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Oil Independence: Achievable National Goal or Empty Slogan?

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David L. Greene
Oak Ridge National Laboratory
National Transportation Research Center
2360 Cherahala Boulevard
Knoxville, Tennessee 37932
Phone: 865-946-1310; Fax: 865-946-1314; email: dlgreene@ornl.gov

Paul N. Leiby
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, Tennessee 37831
Phone: 865-574-7720; Fax: 865-576-3989; email: leibypn@ornl.gov

Philip D. Patterson
Office of Planning, Budget and Analysis
U.S. Department of Energy
Forrestal Building (EE-3B)
1000 Independence Avenue, S.W.
Washington, DC 20585
Phone: 202-586-9121; Fax: 202-586-1637; email: philip.patterson@ee.doe.gov

Steven E. Plotkin
Argonne National Laboratory
955 L'Enfant Plaza, S.W., Suite 6000
Washington, DC 20024
Phone: 202-488-2403; Fax: 202-488-2413; email: splotkin@anl.gov

Margaret K. Singh
Argonne National Laboratory
955 L'Enfant Plaza, S.W., Suite 6000
Washington, DC 20024
Phone: 202-488-2440; Fax: 202-488-2413; email: singhm@anl.gov

ABSTRACT
Oil independence has been a goal of U.S. energy policy for the past 30 years yet has never been rigorously defined. A rigorous, measurable definition is proposed: to reduce the costs of oil dependence to less than 1% of GDP in the next 20 to 25 years, with 95% probability. A simulation model incorporating the possibility of future oil supply disruptions and other sources of uncertainty is used to test whether two alternative energy policy strategies, Business as Usual and an interpretation of the strategy proposed by the National Commission on Energy Policy (NCEP), can achieve oil independence for the United States. Business as Usual does not produce oil independence. The augmented NCEP strategy comes close to achieving oil independence for the U.S. economy within the next 20-25 years but more is needed. The success of the strategy appears to be robust regardless of how the Organization of the Petroleum Exporting Countries (OPEC) responds to it. Expected annual savings are estimated to exceed $250 billion per year by 2030.

INTRODUCTION

The thesis of this paper is that the lack of a rigorous, measurable definition of oil independence and a way of determining whether or not any particular strategy will achieve it have seriously hindered the formulation of effective public policy. This paper attempts to remove that obstacle to progress by offering a measurable definition of oil independence and demonstrating a workable method for testing strategies for accomplishing the goal. Other important goals such as reducing carbon emissions from petroleum use are not directly considered. Including them would be essential to formulating a comprehensive energy strategy.

In the following section the meaning of the phrase "oil independence" is reconsidered. It is argued that the essence of the oil dependence problem is the actual and potential economic costs it generates. The economic costs of oil dependence are a direct consequence of the monopoly power of the OPEC cartel and the risk of oil supply disruptions. The major components of the costs of oil dependence and a method for measuring them in an uncertain future are then presented. The definition of oil independence is then restated in a measurable form. The Oil Security Metrics Model (OSMM), a tool for estimating the prospective costs of oil dependence in an uncertain future, is then used to estimate a range of future oil dependence costs implied by the EIA projections and to test whether or not implementing the NCEP's oil security strategy would achieve the goal of oil independence.

WHAT IS OIL (IN)DEPENDENCE?

Popular concepts of oil independence include eliminating oil imports from the Middle East and eliminating all oil imports (*1*, *2*), or even eliminating all oil use (*3*). While appealing in their simplicity, these extreme concepts of oil independence are erroneous. They arise from a failure to understand the nature of the problem of oil dependence (*4*). Once the problem of oil dependence is correctly characterized, a meaningful definition of oil (energy) independence can be formulated.

It is useful to consider the meaning of the word independence, to see if its use in this context is appropriate. Merriam-Webster (*5*) defines independence as, "**1** : the quality or state of being independent," while independent is defined as "**1** : not dependent: as **a** (1) not subject to control by others : SELF GOVERNING". Finally, the relevant meaning of control is: **2 a :** to exercise restraining or directing influence over. By the common meaning of the words, *oil independence means achieving a state in which our nation's decisions are not subject to restraining or directing influence by others as a consequence of our need for oil.* This does not necessarily imply that to achieve oil independence we must import no oil or use no oil.

This leads us to the following general definition of oil independence:

> "For all conceivable future world oil market conditions, the costs of oil dependence to the U.S. economy will be so small that they will have no effect on our economic, military or foreign policy."

To test whether any given strategy could actually achieve oil independence, the general definition stated above must be translated into a measurable goal. Given the high degree of uncertainty about future oil market conditions, a measurable definition of oil dependence should be phrased probabilistically.

> "The estimated total economic costs of oil dependence will be less than 1% of U.S. GDP with 95% probability by 2030."

ECONOMIC BASIS OF OIL DEPENDENCE

Oil dependence is fundamentally an economic problem with enormously important political and national security ramifications. The political and national security issues, however, arise almost entirely from the importance of oil to our economy. It is primarily the fear of the economic consequences of oil market disruptions or manipulations that creates oil dependence, our submission to control or influence by others. For decades, Professor Morris Adelman has written extensively and insightfully on the subject of world oil and the nature of the United States' oil problem. He recently summarized its essence as follows.

