Drilling, Alternative Fuels and Efficiency: Can the United States Wean Itself from Imported Oil?

Author

Philip Fairey

Publication Number

FSEC-PF-436-08

A Research Institute of the University of Central Florida
1679 Clearlake Road, Cocoa, FL 32922-5703 • Phone: 321-638-1000 • Fax: 321-638-1010
www.fsec.ucf.edu

Preprint: Peer reviewed and accepted for publication in *Energy Policy*
Elsevier Press, Amsterdam, the Netherlands.

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Philip Fairey
Florida Solar Energy Center
November 3, 2008

Abstract

Perhaps the most daunting challenge the next generation of Americans will face is what President Bush called our "addiction to oil." The challenge is to find the means to provide for our transportation needs in the face of declining world oil production. Perhaps the central question is whether we will export the great wealth of America to foreign countries in payment for oil before we tackle the grand challenge of creating a new transportation future that does not rely completely on oil.

This article presents the historical facts relative to America's oil demand and domestic and world oil production resources. These historical trends are used to construct a scenario of future supply and demand for oil in the U.S. A range of existing technologies, which can reduce the need for petroleum imports, are then evaluated using wedges analysis, giving projections to the year 2030.

Body

The purpose of this essay is to provide a reasoned approach for how the U.S. might wean itself from imported oil over the next generation. This would be accomplished through a broad spectrum of proven technologies that include producing new oil, reducing our demand for oil, and substituting other energy resources in its place. It is important to understand that the proposal does not include technologies and resources that are currently in the research or development but which may become highly productive in the future. Examples include: cellulosic ethanol production, Gulf Stream current, wave and tidal energy conversion and methane hydrate production. Tar sands oil recovery is also not included – because it is not an indigenous U.S. resource. Additionally, some currently available technologies, such as coal-to-liquid and gas-to-liquid fuel technologies, are not included in this analysis.

Increased petroleum supply projections provided in the article, which include aggressive drilling everywhere (on-shore, off-shore and in the Arctic National Wildlife Refuge) and advanced oil recovery techniques and significant shale oil recovery, may be overly optimistic. They are taken from a study commissioned by the U.S. Department of Energy Fossil Energy Office (ARI, 2006) based on data provided by the U.S. Geological Survey (USGS). This report indicates that the U.S. can substantially increase its domestic supply of oil compared with its history, a theory that is strongly criticized by other experts who show through the historical data that this is a highly unlikely outcome. According to these experts, history clearly shows that the large, easy to produce oil supplies are always discovered and produced first with production declining following the peak. Global oil discovery peaked more than 40 years ago, lending significant credence to this perspective (Bartlett, 2006).

Before deciding what might be done to eliminate U.S. oil imports, it is important to understand oil resources and oil production, on both a global and national basis. Virtually all oil experts agree that the Original Oil In Place (OOIP) prior to modern industrial exploitation equaled about 6 trillion barrels. What the experts disagree on is how much of that oil is recoverable. One camp, the U.S. Geological Survey (USGS) and the U.S. Energy Information Administration (EIA), has stated that almost half is recoverable (Wood, 2004). The 2nd camp, composed mostly of scientists, academics and oil geologists, believes that only about one-third is recoverable (ASPO, 2008). The difference between these two camps lies in the fact that the USGS states that about 20% of OOIP will be recoverable through reserve growth and new discoveries while the other camp believes that this is a significant overestimation. In either case, we end with a total of either 3 trillion barrels or 2 trillion barrels that could be produced.

Since the late 1850's, when oil was first produced in the U.S., the world has produced and used over 1 trillion barrels of this oil. Thus, there remains between 1 trillion and 2 trillion barrels in the ground that potentially could be produced. The other fact on which almost all experts agree is that, by far, the largest fraction of the remaining recoverable oil (more than 60%) lies in the Middle East Gulf region of the world (EIA, 2008a).

The world produced about 86 million barrels of oil per day (Mb/d) in 2006 – more than 1000 barrels per second. At this rate, the world has between 30 and 60 years of oil left – one or two generations until complete depletion. Of course, oil depletion does not strictly work out in this fashion and the world will not completely run out of oil in one or even two generations. However, as supplies dwindle, the laws of supply and demand will force prices to rise precipitously, pushing down demand. As a result, the remaining oil will become more and more costly and the last, very expensive remnants likely will last for a many generations, but not in meaningful quantity.

Figure 1 at the right illustrates the situation of world oil peaking from a generational perspective with the labels added by the author to provide a personal perspective. The star, also added by the author, represents the time of the first OPEC oil embargo (Campbell and Laherrere, 1998). The implications for the future presented by this figure are worrisome.

