A NATIONAL STRATEGY FOR ENERGY SECURITY

RECOMMENDATIONS TO THE NATION ON REDUCING U.S. OIL DEPENDENCE

SEPTEMBER 2008

ENERGY SECURITY LEADERSHIP COUNCIL

A PROJECT OF Securing America's Future Energy

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Table of Contents

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Statement of Purpose

Hostile state actors, insurgents, and terrorists have made clear their intention to use oil as a strategic weapon against the United States. Steadily rising global oil prices add to the danger by exacerbating tensions among consuming nations. And even in the absence of full-blown geopolitical crises, oil dependence, with its incumbent exporting of American wealth, exacts a tremendous financial toll on our country. Last but not least, excessive reliance on oil constrains the totality of U.S. foreign policy and burdens a U.S. military that stands constantly ready as the protector of last resort for the vital arteries of the global oil economy.

The Energy Security Leadership Council believes that America's energy security can be fundamentally improved through major reductions in oil demand and increases in domestic energy production. Above all, we must transform our transportation sector so that oil is no longer its primary fuel. The Council's recommendations reflect the realities of global energy interdependence as well as the promise of American ingenuity. Taken as a whole, our proposals constitute a comprehensive and integrated plan for achieving a safer energy future for America. We fully expect that all participants in this deeply entrenched debate will take issue with some of our solutions. Our mission is to secure the support of a bipartisan coalition that has the vision to identify—and the courage to sustain—difficult choices.

Letter to the President, the Congress, and the American People

Russia is leveraging its energy resources to project national power. Iran is poised to interfere with tanker traffic in the world's most active oil transit corridor. And Venezuela has threatened to curtail oil production to inflict economic damage on the United States.

These and other challenges to energy security compel the United States and its allies to confront an inescapable and disturbing reality: oil dependence poses a grave threat to America's national security and economic strength. It constrains foreign policy, limits military options, and threatens the core of the U.S.—and the global—economy. Even in the absence of a geopolitical crisis, oil dependence could place the nation on a path of gradual but inexorable decline, with dire consequences for global security and economic progress.

The United States imports approximately 60 percent of its oil, most of which is produced by hostile and/or unstable nations. The transportation sector accounts for 70 percent of the total oil consumed by the United States; oil fuels 96 percent of U.S. transportation needs with no readily available substitutes. Simply put, energy security cannot be improved without addressing oil dependence, and oil dependence cannot be meaningfully reduced without addressing transportation.

The Energy Security Leadership Council, a project of Securing America's Future Energy (SAFE), was founded to improve U.S. energy security by promoting polices that can reduce oil dependence. This report presents the updated recommendations of the Council for achieving this goal. It offers a specific and comprehensive energy security agenda designed to effect systemic change.

The Council's agenda for improved energy security will be realized over many decades. In the short and medium term, the United States must reduce the oil intensity of its economy and increase access to secure supplies of oil and natural gas. Together, these measures will strengthen our trade balance and maintain the competitiveness of our economy. Over the long term, the United States must strive toward a post-oil transportation sector. With the mass adoption of electric vehicles that can draw their power from a wide variety of domestic energy resources, Americans will be in a position to end the scourge of oil dependence.

The Council pursues this goal mindful of two other important objectives: preserving robust economic growth and limiting undesirable environmental consequences, particularly those related to climate change. However, to be clear, we believe that any significant shifts in energy policy—including those related to climate-change mitigation—must be crafted so as to enhance rather than imperil our energy security.

In December 2006, the Council issued its inaugural report, *Recommendations to the Nation on Reducing U.S. Oil Dependence.* Improved and strengthened vehicle fuel-economy standards were a core element of that comprehensive plan. A year later, in December 2007, Congress and President George W. Bush joined together to enact significant increases in fuel-economy standards for the first time in a generation. This laudable achievement suggests the opportunity for future progress in the energy debate, though formidable political obstacles remain.

The dangers of U.S. oil dependence can only be managed through a serious and sustained national effort. Moreover, meaningful energy security policies sometimes carry difficult and unavoidable trade-offs. For these reasons, it is essential that members of both political parties commit themselves to principled compromise. Whatever the merits of the respective Democratic and Republican energy policy programs, systemic reform over decades will not be possible without a durable, and therefore bipartisan, commitment.

We urge policymakers and the American people to pursue the task of improving energy security as a mission of the greatest national importance. The dangers are great, and time is not on our side.

General P.X. Kelley, USMC (Ret.)
28th Commandant,
United States Marine Corps

Frederick W. Smith
Chairman, President and CEO
FedEx Corporation

OUTLINE

Outline of Main Body of Report

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I. DIVERSIFY ENERGY SUPPLIES FOR THE TRANSPORTATION SECTOR

A. ELECTRIFICATION OF THE TRANSPORTATION SECTOR

— Establish development of advanced battery technology as a top research priority and spend at least $500 million per year toward their development.

— Replace existing vehicle tax credits with new tax credits of up to $8,000 per vehicle for the first two million domestically produced highly efficient vehicles.

— Federal government should help create a market and exercise leadership by purchasing highly efficient vehicles.

— Establish production tax incentives to aid in the retooling of U.S. vehicles manufacturing facilities and to create and maintain a domestic capacity to manufacture advanced batteries.

— To encourage business participation, extend and modify federal subsidies for hybrid medium-duty vehicles (Classes 3–6) and heavy-duty vehicles (Classes 7-8) to 2012 and remove the cap on the number of eligible vehicles.

— Grants to municipalities and tax credits to commercial real estate developers to encourage the installation of public recharging stations.

B. ENHANCING THE NATION'S ELECTRICAL SYSTEM

Increasing Nuclear Power Generation and Addressing Waste Storage

— Continue licensing process for Yucca Mountain while initiating a program of interim storage as an alternative to Yucca Mountain.

— Extend the deadline and increase the funding levels for loan guarantees for new nuclear generation.

Deploying Advanced Coal Technology

— Significantly increase investment in advanced coal R&D including development of carbon capture and storage technology and policy framework.

— Increase funding for loan guarantees for advanced coal generation.

Promoting Renewable Energy

— Reform and extend the Production Tax Credit (PTC) and the Investment Tax Credit (ITC) through December 31, 2013, while providing certain guidance for the transition to a fundamentally improved, next-generation incentives program.

Development of a Robust Transmission Grid to Move Power to Where It is Needed

— Extend backup federal eminent domain for transmission lines to help expand the use of renewable power and to enhance reliability by moving power from surplus to deficit regions.

— Require the Federal Energy Regulatory Commission (FERC) to approve enhanced rates of return on investments to modernize electrical grid system.

Transforming Consumer Demand for Electricity

— Direct states to implement time of day pricing for electricity, and grant FERC backstop authority to implement time-of-day pricing if states will not.

— Require utilities to install smart meters for all new installations after a specified date.

C. REFORMING THE BIOFUELS PROGRAM

— Shift focus of biofuels deployment by concentrating on R&D and commercialization efforts on next-generation biofuels, fostering competition among fuels derived from differing feedstocks.

— Require increasing production of Flexible Fuel Vehicles (FFVs).

— Accelerate Department of Energy and Environmental Protection Agency testing and performance validation of unmodified gasoline engines running on intermediate-levels, first- and second-generation biofuels blends.

— Replace the 45-cents-per-gallon ethanol tax credit with a 'smart subsidy'.

— Eliminate tariffs on imported ethanol over a period of three years.

II. INCREASING ENERGY ACCESS: EXPANDING DOMESTIC SUPPLY

— Target federal policy and resources to encourage the expanded use of carbon dioxide for enhanced oil recovery.
PROJECTED INCREASE FROM ENHANCED OIL RECOVERY: 1.0 MBD

— Support federal investment in technologies that can limit the adverse environmental impacts of oil shale and coal-to-liquids (CTL) production to ensure long-term viability before undertaking public investment in production.

- Increase access to U.S. oil and natural gas reserves on the Outer Continental Shelf (OCS) with sharply increased and expanded environmental protections.
  PROJECTED INCREASE IN OCS OIL PRODUCTION: 1.0 TO 2.0 MBD
  PROJECTED INCREASE IN OCS GAS PRODUCTION: 1.0 TO 1.4 TCF

- Increase access to U.S. resources in the Arctic and Alaska.
  PROJECTED INCREASE IN ALASKAN OIL PRODUCTION: 0.7 MBD

- Federal support for construction of a natural gas pipeline from Alaska to the continental United States.

- Expand federal R&D initiatives studying the opportunities to exploit methane hydrates, including the initiation of small-scale production tests.

III. ACCELERATING THE DEVELOPMENT AND DEPLOYMENT OF NEW ENERGY-RELATED TECHNOLOGY

- Annual public investment in energy R&D should be increased by roughly an order of magnitude to approximately $30 billion.

- Reform the existing institutions and processes governing federal R&D spending.

- Develop a more effective federal R&D investment strategy.

- Establish new institutions to provide funding for early-stage R&D and for later-stage deployment and commercialization.

- Invest in the next-generation workforce for the energy industry.

IV. REDUCING DEMAND FOR OIL: IMPROVING EFFICIENCY

- Aggressively implement fuel-economy standards established in the Energy Independence and Security Act of 2007 (EISA).

- Increase allowable weight to 97,000 lbs. gross vehicle weight for tractor-trailer trucks that have a supplementary sixth axle installed but which replicate current stopping distances and do not fundamentally alter current truck architecture. In addition, government should study further the safety impacts of significantly longer and heavier tractor-trailers used in conjunction with slower speed limits.

- Require the Federal Aviation Administration (FAA) to implement and fund improvements to commercial air-traffic routing in order to increase safety and decrease fuel consumption.

V. MANAGING RISKS AND GLOBAL ISSUES

- Direct the Department of Energy to develop workable guidelines for the use of the Strategic Petroleum Reserve and evaluate its proper size based on those criteria.

- Work with foreign governments to eliminate fuel subsidies.

- Promote a robust China-U.S. partnership on carbon capture and storage that focuses on private-sector collaboration and sharing of best practices.

- Establish a National Energy Council at the White House to coordinate the development of the nation's energy policy and to advise the president with regard to energy policy.

- The National Intelligence Council should complete a comprehensive National Intelligence Estimate on energy security that assesses the most vulnerable aspects of the infrastructure critical to delivering global energy supplies and the future stability of major energy suppliers.

- Working with the Department of State, the Department of Justice should bolster programs designed to train national police and security forces to defend and secure energy infrastructure in key countries.

- As called for in its recent Maritime Strategy, the U.S. Navy should leverage the maritime forces of other countries to provide protection against terrorists and pirates for oil tankers in vulnerable regions.

- The Department of Defense should engage NATO and other allies in focused negotiations with the intention of creating an architecture that improves the security of key strategic terrain.

- The intelligence community should bolster collection and analysis capabilities on potential strategic conflicts that could disrupt key energy supplies. The State Department should improve its capacity to intervene diplomatically in conflicts that impact U.S. energy security.

- The intelligence community should expand the collection of intelligence on national oil companies and their energy reserves in order to allow policymakers to make better decisions about future alliances and the nation's strategic posture on energy suppliers.

INTRODUCTION

Energy Security Leadership Council:
A National Strategy For Energy Security

Energy Security Leadership Council
A National Strategy for Energy Security

Introduction

Americans consume more than 20 million barrels of oil every day, accounting for nearly one-fourth of total global demand for oil. Over the course of 2007, the nation consumed more than 7.5 billion barrels of oil at a total cost of approximately $550 billion. Sixty percent of this petroleum was imported, at a cost of nearly $300 billion, about 40 percent of the total U.S. trade deficit. This represents an unprecedented transfer of wealth from the domestic economy to foreign oil producers.

The consequences of oil dependence seriously affect all Americans. Exposed to rising and volatile oil prices, businesses and consumers struggle to reduce their demand in the face of fixed capital stock and ingrained consumption patterns. With oil providing 96 percent of the energy for the country's planes, trains, trucks, and automobiles, there is simply no escaping the economic impact of our national addiction.

Oil dependence undermines national security and the conduct of foreign policy by limiting U.S. strategic flexibility, strengthening foreign adversaries, and exacerbating geopolitical competition for resources. It also imposes significant burdens on U.S. armed forces, which must expend enormous military resources protecting the chronically vulnerable global oil production and distribution network while preparing to guarantee international access to key oil-producing regions. This military engagement benefits all nations, but Americans disproportionately bear the cost.

Oil dependence is at the core of the economic and geopolitical problems that challenge the nation's security. Reducing our vulnerability will entail profoundly difficult trade-offs among strategic, economic, and environmental priorities. These trade-offs are unlikely to be made without an enduring bipartisan consensus. And without consensus, tough choices will be difficult to sustain, which in turn will deprive Americans of predictable planning and investment horizons.

Recent events in Washington suggest that such a consensus may be emerging. In the 110th Congress, Democrats and Republicans joined together to pass the Energy Independence and Security Act of 2007 (EISA). This legislation significantly raised the fuel-economy standards for cars and light trucks, while simultaneously making the regulations more flexible for automakers. In addition, it implemented an expanded renewable fuel mandate focused on advanced biofuels that will help foster energy diversity in a transportation sector that is currently utterly reliant on oil. Enactment of EISA may mark a fundamental shift in U.S. energy policy toward reduced oil dependence, but America will remain profoundly vulnerable in the absence of significantly stronger and broader action to improve energy security.

In December 2006, the Energy Security Leadership Council (the Council) released its *Recommendations to the Nation on Reducing U.S. Oil Dependence*, urging a principled compromise to reduce oil demand, increase domestic petroleum supply, expand the availability of renewable energy, and improve international security arrangements. Two years onward, geopolitical instability, low spare petroleum production capacity, rising global energy demand, and a declining dollar have combined to push oil prices to record high levels. In light of these developments, the arguments in favor of a comprehensive program to reduce oil dependence have only grown stronger.

The primary mission of the Council remains the achievement of significant improvements in U.S. energy security, above all through reductions in oil dependence. Of course, the Council pursues this goal mindful of two other substantial objectives: preserving robust economic growth and limiting undesirable environmental consequences, particularly those related to climate change. By our analysis, U.S. energy security, economic growth, and environmental health are linked in ways that require robust government action to address oil dependence.

The recent increase in the national average price of gasoline to more than $4 per gallon in June 2008 has triggered a rational move toward conservation among consumers. Crude oil consumption in June 2008 was 1.17 million barrels per day lower than in June 2007, and U.S. vehicle miles traveled dropped by 4.7 percent during the same year-over-year period. The market response to higher oil prices has, however, been painful. While high oil prices have reduced demand for oil, this unplanned adjustment has harmed our economic and national security. If we wish to avert similar economic dislocation in the future, we should not rely on market forces alone to address oil dependence. Rather, government must establish sound market-oriented policies to help us moderate, and ultimately eliminate, oil-induced economic turbulence.

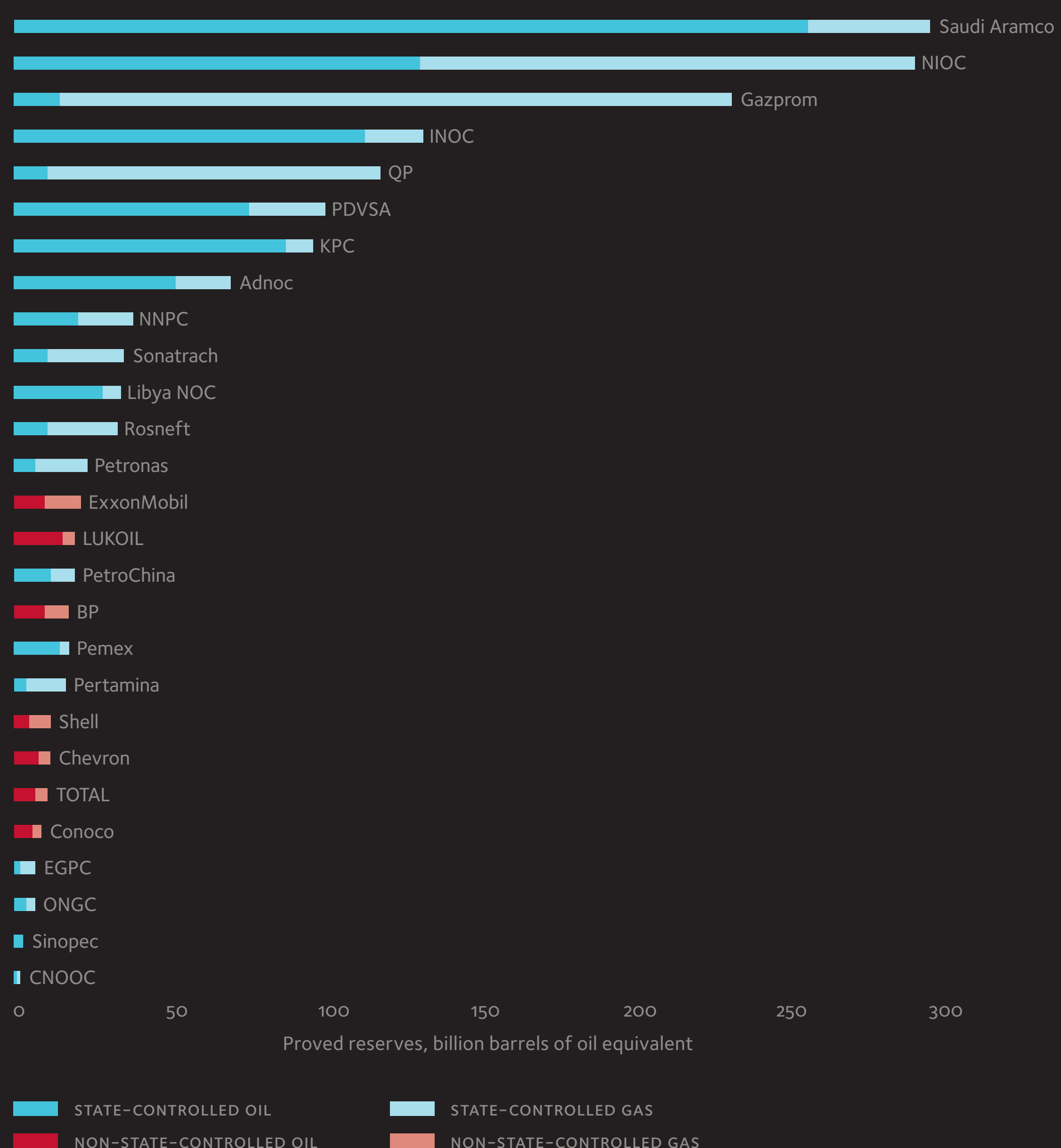
Over the course of 2007, the nation consumed more than 7.5 billion barrels of oil at a total cost of approximately $550 billion. Sixty percent of this petroleum was imported, at a cost of nearly $300 billion, about 40 percent of the total U.S. trade deficit.