> "The real problem we face over oil dates from after 1970: a strong but clumsy monopoly of mostly Middle Eastern exporters cooperating as OPEC." (*6*, p. 16)

The OPEC cartel, organized in 1960, first affected world oil markets late in 1973 when its Arab members organized an oil boycott against the United States and other countries that had given support to Israel in the October War (*7*). The impact of the "strong but clumsy monopoly" on the world oil market since 1973 is patently obvious in the path of the price of oil in world markets since 1950 (Figure 1): oil prices are higher and more volatile, chiefly due to the inconsistent exercise of market power by OPEC.

The cartel's market power arises from its market share and the inelasticity of world oil demand and oil supply by non-OPEC producers (*8*). A key event contributing to OPEC's market power was the peaking of U.S. oil production in 1970 (Figure 2). Prior to 1974 the United States was the world's largest oil producer and possessed substantial spare capacity. The peaking of U.S. production contributed to a rapid increase in demand for oil on international markets that strengthened the market power of the OPEC cartel. The world is facing a similar situation today as rapid growth in Asian oil demand, combined with the peaking of production in other regions has once again reinforced the cartel's market power.

MEASURING OIL INDEPENDENCE

The economic cost of oil dependence has three main components:

1. the transfer of wealth from oil consumers to producers due to higher than competitive market prices;
2. the loss of GDP that arises from the increased economic scarcity (higher price) of oil;
3. the macroeconomic dislocation costs caused by slow and imperfect adjustment to unexpected, large price changes.

There are other costs, such as the cost of purchasing, holding and maintaining strategic reserves, but these are smaller by an order of magnitude. There are also military costs, which are very likely of the same magnitude as the direct economic costs. However, both categories of policy-cost are largely a consequence of the actual or potential direct economic costs. Thus, solving the problem of economic costs would largely solve the problem of derivative costs. Omitted from this economic analysis are any environmental or foreign policy implications of oil use, and dependence costs borne by U.S. trade partners and allies.

Over time, the direct economic costs of oil dependence have been large. Recent estimates put cumulative costs since 1973 at roughly $4 trillion constant 2000 dollars (*9*). The total costs are approximately equally divided among the three categories of costs and are strongly correlated with the world price of oil (compare Figure 3 to Figure 1).

Importance of Uncertainty

One aspect of the future of the world oil market is certain: uncertainty. For example, the EIA's alternative projections of world oil price in 2030 range from $30 to $90 per barrel (*10*). And these projections do not consider possible oil supply disruptions. A good strategy for oil independence must be robust under the full range of likely oil market futures.

Four kinds of uncertainty are considered:

1. *Oil market uncertainty* is represented by testing oil dependence strategies in three alternative AEO projections: (i) Reference case, (ii) High world oil price case and (iii) Low world oil price case.
2. *Oil supply disruption uncertainty* is represented by a stochastic model of oil supply shocks.
3. *OPEC response uncertainty* is represented by two alternative strategies OPEC might use to respond to U.S. oil security policies: (i) maintain the price of oil, (ii) maintain production levels.
4. *Parametric uncertainty* is represented by specifying key parameters, such as price elasticities and adjustment rates, as probability distributions rather than single point estimates.

Detailed explanations of how these uncertainties are represented in the OSMM can be found in Greene and Leiby (*11*). This list does not exhaust the full range of sources of uncertainty. Key items not included are uncertainty about rates and directions of technological progress and uncertainty about the policies of other oil consuming nations.

Energy Market Uncertainties

The EIA's AEO 2006 High and Low Oil Price Cases are intended to reflect different assumptions about the size of world conventional oil resources and OPEC's willingness to increase oil production to satisfy growing world demand (*10*, p. 92). The price of crude oil in 2030 ranges from $28 per barrel in the Low Price Case to $90 per barrel in the High Price Case. OPEC oil production in 2030 ranges from 32 million barrels per day in the High Price Case to 51 million barrels per day in the Low Price Case. In the simulations reported below, the Reference Case is assigned a probability of 40%, while the High and Low Oil Price Cases are each given probabilities of 30%.

Supply Disruption Uncertainty

AEO projections of OPEC oil supply are generally smooth, undisrupted paths over time. The history of OPEC production since 1970 does not resemble such projections. The OSMM represents the potential for future oil market disruptions by means of a stochastic supply disruption model, calibrated to the deviations of historical OPEC production paths from past AEO projections of those paths. The resulting model is also generally consistent with recent evaluations of the probability of future supply disruptions (*12*, *13*).

OPEC Response Uncertainty

As a cartel, OPEC can choose how to respond to efforts by the United States to reduce its oil dependence. However, OPEC's options are limited to increasing oil production, decreasing oil production, or continuing with its original production plan. If OPEC chose to increase production as a response to decreasing U.S. oil demand, this action would further depress world oil prices and reduce OPEC revenues, due to the inelasticity of world oil demand. Therefore, we limit consideration of OPEC's response to two strategies: (1) maintain the original scenario output plan, and (2) maintain the original scenario price path (by decreasing output). By comparing U.S. oil dependence costs under the two alternative strategies, sensitivity to OPEC's response can be measured.

Parametric Uncertainty

Key parameters, such as price elasticities and temporal adjustment rates are not known with precision. In the OSMM these parameters are specified as probability distributions (see Greene and Leiby (*11*)).

Energy Policy Scenarios

Two strategies for addressing the problem of U.S. oil dependence are tested:

1. *Business as usual*, represented by the AEO 2006 Reference, Low Oil Price and High Oil Price Cases which include all current but no new policy initiatives.
2. *NCEP Strategy*, which attempts to capture the key elements of the National Commission on Energy Policy's recommendations for addressing oil security (*14*).