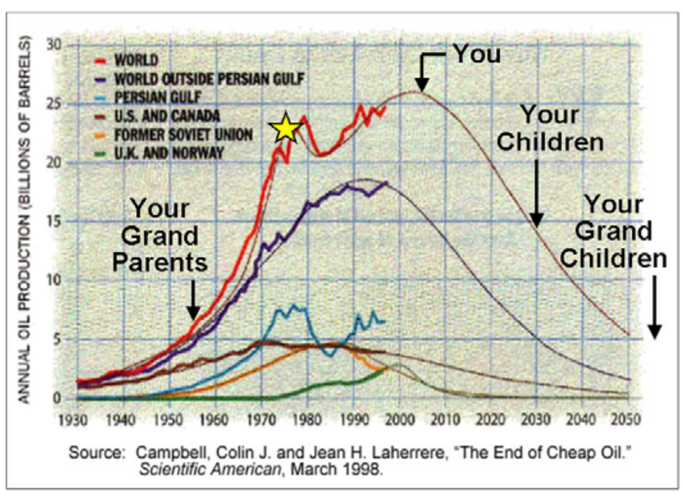

Figure 1. World peak oil – putting it in perspective.

Beginning in 1980 there was a

decline in world oil production lasting through 1992. In part, this decline was caused by the introduction of the Corporate Average Fleet Efficiency (CAFE) standards for vehicles, advanced building codes and appliance standards and a general movement in America to achieve greater levels of efficiency across the board. Yes, world oil production can be strongly impacted by what America does because the U.S. uses about one-quarter of the world's oil.

U.S. domestic oil production peaked in 1970. The U.S. oil peak was predicted in the late 1950's by M. King Hubbert, an oil geologist who was roundly criticized at the time (Hubbert, 1956). However, Hubbert's analytical methods are used today by many petroleum experts to predict when world oil production will likely peak. Most of the 2nd camp experts (ASPO, 2008), who use Hubbert's analysis methods, believe that world oil production either already has peaked (in 2006) or will peak prior to 2010. The actual 2006 world oil production was greater than shown in Figure 1, but the principle remains exactly the same – once the oil peak is reached, about half of the recoverable oil will have been produced and oil availability will decline. We will not know for sure until some time afterward that the peak has occurred but most of this group of experts believe that world crude oil production is unlikely to ever exceed 90 Mb/d. In the face of increasing world demand, especially by the most populated and rapidly growing economies on the planet – India and China – this will likely place enormous upward pressure on future oil prices, especially if the U.S. does not seriously reduce its reliance on oil. To put this in another perspective, the U.S. consumes approximately 25.2 barrels of oil per year per capita while China and India consume 6.0 and 2.3 barrels per year per capita, respectively (BP, 2008). Together, China and India have approximately 8 times the population of the U.S. Thus, if their per capita consumption was anywhere near the U.S. per capita consumption, the world simply could not come close to meeting the demand, regardless of price.

Contrary to the Hubbert analysts' predictions, the mean projection of the EIA, using USGS data, estimates that world oil production will peak in 2037 at more than 145 Mb/d. As previously stated, the differences between the two scenarios are caused primarily by the differences assumed for recoverable oil coupled with the assumptions used in determining the peak production rate. In the EIA case, the peak production rate is determined by assuming a 2% demand growth per year until such time that the remaining oil resource is depleted to the point that it results in a production rate decline at a reserves to production ratio (R/P) of 10. This results in projections that show a much more rapid rate of decline in production following the peak than the rate of production increase preceding the peak (Wood et al., 2004). World peak oil analysts who use Hubbert's analytical methods strongly disagree with both the USGS's estimate of ultimate recoverable oil and with the EIA methods of predicting the oil peak (ASPO, 2008).

Understanding oil production is critical to divining what we can do best to mitigate the adverse impacts of peak oil. When U.S. oil production peaked in 1970, we produced about 9.6 Mb/d. In 2007, we produced a little less than 5.1 Mb/d or about 53% of the 1970 peak. The U.S. Energy Information Administration (EIA) provides records for domestic oil production since 1900 and provides regional breakouts of domestic production since 1981 (EIA, 2008b).

Figure 2 provides these data. Not only has the total U.S. production rate decreased since 1985, but so have production rates in each region. The uptick in the production rate between 1977 and 1985 is due to the Alaska North Slope oil fields, which first came on line in1977. These oil fields peaked eleven years later in 1988. At its peak, the North Slope produced about 2 Mb/d. In 2007 it produced about 0.72 Mb/d, a decline of 64%. If not for the North Slope, U.S. production decline would have more closely followed the top of the West Coast area (purple) of the diagram.

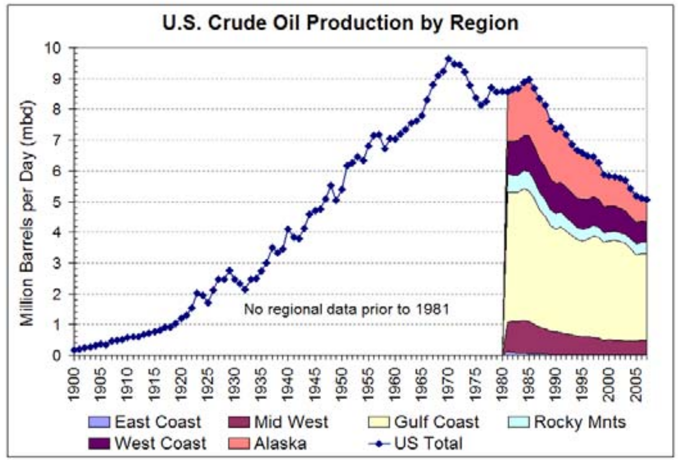

Figure 2. Domestic U.S. crude oil production since 1990.

