vehicles.aspx (accessed June 18, 2014).

capability to an FFV in new LDVs would cost an additional $100 to $200 per vehicle.[69] Since the technology for producing methanol from natural gas is well developed, the inclusion of methanol in the RFS could possibly compensate for the difficulties encountered with the development of cellulosic ethanol. The demand for methanol would be dampened, however, by the fact that its energy content is only half that of gasoline, thus further limiting the range of vehicles with standard sized fuel tanks.[70]

Hydrogen

Some have pinned their hopes for reducing oil consumption on the use of hydrogen to power vehicles. The administration of George W. Bush placed particular emphasis on hydrogen as an alternative transportation fuel, and the 2005 EPACT contained nearly $4 billion for research, demonstration projects, and transition programs involving hydrogen and fuel cells. Another attraction of using hydrogen is that, depending on how it is produced, it could substantially reduce CO2 emissions.

The obstacles faced by hydrogen, however, are greater than those for biofuels and natural gas, because its large-scale use would require major advances in all three areas: production, distribution, and vehicle design. The most efficient use of hydrogen would be in fuel cells that power electric motors, but hydrogen fuel-cell vehicles (HFCVs) are still only in the development stage, and like natural gas, the costs are increased by the need for a high-pressure storage tank.

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[69] MIT, *Future of Natural Gas*, 125-27; Knittel, "Reducing Petroleum Consumption," 103.
[70] L. Bromberg and W.K. Cheng, "Methanol as an Alternative Transportation Fuel in the US: Options for Sustainable and/or Energy-Secure Transportation," (Cambridge, MA: Sloan Automotive Laboratory, Massachusetts Institute of Technology, November 2010), 3-4, available at http://www.afdc.energy.gov/pdfs/mit_methanol_white_paper.pdf (accessed June 21, 2013).

In addition, and unlike natural gas, arrangements would have to be made for the large-scale production of hydrogen, and the use of hydrogen would require an entirely new delivery system, with hydrogen fueling stations alone costing on the order of $1 to $2 million apiece, depending on size.[71]

Nevertheless, according to one recent analysis, HFCVs have the potential to be cheaper than battery-powered vehicles, and estimates of the long-run costs of hydrogen are as low as $2.50 per gallon of gasoline equivalent.[72] Thus, a 2008 National Research Council study found that even with a relatively modest investment by the federal government, HFCVs could become economically competitive on a life-cycle basis with conventional LDVs and constitute some 60 million of the vehicles on the road by 2035. As a result, liquid fuel use could be reduced by nearly one-quarter, and by as much as 70 percent by 2050.[73] To achieve this positive outcome, the government would need to contribute about $5 billion for research and development and half the total cost of building and operating the hydrogen supply infrastructure (another $8 billion). In addition, it would have to subsidize the incremental cost of HFCVs relative to conventional gasoline vehicles ($40 billion), for a total outlay of about $55 billion over 15 years.[74] As high as this figure may seem, it compares favorably with the annual cost of the ethanol excise tax credit – about $6 billion per year – at the time it was phased out in 2011.

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[71] Luft and Korin, *Turning Oil Into Salt*, 51; California Fuel Partnership, *A California Roadmap: Bringing Hydrogen Electric Fuel Cell Vehicles to the Golden State* (West Sacramento, CA: 2012), 24.
[72] Knittel, “Reducing Petroleum Consumption,” 109.
[73] The NRC analysis was based on the CAFE standard increases contained in the 2007 EISA. The potential reductions in liquid fuel use are not as great under the fuel economy standards adopted in 2012.
[74] NRC, *A Focus on Hydrogen.*