Oil prices may be a function of the laws of supply and demand, but the global oil market does not operate freely. At least 75 percent—and by some estimates as much as 90 percent—of all oil and natural gas reserves are held by national oil companies (NOCs) that are either partially or fully controlled by sovereign governments, which often do not have the same incentives as profit-maximizing firms to supply oil to the market. Besides being politicized, the oil market is also distorted by the presence of large economic externalities, such as military expenditures, that are not directly accounted for in the price paid by consumers.

As the nation sets its sights on reducing energy dependence, it does so against a background of concern over the effects of climate change. The Council believes that the national interest will be best served by policies that diminish national and economic security anxieties while fostering a strengthened commitment to the environment. Fortunately, the measures recommended by the Council to bolster national security will also provide a robust foundation on which to address the long-term relationship between energy, the economy, and the environment. Ensuring access to reliable and affordable energy will promote economic growth, which will in turn provide political flexibility and financial resources that can be dedicated to environmental improvements.

State-controlled national oil companies (NOCs) hold most of the world's oil and gas reserves. The six largest NOCs have ten times the reserves of the top six privately owned companies.

TOP OIL AND GAS FIRMS BY PROVED RESERVES (2005)



PFC Energy. Adapted and/or reproduced with permission.

The combination of regulatory uncertainty, an incoherent patchwork of state and regional energy policies, and widespread opposition to the construction of critical energy production facilities has hampered investment in the energy sector. Baseload power plants and large-scale oil and natural gas production facilities are decades-long, multi-billion dollar projects, and investment decisions made today will determine the energy mix through 2050. With high capital commitments, long construction periods, and low operating margins, such projects are highly speculative and highly dependent on the projected costs of capital, labor, raw materials, feedstocks, and fuels. On today's investment landscape, two additional variables must be factored into project planning and finance: the price of carbon and the likely rate of change in that price. But these two critical pieces of information are currently unavailable to energy infrastructure project investors. The country cannot afford any more of the uncertainty that has delayed critical investments. It is time for a clear, transparent, and predictable energy policy.

The Council believes that the national interest will be best served by policies that diminish national and economic security anxieties while fostering a strengthened commitment to the environment.

In keeping with its comprehensive energy security assessment, the Council has crafted recommendations that are consistent with the following principles:

— Oil dependence is an imminent, urgent threat to U.S. economic and national security; reducing this vulnerability continues to be our highest priority.

— U.S. energy policy must be balanced, realistic, and comprehensive, encompassing reductions in oil demand; increases in energy supply; expanded development and deployment of alternatives; improved research, development, and commercialization processes; and greater international cooperation.

— Any significant shifts in energy policy—including those related to climate change mitigation—must be crafted so as to enhance, rather than imperil, our energy security.

— Energy security can be enhanced in an environmentally responsible manner, but sometimes difficult tradeoffs are unavoidable. Without the energy security central to prolonged economic growth, progress on the environment may be politically untenable, because of the public's unwillingness to bear the increased cost of additional environmental regulation. For this reason, energy security improvements are almost certainly a requirement for long-term environmental protection.

Despite the magnitude of the challenges, sound energy policies and fundamental technological advances have the potential to position the United States to significantly enhance its energy security over the coming generation. First and foremost, we must transform the U.S. transportation sector, moving from dependence on cars and trucks that burn oil-based fuels to a diversified system in which vehicles can be powered by a variety of energy sources, including advanced biofuels and electricity.

This 21st-century transportation system will enhance U.S. economic security by reducing the role that oil plays in the economy. While oil supplies are subject to a wide range of geopolitical risks, biofuels and electricity are generally derived from domestic resources. With a transportation system fueled by diverse and secure energy supplies, the United States can fundamentally reduce its dangerous dependence on a global oil market that is shaped by cartel economics and foreign political agendas. This modernization will also significantly lower the trade deficit, nearly half of which in 2007 stemmed from petroleum, natural gas, and refined product imports. Furthermore, this new transportation system will be cleaner, not least of all because reducing greenhouse gas (GHG) emissions from a few thousand central station power plants will be easier and more cost-effective than limiting the carbon footprint of the approximately 250 million petroleum-burning vehicles on the road today.

Regulatory regimes related to carbon emissions, already in evidence in various industries and regions of the world, could pose risks for our national security if not implemented appropriately, for instance by making the nation dependent on imported natural gas. To be sure, rising production of unconventional domestic natural gas has raised new hopes of clean and secure energy supplies, but there are grounds for strategic caution. The ultimate recoverability of these unconventional resources is highly speculative and will depend heavily upon advances in technology and other factors such as the availability of water (needed to 'fracture' shale and release gas), trained personnel, and clear legal titles. With unconventional development uncertain, existing gas sources on the decline, and power demand expected to grow (especially if vehicle electrification progresses), carbon constraints will tend to promote increased imports of liquefied natural gas (LNG), especially if other, lower carbon alternatives are unavailable. If LNG import levels are forced upward, the nation may find it has traded oil dependence for dependence on a world gas market whose major suppliers are no more stable or friendly than OPEC's membership.

While oil supplies are subject to a wide range of geopolitical risks, biofuels and electricity are generally derived from domestic resources. With a transportation system fueled by diverse and secure energy supplies, the United States can fundamentally reduce its dangerous dependence on a global oil market that is shaped by cartel economics and foreign political agendas.

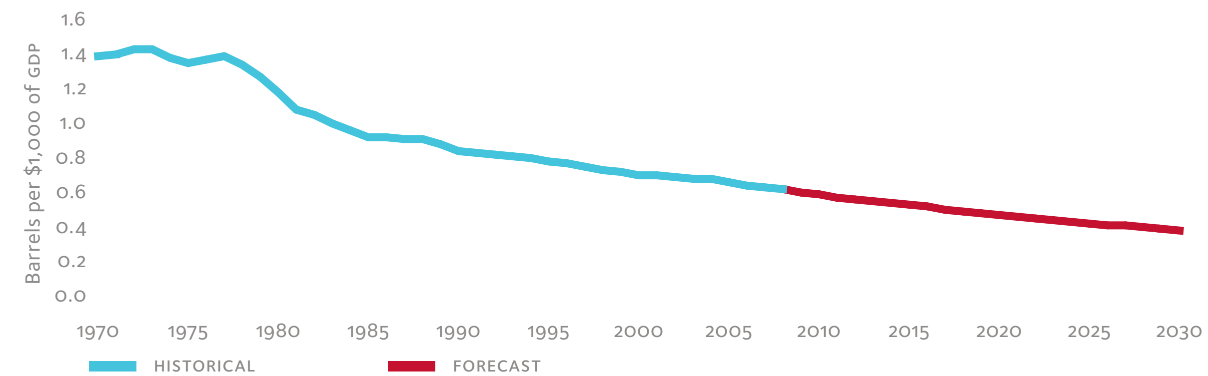
Transportation electrification offers a viable pathway to a more secure energy future, but there should be no mistaking the magnitude of this undertaking. The existing oil infrastructure spans the globe, was created over the course of a century, and is worth trillions of dollars. Replacing it with an alternate infrastructure that delivers similar functionality will take decades, which should not be surprising given that new cars routinely last for 15 years and new power plants are built to operate for 50 years.

With the promise of electrification on the horizon, we must begin transforming our oil consumption patterns, and we must make this commitment now while the cost of oil dependence is prominent in our collective consciousness. This determination will need to be sustained even if gasoline prices fall significantly at some point in the future, as is likely given the pronounced volatility of the global oil market.

Since the mid-1970s, the United States has trimmed the oil intensity of its economy by 50 percent, chiefly by raising the fuel economy of passenger cars, virtually eliminating oil as a fuel for electric power generation, and growing less energy-demanding economic sectors.[1] In other words, the United States now uses half as much oil to produce a dollar of GDP, in real terms, as it did just thirty years ago. Unfortunately, progress in this area has slowed in the last decade. America can do better. The Council recommends a national commitment to a 50 percent reduction in the oil intensity of the U.S. economy by 2030 and an 80 percent reduction by 2050.

1 I. Parry and Joel Darmstadter, Resources for the Future, "The Costs of U.S. Oil Dependency," technical appendix to the National Commission on Energy Policy (NCEP), *Ending the Energy Stalemate: a bipartisan strategy to meet America's energy challenges* (Washington, DC, 2004).

U.S. OIL INTENSITY (REAL 2000 DOLLARS)



Data from U.S. Department of Energy, BP p.l.c. and U.S. Bureau of Economic Analysis

No matter how hard we work toward this transformation, oil dependence will continue to threaten the nation in the near term. This security gap must be actively managed. In its previous report, the Council strongly supported strengthened fuel-economy standards, the deployment of alternative fuels and increased domestic production of oil and natural gas, whether on-shore or off-shore. The Council continues to view these measures — which can help boost the world supply of oil, constrain dependence on world natural gas markets, and reduce our trade deficit — as necessary bridges to a post-oil economy. We also recommend that the United States work to increase the proportion of the global oil supply produced by stable nations and to improve international cooperation on energy security.

The Council divides the areas of needed action into five broad categories:

- Diversifying energy supplies for the transportation sector;
- Securing access to domestic oil and natural gas;
- Accelerating the development and deployment of energy-related technologies;
- Reducing demand for oil; and
- Managing geopolitical risks.

The specific policy recommendations that follow update and expand the measures originally proposed by the Council in 2006. This new document accounts for legislative and technological developments that have occurred over the past two years and incorporates new information and perspectives gained by the Council during the course of its work.

SUMMARY

Policy Recommendations: Summary

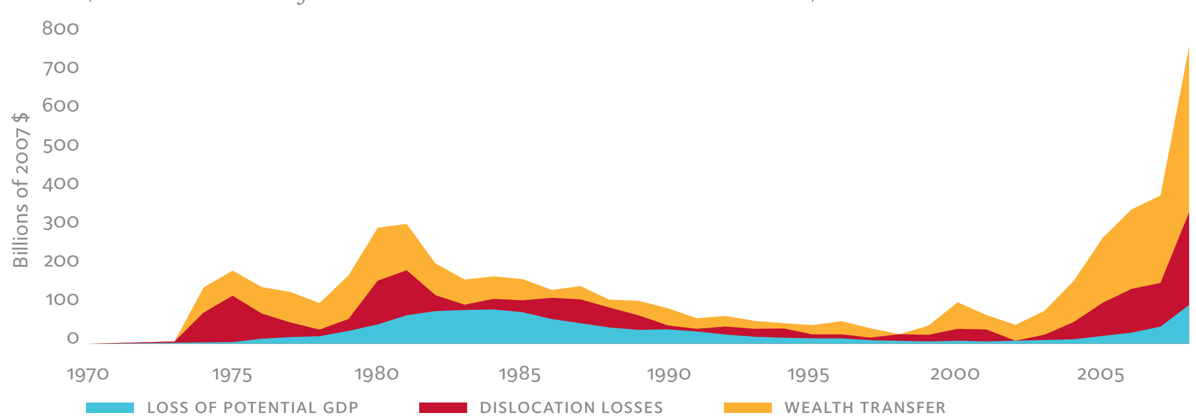
Policy Recommendations: Summary

The United States consumes more than 20 million barrels of oil per day, roughly a quarter of the world total. Almost two-thirds of the oil we use is imported. Nearly 70 percent of our oil consumption goes toward transportation, which relies on oil-based fuels for 96 percent of its delivered energy with no available substitutes.[2] In the event of a severe oil crisis generated by even a relatively minor supply interruption, the costs for the entire transportation system and the broader national economy would be profound and long lasting.

It is unlikely that global commercial imperatives will shield us from such a devastating economic shock. At least since the middle of 2007, and arguably earlier, the global economy has struggled to cope with the debilitating effects of an increasingly volatile oil market. Unlike the supply-driven shocks of the past, today's crisis has evolved out of the interaction of rapidly rising demand in emerging market economies, weak growth in global oil supply, the depreciation of the dollar, and persistent instability in key oil-producing regions. One need not look any further than these fundamental characteristics of the global oil market to identify the conditions that forced a 102 percent increase in the price of oil from July 2007 to July 2008.[3]

High oil prices and resultant high prices for retail fuel, above all gasoline, have had a direct and measurable impact on all Americans. As the national average price for gasoline surpassed the $4.00 per gallon mark in 2008, transportation demand weakened noticeably. While some observers have pointed to this trend as evidence of well-functioning market dynamics, this anodyne interpretation ignores the immense economic damages associated with price-induced demand destruction. One recent estimate forecast the combined economic costs of U.S. oil dependence at $750 billion in 2008.[4]

COSTS OF OIL DEPENDEDNCE TO THE U.S. ECONOMY: 1970–2008
(2008 BASED ON JULY EIA SHORT-TERM ENERGY OUTLOOK)



Source: David L. Greene, ORNL

2 Department of Energy (DOE), Energy Information Administration (EIA), *Annual Energy Outlook 2008* (June 2008), Table A11. Henceforth cited as EIA, *AEO* (2008).

3 DOE, EIA, "Spot Prices," http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm, last accessed 29 August 2008.

4 David L Greene, Oak Ridge National Laboratory (ORNL), "Economic costs of U.S. oil dependence, July 2008 update," (July 2008).

Economic analyses, however, do not capture all of the 'costs' of oil dependence. America's military men and women are deployed in far-flung corners of the world, securing the nation's front-lines and often enough helping to guarantee the free flow of oil; providing that security imposes a significant burden on the American people even if it cannot be easily separated from other military missions or translated into a discrete dollar amount. Even less readily quantifiable, but of greater concern, are the constraining effects that oil dependence has on American foreign policy. Whether we are attempting to compel Iran to relinquish its enrichment of uranium, pressure Russia to accept democracy in its traditional sphere of influence, or deal with brutal dictators in Africa, U.S. foreign policy initiatives are often hamstrung by our oil dependence and by the resource dependencies of our allies.

As long as the U.S. transportation sector remains nearly completely reliant on oil for energy, Americans will remain vulnerable to the volatility of the global oil market. Policies and technologies that bring fuel choice to transportation represent the only long-term solution to American oil dependence. Without such diversity, Americans will be left to act as 'price-takers' in the global energy economy, essentially taxed by the political decisions of national oil companies around the world.

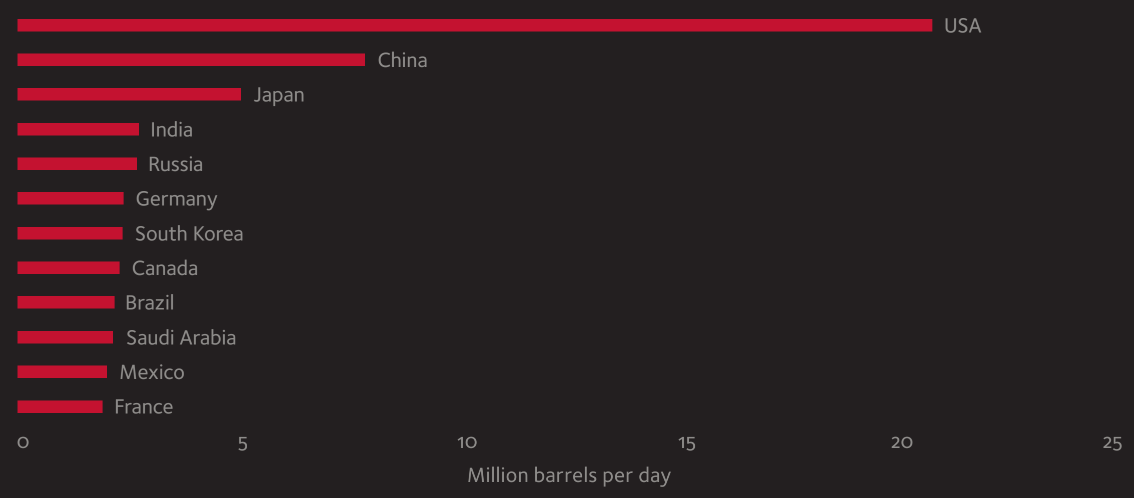
At least since the middle of 2007, and arguably earlier, the global economy has struggled to cope with the debilitating effects of an increasingly volatile oil market. Unlike the supply-driven shocks of the past, today's crisis has evolved out of the interaction of rapidly rising demand in emerging market economies, weak growth in global oil supply, the depreciation of the dollar, and persistent instability in key oil-producing regions.

Market forces alone will not solve our oil problems because the 21st-century oil market is far removed from the free-market ideal. Demand is distorted by the presence of large economic externalities. And, as for supply, it is heavily influenced by a cartel whose collusive practices would be considered illegal in the United States. Even outside of OPEC, oil production and investment decisions are often the result of a political, rather than market, calculus.

Much of the world's oil infrastructure today is vulnerable to attacks by terrorist organizations and non-state actors. Many segments of this vast network of pipelines, platforms and tankers must transit geography marred by persistent ethnic and national conflict. Recent events provide clear examples of the frailty of the global oil supply network. In the summer of 2008, an apparent terrorist bombing in Turkey seriously damaged the 1,100 mile Baku-Tbilisi-Ceyhan (BTC) pipeline, which delivers nearly 1 million barrels of Caspian Sea oil to the Turkish Mediterranean port of Ceyhan each day. During the several weeks of repairs required to restore normal operations, the outbreak of open war in the South Caucasus further threatened the security of the BTC pipeline, leading some experts to question the viability of future infrastructure projects designed to deliver oil and gas from landlocked Central Asian nations to energy-hungry markets in Europe and beyond.