There also has been much recent discussion of the oil resources available within the Arctic National Wildlife Refuge (ANWR). The most recent projections from the U.S. Energy Information Agency on ANWR were done at the behest of Senator Ted Stevens. EIA's May 2008 report to the Congress on ANWAR projects that, for the mean oil resource case, ANWR would begin production in 2018 and peak in 2027 at 0.78 Mb/d (EIA, 2008c). Drilling on the outer continental shelf (OCS) has also been much discussed of late. For this resource, EIA projects production beginning in 2018, increasing the net off-shore production rate by a peak of 0.22 Mb/d by 2025 (EIA, 2008d).

Figures 1 and 2 illustrate one of the most basic facts of oil production – all oil fields peak and then decline over time. Likewise, as illustrated in Figure 2 above, all oil regions peak and all oil producing countries also peak and then decline. The decline in the total U.S. oil production rate since 1985 has been about 0.17 Mb/d per year. Thus, in 10 years we should expect these existing oil resources to produce about 1.5 Mb/d less than they produce today.

Against production, it is fundamentally important to understand the magnitude of U.S. consumption. The U.S. uses almost one-quarter (24%) of all of the petroleum produced by the world. We used about 20.7 Mb/d in 2007. Of this, we imported 13.5 Mb/d or about 65% from foreign countries. By way of contract, in 1970 the U.S. used about 14.7 Mb/d and imported 3.4 Mb/d or about 23% from foreign countries (Davis et al., 2008).

Table 1 presents 2007 U.S. petroleum consumption by end use. It shows that, of total U.S. consumption, 9.29 Mb/d (45%) goes to make motor gasoline. Another 2.95 Mb/d (14%) goes to make transportation diesel fuels and jet fuel constitutes another 1.62 Mb/d (almost 8%). Thus, fully two-thirds (13.86 Mb/d) of total U.S. petroleum consumption goes toward transportation (EIA, 2008e).

Table 1. U.S. Petroleum Consumption

Use:	**Mb/d**		**% of total**
Motor gasoline	9.29		44.9%
Diesel fuel	2.95		14.3%
Jet fuel	1.62		7.8%
Trans subtotal		**13.86**	**67.0%**
Residual FO	0.72		3.5%
Still gas	0.70		3.4%
Petro chemicals	0.64		3.1%
Building heating	0.51		2.5%
Petro coke	0.49		2.4%
Asphalt	0.49		2.4%
All other distillates	0.42		2.0%
Electricity production	0.32		1.5%
Lubricants	0.14		0.7%
Other subtotal		**4.44**	**21.5%**
All remaining uses	**2.39**	**2.39**	**11.5%**
Grand Total	**20.68**	**20.68**	**100.0%**

Recently, we have seen unprecedented increases in crude oil and gasoline prices and much has been made in the U.S. Congress, in presidential campaigns and by television experts about significant “technically recoverable” oil deposits in U.S. territory. Given recent political punditry, many now believe that we sit on so much oil that we have only to “drill our way out” of high oil prices.

To determine the net increase in domestic oil production, one needs to also consider the depletion of existing fields (as shown in Figure 2). Given this fact, it would be useful to have some model of future oil consumption and production. This is often accomplished by constructing a business as usual (BAU) projection of what the future is likely to look like if historical trends remain the same. Such a model serves two purposes: it provides a visual tool for projecting future trends, and it serves as a framework on which one can construct an alternative vision of various scenarios with their outcomes.

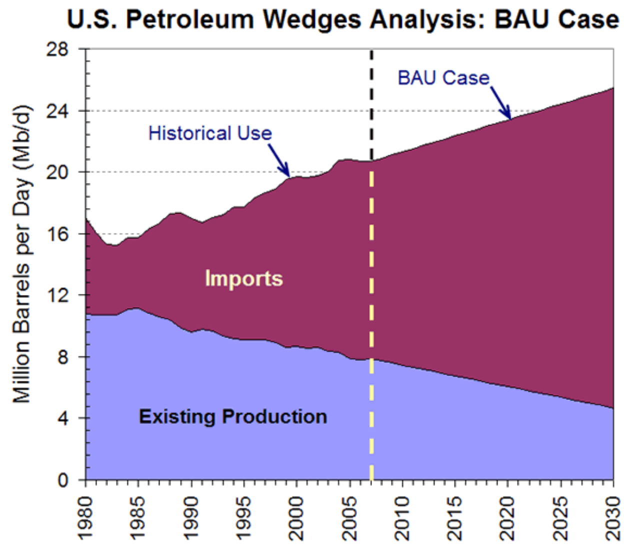

Figure 3. Business as usual model for U.S. oil production and consumption through year 2030.