Electrification of the Transportation Fleet

The final principal option for reducing petroleum consumption is through the electrification of the transportation fleet. This approach may also offer some potential for "fuel switching" in an emergency, through the extensive deployment of vehicles that can be powered both by liquid fuels and energy drawn from the electric power grid. Like biofuels, electricity will increasingly substitute for petroleum as a source of transportation energy with the introduction of all-electric vehicles (EV or BEV - battery-electric vehicle). Likewise, hybrid-electric vehicles (HEV), which combine internal combustion engines and electric motors, and, increasingly, micro hybrids, which have electrically powered auxiliary systems that allow an internal combustion engine to be turned off when the vehicle is idling or coasting but do not use batteries to provide propulsion, will play leading roles in the achievement of higher fuel economy. For example, the EIA has projected that micro hybrids could account for as much as 46 percent of new LDV sales in 2035 as a result of the new, higher CAFE standards.[75]

The key to fuel flexibility, however, is the combination of hybrid propulsion systems (characteristic of hybrids) and plug-in capability and large battery capacity (characteristic of all-electric vehicles). Plug-in hybrid electric vehicles (PHEV) allow consumers to vary substantially the amount of liquid fuel they use by relying more or less on electricity stored in their batteries, which can be replenished from the grid as necessary. Thus when oil prices are low, PHEVs can

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[75] Statement of Howard Gruenspecht, Deputy Administrator of the Energy Information Administration, before the Subcommittee on Energy and Power, Committee on Energy and Commerce, U.S. House of Representatives, July 17, 2012, available at http://energycommerce.house.gov/sites/republicans.energycommerce.house.gov/files/Hearings/EP/20120717/HHRG-112-IF03-WState-GruenspechtH-20120717.pdf (accessed March 21, 2013).

be driven as traditional hybrids, relying mainly on gasoline. When oil prices are high, as during an oil supply disruption, PHEVs can be used exclusively like electric vehicles, recharging their batteries from the electrical power grid as needed.

The realization of this fuel switching potential depends in turn on the widespread penetration of plug-in hybrids into the transportation fleet. The first plug-in hybrids were put on the market only in 2010 (model year 2011), and sales reached 97,100 vehicles in 2013.[76] In 2008 and 2009, Congress approved a federal tax credit of up to $7500 per vehicle (depending on battery capacity), but the credit phased out after a manufacturer had produced 200,000 qualifying vehicles.[77] Because of their redundant features and large batteries, plug-in hybrids are relatively expensive, on the order of $10,000 more than comparable conventional vehicles, so a large tax credit is likely to be important for stimulating initial sales.[78]

How quickly the price of PHEVs can come down to the point where they are competitive with other vehicles is uncertain. Three main technological challenges still need to be addressed: battery capacity, battery life, and recharging time. Thus, in 2015, the EIA projected that PHEVs will account for just two percent of LDV sales in 2040. In the event of breakthroughs in battery technologies that substantially lower the costs, however, sales of plug-in hybrids could reach six percent of total vehicle sales in 2035, or roughly 1 million per year, according to the EIA. Assuming that their fuel economy is about average for hybrid vehicles, this could represent a non-negligible fuel switching capability, depending upon how much they are run on gasoline.

[76] Davis, Diegel, and Boundy, *Transportation Energy Databook*, 6-9.
[77] U.S. Department of Energy, "Federal Tax Credits for Hybrids," http://www.fueleconomy.gov/feg/tax_hybrid.shtml (accessed March 20, 2013).
[78] EIA, *Annual Energy Outlook 2012,* 32.

Sales of non-plug-in hybrid electrics (HEVs) and all-electric vehicles (EVs) would also benefit from such technological advances, enabling them to account for another 19 percent of the light vehicle market in 2035. Altogether, the more rapid penetration of electric vehicles could reduce liquid fuel consumption by an additional five percent by 2035, or nearly 1 mbd.[79]

In order to realize the potential of PHEVs (and BEVs), what other obstacles will have to be overcome? The U.S. electrical generating capacity should be sufficient to meet the needs of a growing number of plug-in vehicles for a number of years, especially if they are charged at night.[80] Instead, the most immediate impediments, other than battery cost, are the limited infrastructure currently available for recharging batteries. Residential recharging is potentially available in about only 40 percent of American dwellings, and the number of public recharging stations (less than 10,000 in mid-2015) is minuscule in comparison with the 160,000 or so gasoline refueling stations.[81] Thus a substantial increase in recharging infrastructure will be necessary in order to ensure the full exploitation of declining vehicle costs.