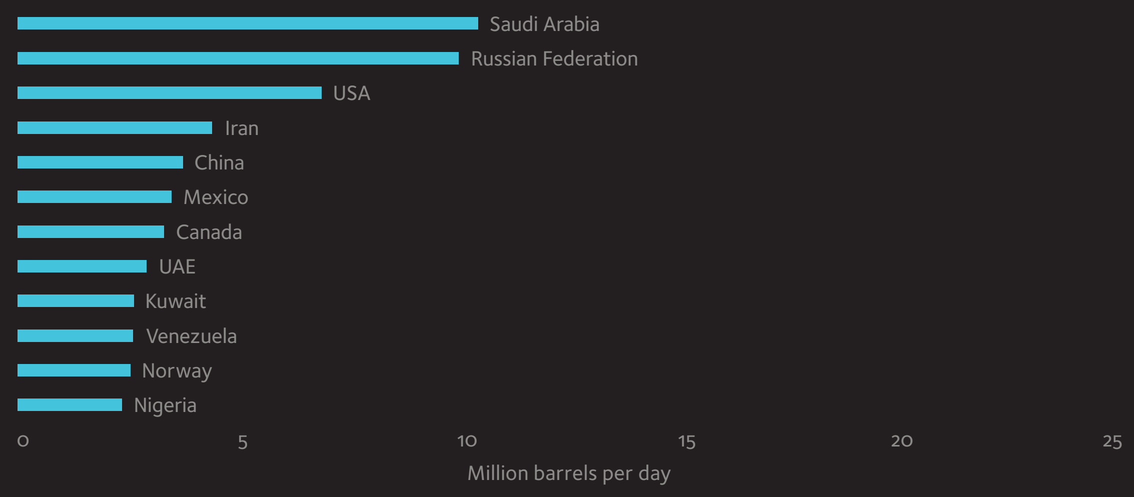
The United States consumed 20.7 million barrels of oil each day in 2007, a quarter of the world total and more than double China's consumption level. At the same time, the U.S. remained the world's third largest oil producer in 2007 at 6.9 million barrels per day.

TOP OIL CONSUMERS (2007)



BP p.l.c., *Statistical Review of World Energy* (2008)

TOP OIL PRODUCERS (2007)



BP p.l.c., *Statistical Review of World Energy* (2008)

In light of these and other costs and dangers, government must be prepared to spur, and in some cases require, private-sector responses. The Council is not inclined to encourage regulation where other effective solutions are available, but in the presence of significant market failures, market-friendly government intervention is not merely desirable—it is essential.

Ultimately, electrification of the transportation sector will provide the fuel diversity necessary to free America from oil dependence. Recognizing this, the Council has developed a national energy strategy focused on accelerating the commercialization of advanced batteries and expanding and strengthening the nation's electric power system. The Council's strategy calls for increased federal R&D expenditures; increased power production from renewable energy sources, nuclear power and conventional fuels; an ambitious modernization of grid and transmission infrastructure; and powerful incentives for the purchase of plug-in hybrid and fully electric vehicles.

Deployment of electric vehicles at levels that meaningfully reduce U.S. oil dependence will take decades and require a dedicated and sustained national effort. In the meantime, the Council believes that an additional set of policies must be employed to improve American economic and energy security. By aggressively implementing recently enacted fuel-economy standards, the government can oversee a significant reduction in U.S. oil demand. Promoting the production of renewable liquid fuels will also offset U.S. oil usage. And with a successful transition from ethanol to so-called third-generation biofuels that do not compete for agricultural feedstocks and which can share the existing distribution system for fossil fuels, the cost-benefit proposition of renewables will improve dramatically.

Finally, the Council has proposed measures for expanding access to domestic sources of oil and natural gas. In the near-term, increased oil production will reduce the portion of oil that the United States must import from abroad. Over the long term, the nation will likely require increasing natural gas resources in the electric power sector, particularly as this sector is called upon to satisfy the nation's growing demand for electric power, including the electricity necessary to power the new fleet of electric vehicles.

I. DIVERSIFY ENERGY SUPPLIES FOR THE TRANSPORTATION SECTOR

The 14.3 million barrels per day (MBD) of oil utilized by the U.S. transportation sector exceeds the *total* oil consumption of any other single country in the world.[5] Because of this simple fact, reducing demand for oil in the transportation sector remains the most promising strategy for addressing U.S. oil dependence.

Of the 230 million light duty vehicles on American roads today, 221 million are powered by conventional, gasoline-only internal combustion engines.[6] Improvements in vehicle efficiency and the promotion of advanced, third-generation biofuels can significantly reduce U.S. oil demand and meaningfully decrease the importance of oil in the U.S. economy. This reduction in oil intensity will help protect the nation from the volatility of global oil prices. Nevertheless, efficiency gains and biofuels will never eliminate U.S. oil dependence. As long as the transportation sector requires oil for energy, America will remain vulnerable.

By successfully electrifying our ground transportation vehicles, we can fundamentally reduce the nation's oil dependence. Plug-in electric vehicles can be powered by the full range of domestic fuels that are used to generate electricity in the United States. Moreover, oil has been nearly eliminated from the power sector.

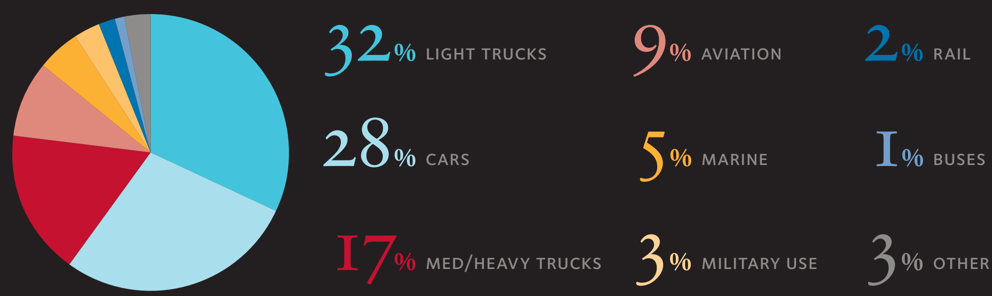
In addition, the nation's power sector requires considerable spare capacity in order to meet peak demand for electricity. Electric vehicles could add predictable demand to the system, increasing the power sector's

5 BP p.l.c., *Statistical Review of World Energy 2008*; *www.bp.com*, last accessed 29 August 2008, henceforth cited as BP (2008); and EIA, *AEO* (2008), Table A7. (Includes blended ethanol.)

6 EIA, *AEO* (2008), supplemental Table 48.

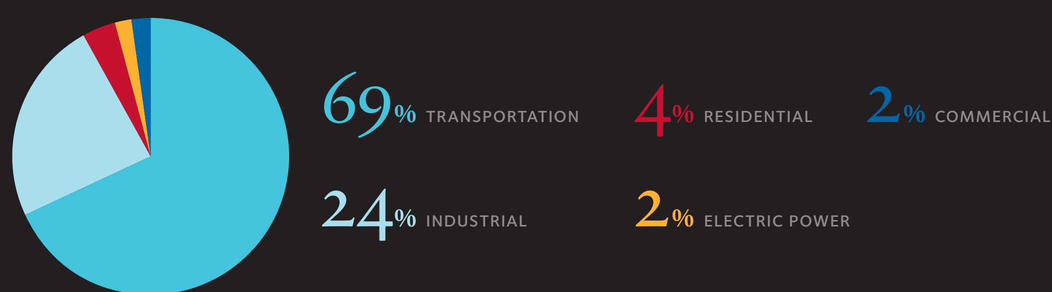
Today, nearly 70 percent of U.S. oil consumption occurs in transportation. Fuel demand in that sector of the economy has grown rapidly after declining slightly at the end of the 1970s, and it is projected to continue growing over the coming decades.

TRANSPORTATION SECTOR DEMAND BY MODE (2007)



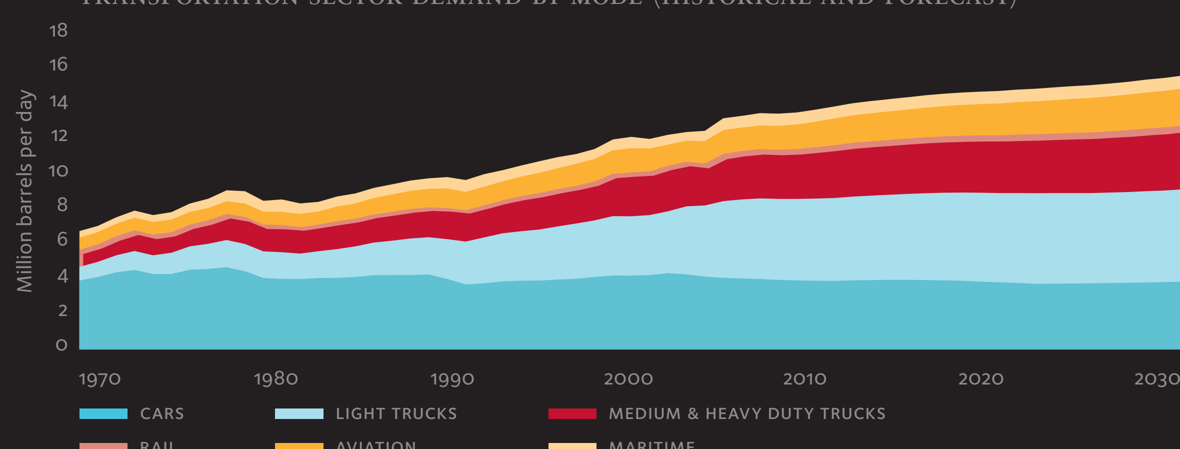
EIA, *AEO* (2008), Table A35.

U.S. OIL DEMAND BY SECTOR (2007)



EIA, *AEO* (2008), Table A11.

TRANSPORTATION SECTOR DEMAND BY MODE (HISTORICAL AND FORECAST)



EIA, AEO (2008), Table A35; DOE, ORNL, Stacy Davis and Susan Diegel, *Transportation Energy Data Book: Edition 27* (2008), Tables A.1–A.15.

return on existing assets and displacing considerable oil usage. Millions of batteries in electric vehicles will also provide an electric storage capability that enhance load management and grid stability.

The promise of transportation electrification will not be realized without a concerted policy commitment, however. Initially, electric vehicles will carry a significant cost premium, attributable in large part to the expense of their battery packs. Roadside recharging facilities will need to be built. And the power sector will need to be modernized and strengthened. But in light of the strategic benefits that will follow from dramatically reduced oil dependence, government must *lead* the nation toward the successful formation of an electrified transportation sector. The Council has a vision for government's role and has proposed a series of policy measures to accelerate the development of battery technologies, incentivize the purchase of electric vehicles, and encourage municipalities to install public roadside recharging facilities.

In light of the strategic benefits that will follow from dramatically reduced oil dependence, government must *lead* the nation toward the successful formation of an electrified transportation sector. The Council has a vision for government's role and has proposed a series of policy measures to accelerate the development of battery technologies, incentivize the purchase of electric vehicles, and encourage municipalities to install public roadside recharging facilities.

Significant market penetration by electric vehicles must be accompanied by critical improvements in the nation's capacity to generate and distribute electricity. The Council envisions a future power sector fueled by a diverse range of energy sources including advanced coal, renewables, and nuclear power. As for a modernized national transmission network, its achievement will require incentives for investors and the elimination of today's pervasive bureaucratic roadblocks.

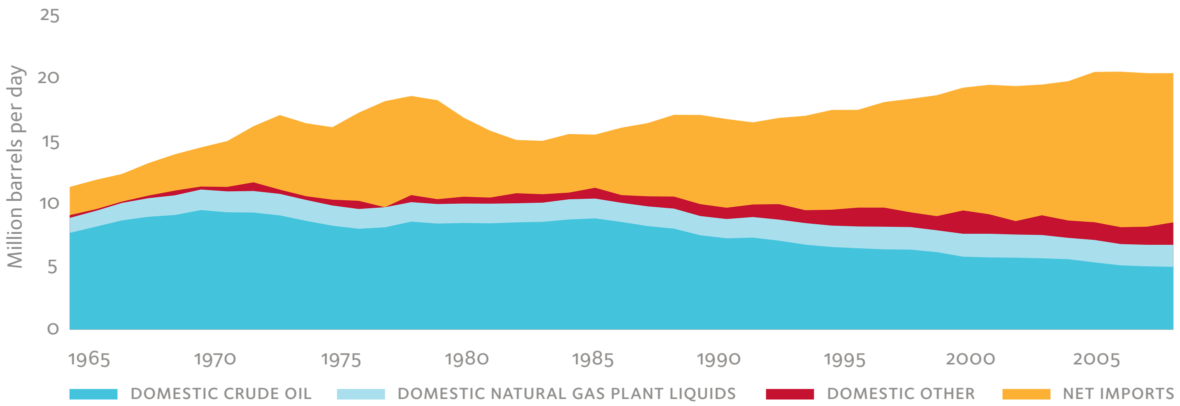
II. INCREASING ENERGY ACCESS: EXPANDING DOMESTIC SUPPLY

Refusing to develop secure sources of domestic production has led to an unnecessary over-reliance on imported oil, much of which flows from unstable parts of the globe. Aside from amplifying the potential risk of a supply interruption, the preference for imported oil unnecessarily transfers billions of dollars of the nation's wealth to other countries. The entire U.S. trade deficit in 2007 was $700 billion. The U.S. deficit with China was $251 billion. Our net *oil deficit*—the cost of U.S. imports less revenue generated by exports—was nearly $295 billion. This represents an unacceptable transfer of national wealth that negatively impacts the U.S. balance of payments and undermines the strength of our currency.

Fortunately, the United States possesses significant reserves of oil and gas that can be developed in the coming years and used to directly offset imports. Combined with measures to increase efficiency and diversify fuels in the transportation sector, producing more of our energy domestically will lead to enhanced energy security for the United States within a decade. This increase in domestic resource production will also act as a secure bridge to a post-oil transportation sector that has made the switch to electric power.

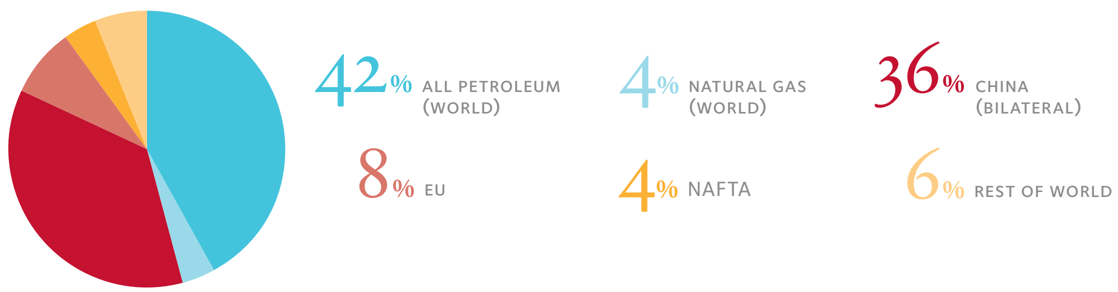
Increasing domestic production will require government support. The days of easy choices on energy policy are behind us. The cheapest, most accessible oil has largely been developed over the past 40 years.

U.S. PETROLEUM SUPPLY BY SOURCE



EIA, *AER* (2007)

U.S. TRADE DEFICIT (2007)



* U.S. Bureau of Economic Analysis; Department of Commerce ; EIA, AER (2007), 81.

** Bilateral and regional trade deficits are net of oil and gas trade.

As conventional onshore reserves have slowly been depleted, and ANWR, the most promising new onshore area, has been restricted from development, the U.S. oil and gas industry has deployed world class technology to extract resources from offshore territory. But here, too, the industry has been challenged, not only by cost and geology, but by restrictive government policies that currently deny access to roughly 85 percent of federal waters, excluding Alaska and Hawaii. As a result of each of these factors, U.S. oil production has steadily declined for decades, resulting in ever-greater quantities of imported oil.

Combined with aggressive deployment of enhanced oil recovery techniques, expanded access to both onshore and offshore resources will result in substantial incremental production in the coming years, directly offsetting some U.S. imports. Though the country will still require a significant amount of oil in the transportation and industrial sectors, a greater portion of that oil will be produced within the United States, preserving national wealth and reducing the amount of America's oil consumption that is directly vulnerable to a catastrophic oil supply interruption.

In addition to the broad economic and security benefits of enhanced domestic production, opening new areas to industry will generate significant new royalty revenue for the federal government. The Council is convinced of the merits of employing these funds to accelerate energy research, development, and deployment/commercialization.

III. ACCELERATING THE DEVELOPMENT AND DEPLOYMENT OF NEW ENERGY-RELATED TECHNOLOGY

Private and public investment in U.S. energy R&D investment, while greater than the efforts of other developed nations, is paltry compared to R&D investments made in other sectors of the economy. The state of current investment in energy technology is particularly troubling if one examines the trends of the past 30 years. From its historical peak of approximately $6 billion in 1978,[7] Department of Energy (DOE) spending on research in renewable, fossil and nuclear energy has fallen to $1.4 billion in 2008.[8] Meanwhile, investments in energy R&D by U.S. companies fell by 50 percent between 1991 and 2003.[9] These expenditure levels are not commensurate with the seriousness of the energy security challenges facing America and the world.

In order to preserve the political support necessary to sustain expanded R&D expenditures, increases in investment must be accompanied by significant structural and programmatic reforms. New institutions and new tools will certainly be needed. Most important, a new sense of mission and purpose must be cultivated using a goal-oriented approach within relevant federal agencies, national laboratories, universities, and the private sector.