The rationale for adopting the NCEP strategy is that it avoids having to create a new strategy from the ground up, including careful analyses of technical feasibility, cost-effectiveness, and political feasibility. The analysis and reasoning behind the construction of the NCEP scenario can be found in the Commission's final report and associated background reports. The following conveys the sense of the NCEP's approach.

> "In choosing among a large number of potential policy options, the Commission applied several general criteria, including economic efficiency; cost-effectiveness and consumer impacts; ability to provide appropriate incentives for future action; flexibility for adjustment in response to further experience, new information, and changed conditions; equity; political viability; and ease of implementation, monitoring, and measurement." (NCEP, 2005, p. viii)

This paper neither endorses nor criticizes the NCEP's policy scenario. Nor does it assess its optimality or cost-effectiveness. It is used here as an illustration of the potential impact of a carefully constructed, broad strategy for dealing with U.S. oil dependence.

A comprehensive strategy for oil independence ought to address all oil use in transportation, not just light-duty vehicles, as well as oil use in the residential, commercial and industrial sectors. The NCEP's strategy comes close to this ideal but omits some transport modes and does not directly address fuel switching outside of the transport sector. For modes and sectors not specifically addressed in the NCEP report or by Grumet's (*4*) testimony concerning it, assumptions based on Elliot, Langer and Nadel (*15*) Moderate Scenario have been adopted. Still, even that source addresses only efficiency improvement and not fuel switching. Unfortunately, there is little analytical work on which to base recommendations in these areas; additional research and analysis is clearly needed to assess the potential to reduce petroleum use in these sectors.

In some cases, the NCEP report declines to specify a numeric target for the policies it recommends. For example, potential oil savings were estimated for a range of feasible light-duty vehicle fuel economy targets, but no single target was endorsed. For this analysis, a numeric target was required. The "NCEP Strategy" scenario tested in this paper should be considered the authors' own interpretation of the NCEP oil security strategy, and the NCEP should not be held responsible for any errors in judgment it may contain.

The specific assumptions made for each sector are described below. In each case, the NCEP assumptions were compared with the AEO 2006 Reference Case Scenario and only incremental changes from the Reference Scenario are attributed to the NCEP strategy.

Light-duty Road Vehicles

The potential to increase light-duty vehicle fuel economy has been extensively studied. These analyses clearly indicate that much higher levels of fuel economy are achievable at reasonable cost, provided that consumers are willing to forego further increases in vehicle power and mass. The NCEP stops short of recommending a specific fuel economy target, but notes that increasing light-duty vehicle fuel economy from 25 mpg today to 32 mpg by 2015 could save 2.2 mmbd in oil consumption by 2025. With greater use of diesel, hybrid and plug-in hybrid technologies, levels of 40-50 mpg would be achievable, saving 3.5 to 4.6 mmbd, respectively.

The AEO 2006 Reference Case predicts a light-duty vehicle fuel economy increase of 17% from 2004 to 2030, from 24.9 to 29.2 mpg. It is assumed here that light-duty vehicle fuel economy would be increased to 43 mpg by 2030, a 75% increase over the 2006 level of 24.6 (*16*). This falls between the NCEP's upper and median estimates of 40 and 50 mpg but occurs five years later, in 2030. It would save 3.5 mmbd in 2030 versus the AEO Reference Case projected light-duty vehicle fuel consumption.

The NCEP strategy also recommends major increases in public and private investment in R&D. The impacts of such investments are very difficult to predict. Here, their potential impact on only light-duty vehicle energy efficiency is simulated by assuming that technologies described in an MIT (*17*) report as possible by 2020 do, in fact, become available. The existence of these advanced technologies increases the response of light-duty vehicle fuel economy to changes in the price of oil.

Heavy-duty Road Vehicles

Directly challenging the prevailing wisdom that heavy truck manufacturers will efficiently adopt fuel economy technology due to their concern for fuel costs, the Japanese government recently implemented fuel economy standards covering these vehicles. The standards call for a 12% reduction in fuel consumption by 2015 (*18*). It is the Japanese government's view that the standards are already having their intended impact (*19*). While the NCEP strategy stops short of recommending fuel economy standards for heavy vehicles, it does recommend establishing fuel economy test procedures. It is assumed that fuel economy standards for heavy trucks are adopted and require an additional increase of 18% beyond the 13% improvement already included in the AEO 2006 Reference Case projection, for a total increase of 33% by 2030.

In the AEO 2006 Reference Case, heavy truck energy use grows from 2.22 mmbd in 2004 to 3.58 mmbd in 2030. Without the estimated 13% increase in freight truck miles per gallon, fuel use would have grown to 4.05 mmbd by 2030. The NCEP strategy calls for a 1 mmbd reduction in heavy truck fuel use by 2025 by means of advanced technology. It is assumed that the 1 mmbd of savings includes the 13% as well as an additional 18%. Thus, in comparison to the Reference Case, an additional 0.53 mmbd of petroleum use is avoided.

Rail, Ships and Aircraft

The NCEP strategy does not address energy use by railroads or ships. The AEO 2006 Reference Case likewise assumes extremely modest energy efficiency improvements for these modes: 0.1%/year for rail and 0.2%/year for shipping. This contrasts sharply with the historical performance of the rail mode, in particular, which cut its energy intensity by 40% from 1978 to 1992 (*20*). It is assumed that a rate of reduction in energy intensity of 1% per year can be achieved in these modes, leading to 20% lower oil consumption than estimated in the AEO 2006 Reference Case. This provides a further reduction in petroleum use of 0.2 mmbd.