The federal government has played and could continue to play a role in accelerating the electrification of the transportation fleet. In addition to the tax credits for electric vehicles noted above, the 2009 stimulus package (American Recovery and Reinvestment Act) included $2 billion in grants for U.S. manufacturing to produce highly efficient batteries and other components for electric vehicles and $400 million to demonstrate and evaluate electric vehicle technologies. In addition, the Department of Energy recently reported that it is on track to

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[79] EIA, *Annual Energy Outlook 2012*, 33-35; EIA, *Annual Energy Outlook 2015, 10*.
[80] Luft and Korin, *Turning Oil Into Salt,* 73-74; National Research Council, *Transitions to Alternative Transportation Technologies: Plug-in Hybrid Electric Vehicles* (Washington, DC: National Academy Press, 2010), 5.
[81] *Alternative Fuels Data Center*, available at afdc.energy.gov (accessed June 16, 2015).

demonstrate a substantial reduction in the cost of producing lithium ion batteries, to $300/kWh, by 2015 that exceeds the goal of $405 contained in the high-technology battery breakthrough scenario described above.[82] Thus the potential for additional federal government spending to help reduce the cost of electric vehicles (PHEVs as well as HEVs and EVs) would seem to be substantial.

Indeed, a 2010 study by the National Research Council found that there could be as many as 40 million PHEVs (out of a total of 300 million LDVs) on the road by 2030 and 240 million by 2050, assuming strong policy intervention. The cost to the government could range from $40 billion to $400 billion, depending on the price of oil, which shapes market incentives, and how much – and how quickly – battery costs could be reduced. Depending on the battery range of the PHEVs, liquid fuel consumption could be cut by 40 to 55 percent by 2050, and according to a 2009 estimate, PHEVs could potentially displace the equivalent of 6.5 mbd in gasoline consumption.[83] To be sure, many of these savings could be attained simply through the large-scale deployment of HEVs purchased to meet higher fuel economy standards, reducing the unique contribution of the plug-in capability to only 7 to 23 percent.[84] Nevertheless, even this more modest differential could represent a substantial fuel-switching capability, on the order of

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[82] EIA, *Annual Energy Outlook 2012,* 33. See also written statement of Dr. Kathleen Hogan, Deputy Assistant Secretary for Energy Efficiency, before the Subcommittee on Energy and Power, Committee on Energy and Commerce, U.S. House of Representatives, July 17, 2012, available at http://energycommerce.house.gov/sites/republicans.energycommerce.house.gov/files/Hearings/EP/20120717/HHRG-112-IF03-WState-HoganK-20120717.pdf (accessed March 21, 2013).
[83] Luft and Korin, *Turning Oil Into Salt*, 73.
[84] National Research Council (NRC), *Transitions to Alternative Transportation Technologies: Plug-in Hybrid Electric Vehicles*, (Washington, DC: National Academies Press, 2010), 2, 23, 28-30.

up to several mbd of liquid fuel, depending on the relative prices and convenience of using electricity and gasoline prior to an oil price shock.[85]

Summary of Demand-Side Solutions

Clearly, the federal government has numerous options for substantially reducing oil use in the transportation sector. Some of these options are already being pursued in the form of rising fuel economy standards and the Renewable Fuel Standard. Determining what precise mix of policies would make the most sense, however, would require much more extensive analysis, which is beyond the scope of this chapter One reason is the potentially complicated interactions among them. As a general rule, the adoption of one approach tends to limit the potential contributions of other approaches to reducing U.S. oil consumption. Indeed, improving fuel economy is already complicating the task of incorporating increasing volumes of biofuels into the transportation fuel supply. But it is equally clear that substantial additional reductions in oil consumption, on the order of half of all remaining gasoline and diesel use over the next two to four decades, could be purchased with policies costing the government in the range of $100 to $200 billion. The various measures described above and their potential benefits and costs are summarized in Table 2.