Annual fuel-economy improvements of 4 percent can be reasonably achieved for a decade after the attainment of the 35 miles-per-gallon standard in 2020. Doing so could yield 3.5 MBD of oil savings in 2030, not counting additional savings that would result from electrification and the deployment of advanced biofuels.

IV. REDUCING DEMAND FOR OIL: IMPROVING EFFICIENCY

Recent legislative initiatives designed to reduce U.S. oil dependence demonstrate the potential impact of addressing fuel demand in the transportation sector. Most notably, the Energy Independence and Security Act of 2007 (EISA) directs the Department of Transportation to make much-needed changes in the Corporate Average Fuel Economy (CAFE) standards first implemented in the mid-1970s. Instead of imposing a *one-size-fits-all* fuel-economy requirement on all automakers, the National Highway Transportation Safety Administration (NHTSA) will set standards for individual vehicles in order to raise the fuel economy of all new vehicles to 35 miles-per-gallon by 2020. Beyond 2020, EISA instructs NHTSA to increase fuel-economy standards by the "maximum feasible" amount depending on available technology and economic conditions.

Though much will depend on how NHTSA implements its fuel-economy rulemaking, EISA should make a significant impact on U.S. oil consumption over the next two decades. In order to maximize the long-term oil-savings, NHTSA will need to continue to set ambitious improvement targets for light-duty vehicles for the period after 2020. Based on its knowledge of available technology and in keeping with its 2006 *Recommendations*, the Council believes that annual fuel-economy improvements of 4 percent can be reasonably achieved for a decade after the attainment of the 35 miles-per-gallon standard in 2020. Doing so could yield 3.5 MBD of oil savings in 2030, not counting additional savings that would result from electrification and the deployment of advanced biofuels.

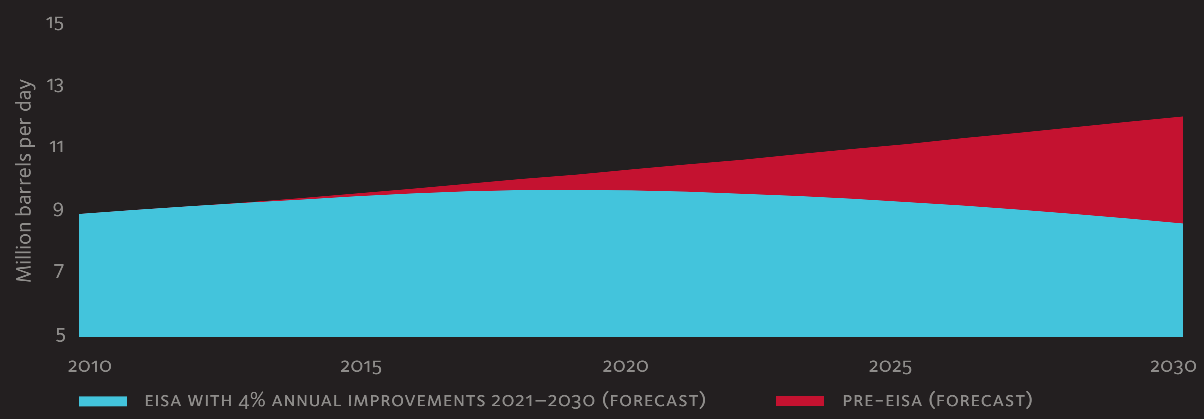
7 2008 dollars.

8 U.S. Government Accountability Office, "Advanced energy technology: budget trends and challenges for DOES energy R&D program," Statement of Mark E. Gaffigan before the Subcommittee on Energy and Environment, Committee on Science and Technology, 5 March 2008.

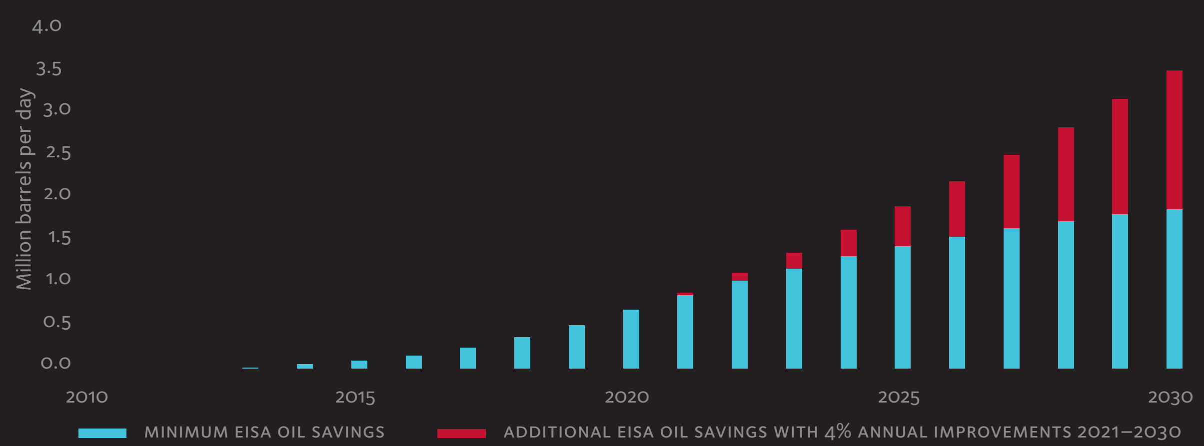
9 Gregory F. Nemet and Daniel M. Kammen, "U.S. energy research and development: declining investment, increasing need, and the feasibility of expansion," *Energy Policy* 35, no. 1, (2007).

The improvements in fleet-wide fuel-economy standards mandated by EISA are expected to significantly enhance U.S. energy security over the next two decades. Compared with prior forecasts, EISA reduces transportation sector oil demand by more than 3 MBD in 2030. By aggressively supporting the deployment of electric vehicles, these oil savings can be dramatically increased.

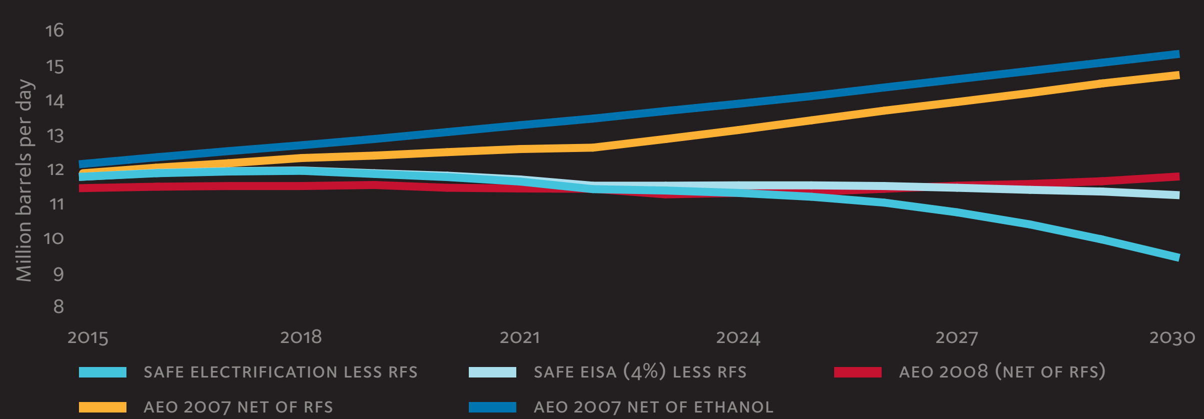
PROJECTED OIL DEMAND: CARS AND LIGHT TRUCKS*



ANNUAL OIL SAVINGS RELATED TO EISA**



HIGHWAY TRANSPORTATION OIL DEMAND SCENARIOS†



* EIA, *AEO* (2007), Table A35; EIA, *AEO* (2008), Table A35; SAFE analysis.
** SAFE analysis.
† EIA, *AEO* (2007); EIA *AEO* (2008); SAFE analysis. (Ethanol and other non-petroleum fuels removed.)

The U.S. medium- and heavy-duty truck fleet is responsible for nearly 20 percent of domestic transportation fuel demand, but these vehicles are not currently regulated for fuel economy. Recognizing the need for energy efficiency in the truck sector, EISA mandates the development of fuel-economy standards for commercial vehicles. Congress, however, declined to set specified rates of improvement for these vehicles, instead deferring specifics to the NHTSA rule-making process. Taking into account research performed by the federal government, the Council believes 4 percent annual rates of improvement in fuel economy are attainable for the nation's medium- and heavy-duty vehicle fleet. Indeed, we are convinced that an aggressive but cost-effective pursuit of the highest possible fuel economy is essential for U.S. national security.

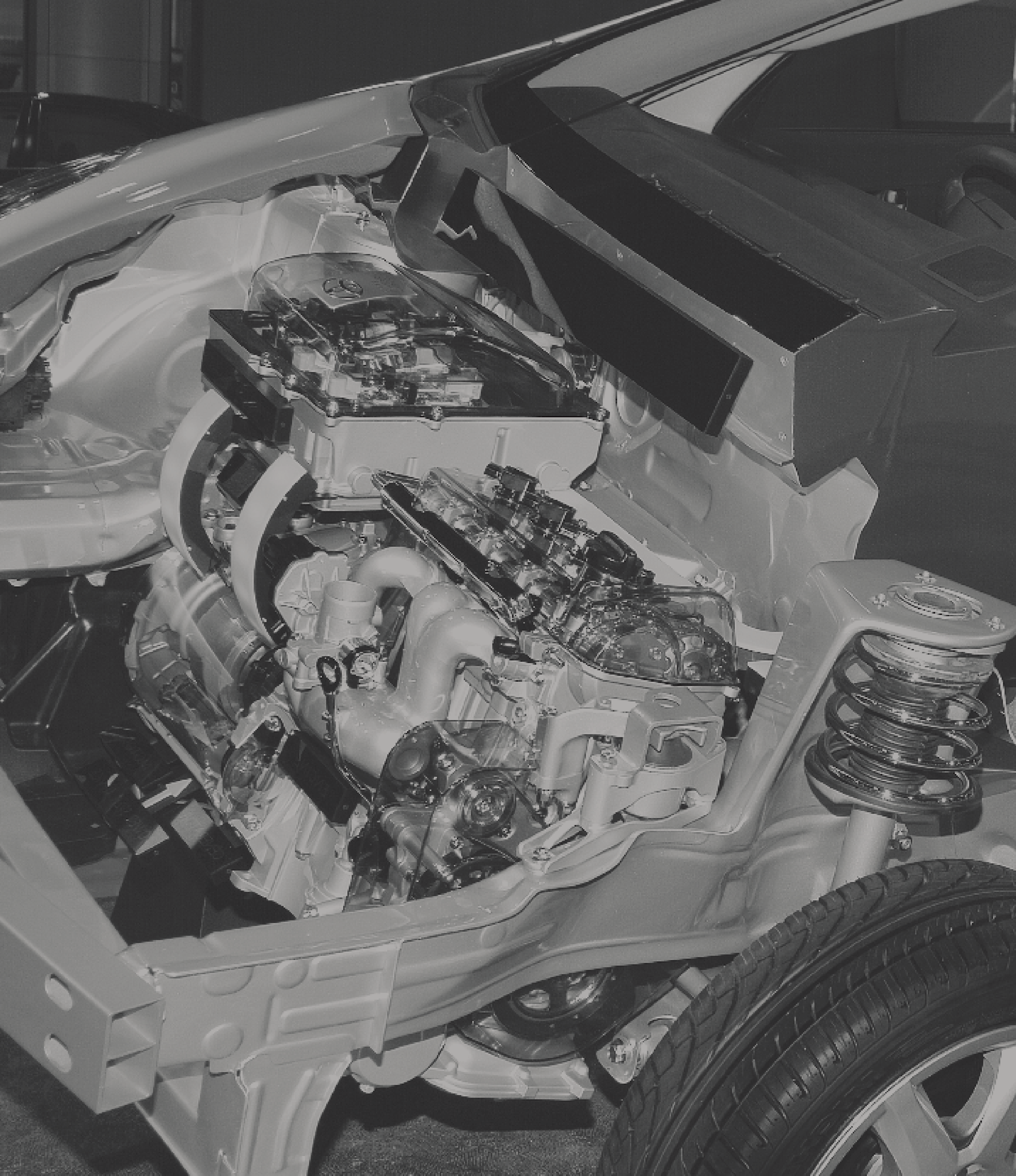
V. MANAGING RISKS AND GLOBAL ISSUES

Too often, the energy security debate ignores traditional security matters. While energy policy and technological innovation must play an integral role in improving the nation's energy security, all aspects of national power, including the military, diplomatic and intelligence services, need to be mobilized. The Department of Defense, the State Department, and the various branches of the intelligence community must consciously focus on issues of energy supply as part of their comprehensive pursuit of national security; working in concert, they must develop policies and strategies that protect the global infrastructure, secure key geographic transit areas, and mitigate political instability in energy-supplying countries. The national security apparatus can also make a vital contribution by improving the state of energy intelligence data, especially with regard to world reserves of energy.

At home, the President should be staffed by a National Energy Council at the White House that coordinates energy policy on the full range of domestic and international issues. In addition, the United States must efficiently deploy its strategic resources in order to protect the economy in the event of a prolonged disruption of oil supplies. In particular, the rules governing proper usage of the 700 million barrel Strategic Petroleum Reserve (SPR) must be clearly defined.

The Council maintains that *fuel diversity* is the key to *energy security*. For decades, the nation has been exposed to the concentrated risk of oil dependence. Going forward, multiple and redundant energy options must be pursued in order to preserve the nation's strategic flexibility. Within the transportation sector, electrification represents the pathway to meaningful fuel diversity that will end our dangerous dependence on petroleum. For electrification of transportation to reach its full promise, however, the robustness of the nation's electric power sector must be ensured through the promotion of generation, transmission, and grid improvements. To reach these goals, the nation's research, development, and deployment efforts must be expanded and reformed to be commensurate with the challenge we face. More immediately, U.S. production of biofuels will contribute substantial volumes to the liquid fuels supply, thereby easing tightness in the global oil market. Over a similar time horizon, increased domestic supply can help to preserve our national wealth while adding reliable supplies to a market that will otherwise be subject to increasing cartelization and continuing instability. Multilateral partnerships and other security measures can also reduce the risk profile of the oil market over the next few decades.

The possibilities are before us. Now it is time for America to act.



PART I

Diversify Energy Supplies for the Transportation Sector

By successfully electrifying our ground transportation vehicles, we can fundamentally reduce the nation's oil dependence. Plug-in electric vehicles can be powered by the full range of domestic fuels that are used to generate electricity in the United States. Significant market penetration by electric vehicles must be accompanied by critical improvements in the nation's capacity to generate and distribute electricity so that we do not create unintended security risks.

I. Diversify Energy Supplies for the Transportation Sector

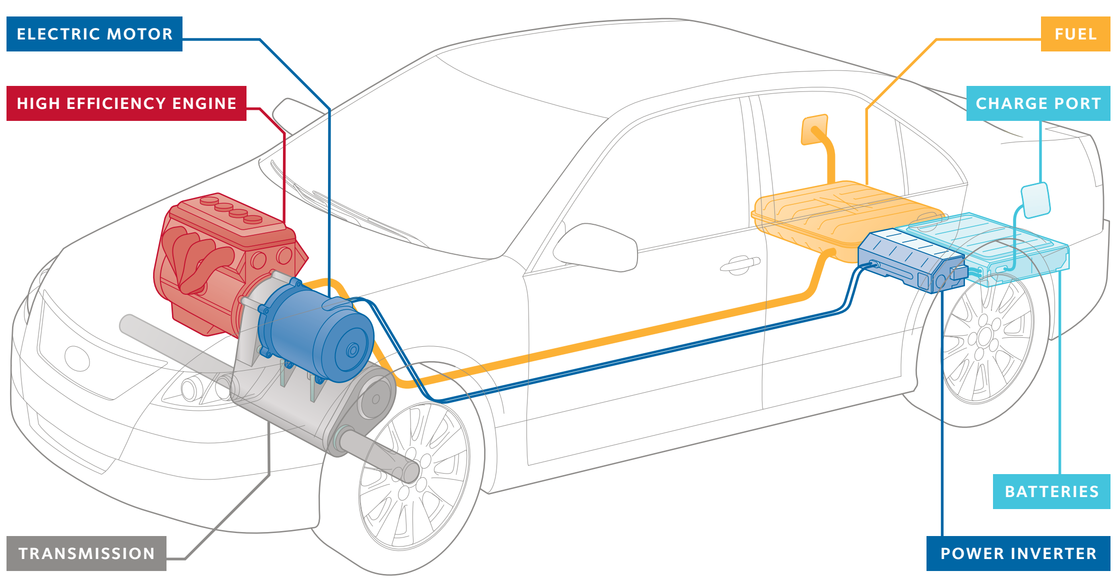
With 70 percent of U.S. oil consumption occurring in the transportation sector, reducing gasoline consumption is of critical importance to improving U.S. energy security. Stronger fuel-economy standards can limit the expansion of gasoline demand growth over the coming decades, but incremental improvements alone will never break the oil dependence of the transportation sector. This greater goal will require fundamental technology shifts.

Electrification of the Transportation Sector

Vehicle electrification has the potential to decouple the U.S. transportation sector from the volatility of the global oil market. Because the power sector is fundamentally scalable, relies on a diverse set of fuels, and derives its primary energy almost exclusively from domestic resources, electrification would offer the American transportation sector—and thus the entire American economy—a significantly increased level of energy security.

Similar to today's familiar hybrids, plug-in electric hybrids (PHEVs) incorporate both an internal combustion engine and an electric motor. With a hybrid drive-train, batteries charge off the internal combustion engine either directly or by recapturing energy normally lost in braking. By means of recapture and by taking advantage of the torque advantage of the electric motor at low speeds, these vehicles use the energy contained in fossil fuels more efficiently. But whereas all motive power in today's hybrids derives ultimately from liquid fuels, a plug-in hybrid can also charge its batteries by connecting directly to the electric power grid. This technological improvement has radical implications for energy security.