The AEO 2006 projects substantial improvement in aircraft energy efficiency, from 55.5 seat-miles per gallon of jet fuel in 2004 to 76.0 smpg in 2030 (38%). Reviewing assessments of aircraft energy efficiency potential, Greene and Schafer (*21*) concluded that improvements of 25% to 40% were achievable by 2030. Since the efficiency improvement projected by the AEO 2006 is already at the high end of this range, no further reductions in petroleum use are assumed.

Residential, Commercial and Industrial Sectors

The NCEP does not directly address the potential to reduce oil use outside of the transportation sector. Indirectly, policies proposed by the NCEP to increase energy efficiency in these sectors should provide some benefits in terms of reduced petroleum use, but quantitative estimates are not presented. Estimates of the potential to reduce oil use in these sectors by means of energy efficiency improvements have been recently published (*15*). That study considered a variety of measures for increasing the energy efficiency of buildings, ranging from insulation to oil burner replacement to new windows. The moderate scenario estimated reductions in oil use of 0.08 mmbd in 2015 and 0.13 in 2020. In addition to these savings, the aggressive scenario estimate for 2020 of 0.19 mmbd was use to estimate potential efficiency savings in 2030.

In the residential sector, 5% of the homes heated with distillate oil are assumed to be switched to other energy sources by 2010, 50% by 2020 and 90% by 2030. In the commercial sector both distillate and residual fuel use are switched to other energy sources on the following schedule: 5% in 2010, 25% in 2020, 50% in 2030. Together with efficiency improvements this produces the reductions in residential and commercial oil demand shown in Table 1.

Elliot, Lange and Nadel (*15*) considered opportunities for reducing industrial oil use in heat and power, asphalt and road oils, and off-road motor fuel use. About three fourths of the total reduction is due to increased use of recycled pavement and crumb rubber from tires in road paving. Greater recycling of plastics and substitution of other fossil or biomass fuels for petrochemical feedstocks were not considered. Once again, this is clearly an area in which additional analysis of oil reduction potential is needed. To the estimates of (*15*) were added 0.1 mmbd of distillate and residual fuel use considered “switchable” in the EIA’s 1994 Manufacturing Energy Consumption Survey (*22*). The definition of switchable applies to energy for heat, power and onsite electricity generation only, and measures only the capability to switch within 30 days of a decision to switch. Allowing time for replacement of capital equipment a much greater potential for fuel switching probably exists. This is an area in need of analysis.

No quantitative analyses appear to have been made of the total potential to substitute non-petroleum feedstocks for petroleum feedstocks in the industrial sector. Especially with the additional agricultural resources required for producing 1.5-2 mmbd of ethanol from cellulose, whether significant quantities of biomass could be supplied to the industrial sector for use as feedstocks is an open question that needs to be answered. Here, no additional use of biomass in the industrial sector beyond that contained in the AEO projections is assumed. The reductions of industrial petroleum use from all sources are shown in Table 2.

Conventional and Unconventional Oil Supply

The NCEP strategy calls for 0.5 mmbd to 3.0 mmbd of coal-to-liquids (CTL) to be produced in the year 2025. The EIA Reference Case projection actually anticipates 0.6 mmbd of CTL produced in 2025 and 0.8 mmbd in 2030. In the High Oil Price Case, 0.8 mmbd are anticipated in 2025 and 1.7 mmbd in 2030, while in the Low Oil Price Case no CTL is expected. (*10*, table 11.) Production of CTLs as a part of the NCEP strategy is represented by increasing the AEO Case's production levels by 1 mmbd in 2030. The increase begins in 2015 and ramps up linearly.

The NCEP strategy notes that there are approximately 21 billion barrels of oil in U.S. reserves located in the Arctic National Wildlife Refuge and the Pacific Offshore region but takes no position on whether or not such resources should actually be developed. On the other hand, it notes that if these reserves were tapped, U.S. oil production in 2020 could be increased by about 2 mmbd. It is assumed that production begins in 2010 and ramps up linearly to 2 mmbd in 2020 and continues at that level through 2030. At that point approximately half of the estimated 21 billion barrels would have been produced.

The NCEP strategy posits 30 billion gallons (2 mmbd) of ethanol production sometime after 2012. The AEO 2006 Reference Case projects ethanol use in gasoline and E85 increasing from 0.13 mmbd in 2004 to 0.48 mmbd in 2030. Nearly all of that ethanol is projected to be derived from corn. The NCEP strategy is therefore assumed to increase ethanol for use in light-duty vehicles starting after 2012 and increasing linearly to a total of 2.0 mmbd in 2030. The NCEP believes that most or all of the additional ethanol can be produced from cellulosic feedstocks at competitive costs. Increased substitution of ethanol is assumed to reduce the demand for petroleum rather than to increase its supply.

The net effect of the conventional and unconventional oil supply initiatives is to increase domestic petroleum supply by 3 million barrels per day in 2030. The net effect of the demand initiatives is to reduce AEO 2006 Reference Case U.S. oil demand by 7.2 mmbd in 2030, about 26% of projected U.S. oil consumption in that year (Table 3). These numbers are before world oil price adjustments. If OPEC were to maintain its original production schedule, these shifts in supply and demand would reduce the world price of oil resulting in some increase in demand and decrease in rest-of-world supply. This market "rebound" effect is taken into account in the OSMM.