V. International Policy Extensions

[85] The upper end estimate assumes a per vehicle average annual mileage of 12,000 miles and fuel economy of 50 mpg when using gasoline and that all vehicles switch from gasoline to electricity in response to an oil price shock.

Through the measures discussed above, the United States could substantially reduce the amount of oil that it consumes and the amount that it imports, thereby reducing proportionately the potential economic costs of a future oil supply disruption. It could also dampen the impact of a supply disruption on oil prices by releasing oil from the SPR to compensate for losses elsewhere and by encouraging the proliferation of vehicles that can run on either liquid fuels or electricity and, to a lesser extent, on combinations of petroleum products and biofuels, thereby quickly reducing demand for the former in a crisis.

The United States can do only so much by itself, however, to bring down the baseline world price of oil through various supply- and demand-side measures and, perhaps more importantly, to stabilize the price of oil in the event of an oil supply disruption by quickly increasing supply or reducing demand. Success in these areas will also depend on efforts by and developments in other countries. In principle, then, it would be useful, if not essential, for the United States to promote similar policies in other consumer states. What measures can it take in this regard, and what are their prospects for success? This penultimate section explores some of the most promising options, organized, as above, according to whether they fall on the supply or demand side of the ledger.

Supply Side

On the supply side, it is once again useful to distinguish between increasing oil production and production capacity, on the one hand, and increasing strategic stocks of crude oil and petroleum products, on the other. The United States has long promoted oil exploration and development, both by the private sector and state-owned enterprises, outside the Persian Gulf in places like the Caspian region, West Africa, and Latin America.[86] Thus it is unclear what more the government could do in this regard. There do not appear to be substantial amounts of easily accessible oil reserves outside the Persian Gulf whose exploitation could fundamentally alter the world market. Indeed, the EIA projects that the Persian Gulf's share of petroleum production will actually grow, from less than 28 percent in 2010 to more than 32 percent in 2040.[87]

The United States might have more to offer with regard to the more technologically challenging process of producing unconventional forms of oil, such as oil (tar) sands, extra-heavy oil, tight oil, and liquids from coal and natural gas, but the potential here too seems highly limited. For example, the EIA has projected that total unconventional liquids production (excluding biofuels) will reach just 8.4 mbd in 2035, or less than 9 percent of conventional oil production. Thus the Persian Gulf's share of the production of all liquid fuels will rise from around 27 percent to 31 percent over the same period. Even in the event that oil prices were to rise to 200 dollars (in 2009 dollars), production of unconventional liquids (again excluding biofuels) would reach just 13 mbd. The Paris-based IEA is more optimistic in its projection of unconventional oil production, which it expects to surpass 15 percent of total world oil production in 2035 in its central scenario, but it also projects the share of output from the Persian Gulf to increase to more than 34 percent. Thus even if U.S. policy were able to promote greater

[86] For an overview, see Duffield, *Over a Barrel.*
[87] U.S. Energy Information Administration (EIA), *International Energy Outlook 2013* (Washington, DC: EIA, 2013), 248.

production of unconventional liquids abroad, the resulting additional volumes would likely be insufficient to reduce the role of the Persian Gulf in the world oil market.[88]