Figure 3 at the right is a BAU model for oil production and consumption in the U.S. between 2008 and 2030. The vertical dashed line at year 2007 represents the point at which the historical data ends. Thus, the data for the 27 year period from 1980 – 2007 is actual and the data from 2008 – 2030 is a projection of these data based on straight line historical trends.

In Figure 3, domestic oil production, natural gas liquids and refinery gains are represented by the lower, light blue area and oil imports (the magenta area) are calculated by subtracting these data from the petroleum products supplied data (EIA, 2008f). Both consumption and production are projected into the future at a slightly lower rate of incline (or decline) than is shown by the previous 20 year's history. It is clear from this figure that business as usual is not a tenable option if the U.S. is to achieve any meaningful energy security or energy independence.

There are a number of options for altering the BAU case into the future. One might reduce the requirement for imported oil in a number of ways: by increasing the use of ethanol, by aggressive drilling for new oil and advanced oil recovery techniques, by increasing the efficiency of vehicles, by reducing the number of vehicle miles traveled (VMT) and by substituting other fuels (natural gas or electricity) for gasoline.

On the supply side of the equation we find increased ethanol production and aggressive oil drilling. The U.S. Congress and many state legislatures have passed laws providing financial incentives or requiring the greater use of ethanol. As a result, we have seen U.S. ethanol production increase from 2.7 billion gallons per year in 2002 to 5.3 billion gallons per year in 2007 – almost a 100% increase in production in 5 years. Recently, we have also seen a substantial increase in competition for fuel versus food croplands as a result of the precipitous rise in fuel prices and legislation requiring the use of ethanol. Surprising to many, the U.S. is the world's largest producer of ethanol – many believe it is Brazil, but Brazil is second to the U.S. with 4.4 billion gallons in 2007. Total world production of ethanol in 2007 was 13.5 billion gallons, meaning that the U.S. and Brazil produced more than 72% of the world's ethanol (RFA, 2008).

We must also ask what our domestic ethanol production displaces in terms of U.S. petroleum use and imports. To answer this question, we need to know the energy content of ethanol. All barrels are not created equal and ethanol has an energy content that is only 61% of the energy content of crude oil. On doing the math, we find that current U.S.

ethanol production is equivalent to about 0.26 Mb/d of oil. To supply 10% of our motor gasoline with ethanol (often referred to as E10 gasoline), would require almost 1 million equivalent barrels per day. Using current practice, this would require a four-fold increase in croplands dedicated to the production of ethanol, a figure that our need for agricultural food products may not be able to support without large increases to food prices. Nonetheless, this article uses 1 Mb/d as the ethanol goal for 2030.

Increased oil drilling is another supply side option. The magnitude of our "technically recoverable" oil deposits is estimated by a 2006 U.S. Department of Energy report, entitled "Undeveloped Domestic Oil Resources: The Foundation for Increasing Oil Production and a Viable Domestic Oil Industry." Appendix 1 of this report provides a breakdown of the available resources along with projected production rates for each of them. They include heavy oil, advanced oil recovery and a large amount of shale oil production (about 3 Mb/d by 2030) (ARI, 2006). We can add to these resources the production potential of the Arctic National Wildlife Refuge (ANWR) as projected by (EIA, 2008c) and the Outer Continental Shelf (OCS) potential as projected by (EIA, 2008d) to obtain the figures presented in Table 2.

Table 2. Projected U.S. Oil Resources

Source	2020	2030
Heavy Oil (1)	0.3	0.7
ANWR & OCS (2)	0.2	1.0
CO2 Recovery (1)	0.8	1.7
Oil Shale (1)	0.4	3.0
Total	1.7	6.4

As previously stated, these estimates are discounted by some studying the history of oil discovery and production, who believe the oil resource values from the USGS, on which these projections are based, as well as the assumptions about the cost-effective recovery of shale oil are likely inflated (ASPO, 2008).

When we apply these values to our BAU model we obtain Figure 4. It is interesting to note that while these oil supply options are considered by many to be overly optimistic, they do very little to impact the net magnitude of oil imports over time. This occurs since consumption continues to grow and existing production continues to decline at rates that causes the total quantity of oil imports to remain somewhat similar over the time period. Even with very

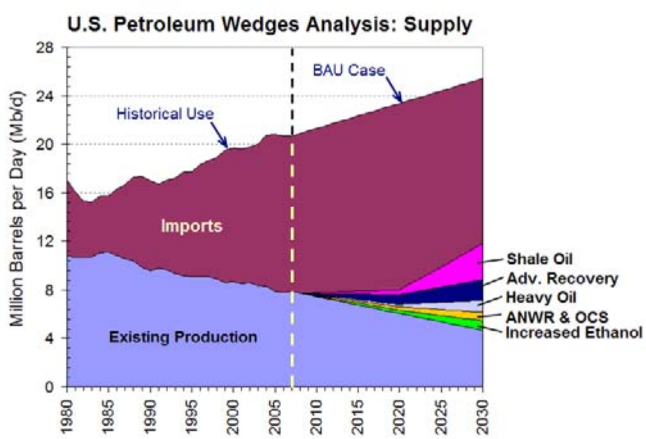

Figure 4. Supply side options for reducing dependence on imported oil.

aggressive drilling and quadrupled ethanol production, we are able to achieve total U.S. oil production rates only roughly equal to those of 1985.