The Oil Security Metrics Model

The OSMM is a simulation tool for calculating the potential costs of U.S. oil dependence through 2030 and estimating the impacts of advanced technologies and policy measures on oil dependence costs (for detailed documentation, see *11*). The OSMM includes a simple representation of the world oil market with simultaneous, linear, lagged adjustment equations for United States and rest-of-world oil demand, as well as United States and other non-OPEC oil supply. OPEC oil supply can be changed to represent different production strategies. The model can calibrate itself to up to four AEO world oil market projections, representing alternative futures.

Since the AEO forecasts do not allow oil supply shocks, a probabilistic model of future oil supply disruptions is included in the OSMM. In any given year, an oil supply shock may occur with specified probability (15% is the default value). If a supply shock occurs, its duration is randomly chosen (the default is from 1 to 7 years). In each year of the disrupted period, a random change in OPEC supply is chosen from a distribution calibrated to historical data. The model recalculates a new oil market equilibrium path to 2030 in the (potentially) disrupted scenario. In any particular simulation run, there could be none to several supply disruptions.

The impacts of technologies and policies are entered as shifts in the oil demand and supply curves from the Reference Case levels. Reductions in demand and increases in supply are converted to percent changes so they can be more appropriately applied in the alternative AEO Cases. Changes in the price elasticities of demand or supply due to technological change are also calculated.

The OPEC cartel may respond to the changes in U.S. oil supply and demand in three ways: (1) increase production, (2) decrease production, and (3) maintain the original (disrupted) production schedule. If OPEC maintains the original production schedule, decreased U.S. oil demand and increased supply will cause the world market price of oil to fall. The lower price of oil will induce demand and supply responses in the United States and the rest of the world. The world oil market model estimates these effects. On the other hand, OPEC could cut back production in response to reduced demand and increased supply. The OSMM assumes that OPEC will cut back on production just enough to restore world oil prices to the levels of the (disrupted) scenario before the technology and policy impacts. New equilibrium solutions are computed for both OPEC response strategies.

The OSMM simulations represent uncertainties due to fundamental oil market conditions, supply disruptions, OPEC's response, and the values of key parameters. Each simulation run represents a different realization of the many possible futures. Oil dependence costs are calculated by year for each simulation as the sum of wealth transfer, potential GDP losses and disruption losses. The distributions of costs and summary statistics presented below are based on 10,000 simulation runs.

Is Oil Independence Achievable?

Business as usual will not achieve energy independence. The Business as Usual strategy makes little improvement in U.S. oil security over the current situation. The expected value of oil dependence costs decreases by about 0.5% of GDP from current levels but the variance increases (Figure 4). This is despite more than a doubling of GDP from 10.8 trillion in 2004 to 23.1 trillion in 2030. Future oil dependence costs in the BAU Scenario are estimated to be less than 3.5% of GDP with 95% probability (Table 4). In constant 2000 dollars, 3.5% of GDP would be $375 billion today, but $810 billion in 2030.

The two cases of the NCEP Strategy (first with OPEC maintaining the price of oil (Figure 5), and second with OPEC maintaining its original production path (Figure 6)), come close but do not satisfy the definition of oil independence in 2030. Under the OPEC maintains price assumption, oil dependence costs in 2030 are less than 1.5% of GDP with 95% confidence. The probability of oil costs being less than 1% of GDP in 2030 is 69%. In the OPEC maintains production scenario the 95th percentile = 1.6% of GDP and the likelihood that costs will be less than 1% of GDP is 68%. The NCEP strategy achieves levels of oil dependence costs relative to GDP similar in magnitude to those experienced during the period from 1990 to 2002.

To reach the stated definition of oil independence, however, more is needed. Additional reductions could come from advanced technologies not included in the modified NCEP strategy, such as hydrogen fuel cell vehicles, or from additional policies such as a tax on petroleum. Thorough analysis of the potential for reducing petroleum use in the industrial sector might also yield additional cost-effective options.

Whether OPEC reacts to the NCEP strategy by defending the price of oil or maintaining its original production schedule has little impact on the distribution of oil dependence costs. This is because the effect of the NCEP strategy is to, (1) undermine OPEC's market power by, reducing the demand for oil and increasing its price elasticity, and by increasing the supply of conventional and unconventional petroleum products from outside OPEC, and (2) decrease the U.S. economy's vulnerability to higher oil prices. If OPEC chooses to respond by cutting back production, it gains an initial victory in higher prices but at the expense of reducing its market share. This, in turn, further undermines it market power, thereby limiting OPEC's future ability to influence the market.

CONCLUSIONS

Given a measurable definition of oil independence (oil dependence costs not exceeding 1% GDP with 95% probability by 2030), oil independence appears to be achievable without eliminating oil use and without eliminating oil imports. The augmented NCEP strategy falls short of achieving oil independence for the United States by 2030 but by only 0.5% of GDP. The Business As Usual strategy does not improve significantly on the current situation.

The augmented NCEP strategy is comprehensive, addressing both supply and demand and affecting all sectors of the economy. However, much less appears to be known about the potential to reduce oil use outside of the transportation sector than within it, and within the transport sector less is known about the non-highway modes. Analysis of oil reduction opportunities outside of transportation and for non-highway modes is needed to better understand the contribution these sectors might make to achieving oil independence.