In the EIA scenarios, half or more of the production of unconventional liquids (excluding biofuels) would take place in Canada. This observation raises the question of what energy security benefits the United States might obtain by building additional pipelines linking Canadian oil sands to the U.S. market, such as the controversial Keystone XL pipeline. Insofar as oil from Canada is refined at inland refineries with excess capacity and cannot be readily exported to third countries, it will sell at a discount in comparison with world prices. But part of the Keystone XL project connects the pipelines bringing oil from Canada to the Gulf of Mexico, so the Canadian oil will become part of the world supply and command the same price as comparable grades from other regions. It could also be argued that Canada represents a more secure source of oil, but the United States now imports less than 10 percent of the oil it uses from the Persian Gulf.[89]

It follows that there is also little the United States could do to increase the world's secure spare oil production capacity. For the last several decades, the world's spare capacity has been concentrated in the Persian Gulf, reflecting the relatively low cost of producing oil in the region.[90] Unless heavily subsidized to do otherwise, producers of more expensive oil will want to maximize output, and any oil production that is withheld from the market will tend to push

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[88] EIA, *International Energy Outlook 2011*, 229, 232, 236; International Energy Agency, *World Energy Outlook 2013* (Paris: IEA, 2013), 458 and 484.
[89] EIA, *Monthlyl Energy Review*(May 2015), 49.
[90] IEA, *World Energy Outlook 2013*, 454.

world oil prices higher, unless compensated for by higher levels of production from the Persian Gulf.

More promising, then, would seem to be efforts to increase the world's strategic oil reserves. Currently, the members of the IEA are required to maintain oil stocks equivalent to no less than 90 days of net imports, and the 26 members that are net oil importers hold an average of 74 days of imports in government-held stocks and 100 days in commercial stocks.[91] In recent years, these combined stocks amounted to more than 4 billion barrels of crude oil and petroleum products, although government-controlled stocks consisted of just 1.5 billion barrels and the actual availability of some commercial stocks has been questionable.[92] The IEA also maintains an emergency mechanism for sharing oil stocks in the event of a major supply disruption.

As the developing world's share of global oil consumption has grown – from 28 percent in 1974, the year the IEA was founded, to 48 percent in 2011—however, the IEA stockpiling program has become increasingly inadequate to stabilize world oil prices by itself in the event of a supply disruption. Instead, it may be necessary for developing countries, especially major consumers such as China and India, to create substantial stocks of their own. China is in fact well into the process of developing a government-controlled reserve of 475 million barrels, with an expected completion date of 2020. China also plans to require industry to maintain additional reserves of more than 200 million barrels. India is much further behind, with plans to create a

[91] See "Closing Oil Stock Levels in Days of Net Imports," available at http://www.iea.org/netimports (accessed June 16, 2015).
[92] See EIA, International Petroleum Monthly (October 2010), Table 4.5 and EIA, "International Energy Statistics," http://www.eia.gov/countries/data.cfm (accessed March 20, 2013).

reserve holding just 37.4 million barrels.[93] It is not clear, however, what the U.S. could do to promote this stock-building process. One area in which it could exercise leadership would be in developing mechanisms to coordinate the release of IEA and other stocks in the event of a crisis.

Demand Side

What about the demand side of the equation? Here, too, the greatest potential for reductions in other countries would appear to lie in the transportation sector. Globally, transportation accounted for 55 percent of all liquid fuel consumption in 2010. The EIA projects that share will grow to more than 58 percent – and that total consumption will increase by nearly 50 percent in absolute terms – by 2040 due to the rapid motorization of many developing counties. Transportation's closest competitor is industry, whose share of consumption is projected to remain around 30 percent. All other uses – residential, commercial, and electric power -- will account for only a small and declining share of liquid fuel consumption.[94]

In addition, the use of energy in transportation will shift steadily from the United States and other developed (OECD) countries to the developing world. The EIA projects that the OECD's share of liquid fuel consumption for transportation will drop from 59 percent in 2010 to 37 percent in 2040. The biggest increases will occur in the developing (non-OECD) regions of Asia, especially China and India, which will see their combined share increase from 11 percent