We now consider a number of demand side options, including increased vehicle efficiency, reduced vehicle miles traveled and natural gas fuel substitution options.

Reducing the highway speed limit to 55 miles per hour was used in the 1970s to decrease vehicle fuel use. An evaluation of this speed limit reduction was performed by Congress. The findings, taken from a National Academy of Science study, were that motor vehicle energy use had been reduced by 167,000 barrels of oil per day or just under 2% at that time (Segal, 1987). Today, 2% of vehicle energy use would equate to about 270,000 barrels of oil per day – like ethanol, about one-quarter of a million barrels per day.

Perhaps our most powerful demand side tool is the Corporate Average Fleet Efficiency (CAFE) standards, originally passed in the early 1980s to deal with a similar but far less substantive run up in oil and gasoline prices. Due to the "light truck" loophole in the CAFE standards, the relatively low price of gasoline in the U.S. and Americans' penchant for SUVs, the actual fleet average miles per gallon for the U.S. passenger fleet has actually declined slightly since its peak in 1987 of about 22 miles per gallon (mpg) and it now stands at about 20 mpg (Pew, 2008). Increasing that passenger vehicle fleet average to 35 mpg for gasoline vehicles, 35 mpg for diesel vehicles and 72 passenger miles per gallon for jet aircraft and then increasing them further to 50 mpg for vehicles and 84 passenger miles per gallon for jets by 2030 would result in a reduction of about 4.3 Mb/d by 2020 and 7.4 Mb/d by 2030. This is more than an order of magnitude beyond the impact of a four-fold increase in ethanol production and a 55 mph national speed limit, combined. Even then, the 2020 goal of 35 mpg falls far short of current technology, where aftermarket Plug-in hybrid vehicles are capable of greater than 80 mpg, although this involves fuel substitution by electricity in the transportation sector.

Recently a lot has been made of the energy plan of Texas oilman T. Boone Pickens (Pickens, 2008). Pickens recently introduced a $10 million media blitz, claiming that "we can not drill our way out of this emergency" but we can solve it nonetheless. His plan revolves around two fundamentals: first, that wind power has come of age and calculations show that the wind resource in the Central United States could produce 20% or more of our current national electricity needs. Secondly, that this electrical generation could free up significant quantities of natural gas otherwise burned in power plants that could be used for transportation needs and provide the "bridge" over time that we need to wean ourselves from the use of oil as a transportation fuel.

So far, we have not discussed natural gas with respect to U.S. energy production. It is also not included in our earlier U.S. petroleum consumption value of 20.7 Mb/d. The U.S. domestically produces about 18.5 trillion cubic feet of dry natural gas per year. Current U.S. production of natural gas is equivalent to 9.2 Mb/d of oil, or about the same amount as the current national demand for motor gasoline.

We also have not discussed electricity use in the U.S. In oil equivalence (i.e. if we used oil to produce it), the 2006 U.S. electricity use of about 4 trillion kWh is equal to about 20.2 Mb/d of oil. The Central U.S. wind resource is estimated at 20% or more of this value and wind machines are currently cost-effectively producing about 1% of total U.S. electrical power. Thus, producing 20% of our electrical power from wind (which coincidentally is the same as is currently produced using natural gas), would free up about 4 Mb/d oil equivalent in natural gas, enough to cut our oil demand for motor gasoline almost in half. Combining this with substantially enhanced CAFE standards could make a very meaningful difference in oil imports.

However, as Pickens points out, it would also require a healthy investment in infrastructure to provide for a national electric grid and the necessary changes to existing fleets and fueling stations to allow our vehicles to run on compressed natural gas (CNG). The technology challenges, however, are not great. Converting an internal combustion engine to run on compressed natural gas is straightforward and the price of natural gas is currently less than the price of gasoline equivalent, so price strain might be reduced. Also, as Pickens point out, at $136 per barrel, we are exporting about $700 billion dollars per year to foreign counties for our oil habit. Reducing this dependence by some 4 Mb/d would result in a net national economic gain of about $230 billion per year. To place this in perspective, this amount is greater than the estimated annual cost for the Iraq war (Bilmes and Stiglitz, 2006; Leonhardt, 2007)!