PLUG-IN HYBRID SCHEMATIC



Electric vehicles (EVs) are in theory simpler and potentially cheaper than hybrids, since they have no need for a second power source (i.e., an internal combustion engine) or a complicated power-splitting device. The current stumbling block is range. While a plug-in hybrid can make use of its internal combustion engine for extended driving, an electric-only vehicle must rely solely on battery capacity or access to roadside recharging. Unfortunately, current-generation batteries are bulky, heavy, and relatively costly, placing practical limits on the amount of onboard storage, while recharging is slow and roadside recharging opportunities are not widely available.

Battery technology is advancing at a rapid pace, encouraging automakers to move forward with the development and production of plug-in vehicles. General Motors has repeatedly underscored its commitment to bring the Chevrolet Volt—a vehicle credited with a 40-mile electric range—into production by 2010. Bosch, the German auto parts supplier, recently announced its expectation that as many as 500,000 electric vehicles will be on the roads by 2015.[10]

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Government has also ramped up support for electric vehicles. EISA established a Plug-in Hybrid Electric Drive Vehicle Program to incentivize the adoption of these vehicles by governments and private users. In addition, the law modified the Energy Policy Act of 1992 (EPAct 1992) to allow fleet operators to satisfy alternative fuel vehicle requirements with plug-ins, created an Advanced Battery Loan Guarantee Program to accelerate technology breakthroughs, and signaled a commitment to U.S. leadership in energy storage research and development (R&D) with $290 million in annual funding for the next decade.

Since the majority of Americans drive only relatively short distances each day, electric cars should be able to satisfy most driving needs even if they need to 'refuel' more often than gasoline-powered vehicles. According to data assembled by the U.S. Department of Transportation, vehicles driven 40 or fewer miles per day log an estimated 70 percent of all vehicle miles traveled.[11] On weekends, the share is believed to exceed 80 percent.

The national security implications of electrification are profound. Of total U.S. oil consumption of 20.7 million barrels per day (MBD), only 0.3 MBD was used to produce electricity in 2007, accounting for less

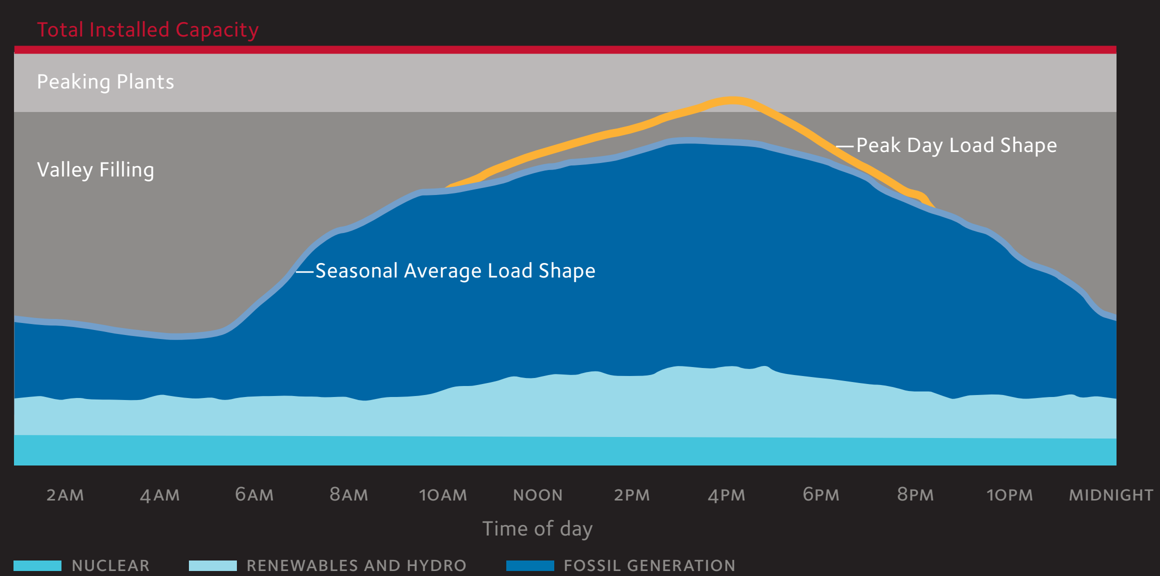
10 Bernard Simon, "GM set to bring Volt electric car to Europe," *Financial Times*, 17 August 2008.

11 Alan L. Madian, Lisa A. Walsh, and Kim D. Simpkins, "The impact of plug-in hybrids on U.S. oil use and greenhouse gas emissions," (July 2008), citing Bureau of Transportation Statistics, National Household Travel Survey 2001, 2004, specifically 2001 National Household Travel Survey User's Guide, Version 3, U.S. Department of Transportation, January 2004 and 2001 National Household Travel Survey Database, DAYPUB, VEHPUB, HHPU, LDTPUB and PERPUB files.

Current U.S. electric power generation relies on a diverse mix of fuels, the vast majority of which is sourced domestically. Allowing the transportation sector to access this diverse fuel-mix will dramatically improve U.S. energy security.

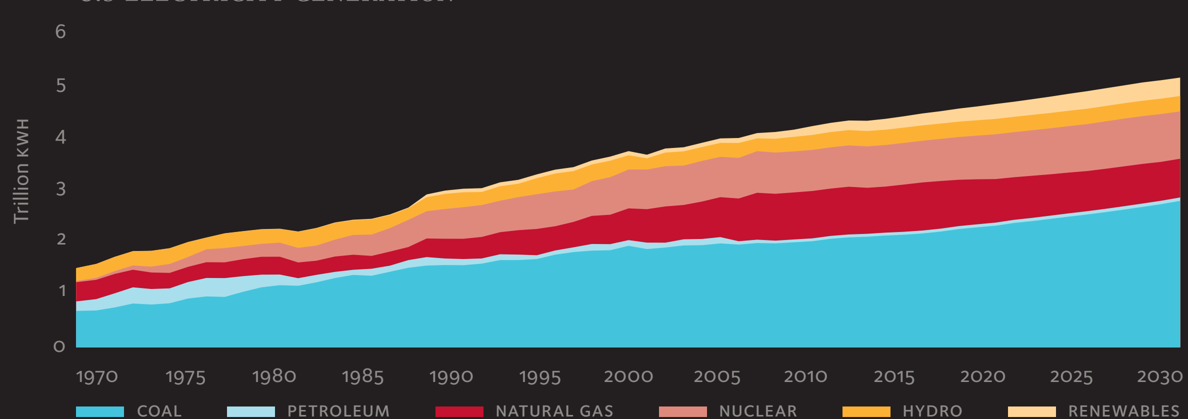
Moreover, because electric power cannot be readily stored, U.S. generating capacity is designed to meet peak daily loads. This creates 'valleys' off-peak, which could theoretically be filled with demand from electric vehicles.

STYLIZED LOAD SHAPE FOR 1 DAY DURING PEAK SEASON, GENERATION DISPATCH, AND INSTALLED CAPACITY



Source: PNNL

U.S ELECTRICITY GENERATION



U.S. Department of Energy, *Annual Energy Review 2007; Annual Energy Outlook 2008*

than 2 percent of electric power generation.[12] Far from being dependent on oil, the power sector relies on a diverse set of fuels, generating electricity from coal, natural gas, nuclear fission, and various renewable alternatives. Coal and renewables are essentially completely domestically derived. As for nuclear power, fuel costs are only a small fraction of the total expense of generation, and the U.S. sources nearly all of its uranium imports from Canada and Australia, two of our most stable allies. While we do import significant quantities of natural gas, nearly all of U.S. demand is currently met by domestic and Canadian sources.

Electric vehicles will enable the nation to more efficiently leverage existing capital assets in the power sector. The nation's generating capacity is structured to be able to meet peak loads, which in practice equates to daytime demand during hot summer days. In periods of lower demand, the system generally has excess generating capacity. According to the Pacific Northwest National Laboratory (PNNL), unused capacity in the existing U.S. power sector could power 158 million cars and light trucks for up to 33 miles of driving per day.[13] This level of electric vehicle penetration and usage would displace approximately 6.5 million barrels of oil per day, more than half of current U.S. imports. Even if vehicle charging were physically limited to the 6 p.m. to 6 a.m. period to avoid overtaxing the grid during daytime hours, over 90 million cars and light trucks could still be powered using existing spare capacity.[14]

For each of the ten regions of the North American Electric Reliability Council, PNNL deducted existing electricity demand on typical summer and winter days from generating capacity, with the difference, or 'valley', being deemed available for electric-vehicle recharging. Relatively inefficient natural gas combustion turbines known as peaking plants were excluded from the analysis as too costly for extended use, and baseload fossil fuel plants (i.e., combined cycle natural gas plants and steam coal plants) were down-rated by 15 percent to account for maintenance, even though these activities would normally be scheduled outside of the high-demand winter and summer seasons.

To be sure, 'valley-filling' exercises are highly theoretical. Electricity would need to be routed from surplus regions to deficit regions in optimal fashion, and pricing signals would be required to shift demand away from daytime 'peaks.' On seasonal peak days, when loads far exceed seasonal averages, spare capacity would be considerably reduced or even eliminated. And, in practice, plug-in hybrids are unlikely to draw down their batteries fully before switching to their internal combustion engines, relying instead on complex, computer-controlled power-mixing strategies that optimize performance and preserve battery life. But qualifiers notwithstanding, the core lesson is obvious: the difficulties inherent in electricity storage already compel the nation to sustain a power sector that maintains considerable spare capacity; to the extent that electric vehicles could add predictable demand to the system, the power sector could increase its return on existing assets and displace considerable oil usage, even without any additional generating capacity.

The Oak Ridge National Laboratory has criticized the PNNL study on the grounds that it oversimplifies the demand impact of PHEVs and ignores the potential for price increases.[15] Oak Ridge investigated the grid impact of 19 million PHEV vehicles by 2020 and 50 million by 2030, using power generation capacities modeled without allowance for the electrification of the transportation sector. Oak Ridge concurred that nighttime recharging would not necessitate major new capacity additions, but the least economical plants would be called on more often, raising the marginal cost of power production. However, if vehicle recharging were to begin in the evening, all of the nation's electric regions would see new peak levels by 2030. Combined with 240 volt recharging systems, which would reduce recharging times in exchange for

12 DOE, EIA, *Annual Energy Review 2007* (June 2008), 153 and 226. Henceforth cited as EIA, AER (2007).
13 DOE, Pacific Northwest National Laboratory (PNNL), Michael Kintner-Meyer, Kevin Schneider, and Robert Pratt, "Impacts assessment of plug-in hybrid vehicles on electric utilities and regional U.S. power grids, part 1: technical analysis," (November 2007), http://www.pnl.gov/energy/eed/etd/pdfs/phev_feasibility_analysis_combined.pdf , last accessed 27 August 2008, 1-6.
14 Ibid., 11.
15 See ORNL, Stanton W. Hadley and Alexandra Tsvetkova, "Potential impacts of plug-in hybrid electric vehicles on regional power generation," (January 2008).

higher 6 kW loads, evening charging would push peaks significantly above current expectations (as much as 27.9 percent higher in California) and 10 of the electric regions would require additional capacity construction to avoid leaving customers unserved. The Council thus believes that additional power generation capacity will be needed to maximize the national and economic security benefits of transportation electrification.

ECONOMIC FACTORS AND ISSUES OF CONSUMER ACCEPTANCE

Plug-in vehicles have yet to be commercialized, and cost estimates for scaled production of vehicles should be treated with caution. Still, a 2006 study by the National Renewable Energy Laboratory (NREL) offers a useful starting point for estimating the cost-benefit proposition of PHEVs.[16] Using a $23,392 conventional midsize sedan as a benchmark, NREL estimated that the near-term cost of a PHEV with a 20-mile range (PHEV20) would approach $39,000, whereas a PHEV60 might top $50,000. Given these retail prices, the study concluded that owners of PHEVs would not be able to recoup their incremental investments over the 15-year lifetimes of their vehicles.[17] By 2015-2020, however, a far more encouraging cost-benefit relationship is possible, and even likely. Positing R&D advances and economies of scale, NREL estimated that the price of a PHEV20 would fall to $31,828, in effect reducing the premium over a conventional vehicle from 66 percent to just 36 percent. In the case of a PHEV60, the long-term price was expected to sink to $36,681, lowering the premium from 115 percent to just 57 percent. With their larger battery backs, longer-range PHEVs were expected to benefit disproportionately from battery advances, including a switch from NiMH batteries to lithium-ion models. With these costs and $5 per gallon gasoline, NREL concluded that cost-effective payback for PHEV owners would be possible within 12 years, well below the average lifetime of a modern automobile.

> The difficulties inherent in electricity storage already compel the nation to sustain a power sector that maintains considerable spare capacity; to the extent that electric vehicles could add predictable demand to the system, the power sector could increase its return on existing assets and displace considerable oil usage, even without any additional generating capacity.

One way to address the near-term PHEV price problem (as well as consumers' concerns about battery reliability) is to separate ownership of the vehicle from ownership of the battery. By leasing the battery, car owners could lower the upfront purchase cost in exchange for future payments. In this vein, Nissan/Renault recently entered into an agreement with Better Place, a company working on transportation solutions, to produce all-electric vehicles with swappable lithium-ion batteries for sale in Israel. Under this business model, consumers will buy a car and then 'subscribe' for energy on a pay-as-you-go, distance-driven basis. Nissan/Renault will sell the vehicles, and Better Place will establish a network of electric charging spots and battery exchange stations. Similar arrangements have been announced for Denmark.

Compared to capital costs, operating costs for electric vehicles are more firmly estimable, as they are chiefly a function of power prices. A prototype Ford Escape plug-in hybrid that stores 10 kilowatt-hours (kWh)

16 DOE, National Renewable Energy Laboratory (NREL), A. Simpson, "Cost-benefit analysis of plug-in hybrid electric vehicle technology," NREL/CP-540-40485, (November 2006), http://www.nrel.gov/vehiclesandfuels/vsa/pdfs/40485.pdf, last accessed 27 August 2008.

17 Ibid., 10. The study assumed constant $3/gallon gasoline, which is of course below the current price level. On the other hand, future cash flows were not discounted; nor did the study account for higher PHEV maintenance (e.g., battery replacement) costs.

has been credited with a range of 30 miles in the city.[18] At a retail power cost of $0.104 per kWh,[19] thirty miles would cost $1.04. A standard production Escape (admittedly, not perfectly comparable in performance to the prototype) is rated at 22 miles per gallon for combined city/highway driving.[20] To cover 30 miles, this vehicle would consume 1.36 gallons, costing more than five dollars at current prices.[21] Stipulating a slightly lower power cost of $0.085 per kWh, the Electric Power Research Institute (EPRI) estimates that plug-in hybrids could achieve cost-per-mile performance that is equivalent to conventional cars running on gasoline priced at $0.75 per gallon.[22]

ENVIRONMENT

By helping to localize transport-sector emission at points of electric power production, an electrified transport economy could facilitate carbon capture, storage, and avoidance goals. In states such as California, where coal is not a major source of power generation, electric-only operation would produce far fewer greenhouse gas (GHG) emissions, bettering conventional gasoline operation by over 70 percent.[23] Where coal is the principal source of power generation, the emissions benefits of electric vehicles will be smaller, with electric-only operations improving on the performance of conventional cars by approximately 30 percent.[24]

EPRI recently concluded that, with coal-fired electricity, real-world driving conditions, and near-term battery technology, plug-in hybrids may actually emit more GHG than today's hybrids. To correct for the added battery weight of plug-ins, EPRI credited current-model hybrids and PHEV20s with equal gasoline-powered fuel economy.[25] Nonetheless, the emissions benefits accruing to a hybrid (from regenerative braking, reduced idling, etc.) were partially negated when a plug-in hybrid had to rely on coal-generated electricity for its grid-powered travel. But from an energy security perspective, the plug-in hybrid would dominate by consuming less oil than a traditional hybrid. The energy security benefits are clear despite the potential for short-term increases in GHG emissions.

Electrification will also place new demands on the power sector, not initially in terms of capacity, but unavoidably in terms of fuel consumption. In the absence of increased domestic natural gas production, the wide-scale adoption of nuclear power, or technological advances in renewable energy, carbon constraints could force the power sector to heavily depend on imported liquefied natural gas (LNG) to meet this new demand. An electrified transportation sector constrained in ways that foster dependence on LNG imports could essentially mean trading oil dependence for another national security vulnerability.[26]

18 James R. Healey, "Ford Escape plug-in prototype shows potential," *USA Today*, 28 January 2008.

19 The average U.S. residential price in 2006; see http://www.eia.doe.gov/cneaf/electricity/epa/epat7p4.html, last accessed 27 August 2008. There is, however, wide regional variation in pricing.

20 See http://fueleconomy.gov.

21 DOE, EIA, "Weekly retail gasoline and diesel prices," http://tonto.eia.doe.gov/dnav/pet/pet_pri_gnd_a_epmr_pte_cpgal_w.htm, last accessed 25 August 2008.

22 Electric Power Research Institute (EPRI), Natural Resources Defense Council (NRDC), "Technology primer: the plug-in hybrid electric vehicle," (2007), http://mydocs.epri.com/docs/public/PHEV-Primer.pdf, last accessed 27 August 2008, 2.

23 Institute of Transportation Studies (ITS), Alexander E. Farrell and Daniel Sperling, "A low-carbon fuel standard for California, part 1: technical analysis - FINAL REPORT," University of California, Davis (2007), http://pubs.its.ucdavis.edu/download_pdf.php?id=1082, last accessed 27 August 2008, 13.

24 David Sandalow, *Freedom from oil: how the next president can end the United States' oil addiction* (New York: McGraw-Hill, 2008), 64-65.