[93] See Javier Blas, "China Stops Filling Strategic Oil Reserve," *Financial Times*, November 23, 2012, available at http://www.ft.com/intl/cms/s/0/c7090954-347d-11e2-8b86-00144feabdc0.html (accessed March 20, 2013); Rakesh Sharma, "India Unveils Strategic Oil Stockpile Plans," *The Wall Street Journal (Online)*, December 21, 2011, available at http://www.wsj.com/articles/SB10001424052970204464404577111893998225190 (accessed June 15, 2015).
[94] EIA, *International Energy Outlook 2014*, 30.

in 2010 to 24 percent in 2040. In absolute terms, liquid fuel consumption for transportation in developing countries will more than double.[95]

What can the United States do to promote less oil consumption in the transportation sector in other countries? The United States has made tremendous strides in the area of raising fuel economy standards for LDVs in recent years. Nevertheless, it has lagged behind the other biggest automobile markets – the European Union, Japan, and China – in this regard.[96] Thus it is not clear what U.S. policy could offer to these other major consumers, although opportunities may exist in other developing countries where fuel economy standards have not yet been put in place. Also, the United States could assume a leadership role in the promotion of fuel economy standards for the road freight sector, where only it and Japan have taken action.[97]

In recent years, the United States has also emerged as the world leader in biofuels production. But the principal process currently used in this country, converting corn to ethanol, is increasingly regarded as environmentally as well as economically problematic. Although corn is a renewable feedstock, the process of creating corn ethanol requires almost as much energy as is produced, and if other fossil fuels, such as natural gas, are used, then substituting ethanol for gasoline results in little or no net reduction in greenhouse gas emissions. Thus the long-term potential for biofuels hinges on the development and widespread deployment of more environmentally friendly means, such as sugar cane-based and cellulosic ethanol, which have much more favorable energy balances.

[95] EIA, *International Energy Outlook 2014*, 27-30.
[96] Feng An, Robert Earley, and Lucia Green-Weiskel, *Global Overview on Fuel Efficiency and Motor Vehicle Emission Standards: Policy Options and Perspectives for International Cooperation* (New York: Commission on Sustainable Development, 2011), 18.
[97] International Energy Agency (IEA), *World Energy Outlook 2012* (Paris: IEA, 2012), 89.

What is the global potential for advanced biofuels production? A 2008 Department of Energy (DOE) study projected that world production of ethanol-equivalent biofuels would reach 54 billion gallons in 2020 and 83 billion gallons in 2030, of which 30 and 54 billion gallons, respectively, would be produced outside the United States. Thus the non-U.S. production amounts to the energy equivalent of about only 2.5 mbd of petroleum. In addition, the two biggest non-U.S. sources are expected to be Brazil and possibly Western Europe, which together, even in 2030, would account for more than half of the non-U.S. supply.[98] These, however, are already the two most-advanced biofuels markets outside the United States, so it is not clear what this country would have to offer them to increase their output. Thus the main question is whether the U.S. government can play a role in fostering the spread of technologies for making cellulosic biofuels to other potential biofuel producing areas, such as China and India, once those technologies are sufficiently mature to be applied commercially on a large scale.

Even greater uncertainty would seem to attend what the United States could do to promote the electrification of transportation in other countries, given the limited amount of progress that has occurred so far in this country as well as the relative immaturity of U.S. policy in this area. The United States has initiated an electric vehicle initiative with China, involving the joint development of standards, demonstration projects, and data sharing.[99] But given the relatively high cost of BEVs and PHEVs, advances are likely to lag behind those in the areas of fuel economy and biofuels. And, clearly, the potential for progress will depend on the extent and

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[98] U.S. Department of Energy (DOE), *World Biofuels Production Potential* (Washington, DC: DOE, 2008), 34; EIA, *International Energy Outlook 2011*, 232, 236.