Finally, we can reduce vehicle miles traveled (VMT) through several means. Increased use of heavily occupied vehicles (HOV, i.e. carpooling) and increased use of mass transit are two immediate options, but much more significant would be shifting more of our product distribution from the roads to the rails, where efficiencies are greater than 420 ton-miles per gallon (CSX, 2008). By contrast, our most widely used carriers of goods – Class 8 trucks or “18-wheelers” – are capable of about 175 ton-miles per gallon (Lovins et al., 2005). It also seems advisable to increase our use of the rails for city-to-city and interstate travel. We can power our trains with electricity rather than oil and we can build and deploy high-speed trains that travel in excess of 225 miles per hour, as European trains do. The goal would be to reduce VMT by 10% by 2020 and by 30% by 2030, providing the necessary time to replace single-occupancy passenger vehicle travel with other forms of effective electric mass transit by 2030. This would produce about 1.5 Mb/d in oil savings by 2020 and 2.9 Mb/d by 2030.

As seen in Figure 5, these demand side options can significantly reduce U.S. oil imports, much more so than the supply side options shown in Figure 4. Under this scenario, we are still left with imports, but at a sharply reduced level.

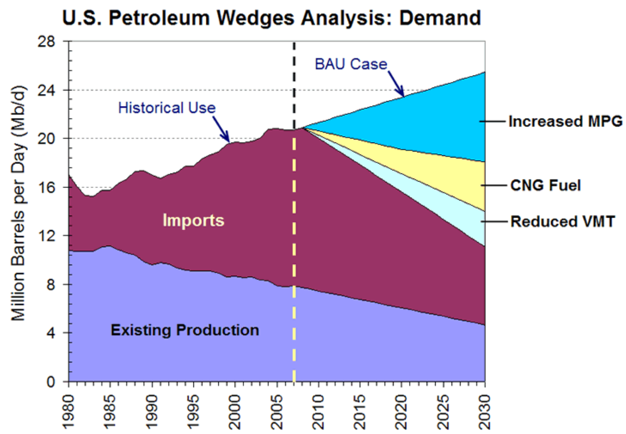

Figure 5. Demand side options for reducing U.S. oil imports.

However, even more will be required. How will we obtain the new electric power capacity needed to power the electric vehicles and trains that will displace the oil used in our internal combustion engines and provide for electric mass transit? Recall that in Picken's energy future, he plans to use electricity produced by natural gas in a "net zero sum game" to power a large percentage of our passenger vehicles to build his "bridge to the future" for renewable energy resources.

Where will we get the additional needed electricity? The buildings we live and work in may be the best resource to free the required generation capacity. America's homes and commercial building stock consume 70% of national electricity and are quite energy inefficient compared with what is cost effective today (i.e. what will pay for itself in reduced energy costs). The oft quoted claim appears true: "the quickest and most cost-effective kilowatt-hour we can produce is the one we gain through increased energy efficiency." And both the International Energy Agency (IEA) and the European Union (EU) have identified building energy use and aggressive goals to improve building energy efficiency as a key component of their climate change initiatives (OECD/IEA, 2008; EU, 2002).

Estimates are that with aggressive programs we could cost-effectively save about 30% of U.S. existing building energy use today through improved efficiency (Ehrhardt-Martinez and Laitner, 2008; Elliot et al., 2007). As energy prices climb, it may be reasonable to expect that, through efficiency technology advances, new building energy use could be reduced by 60% and existing building energy use by 40% by 2030. This would result in freeing up about 21% (0.85 trillion kWh/y) of 2006 electric energy use by 2020 and 35% of 2006 use (1.4 trillion kWh/y) by 2030. Increased building energy efficiency is so powerful that many energy experts are now calling it the "first fuel" (Eldridge et al., 2008).

These electricity energy use savings can be converted to their oil equivalent by assuming that the electricity is produced from oil using a heat rate of 10,500 Btu/kWh. This heat rate equates to a generating efficiency of 32.5%, which is a reasonable assumption for current, fossil fuel-fired electric generation plants. It is important to point out that electricity savings at the point of use (efficiency), avoid the significant inefficiency of converting fossil fuels to electricity. The conversion to oil equivalence yields 4.3 Mb/d savings by 2020 and 7.0 Mb/d savings by 2030. Currently, we make only about 1.5% of our electrical energy from oil so this conversion to oil equivalence, while useful for comparison, does not represent a direct displacement of oil. Nonetheless, these electricity savings are vitally important because electricity will be needed to meet transportation needs in the future, particularly with plug-in hybrids that are likely to be part of the future of the automobile.

Additionally, the U.S. solar energy resource is extensive. Enough sunlight strikes the earth each hour to provide the world's energy needs for a full year. The solar energy falling on a 30,000 square mile area converted at 15% efficiency would be able to provide all of the energy needs in the U.S. The U.S. solar energy resource is at least twice that of Germany, the world's largest installer of solar electric power systems (SEIA, 2008). Solar water heating is a cost effective option across much of the country and the global solar electricity industry (both solar thermal electricity generation and photovoltaic electricity) are rapidly growing. During the past 10 years, from 1998-2007, photovoltaic (PV) installations in the U.S. grew at rate of 32% per year. And during 2007, installed U.S. PV power grew at the rather phenomenal year-over-year rate of 48% as compared with 2006 (Sherwood, 2008).