The augmented NCEP strategy reduces both the expected costs of oil dependence and their variability. Expected annual costs of oil dependence in the Business as Usual scenario are $450 billion; expected costs in the NCEP strategy scenario are $190 billion. As a percent of GDP, these costs are comparable to the costs of oil dependence experienced from 1990 to 2002. In addition, 95^{th} percentile costs are $850 billion under Business As Usual but only $350 billion if the NCEP strategy is implemented.

How OPEC responds to the United States' oil independence strategy does not appear to affect the United States' ability to achieve the oil independence goal. In this sense, the U.S. already possesses the freedom to choose to solve its oil dependence problem.

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TABLE 1 Assumed Reductions in Residential and Commercial Petroleum Use

	2004	2010	2020	2030
Efficiency and Fuel Switching (mmbd)	0.00	0.13	0.27	0.37
Percent Reduction in Petroleum Use	0%	19%	40%	59%

TABLE 2 Assumed Reductions in Industrial Petroleum Use

	2004	2010	2020	2030
Efficiency and Fuel Switching (mmbd)	0.000	0.346	0.492	0.622
Percent of Industrial Petroleum Use	0.0%	6.9%	9.8%	11.3%

TABLE 3 Oil Independence Assumptions in 2030 for the NCEP Case (Millions of Barrels per Day)

	Oil Demand	Oil supply
Reference Case	27.57	10.42
NCEP Case Changes		
Light vehicles	-3.50	
Heavy vehicles	-0.53	
Rail and ships	-0.20	
Residential and commercial	-0.37	
Industrial	-0.62	
Coal to liquids		1.00
ANWR and Pacific Offshore		2.00
Ethanol	-2.00	
Subtotal: Decrease in Demand	-7.22	
Subtotal: Increase in Supply		*3.00*
NCEP Case Totals	**20.35**	**13.42**
Percent Change from Reference Case	-26%	29%

TABLE 4 Summary Statistics for the Distribution of Oil Dependence Costs in 2030

	Business As Usual	NCEP Strategy OPEC/Price	NCEP Strategy OPEC/Production
Average	1.9%	0.83%	0.81%
Std. Dev.	0.90%	0.38%	0.42%
5th Percentile	0.82%	0.37%	0.30%
95th Percentile	3.5%	**1.5%**	**1.6%**

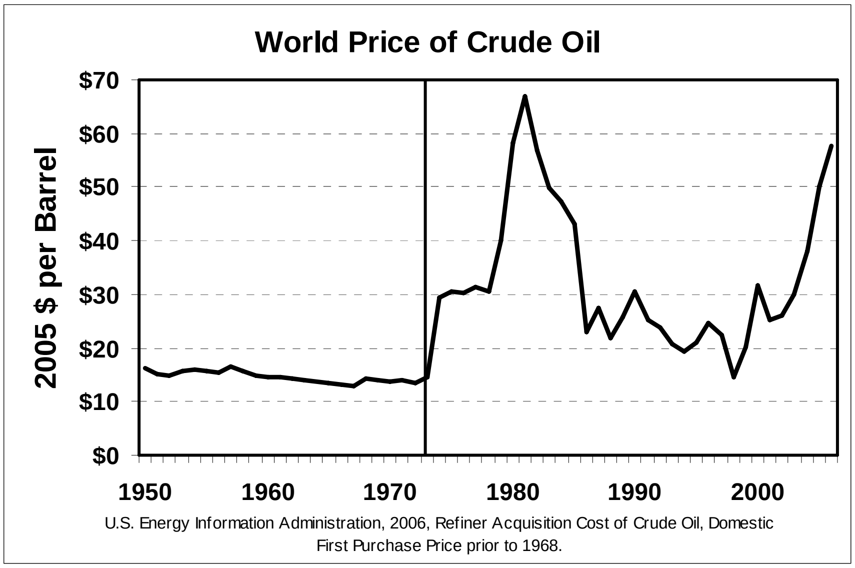

FIGURE 1 The world price of crude oil since 1950.

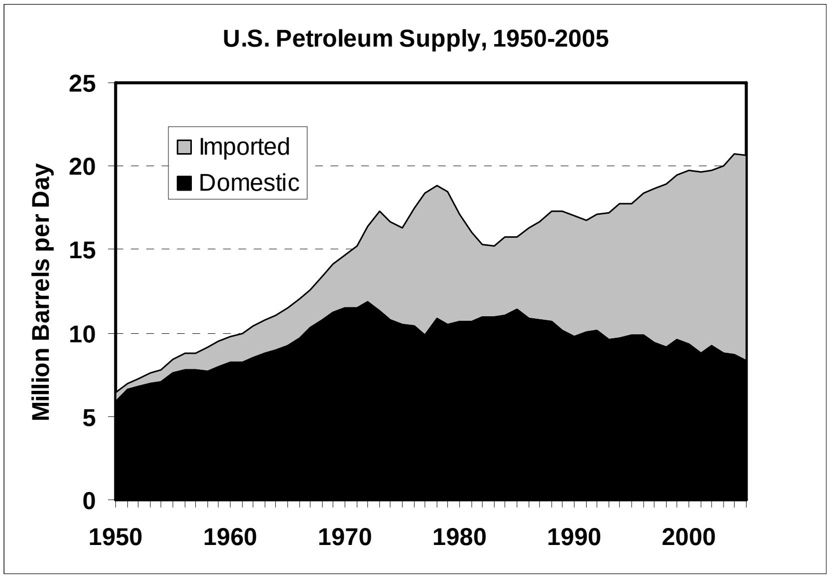

FIGURE 2 U.S. petroleum supply since 1950.