[99] U.S. Department of Energy (DOE), *U.S.-China Clean Energy Cooperation: A Progress Report by the U.S. Department of Energy* (Washington, D.C.: DOE, 2011).

capacity of the electric power systems in other countries. Where the United States might be able to help most is not necessarily in the markets where PHEVs will be built and sold, but in promoting access to the relatively scarce raw materials, such as lithium and various rare earth metals, that are needed to fashion advanced batteries and other components of electric vehicles.

VI. Conclusion

This chapter has examined what steps the United States might take to reduce the economic costs of a future oil supply disruption originating in the Persian Gulf. It has identified a number of measures that the United States might implement, or has already begun to implement, both on the supply side and on the demand side. It has found that the most promising opportunities lie at home, since it is unclear how much the United States might also be able to contribute to the adoption of similar policies in other major oil consuming countries.

In terms of measures intended to affect the overall supply-demand balance over the long term, the most promising ones would seem to lie on the demand side. Indeed, a substantial reduction in petroleum demand can be achieved simply through the implementation of existing policies for raising fuel economy standards and the amount of biofuels in the transportation fuel supply. Together, if fully implemented, they could cut petroleum consumption by LDVs roughly in half, and thus total U.S. petroleum consumption by roughly one quarter, over the next two decades. A tax on petroleum-based fuels of sufficient magnitude and/or government efforts to promote the use of natural gas-, hydrogen-, or electricity-powered vehicles could yield even deeper reductions (see Table 2).

It should be recalled, however, that there are usually negative interaction effects among these approaches. For example, rising fuel economy will tend to reduce the amount of biofuels that can be absorbed in the fuel supply, while a higher percentage of biofuels will limit the impact of greater fuel economy on petroleum demand. Nevertheless, such demand side measures have the potential to reduce U.S. petroleum consumption to a much greater extent than the United States government could increase petroleum production by relaxing current restrictions on exploration and development in ANWR and the OCS. In addition, increasing domestic production, while reducing net outlays for imports, would do nothing to reduce the increased amounts that U.S. consumers would have to pay for oil in the event of a sudden jump in oil prices as a result of a major supply disruption elsewhere.

As for short-term measures designed to mitigate the impact of supply disruptions, ideally by preventing or limiting oil price increases, here the greatest potential appears to lie on the supply side with the maintenance of the SPR and its possible expansion. The current SPR, by itself and especially when used in conjunction with the strategic reserves held by other countries, could neutralize the negative consequences of a range of small to medium-size disruptions totaling as much as 1.5 billion barrels of lost production.[100] Nevertheless, without considerable expansion, it would be of limited effectiveness in the event of a large-scale and/or extended supply disruption, such as a months-long closure of the Strait of Hormuz or a prolonged loss of Saudi Arabian oil production. In addition, a smaller percentage of the benefits of such action on the supply side would accrue to the United States, in comparison with demand reduction measures, since all consumers would benefit from the release of U.S. reserves. Thus, from an

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[100] GAO, *Strategic Petroleum Reserve*, 27.

energy security perspective, it is worth examining what else the United States could do to accelerate the penetration of plug-in hybrid electric vehicles and perhaps even the possibility of introducing standby rationing plans, which were last developed at the end of the Carter administration.

This analysis suffers from some important limitations. In some cases, it has not tried – or been able – to quantify the economic costs of these measures, which would be a necessary component of a thorough cost benefit analysis. Nor has it sought to identify or evaluate potential externalities of these measures, especially the potential environmental consequences of greater use of alternative fuels and electricity to power the transportation fleet.