In addition to PV, solar thermal electric generation (STEG) is proving increasingly cost-effective as a power production technology to utilities and others. Estimates provided here are that, at a conservative growth rate compared to recent history of 12% per annum, PV will provide 0.03 trillion kWh/y and STEG will provide 0.05 trillion kWh/y by 2020. By 2030, the estimates are 0.15 trillion kWh/y and 0.17 trillion kWh/y for PV and STEG, respectively (Grover, 2007). This equates to 2% of current electric energy use by 2020 and 8% of current electric use by 2030.

Nuclear power production also might be increased to meet growing U.S. electricity demand. The U.S. Congress has recently provided loan guarantees for additional new nuclear power production facilities. However, the cost will be high. Recent price quotes for approximately 4,000 MW of new nuclear power production in Florida are running at approximately $7,091 per kW (Florida, 2008). And at least some experts believe that the cost and uncertainty associated with nuclear power production facilities means that they are no longer "too cheap to meter" but rather "too costly to matter" (Lovins, 2008).

Thus, between enhanced building energy efficiency, significantly more wind power and increased use of solar electric energy, we have effective means to displace much of our needed electricity. When combined, these resources could generate the equivalent of 1.5 trillion kWh per year by 2020 and 2.8 trillion kWh per year by 2030. This equates to 38% and 68% of total 2006 U.S. electric energy use by 2020 and 2030, respectively. All will be needed due to increasing electricity demand due to population increases and anticipated added demands for electricity for transportation.

Combining the supply side options shown in Figure 4 with the demand side options shown in Figure 5 yields the results shown in Figure 6. This figure indicates that it may indeed be possible to eliminate the need for imported oil by 2030, but only by thoroughly exploiting all options in concert. Thus, to achieve the goal of weaning ourselves from imported oil, we need it all – all of the supply options as well as all of the demand reduction options plus the increased electricity derived from building efficiency and renewable energy gains. There is much to be optimistic about and Figure 6 shows that, yes, if we have the political will, we might wean ourselves from imported oil within a generation.

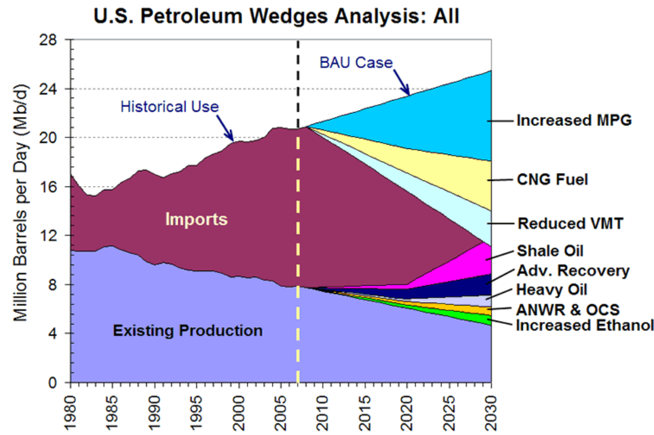

Figure 6. Combined supply and demand options for reducing U.S. dependence on oil imports.

Providing for the energy needs of our children and grandchildren will require substantial investments now – and dedication to multiple alternatives to buy time for transition from oil to renewable fuels. We will also need far greater energy efficiency in our vehicles and our homes and buildings. However, time is important within this task; we must invest our energy in moving to more sustainable sources before our very financial wherewithal to accomplish the task is exhausted.

Any such program will dwarf preceding public efforts such as the oft-cited Manhattan project or the WPA. For success, cost will remain a daunting hurdle and it is certain that energy over the next generation will come at greater expense. The escalating worldwide global demand for oil and the waning supply – a fact that we must face head-on – will continue to escalate future oil prices.

We must face the fact that providing for the energy and economic security of our children and grandchildren will require that we begin to make substantial investments now – in multiple alternatives that buy us the time to transition from oil to renewable transportation fuels, in far greater energy efficiency in our vehicles and our homes and buildings, in a new transportation infrastructure based largely on electricity, and in sustainable, renewable energy technologies that will one day be our energy and economic mainstay.

By far, the largest opportunities lie on the demand side of the equation – greater efficiency must be our first order of business, in both the transportation and building sectors. Only after we dramatically improve the efficiency with which we use energy should we invest in more costly options and alternatives – this only makes good economic sense. And we must get serious about this now and we must act now on the opportunities – before America's great wealth is completely drained by foreign oil imports and we no longer have the capital resources we need. Nothing less than the well being of our children and grandchildren is at stake. It is high time that we get on with the task.

References:

ARI, 2006. "Undeveloped Domestic Oil Resources: The Foundation for Increasing Oil Production and a Viable Domestic Oil Industry." U.S. Department of Energy, Office of Fossil Energy, Washington DC.

ASPO, 2008 (Association for the Study of Peak Oil & Gas, International), http://www.peakoil.net/

Bartlett, Rosco, February 8, 2006. "The Peaking of World Oil." Congressional Record, U.S. House of Representatives, (http://www.aspousa.org/assets/pdf/BartlettFEB06.pdf).