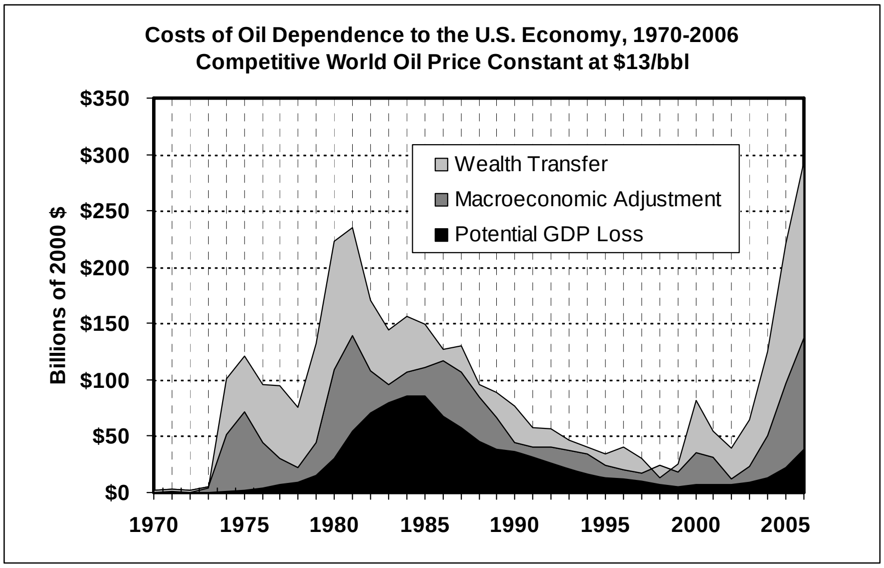

FIGURE 3 Direct costs of oil dependence to the U.S. economy since 1970 (*9*).

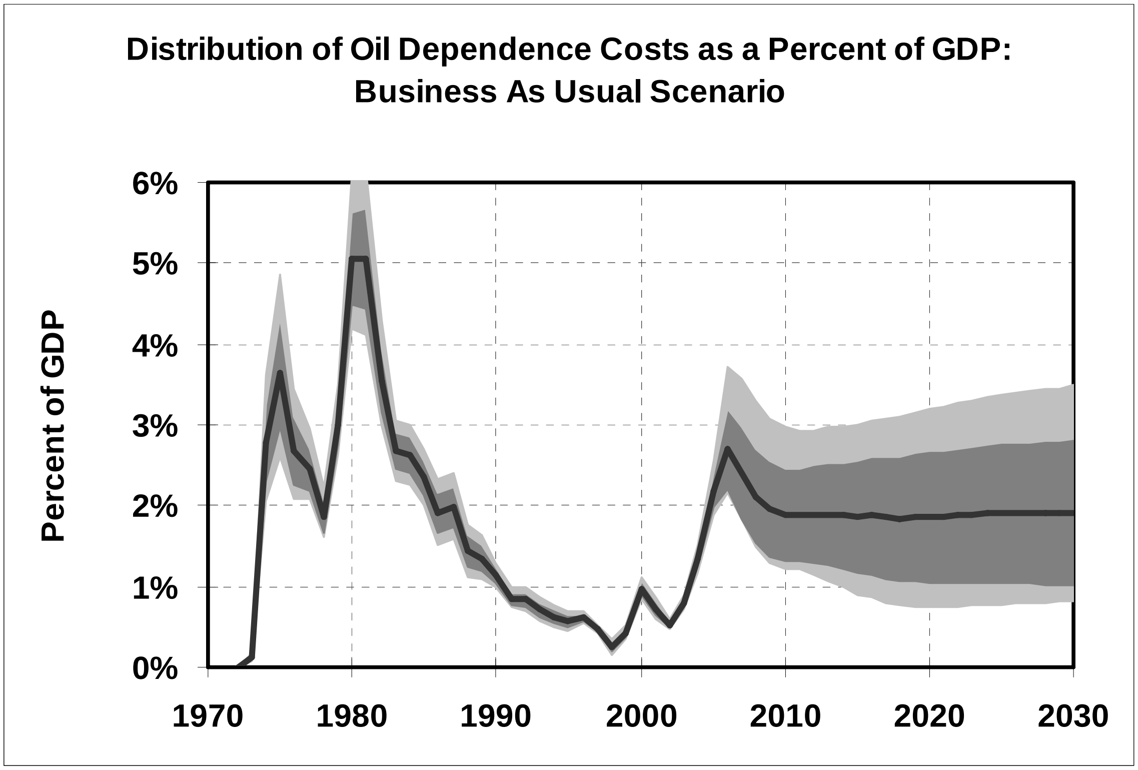

FIGURE 4 Oil dependence costs: business as usual scenario.