25 EPRI, NRDC, and Charles Clark Group, "Environmental assessment of plug-in hybrid electric vehicles, vol. 1: nationwide greenhouse gas emissions," (July 2007), 4-5, footnote 13, http://mydocs.epri.com/docs/public/000000000001015325.pdf, last accessed 27 August 2008.

26 Monika Ehrman, "Competition is a sin: an evaluation of the formation and effects of a natural gas OPEC," *Energy Law Journal* 27, no. 1 (2006): 175, http://www.eba-net.org/elj/Energy%20Journals/Vol27_No1_2006_Contents.pdf?PHPSESSID=6fdda26028888e8c9097c2b2ccd28d2f, last accessed 27 August 2008.

RECOMMENDATION

Establish development of advanced battery technology as a top research priority and spend at least $500 million per year toward their development.

The absence of advanced batteries that can store sufficient power to operate an electric vehicle or plug-in electric hybrid is the most significant stumbling block to the widespread adoption of these vehicles. Current-generation batteries are bulky, heavy, and relatively costly, placing practical limits on the amount of onboard storage. For instance, while the new Tesla EV can travel more than 200 miles on a single charge, its batteries reportedly cost more than $30,000 and still take several hours to recharge. Similarly, while Toyota and General Motors have announced plans for commercial introduction in 2010 of PHEVs equipped with large-format lithium-ion batteries, the lack of sufficient manufacturing capacity for these specific battery cell types will negatively impact vehicle affordability in the near term. Fortunately, there are no inherent characteristics of large-format lithium-ion batteries (materials, packaging, etc.) that translate into high cost; the nation must make an investment that is commensurate with the value—in particular in terms of improved national security—of this technology. This must be an area of strategic priority.

Because advanced batteries are a prerequisite for vehicle electrification—and thus reduced oil dependence—the government should commit at least $500 million per year toward their development.

RECOMMENDATION

Replace existing vehicle tax credits with new tax credits of up to $8,000 per vehicle for the first two million domestically produced highly efficient vehicles.

Congress should establish stronger consumer incentives for the purchase of efficient vehicles that deliver oil savings beyond those required by EISA 2007. The tax credits should be structured to provide substantial tax credits to purchasers of PHEVs and EVs. Specifically, Congress should establish a tax credit of $4,000 for any vehicle that is twice as efficient, in terms of oil consumption, as the relevant attribute-based fuel-economy standard for the year the car was sold and a tax credit of $8,000 for any vehicle that is three times as efficient, in terms of oil consumption, as the relevant attribute-based fuel-economy standard for the year the car was sold. While these standards are most likely to be met by PHEVs and EVs, they should be available to other types of vehicles that achieve significant oil savings (such as vehicles that run on natural gas). If no vehicle in a particular attribute class qualifies for either of these incentives, the most efficient vehicle in the class should nevertheless receive a $2,000 credit.

The new tax credits should not incorporate the current per-manufacturer cap on tax credits for the purchase of advanced technology efficient vehicles. Companies that have taken the lead in developing fuel-efficient vehicles with real market potential should not be penalized for their early success by losing eligibility for tax credits before their competitors.

RECOMMENDATION

The federal government should help create a market and exercise leadership by purchasing highly efficient vehicles.

As the largest consumer in the nation, with a presence that extends throughout the economy, the federal government is well situated to help establish the market for highly efficient vehicles. President Bush's most recently issued Executive Order on the subject, Executive Order No. 13423, directs agencies with 20 or more vehicles to reduce their fleet fuel consumption by 2 percentage points annually from 2005 to 2015 (a 20 percent reduction). Either Congress, by statute, or the President, by Executive Order, should direct government agencies with a minimum size fleet to purchase either PHEVs or EVs, if available and if they meet agency requirements. If suitable PHEVs and EVs are not available, agencies should be required to choose among the three most efficient vehicles for each class of car as defined by the Environmental Protection Agency for the purpose of calculating fuel-economy standards. Doing so will promote the development of markets for vehicles that will enhance our energy security.

RECOMMENDATION

Establish production tax incentives to aid in the retooling of U.S. vehicles manufacturing facilities and to create and maintain a domestic capacity to manufacture advanced batteries.

In October 2007, equity researchers at Citigroup Global Markets estimated the automakers would be required to make $5 billion in incremental investments to meet U.S. fuel-economy standards similar to ones included in EISA.[27] For the six largest automakers, the capital outlays were forecast as noted here:

INCREMENTAL CAPITAL EXPENDITURES

Firm	$ (MILLIONS)	% 2009 Estimated CAPEX
Chrysler	625.1	N/A
Ford	915.7	9.8%
GM	1,134.0	12.1%
Honda	520.8	5.6%
Nissan	373.6	4.0%
Toyota	864.1	9.3%

Source: Citigroup Global Markets

These are non-trivial costs, especially for an industry that has been seriously challenged by the recent surge in oil prices. Moreover, they do not account for the costs that will accompany full-scale development of

27 Citigroup Global Markets: Equity Research, "CAFE and the U.S. auto industry," 22 October 2007, 18.

PHEVs or EVs. In order to reduce costs to consumers, promote the health of a domestic automobile manufacturing industry, and ensure that this industry can compete globally in the production of highly efficient and especially electric vehicles, the Council recommends that government provide significant financial assistance for retooling and other capital outlays. Making these incentives available to all manufacturers with existing U.S. facilities should enable them to survive any World Trade Organization (WTO) scrutiny. A combination of tax credits and loan guarantees should allow all manufacturers to obtain assistance, regardless of their current profitability.

Just as it is strategically imperative that the nation retain a robust vehicle manufacturing capacity, the United States must not become overly reliant on foreign sources of batteries. Production tax credits should include makers of batteries and other components essential to an electrified transportation sector.

RECOMMENDATION

To encourage business participation, extend and modify federal subsidies for hybrid medium-duty vehicles (Classes 3–6) and heavy-duty vehicles (Classes 7-8) to 2012 and remove the cap on the number of eligible vehicles.

The Energy Policy Act of 2005 (EPAct 2005) established tax credits for hybrid medium- and heavy-duty vehicles. The credits are set to expire December 31, 2009. At this point, however, few eligible vehicles have been sold.

Congress should extend these rebates and modify them to allow participation by non-taxable entities, including state, county, and municipal fleets that are currently excluded from tax-based programs. The rebates should incorporate a sliding scale that reflects the fuel-efficiency gain associated with a particular model, as verified by EPA or CARB testing procedures.[28] To place as many vehicles on the road as possible and to ensure that companies that have taken the lead in developing hybrid medium-duty vehicles will not be penalized for their early success, Congress should eliminate the per-manufacturer cap on eligibility for tax credits. For heavy-duty vehicles, especially those subject to frequent starting and stopping, hydraulic hybrids that recapture braking energy in pressure tanks offer significant efficiency benefits. Until this technology reaches scale production, deployment should be incentivized through a rebate to vehicle purchasers to offset incremental costs.

RECOMMENDATION

Grants to municipalities and tax credits to commercial real estate developers to encourage the installation of public recharging stations.

In order to take full advantage of the oil savings possible through the use of plug-in hybrid electric or fully electric vehicles, drivers will need access to recharging stations not just at their homes, but also at other places where they park their cars, particularly at work. Yet, until there is a critical mass of plug-in electric or fully electric vehicles, installation of public recharging stations may not be a high priority for local governments or commercial real estate developers. Public recharging stations are estimated to cost under

28 As proposed by the Hybrid Truck Users Forum (HTUF) Incentives Working Group; see draft "Recommendations for Warner-Lieberman America's Climate Security Act," 27 March 2008.

$700 per outlet.[29] Congress should establish grants to municipalities of $350 per installed outlet, provided that a minimum number of units are installed. The minimum number of units required to become eligible for the credit should be determined by the Department of Energy and should be a function of city size.

Congress should also provide tax credits of $350 per outlet to commercial real estate developers that install recharging facilities accessible to at least 5 percent of their parking spaces and make those spaces available to PHEVs and EVs. Promoting the establishment of recharging stations will facilitate the deployment of PHEVs and EVs, thereby reducing our oil dependence and enhancing our energy security.

Enhancing the Nation's Electrical System

Transportation electrification could meaningfully reduce U.S. dependence on oil and significantly mitigate exposure to the volatility of the global oil market. However, this advance will place new strains on the power sector. To enhance overall energy security, the United States must ensure that power is adequately supplied to meet peak demand. Implementing common-sense transmission regulations and reforming the way consumers pay for electricity will also provide the flexibility needed to realize the full benefits of transportation electrification.

In a sense, the electrical system is merely a network that delivers a commodity, just like oil infrastructure. Unlike oil, however, electricity cannot be stored easily or economically in any appreciable quantities; as a result, it must be generated, transmitted, and distributed at the precise moment of demand.[30] To accomplish this critical and complex task, the electrical system integrates three key components: 1) generation facilities and equipment, 2) the transmission grid, which moves power from generating facilities to the areas where the power is consumed, and 3) the distribution system, which connects the transmission system to end use consumers of electrical power.[31]

The United States consumes approximately 4.1 billion megawatt-hours (MWh) of electric power each year, generated by a fleet of approximately 17,000 power plants.[32] The power sector uses a diverse set of fuels, none of which is clearly dominant across the full spectrum of economic, environmental, and energy security criteria. Coal, which provides nearly fifty percent of our electricity,[33] is abundant, but burning it releases significant emissions, including carbon dioxide, the most abundant greenhouse gas.[34] While levels of many other pollutants (NOx, SOx, and particulate matter) have been reduced substantially in recent decades,[35] reducing carbon emissions from coal power plants represents a formidable challenge. Natural gas is plentiful, though less so than coal.[36] And while it burns cleaner than other fossil fuels, natural gas still emits carbon dioxide.[37] Nuclear power, which provides nearly 20 percent of our electrical power, generates no emissions from operations, but construction costs, issues of plant safety, and the disposition of nuclear waste all militate against the attractiveness of this generation option.[38] Hydroelectric power is clean, but sites are limited and existing facilities are subject to environmental criticism. Wind and solar power generation are

29 Portland General Electric, "Plug-in vehicle charging stations from PGE," http://www.portlandgeneral.com/about_pge/current_issues/pdf/charging_station_fact_sheet.pdf., last accessed 25 August 2008.

30 Edison Electric Institute, "Electricity 101," http://www.eei.org/industry_issues/industry_overview_and_statistics/Electricity_101.pdf, last accessed 25 August 2008, 22.

31 Ibid., 18.

32 DOE, EIA, *Electric Power Annual 2006* (November 2007), Table 2.2.

33 DOE, EIA, *Electric Power Monthly* (March 2008), Figure 1 & Table ES1.B.

34 World Coal Institute, "Environmental impacts of coal use," http://www.worldcoal.org/pages/content/index.asp?PageID=127, last accessed 25 August 2008.

35 EIA, *AEO* (2008), 86–87.

36 DOE, EIA, "Coal reserves," http://www.eia.doe.gov/cneaf/coal/reserves/reserves.html#_ftn1, last accessed 25 August 2008.

37 Natural Gas Supply Association, "Natural gas and the environment," http://www.naturalgas.org/environment/naturalgas.asp#greenhouse/, last accessed 27 August 2008; DOE, EIA, "Natural Gas 1998 Issues and Trends," (April 1999), 49, http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_trends/pdf/it98.pdf, last accessed 25 August 2008.

38 Massachusetts Institute of Technology, *The future of nuclear power* (Cambridge, MA: 2003), ix.

emission free, but historically they have been relatively expensive and their intermittency requires the availability of additional generating capacity to ensure that power demand can be satisfied.[39]

Once generated, electricity is transmitted over the grid, a network with over 165,000 miles of high voltage power lines that connects power plants to areas where power is consumed. Traditionally, utilities generated electricity within well-defined service territories and transmitted it over the high voltage transmission network to their customers. Adjoining utilities were generally interconnected to each other to enhance reliability and to share excess power, but, as a general matter, little power was transmitted between them. In other words, the system as it existed before the advent of wholesale power competition in the 1990s was not designed to move large quantities of electric power over large distances and between different utilities.[40]

While many new transmission lines have been built over the last two decades,[41] the network is still not sufficiently robust.[42] EPAct 2005 sought to address this in part by establishing new procedures for siting electric transmission lines, including federal preemption of state siting authority in specified circumstances, and by creating an independent organization to improve the reliability of the transmission grid through mandatory and enforceable standards.[43] Nevertheless, obtaining approval to site power lines is still difficult, as their construction is frequently opposed by local communities.[44] Moreover, the capability of the transmission network is constrained by its reliance on dated technology. Most of the grid is controlled by analog signals and electromechanical switches. Upgrading the grid to a digitally managed *smart grid* will enhance its reliability and enable better service.[45]

SMART OR MODERN GRID

To efficiently fill in the 'valleys' and to prevent loads surging beyond total generating capacity, electric vehicle charging patterns will have to be shaped, through variable (time-of-day) pricing and other practices that presuppose the availability of information technologies not currently integrated into the grid. Performance expectations for such an improved grid, often termed *smart* or *modern*, include the ability to:

— detect, analyze, respond to and recover from perturbations;
— incorporate consumer behavior into the operation of the grid;
— mitigate and withstand physical and/or cyber attacks;

39 PNNL, Global Energy Technology Strategy Project, J.A. Edmonds, M.A. Wise, J.J. Dooley, S.H. Kim, S.J. Smith, P.J. Runci, L.E. Clarke, E.L. Malone, G.M. Stokes, "Wind and solar energy a core element of a global energy technology strategy to address climate change," (May 2007), http://www.pnl.gov/gtsp/docs/getspwind.pdf , last accessed 27 August 2008, 4. Wind turbines operate at a 33 percent capacity factor, while nuclear and coal power plants operate at 90 and 73 percent capacity factors respectively. See "Wind energy basics," http://www.awea.org/faq/wwt_basics.html, last accessed 27 August 2008; See EIA, Electric Power Annual, Figure ES 3, "Average capacity factor by energy source," http://www.eia.doe.gov/cneaf/electricity/epa/figes3.html, last accessed 27 August 2008. Although other forms of power operate at lower capacity utilization factors, they are used to serve intermediate and peak load and they are dispatchable, which wind is not. See Ed DeMeo and Brian Parsons, "Some common misconceptions about wind power," presented 22 May 2003, to All States Wind Summit, Austin, TX, www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/wpa/34600_misconceptions.pdf, last accessed 27 August 2008.

40 See remarks of Secretary of Energy Samuel Bodman to National Governors Association (NGA), Winter Meeting, 26 February 2007, http://www.energy.gov/news/4822.htm, last accessed 27 August 2008. DOE, National Transmission Grid Study, (May 2002), 5-6.

41 DOE, EIA, "Electricity transmission fact sheet," http://www.eia.doe.gov/cneaf/electricity/page/fact_sheets/transmission.html, last accessed 26 August 2008.

42 DOE, "National electric transmission congestion study," http://nietc.anl.gov/documents/docs/Congestion_Study_2006-9MB.pdf, last accessed 26 August 2008.

43 *Energy Policy Act of 2005*, P. L. No. 109-58, § 1221, 119 Stat. 594 (2005), codified at 16 U.S.C. § 824.

44 Cecilia Chan, "Vistancia residents irate over proposed power lines: residents of affected area speak out against proposed alignment," *Arizona Republic*, 19 August 2008, http://www.azcentral.com/arizonarepublic/local/articles/2008/08/19/20080819vistancia0819.html, last accessed 28 August 2008. Mike Lee, "Renewable-energy push puts all eyes on desert," San Diego Union-Tribune, 3 June 2008, http://www.signonsandiego.com/news/state/20080603-9999-1n3desert.html, last accessed 28 August 2008. ; and Daniel B. Wood, "Green power may ruin pristine land in California," *Christian Science Monitor*, 24 April 2007, http://www.csmonitor.com/2007/0424/p02s01-wogi.html, last accessed 28 August 2008.

45 Kurt Yeager, testimony prepared for House Committee on Energy and Commerce, 110th Cong., 1st sess., 3 May 2007, http://energycommerce.house.gov/cmte_mtgs/110-eaq-hrg.050307.Yeager-Testimony.pdf , last accessed 29 August 2008.

— provide consistent power;
— accommodate a wide variety of generation technologies, including renewable power and distributed generation;
— allow for more efficient market operations; and
— optimize the use of capital assets while minimizing operational and maintenance costs.[46]

GENERATION

With the capabilities of a smart grid, unused capacity could be more efficiently employed to charge large numbers of electric vehicles during off-peak periods. Nevertheless, the Council believes that the transformation to electric vehicles will require more generating capacity for several reasons. First, operating cars on electricity is less expensive than fueling cars with gasoline, and that cost differential will create an incentive for owners of electrically powered vehicles to maintain a fully charged battery, maximizing the distance they drive powered by electricity and minimizing the miles they drive fueled by gasoline or other liquid fuels. Second, the batteries in plug-in electric hybrid vehicles will have limited capacity, at least initially, and this may lead many consumers to recharge or merely top-off during the daytime. Indeed, because of the time it takes to recharge, consumers will have a greater incentive to keep their cars fully charged, even if this requires daytime charging. Third, while it will take time for plug-in hybrids to penetrate the market, their sales are likely to accelerate more rapidly than the power industry can add generating capacity. To meet these demands, the Council believes that the United States must simultaneously increase its generating capacity as well as its ability to deliver electricity to end-use customers.

Given the expectation that the federal government will establish a system for regulating carbon emissions in the near future, the Council believes that renewable sources of electric power will play an important role in helping to meet our increasing need for power and supports policies to promote their deployment. In fact, a recent DOE report concluded that the United States could produce 20 percent of its electricity from wind by 2030.[47] Solar, especially large-scale solar thermal plants, could also generate significant amounts of electricity, especially in the western states.[48] However, wind and solar power generation do not offer a complete solution to our nation's need for generating capacity, because they cannot be reliably 'dispatched' by grid operators to meet real-time power needs.