Bilmes, Linda and Joseph Stiglitz, January 2006. "The Economic Costs of the Iraq War," presentation at the Allied Social Sciences Associations, Boston, MA.

BP, 2008. "BP Statistical Review of World Energy, June 2008." British Petroleum Company, http://www.bp.com/statisticalreview

Campbell, C.J. and J.H. Laherrere, March 1998. "The End of Cheap Oil." *Scientific American Magazine*.

CSX, 2008. http://www.csx.com/?fuseaction=about.environment_sustainability

Davis, S., S.W. Diegel and R.G. Boundy, 2008. "Transportation Energy Data Book." ORNL-6981, Oak Ridge National Laboratory, Oak Ridge, TN, http://cta.ornl.gov/data/index.shtml

Ehrhardt-Martinez, K. and J, Laitner, May 2008. "The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture." ACEEE Report #E083, American Council for an Energy Efficient Economy, Washington, DC.

EIA, 2008a. http://www.eia.doe.gov/emeu/international/oilreserves.html

EIA, 2008b. http://tonto.eia.doe.gov/dnav/pet/pet_crd_crpdn_adc_mbblpd_a.htm

EIA, 2008c. "Analysis of Crude Oil Production in the Arctic National Wildlife Refuge" Report No. SR/OIAF/2008-03, Energy Information Administration**,** U.S. Department of Energy, Washington, DC. http://www.eia.doe.gov/oiaf/servicerpt/anwr/pdf/sroiaf(2008)03.pdf

EIA, 2008d. http://www.eia.doe.gov/oiaf/aeo/otheranalysis/ongr.html

EIA, 2008e. http://www.eia.doe.gov/neic/quickfacts/quickoil.html

EIA, 2008f. "2007 Annual Energy Review." DOE/EIA-0384(2007) Energy Information Administration, U.S. Department of Energy, Washington, DC.

Eldridge, M., et al., February 2008. "Energy Efficiency: The First Fuel for a Clean Energy Future." ACEEE Report #E082, American Council for an Energy Efficient Economy, Washington, DC.

Elliot, N., et al., June 2007. "Potential for Energy Efficiency and Renewable Energy to Meet Florida's Growing Energy Demands." ACEEE Report #E072, American Council for an Energy Efficient Economy, Washington, DC.

EU, December 2002. "Directive 2002/91/EC of the European Parliament and of the Council on the Energy Performance of Buildings." Official Journal of the European Communities, Brussels, Belgium. http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:001:0065:0071:EN:PDF

Florida, 2008. "Florida's Energy and Climate Change Action Plan." Florida Governor's Action Team, Tallahassee, Florida, October 15, 2008. http://www.dep.state.fl.us/climatechange/actionplan_08.htm

Grover, S., August 2007. "Energy, Economic and Environmental Benefits of the Solar America Initiative." NREL/SR-640-41998, National Renewable Energy Laboratory, Golden, CO.

Hubbert, M.K., 1956. "Nuclear Energy and the Fossil Fuels." Presented before the Spring Meeting of the Southern District, American Petroleum Institute, Plaza Hotel, San Antonio, Texas. http://www.hubbertpeak.com/hubbert/1956/1956.pdf

Leonhardt, David, January 17, 2007. "What 1.2 Trillion Can Buy," New York Times,

Lovins, Amory, et al., 2005. Winning the Oil Endgame: Innovation for Jobs, Profit and Security, Rocky Mountain Institute, Snowmass, CO.

Lovins, Amory B. and Imran Sheikh, "The Nuclear Illusion", Ambio, 27 May 2008, available (in draft form) as http://www.rmi.org/images/PDFs/Energy/E08-01_AmbioNucIllusion.pdf.

OECD/IEA, 2008. "Energy Technology Perspectives 2008 in Support of the G8 Plan of Action: Scenarios & Strategies to 2050." International Energy Agency, Paris, France. http://www.iea.org/Textbase/techno/etp/ETP_2008_Exec_Sum_English.pdf

Pew, 2008. http://www.pewfuelefficiency.org/docs/cafe_history.pdf

Pickens, 2008. http://www.pickensplan.com/

RFA, 2008. Renewable Fuels Association, http://www.ethanolrfa.org/industry/outlook/

Segal, M. R., April 9, 1987. "Speed Limits for Motor Vehicles," p.3. Science Policy Research Division, Congressional Research Service, Library of Congress, Washington, DC,

SEIA, 2008. http://www.seia.org/galleries/pdf/PV_general_one_pager_Final.pdf

Sherwood, Larry, August 2008. "U.S. Solar Market Trends 2007." Interstate Renewable Energy Council http://www.irecusa.org/index.php

Wood, J.H., et al., July 2004. "Long Term World oil Supplies." U.S. Energy Information Administration, U.S. Department of Energy, Washington, DC. http://www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/2004/worldoilsupply/oilsupply04.html