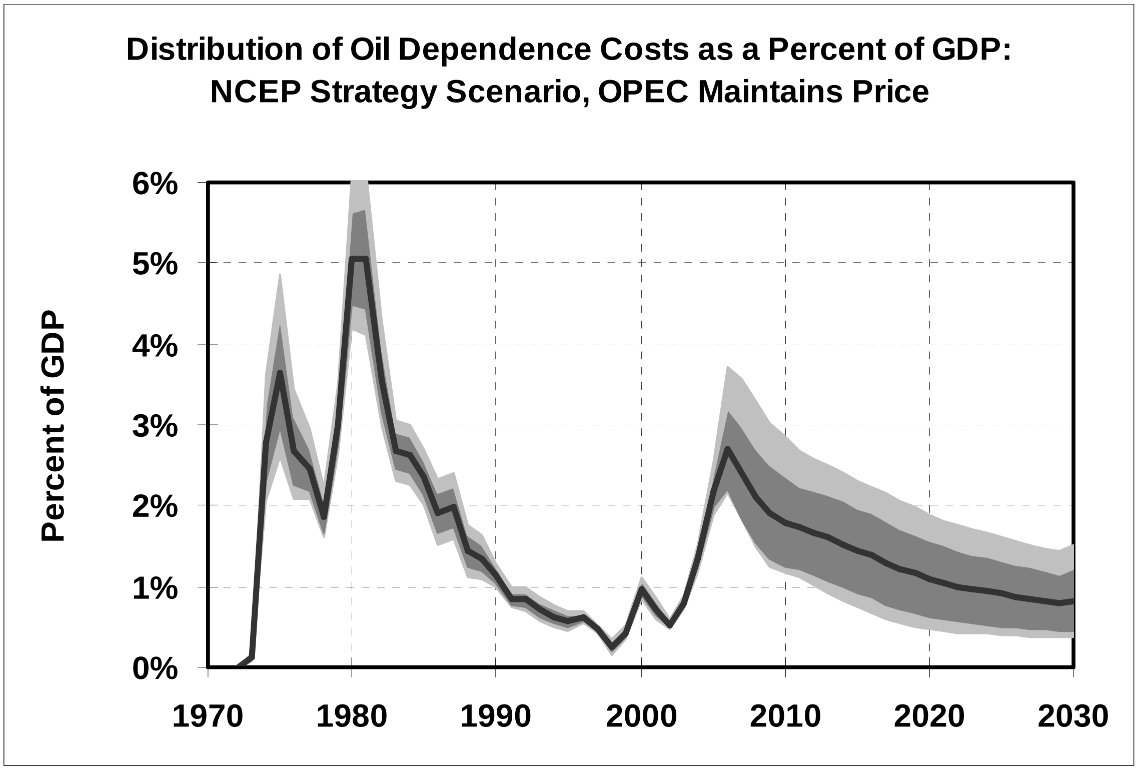

FIGURE 5 Oil dependence costs: NCEP strategy scenario, OPEC maintains oil price.

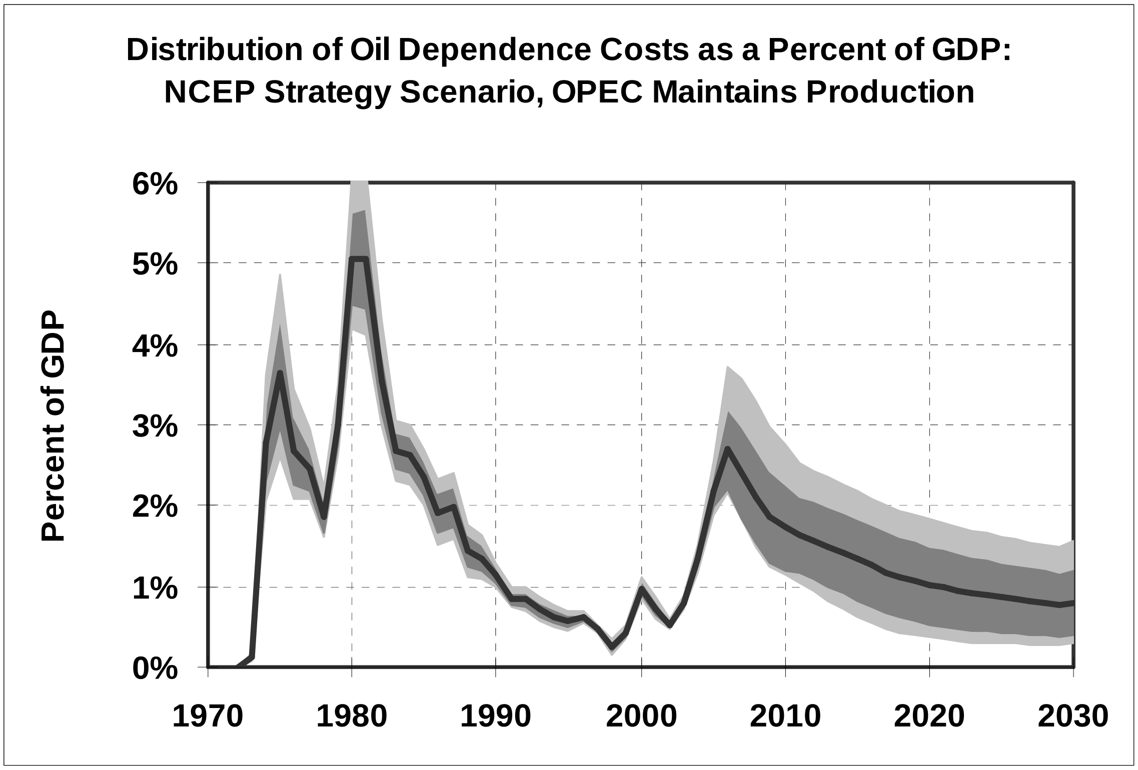

FIGURE 6 Oil dependence costs: NCEP strategy scenario, OPEC maintains production.