INCREASING NUCLEAR POWER GENERATION AND ADDRESSING WASTE STORAGE

Nuclear power is the most promising technology available for generating dispatchable power at scale without carbon emissions. In 2007, nuclear power generated nearly 20 percent of the power generated in the United States.[49] EIA forecasts that demand for electricity will grow by about 25 percent by 2030, without taking into account any significant increase due to electric vehicles.[50]

No new nuclear plant has been completed and brought on line since 1996, and no nuclear plant ordered after 1977 was completed and brought on line.[51] The three primary issues related to the development of a new nuclear plant in the United States are safety, waste disposal, and construction costs.[52]

46 National Energy Technology Laboratory (NETL), "The NETL modern grid initiative: powering our 21st-century economy, modern grid benefits," (August 2007); NETL, http://www.cis.state.mi.us/mpsc/electric/capacity/energyplan/alttech/smartgrid_draftreportoutlinejul19_2006.pdf

47 DOE, Energy Efficiency and Renewable Energy (EERE), "20 percent wind energy by 2030," (May 2008).

48 NREL, "Fuel from the sky: solar power's potential for western energy supply," (July 2002).

49 DOE, EIA, *Electric Power Monthly* (March 2008), Figure 1 & Table ES1.B.

50 EIA, *AEO* (2008), Table A8.

51 DOE, EIA, "U.S. nuclear reactors," http://www.eia.doe.gov/cneaf/nuclear/page/nuc_reactors/reactsum.html, last accessed 27 August 2008, see link to Reactor Status List.

52 MIT, *Future of nuclear power*, ix.

Safety: Since the opening of the first civilian nuclear power plant in the United States in 1957,[53] there has been only one significant accident, and the federal government concluded that damage from that accident was contained at the facility.[54] The newest generation of nuclear plants, already operating abroad but still absent from the U.S. market, incorporate passive safety features that significantly reduce the likelihood of a nuclear accident. Thus, while the Council believes that the Nuclear Regulatory Commission (NRC) must remain vigilant in its oversight of nuclear power plant safety, the operating history of the civilian nuclear power industry in the United States demonstrates that the industry is safe.

Waste Disposal: The fuel in nuclear power plants consists of small uranium pellets that are sealed in strong metal tubes, which are then bundled together into a nuclear fuel assembly. After several years, the pellets no longer efficiently generate power and are replaced. Once removed from a nuclear reactor, the spent fuel assemblies are highly radioactive. When removed from a reactor, spent fuel is placed in a pool of water that cools the fuel and protects workers from radiation. After several years, the spent fuel may be placed into dry-storage containers made of steel or concrete to shield radiation. The containers may then be stored safely and relatively inexpensively on concrete pads.

In 1982, Congress decided that civilian nuclear waste should be disposed of deep underground in geologic repositories,[55] a decision that has been supported by two studies by the National Research Council of the National Academy of Sciences (NRC/NAS). In a 1990 study, NRC/NAS concluded that there is "a worldwide scientific consensus that deep geological disposal, the approach being followed by the United States, is the best option for disposing of highly radioactive waste."[56] In its 2001 study, NRC/NAS reaffirmed that conclusion, stating that "geologic disposal remains the only scientifically and technically credible long-term solution available to meet the need for safety without reliance on active management."[57] In 1987, Congress directed that Yucca Mountain in Nevada be the only site studied for use as a nuclear waste repository.[58]

Despite the scientific opinion, significant controversy remains over the safety of Yucca Mountain. The controversy has already delayed the anticipated opening of the facility by decades. While DOE was legally obligated to start taking custody of civilian nuclear waste in 1998,[59] it has failed to do so.[60] DOE currently does not expect Yucca Mountain to open prior to 2017, at the earliest.[61] Given the uncertainty regarding the disposition of spent nuclear fuel, there is hesitancy among some policymakers to support the construction of new nuclear plants that will increase the volume of waste generated by the power sector.

Construction Costs: Electric utilities in the United States are small relative to electric utilities in other parts of the world,[62] and for many of them, the estimated total cost of building a new nuclear power plant rivals total capitalization, meaning that the decision to build a nuclear power plant must be weighed against the danger of severe financial distress. In light of these factors, construction of a new nuclear plant is a prohibitively risky proposition for many U.S. utilities.

53 DOE, EIA, "Nuclear time line," http://www.eia.doe.gov/kids/history/timelines/nuclear.html, last accessed 26 August 2008.
54 Nuclear Regulatory Commission (NRC), "Fact sheet on the Three Mile Island accident," (March 2004), http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html, last accessed 27 August 2008.
55 See "Legislative History" to *Nuclear Waste Policy Act of 1982*, P.L. 97-425 (1982) at 1997 U.S.C.C.A.N. 3792-3802.
56 National Research Council's Committee on Disposition of High-Level Radioactive Waste Through Geological Isolation, Board on Radioactive Waste Management, *Rethinking high-level radioactive waste disposal*, (Washington, D.C.: National Academy Press, 1990), vii.
57 National Research Council's Committee on Disposition of High-Level Radioactive Waste Through Geological Isolation, Board on Radioactive Waste Management, *Disposition of high-level waste and spent nuclear fuel: continuing societal and technical challenges*, (Washington, D.C.: National Academy Press, 2001), 3.
58 *Nuclear Waste Policy Act Amendments of 1987*, P.L. 100-203, § 5002, 5011, codified at 42 U.S.C. §§ 10101, 10121.
59 *Me. Yankee Atomic Power Co. v. United States*, 225 F.3d 1336, 1337-40 (3d Cir. 2000).
60 Matt Wald, "As nuclear waste languishes, expense to U.S. rises," New York Times, 17 February 2008.
61 DOE Press Release, "DOE announces Yucca Mountain license application schedule," 19 July 2006, http://energy.gov/news/3846.htm, last accessed 26 August 2008.
62 Goldman, Sachs & Company, John Gilbertson. *Nuclear construction: financial markets perspective* (Washington, D.C.: Center for Strategic and International Studies (CSIS)), slide 6, http://www.csis.org/media/csis/events/080731_nuclear_gilbertson.pdf, last accessed 26 August 2008.

In the past, the regulatory process has added significantly to construction and financing costs. While the NRC has now modified its licensing process to offer a combined construction and operating license issued before plant construction begins, the process is as yet untested. Numerous studies estimate that the levelized cost of power generated at new nuclear power plants is generally comparable to the cost of power from integrated gasification combined cycle coal, super critical pulverized coal, and combined cycle gas.[63] In a carbon-constrained world, nuclear power should be even more cost competitive.[64] Moreover, advances in technology—new construction methods and plant design approaches—should reduce construction cost and risk even further. Nevertheless, given the significant cost overruns that marred the construction of the last generation of nuclear power plants and the lack of any recent domestic construction, skepticism regarding the reliability of cost estimates for new plants is understandable.

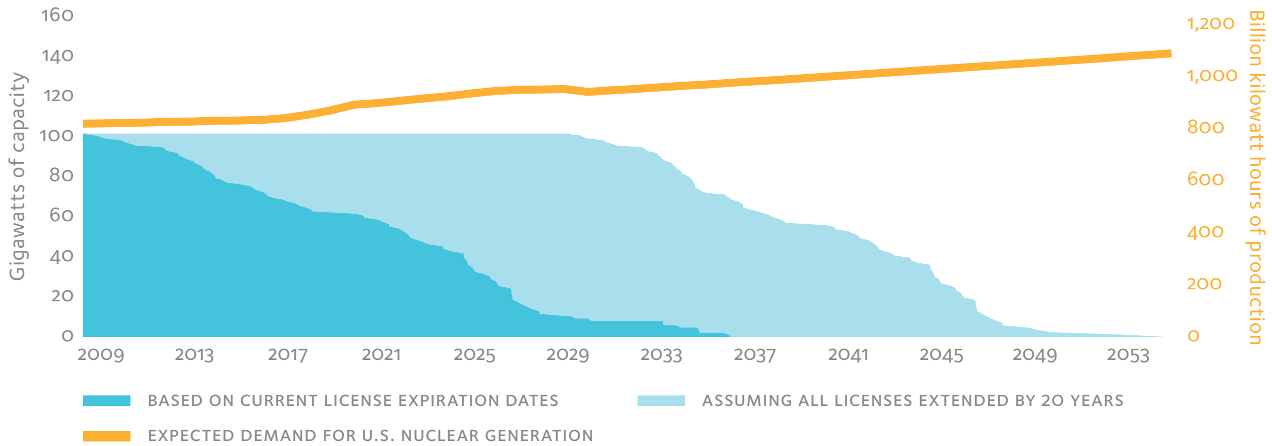
Congress has sought to address these concerns with the establishment of a regulatory insurance program and a separate loan guarantee program. To minimize the risk associated with delays in the regulatory approval process, EPAct 2005 established a federal risk insurance program for utilities building new nuclear power plants. A total of $2 billion in federal risk insurance will be available to cover costs associated with regulatory or litigation-related delays that stall plant start-up beyond 180 days through no fault of the covered utility.[65] The first six companies granted a Construction and Operating License by the NRC are eligible to participate in the program, which will provide indemnification of 100 percent of covered costs—up to $500 million—for each of the first two reactors and 50 percent of covered costs—up to $250 million—for each of the subsequent four reactors.[66]

To address the general risk associated with the construction of large, advanced technology, energy-related projects, EPAct 2005 authorized DOE to issue loan guarantees to eligible projects that "avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases" and "employ new or significantly improved technologies as compared to technologies in service in the United States at the time the guarantee is issued." Technologies that might qualify for loan guarantees under the law include biomass, hydrogen, solar, wind, hydropower, advanced coal, carbon storage technologies, and nuclear. In Fiscal Year 2008, Congress authorized $38.5 billion in loan guarantee authority for innovative energy projects.[67] Of the total provided, $18.5 billion is set aside for nuclear power facilities, $2 billion for advanced nuclear facilities for the "front-end" of the nuclear fuel cycle, $10 billion for renewable and/or energy efficient systems and manufacturing and distributed energy generation/transmission and distribution, $6 billion for coal-based power generation and industrial gasification at retrofitted and new facilities that incorporate carbon capture and storage or other beneficial uses of carbon, and $2 billion for advanced coal gasification.[68]

While these loan guarantees are a constructive measure, the total level of funding is insufficient, especially given the cost of building new nuclear facilities. Further, DOE's authority to issue loan guarantees is currently set to expire in 2009, far too soon to allow industry to apply this incentive to planned projects.

63 See The Brattle Group, "Integrated resource plan for Connecticut," 1 January 2008, www.brattle.com/_documents/UploadLibrary/Upload656.pdf, last accessed 27 August 2008; Congressional Budget Office, Justin Falk, "Nuclear power's role in generating electricity," presentation at CSIS, 31 July 2008, http://www.csis.org/media/csis/events/080731_nuclear_falk.pdf, last accessed 27 August 2008.
64 Falk, "Nuclear power's role."
65 *Energy Policy Act of 2005*, P.L. 109-58 at § 638, codified at 42 U.S.C. § 16,014; see, also, DOE, "*Energy Policy Act of 2005*: new plant incentives within the *Energy Policy Act of 2005*," http://www.ne.doe.gov/energyPolicyAct2005/neEPACT2a.html, last accessed 27 August 2008.
66 *Energy Policy Act of 2005*, P.L. 109-58 at § 638.
67 See "Title XVII 2008 Omnibus [Appropriations Bill] Report Language," http://www.lgprogram.energy.gov/appro/rptLanguage.pdf, last accessed 27 August 2008.
68 Ibid.

TOTAL U.S. NUCLEAR POWER PLANT CAPACITY



Source: Energy Information Administration

RECOMMENDATION

Continue licensing process for Yucca Mountain while initiating a program of interim storage as an alternative to Yucca Mountain.

On June 3, 2008, the DOE submitted an application to the NRC for a license to construct and operate the nation's geologic repository for high-level nuclear waste at Yucca Mountain.[69] Submission of the application marks a major milestone in the nation's policy on nuclear power and high-level waste, as the focus has shifted from DOE efforts to determine a suitable site and design to the NRC's independent review of the repository's adequacy. The Council believes that the government should continue with this licensing process to determine if the repository meets the legal standard for initiating operations.

Recognizing that Yucca Mountain remains politically controversial and that the site may not be approved, DOE should pursue an alternative path, namely, developing plans to build two interim nuclear waste storage sites where civilian waste may be stored pending a decision regarding the permanent disposition of the waste. The Secretary of Energy should focus on government sites that already host nuclear material and have adequate or easily upgradable security measures in place.

Consolidating waste storage in two government-owned facilities that can be properly secured may prove more acceptable to the American people than having waste stored on-site at nuclear power plants throughout the country, although DOE would have to address concerns regarding the transport of spent fuel to interim storage facilities. In addition, storing nuclear waste in interim facilities would also allow the government to pursue the development of a closed fuel cycle, in which spent nuclear fuel is reprocessed into new fuel in order to better utilize uranium resources and to reduce the volume of waste, an approach already adopted by France and Japan.

Finally, interim storage would preserve the option to permanently store waste using safer technologies that may be developed in the near future. Given that nuclear waste must be stored for long periods of time, delaying disposal for a few years or decades while finalizing a solution is justifiable, but should not delay new nuclear generation.

69 NRC Press Release, "NRC receives DOEs license application to construct high level nuclear waste repository at Yucca Mountain", 3 June 2008, http://www.nrc.gov/reading-rm/doc-collections/news/2008/08-106.html, last accessed 26 August 2008.

RECOMMENDATION

Extend the deadline and increase the funding levels for loan guarantees for new nuclear generation.

Even since the passage of EPAct 2005, the anticipated cost of building a new nuclear plant has risen sharply.[70] As a result, it is now doubtful that the loan guarantee program will be sufficient to support the construction of more than one or two facilities. The Council, therefore, recommends that Congress increase funding for loan guarantees for nuclear facilities to a minimum of $30 billion, sufficient to support the construction of four to six nuclear plants. This will facilitate a nuclear revitalization and help the nation securely meet its growing need for power, including the power demand created by EVs and PHEVs. Congress should also extend the deadline by which DOE must issue loan guarantees from its current expiration date in September 2009 for at least two years.

DEPLOYING ADVANCED COAL TECHNOLOGY

One-quarter of the world's coal reserves are found within the United States, and the energy content of this domestic resource exceeds the energy content of all the world's known recoverable oil. More than 500 coal-fired plants are responsible for generating nearly half of our nation's electricity, making coal the bedrock of America's central power system. At the same time, combusting coal for electricity generation using conventional technologies can have serious local air pollution impacts and is a significant source of anthropogenic carbon dioxide (CO2) emissions.

Advanced generation technologies such as integrated gasification combined cycle (IGCC) can dramatically reduce the emissions of particulate matter, sulfur dioxide, nitrogen oxides, and mercury, pollutants that are traditionally associated with even the cleanest traditional coal plants. IGCC can also facilitate the capture of 30 to 60 percent of CO2 emissions with known technologies, and is expected to be the most cost-effective option for capturing higher levels of CO2. Because the coal is gasified before being used to generate electricity, both conventional pollutants and CO2 are easier to separate. The CO2 stream can then be pressurized and transported for underground injection and storage. With current technologies, the process of separating, capturing, compressing, and transporting the CO2 will consume upwards of 25 percent of the power generated by a facility, a not insignificant 'energy penalty.'

In spite of the energy penalty, cost, and current regulatory uncertainty, the implementation of carbon capture and storage (CCS) is widely considered to be the key to continued reliance on coal in a future governed by legislation or regulations mandating greenhouse gas reduction efforts. When carbon limits are imposed, the cost of freely emitting coal and natural gas will increase, creating a potential cost advantage for IGCC with CCS. Nevertheless, regulatory uncertainty and cost escalation, as well as political opposition to coal in any form, are hindering IGCC construction. In addition to two plants already in operation in Indiana and Florida, only two other projects, in Indiana and Minnesota, are moving forward. Nine separate IGCC projects were cancelled or postponed in 2007, representing approximately 4,189 megawatts of much-needed electrical generating capacity. These projects were in addition to the 20 conventional coal projects, representing more than 22,000 megawatts of capacity, cancelled or postponed last year.

The Council recognizes that some additional baseload capacity may be needed before the nation can deploy new nuclear or coal with CCS power plants. On economic, security, and long-term

70 Rebecca Smith, "New wave of nuclear plants faces high costs," *Wall Street Journal*, 12 May 2008; Pam Radtke Russell, "Prices are rising: nuclear cost estimates under pressure," *EnergyBiz*, (May/June 2008), 22; and Joe C. Turnage, "New nuclear development: part of the strategy for a lower carbon energy future," *UniStar Nuclear*, presentation at CSIS, 31 July 2008, http://www.csis.org/media/csis/events/080731_nuclear_turnage.pdf, last accessed 30 August 2008

environmental grounds, IGCC plants designed to allow for the future addition of CCS technology offer a practical solution for this near-term demand, and government must be prepared to facilitate their construction.

RECOMMENDATION

Significantly increase investment in advanced coal R&D, including development of carbon capture and storage technology and policy framework.

In order to accelerate the process of developing advanced coal plants that can operate within a carbon-constraining regulatory regime, the government must increase its support for coal-related R&D, with a focus on both pre- and post-combustion CCS. DOE currently spends about $100 million per year on CCS R&D, which it should increase to a minimum of $1.5 billion per year within five years. Several large-scale demonstration projects that integrate advanced coal-fired generation and CCS in different geologic formations must be undertaken.

RECOMMENDATION

Increase funding for loan guarantees for advanced technology coal generation.

As discussed above in the section on nuclear power, funding levels for the loan guarantees in EPAct 2005 are not commensurate with the underlying policy objective of incentivizing the construction of advanced power generating facilities. Congress should increase the funding for loan guarantees for advanced coal plants with carbon storage to $18 billion, double the current level and sufficient to support the construction of perhaps six new advanced coal plants.