Nevertheless, the analysis suggests that the United States could substantially reduce—and indeed is in the process of reducing to a significant extent—the economic costs of a future oil supply disruption through a combination of realistic and affordable supply and demand side measures. That possibility, in turn, raises questions about the continued necessity of using diplomacy and costly military preparations to influence the flow of oil from the Persian Gulf. A principal caveat to concluding that the United States could reduce its role in the region concerns the continued dependence of other parts of the world on Persian Gulf oil. A future oil supply disruption in the region might still have a devastating impact on the economies of other countries with which the United States is tightly integrated economically. U.S. oil consumption may stagnate or decline, but that of the rest of the world is projected to continue to increase, and the Persian Gulf is projected to provide a growing share of the total. In particular, Asian countries, such as China and India, which will play ever larger roles in the world economy are also becoming increasingly dependent on Persian Gulf oil. If their economies were ever to be hit hard by an oil supply disruption, the effects would soon be felt in the United States. Given these potential indirect effects, whether the United States could ever afford to allow a major disruption to occur bears further analysis.

Table 1

Summary of Possible Measures and Potential Benefits

	Sustained Effects	Temporary Effects
Supply Side	Measures: Increase in baseline level of domestic oil production via subsidies, price supports, etc. Benefits: Reduction of oil imports and wealth transfer	Measures: Short-term increases in oil supply, i.e., releases of strategic stocks Benefits: Moderation of price increase due to an oil shock
Demand Side	Measures: Reduction of baseline level of oil consumption via taxes, higher energy efficiency, alternative fuels, etc. Benefits: Reduction of spending on oil	Measures: Short-term decreases in oil consumption, e.g., fuel-switching, rationing, etc. Benefits: Moderation of price increase due to an oil shock and reduction in spending on oil

Table 2: Summary of Possible Demand-Side Solutions

Policy Measure	Oil Consumption Reduction Potential[1]			Cost to Government	Fuel-switching Potential in Crisis
	2025	2035	2050		
<u>Reducing Oil Consumption</u>					
Feebates ($120/gal/1000miles)[2]	1.2-1.8 mbd	2.4-3.6 mbd		Several billion dollars	No
2012 CAFE standards[3]	1.7 mbd	3.6 mbd		Minimal	No
Taxes on gasoline, diesel[4]	1.5 mbd	3 mbd		Minimal	No
<u>Alternative Fuels and Energy Sources</u>					
Biofuels (chiefly ethanol)[5]	1.6 mbd	1.6 mbd	3.3 mbd		Up to 1 mbd
2007 Renewable Fuel Standard				Minimal	
Open Fuel Standard				Minimal	
Vehicle Subsidies (100 million LDVs)				$10-20 billion	
Infrastructure Subsidies				$3 billion	
Natural Gas[6]					
CNG (40 million LDVs)	0.5 mbd	1 mbd		Up to $100 billion	No
LNG (100,000 trucks/1,000 stations)	0.5 mbd	1 mbd		$5 billion	No
Methanol	0.5 mbd	1 mbd			Less than 1 mbd
Hydrogen[7]		3 mbd	7 mbd	$55 billion	No
Electric Vehicles (PHEVs) [8]	0.5 mbd	2.2 mbd	4.1-5.6 mbd	$40-400 billion	Up to 3-5 mbd

[1] Estimates are not additive, as most assume that limited additional measures are taken.
[2] Assumes that feebates reduce projected gasoline and diesel consumption by 20-30 percent over 20 years.
[3] Estimate is for total reduction in liquid fuels.
[4] Assumes implementation of a 50 percent tax on gasoline and diesel over 10-20 years, eventually resulting in a 25 percent reduction in projected gasoline and diesel consumption of 12 mbd in 2035. EIA, *Annual Energy Outlook 2012*,153.
[5] Assumes full implementation of the 2007 RFS by 2022.
[6] Assumes half of 2035 estimate is achieved by 2025.
[7] Assumes gasoline contains up to 10% ethanol and implementation of 2007 fuel economy standards. See NRC, *A Focus on Hydrogen*, 76 and 83.
[8] NRC, *Plug-in Hybrid Electric Vehicles*, is based on the same reference case as is NRC, *A Focus on Hydrogen*. Assumes linear growth in EV market penetration between 2015 and 2035.