PROMOTING RENEWABLE ENERGY

The Council strongly supports the continued development of renewable sources of electric power generation. The primary renewable power generation technologies—wind and solar—must be backed up by dispatchable generation sources, but they can help meet our growing electricity demand by producing clean and secure power with few if any safety concerns. Moreover, since they possess a risk profile that is very different from fossil-fuel or nuclear generation, renewables can contribute to the diversification of our power sector.

In response to the energy crisis of the early 1970s, Congress passed the Public Utility Regulatory Policies Act of 1978 (PURPA). Intended to support the development of independent power producers in the United States, PURPA contributed significantly to the development of renewable electrical power generation by requiring utilities to buy electricity from qualifying facilities, which it defined as small- to medium-sized non-utility generators that produce electricity using cogeneration technology or renewable power.[71] The Energy Tax Act of 1978 established the first tax credits for renewable energy, many of which were modified or allowed to expire in the 1980s.[72] EPAct 1992 established a ten-year,

71 *Public Utility Regulatory Policies Act of 1978*, P.L. 95-617, title II, § 210, 92 Stat. 3144, codified as amended at 16 U.S.C. § 824a-3. Henceforth cited as PURPA (1978).

72 DOE, EIA, "Production tax credit for renewable electricity generation," (2005), http://www.eia.doe.gov/oiaf/aeo/otheranalysis/aeo_2005analysispapers/prcreg.html, last accessed 27 August 2008.

1.5 cents per KWH production tax credit (PTC) for wind generators or 'closed-loop' generators (which are fueled by organic material from a plant which is cultivated exclusively for the purpose of being used to generate electricity) brought online between 1994 and 1999.[73] The current PTC is valued at 2.0 cents per KWH for wind, solar, geothermal, and closed-loop bioenergy facilities. Other technologies, such as 'open-loop' biomass, incremental hydropower, small irrigation systems, landfill gas, and municipal solid waste, receive a lesser value tax credit.[74]

EPAct 1992 also extended a business energy investment tax credit (ITC) for certain investments in solar and geothermal equipment.[75] The ITC helps offset the investment in renewable energy projects and provides an economic incentive to deploy more capital-intensive renewable energy technologies.

RECOMMENDATION

Reform and extend the Production Tax Credit (PTC) and the Investment Tax Credit (ITC) through December 31, 2013, while providing certain guidance for the transition to a fundamentally improved, next-generation incentives program.

Since their creation, the PTC and ITC have each been renewed several times.[76] They were most recently extended in December 2007 through the end of 2008.[77] Each time the credits are set to expire, however, the ability of the industry to plan over the long term is undermined.

In order to promote the continued development and deployment of renewable power generation technologies, the Council recommends that Congress extend the PTC and ITC for five years. As a condition of their extension, the credits should be reformed. In particular, the dollar value of the credits should be scaled on the basis of domestic manufacturing content, and restrictions that disqualify many small businesses from PTC eligibility should be removed.

Congress should also provide certain guidance that will transition the renewables industry to a fundamentally improved, next-generation system of incentives. Over the long-term, taxpayer dollars should be directed away from output incentives such as the PTC and toward investment enhancements specifically designed to sustain and expand a strategic domestic manufacturing capacity for advanced renewable technologies.

If carbon emissions are regulated, most forms of renewable generation will benefit insofar as they will be shielded from carbon taxes or from the burden of obtaining emissions allocations. Accordingly, if and when Congress establishes a program to regulate carbon emissions, it should reexamine whether continuation of the PTC and ITC is warranted.

73 *Energy Policy Act of 1992*, P.L. 102-486, § 1914, 106 Stat. 2776, codified at 26 U.S.C. § 45.

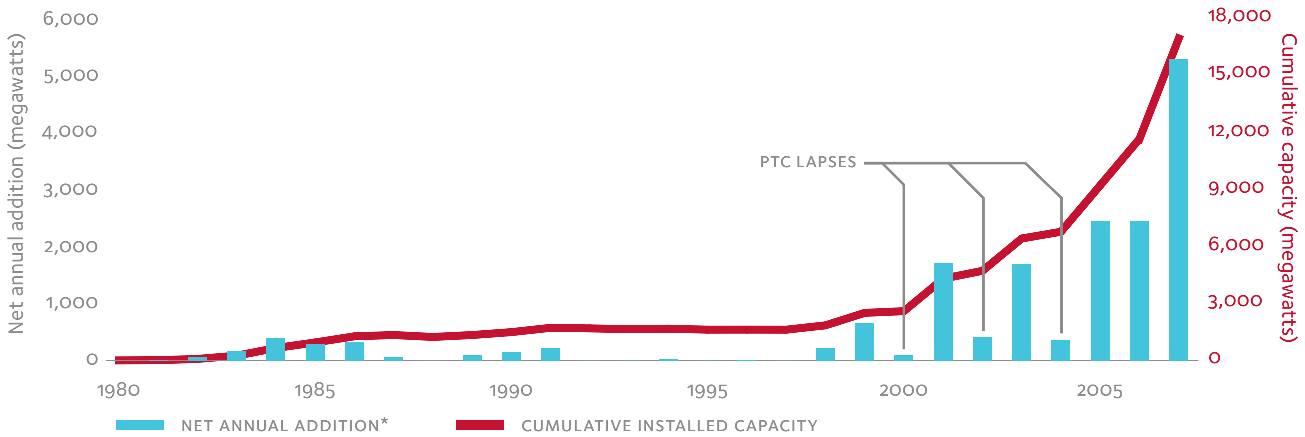
74 26 USC §§ 45(b)(4)(A).

75 *Energy Policy Act of 1992*, P.L. 102-486, § 1916, codified at 26 U.S.C. § 48.

76 Ryan Wiser, "Wind power and the production tax credit: an overview of research results," testimony prepared for Senate Finance Committee, 110th Cong., 1st Sess., 29 March 2007.

77 Tax Relief and Health Care Act of 2006, P.L. 109-432, §§ 201, 207, 120 Stat. 2922, codified at 26 USC §§ 45, 48.

IMPACT OF PRODUCTION TAX CREDITS ON U.S. WIND POWER



Source: Lawrence Berkeley National Laboratory

DEVELOPMENT OF A ROBUST TRANSMISSION GRID TO MOVE POWER TO WHERE IT IS NEEDED

Transmission bottlenecks are a major source of vulnerability in the power grid. Overburdened high-tension power lines increase the probability of service failures and prevent efficient redistribution of power from surplus to deficit regions. Recent studies of the transmission system concluded that congestion on the transmission grid was costing consumers billions of dollars each year.[78]

Rather than constituting a national network, the transmission grid is in effect a patchwork that is not subject to the jurisdiction of any common regulator—indeed, some areas are wholly unregulated at the federal or state level. This balkanized structure makes it difficult to both site and finance transmission lines.

EPAct 2005 sought to address this in part by granting the federal government the authority to approve the siting of certain transmission lines, preempting a traditionally state and local function.[79] Under the act, DOE may designate "national interest electric transmission corridors," areas where transmission congestion or constraints adversely affect consumers and within which state and local authority to deny or condition transmission line permit requests is severely limited. If a state denies a permit, places certain conditions on a permit, or has not acted on a permit within one year for any reason, the Federal Energy Regulatory Commission (FERC) can issue the permit. In addition, utilities that have received a permit from FERC to construct a power line against state objections can petition a federal court for the right to exercise the power of eminent domain over private property in order to construct new transmission lines.[80] Nevertheless, there are still many areas where utilities have had trouble obtaining regulatory approval to site transmission lines.

The Council believes that national leaders must treat grid expansion as a national security imperative. Grid expansion will be necessary to fully exploit the opportunities presented by wind and solar energy, production of which is most promising in sparsely populated areas distant from significant electrical loads. DOE's recent report on wind energy included estimates that identified the need for about 20,000 miles of transmission lines at a cost of about $60 billion to take full advantage of the available wind resource.[81]

78 David Cay Johnson, "Grid limitations increase prices for electricity," *New York Times*, 13 December 2006; and DOE, "National electric transmission congestion study," (2006), http://nietc.anl.gov/documents/docs/Congestion_Study_2006-9MB.pdf , last accessed 27 August 2008, 26. The Department did not make an estimate for the Western grids.

79 P.L. No. 109-58, § 1221, 119 Stat. 594 (2005), codified at 16 U.S.C. § 824.

80 Ibid.

81 EERE, "20 percent wind energy," 96 and 98.

RECOMMENDATION

Extend backup federal eminent domain for transmission lines to help expand the use of renewable power and to enhance reliability by moving power from surplus to deficit regions.

Congress should expand FERC's transmission line permitting authority, allowing it to approve the siting of all high voltage transmission lines, not just those that are located in "national interest electric transmission corridors". Such expanded authority will facilitate the construction of transmission lines from sites of renewable generation, contributing to a robust national network that benefits all communities.

EPAct 2005 granted the Western Area Power Administration and the Southwestern Power Administration authority to accept third-party financing to assist in the construction of transmission lines, a task for which they already have the authority to exercise the power of eminent domain. The power marketing administrations are limited, however, to accepting $100 million in third-party financing between 2006 and 2015. Congress should eliminate this cap and encourage the agencies to actively promote the development of new transmission lines to meet the national need for a more robust grid.

Although siting new transmission lines often is difficult, determining who pays for them, particularly when they cross utility or control area boundaries, is perhaps an even more challenging barrier. Transmission lines tend to benefit all users of the grid, no matter who pays for them. Thus, each utility has an incentive to wait for other grid users to make transmission investments. FERC has been examining how to improve the allocation of costs for new long distance transmission lines. The Council believes that the states, FERC and Congress should redouble their efforts to address this problem. If FERC is unable to do this in the near future, the Council believes it may be necessary for Congress to consider more direct policies, such as requiring utility participation in regional transmission organizations or imposing federal surcharges to finance such lines.

RECOMMENDATION

Require the Federal Energy Regulatory Commission to approve enhanced rates of return on investments to modernize the electrical grid system.

Much of the technology necessary for the development of a smart grid already exists. One primary obstacle to its deployment is determining who will pay for the necessary upgrades. EPAct 2005 required FERC to establish incentive rates for certain new transmission lines.[82] In response, FERC issued a rule that provided for higher rates of return on equity for new investments by public utilities (both traditional utilities and stand-alone transmission companies) and higher rates of return on equity (ROE) for utilities that join and/or continue to be members of independent transmission organizations.[83]

Congress should expand the use of incentive rates to help facilitate the development of the smart grid. Congress should direct DOE to engage in a rulemaking to identify a list of technologies that are necessary for the development of a smart grid. It should then amend the Federal Power Act to direct FERC to offer incentive rates for investment in qualifying equipment. FERC generally establishes a utility's ROE near the

82 P.L. No. 109-58, § 1241, 119 Stat. 594 (2005), codified at 16 U.S.C. § 824.

83 Federal Energy Regulatory Commission (FERC), *Promoting Transmission Investment Through Pricing Reform*, 116 FERC ¶ 61,057 (2006), 71 Fed. Reg. 43,294.

middle of the "zone of reasonableness," which typically reflects what other similarly situated utilities are earning on their transmission-related investments. The Council recommends that FERC be required to grant a utility an ROE at the top end of the zone of reasonableness, but in no instance less than three percentage points higher than the midpoint of the zone of reasonableness.

Because transmission costs are a relatively small portion of the consumer's overall electricity bill, and a utility's return on equity is a small portion of overall transmission costs, this provision would be virtually imperceptible to most consumers. It would, however, encourage utilities to invest in upgrades necessary to facilitate the deployment of smart-grid technologies.

The Council recognizes, however, that many of the investments necessary to upgrade the grid must be made at the distribution level, which is subject to state, not federal, jurisdiction. While the Council hopes that state public utility commissions (PUCS) will promote smart grid investments, it may be necessary for Congress to consider more direct policies. These could include tax incentives to promote investments or mandates requiring each state to establish incentives for distribution-level, smart-grid investments, and directing FERC to promulgate a uniform incentive as a backstop. For any state failing to meet a federally imposed deadline, a FERC-prescribed national incentive could apply and would need to be recognized in rates otherwise subject only to state jurisdiction.

TRANSFORMING CONSUMER DEMAND FOR ELECTRICITY

System reliability and efficiency can be enhanced by policies that flatten utilities' load curves over the course of the typical day. Energy demand fluctuates during the course of the average day, generally peaking late in the day or early evening when offices and stores may still be open but residential consumers returning home are turning on appliances and heating or air conditioning systems.[84] As mentioned, because utilities cannot store electricity, they must construct sufficient generating capacity to serve the peak amount of load their customers consume at any moment, even if the peak levels are only reached for a few hours on the hottest afternoons of the year. Operating at peak generating capacity, however, is generally very inefficient. As a general practice, when deciding which generators to use to serve load, transmission grid operators try to employ the least costly set of generators available to generate sufficient power to serve load.[85] Accordingly, the generators used to serve peak load generally are among the least efficient generators available to grid operators. Moreover, by placing the greatest stress on the electrical supply system, operating at or near peak capacity increases the likelihood of service interruptions.

Demand response programs use market tools to reduce consumer demand for electricity at certain times, thereby promoting more efficient and reliable utility operations. Most consumers face electric rates that are based on average costs of production that bear little relationship to the cost of the electricity they are actually consuming. Thus, consumers have little incentive to reduce demand even when the cost of producing electricity rises sharply due to peak demand. Demand response programs try to motivate consumers to shift their demand for electricity to times where it is less expensive to produce, reducing consumption at periods of peak demand when grid operations are relatively inefficient and reliability is jeopardized.

A critical feature of the smart grid is the ability to facilitate two-way communications between utilities and customers and their appliances, including plug-in electric cars, household appliances, and other household energy systems. The availability of smart meters and smart appliances will enable utilities to offer innovative pricing plans that help meet customer needs while enhancing the

84 Richard C. Dorf, *The electrical engineering handbook*, Section 7.6, (CRC Press, 2006).

85 DOE, "The value of economic dispatch: a report to congress pursuant to section 1234 of the *Energy Policy Act of 2005*," 7 November 2005, http://www.oe.energy.gov/DocumentsandMedia/value.pdf., 4, last accessed 26 August 2008.

reliability of the grid. For instance, utilities may offer customers reduced rates in exchange for the ability to prevent the charging of certain household appliances—or plug-in vehicles—during periods of peak demand. These reforms should be pursued in a manner that protects consumer privacy and preserves consumer choice.

RECOMMENDATION

Direct states to implement time-of-day pricing for electricity and grant FERC backstop authority to implement time-of-day pricing if states will not.

Congress should direct state PUCs to initiate proceedings to implement time-of-day retail pricing plans for electricity, including electricity used to recharge vehicles. This should occur as soon possible, but no later than 2015 for customers with smart meters. While it is uncommon for Congress to order state public utilities commissions to undertake specific proceedings, it is not unprecedented.[86] Congress should grant FERC backstop authority to develop electricity tariffs in the event that a state public utility commission fails to develop and implement qualifying pricing plans by the statutory deadlines.

Though widespread electrification of transportation will undoubtedly require power sector expansions and improvements, the costs are likely to be smaller than those associated with the wholesale creation of dedicated production and delivery infrastructure for biofuels, compressed natural gas, or hydrogen. Electric vehicles also have the potential to add resiliency to a smart grid, since their batteries could store electricity in distributed fashion and feed this power back into the grid upon automated request during emergencies. In many scenarios, the ability to utilize distributed electric vehicles for storage could prevent power quality interruptions and even blackouts — events whose total annual cost has been estimated at more than $100 billion.[87]

RECOMMENDATION

Require utilities to install smart meters for all new installations after specified date.

The smart grid cannot achieve its promise without the installation of advanced electrical meters that enable such communications and also are capable of metering electricity so that it may be sold based on a time-of-day or real time rate. There is a federal role for facilitating this residential system efficiency, just as there is a federal role in ensuring uniform consumer appliance efficiency standards. In order to accelerate the installation of "smart meters" that will be an integral part of the smart grid, Congress should require that all meters installed after 2015 meet minimum requirements for operating in a smart grid environment and that all existing meters be converted to smart meters by 2035.

86 Under PURPA, Congress directed state PUCs to engage in ratemaking cases to determine the avoided cost of power generated by regulated utilities, and then required utilities to pay independent power producers for power they generated at the avoided cost rate.

87 NETL, "NETL modern grid initiative".

Reforming the Biofuels Programs

Increasing the supply of renewable liquid fuels such as ethanol and biodiesel has been a focus of U.S. energy policy for several decades. Since the late 1970s, Congress has provided tax incentives to spur production. The current credit, recently modified by the Food, Conservation, and Energy Act of 2008, remits $0.45 for each gallon of ethanol that is blended with gasoline. More recently, the government has begun to mandate the production of biofuels, including ethanol, while maintaining a broad policy of tax incentives. EPAct 2005 imposed a Renewable Fuels Standard (RFS) in order to guarantee a growing market for biofuels. EISA expanded the RFS, setting a target of 36 billion gallons by 2022, with at most 40 percent to be derived from conventional corn-based ethanol. On an energy basis, 36 billion gallons of ethanol is equivalent to 24 billion gallons of gasoline, or approximately 1.3 MBD of oil.

Tax incentives and mandates have contributed to the rapid expansion of the ethanol industry, and, in 2007, the United States produced 6.5 billion gallons,[88] up from less than 1 billion gallons only fifteen years ago.[89] Still, even at this production level, biofuels remain a niche substitute, satisfying less than one-twentieth of U.S. transportation fuel consumption by volume. Pursuant to the RFS, annual U.S. ethanol production is expected to reach 9 billion gallons in 2008, almost all derived from corn. Using current production methods, even 9 billion gallons of ethanol will absorb 27 percent of the nation's corn crop. Some have suggested that this tremendous incremental demand has driven up prices for this staple food crop and triggered inflationary ripples throughout an economy that is also suffering from higher oil prices.[90] In April 2008, the state of Texas petitioned the Environmental Protection Agency (EPA) to waive the ethanol quota, claiming that economic hardship was being inflicted upon competing corn consumers such as cattle ranchers.[91] The petition was denied, but questions about the societal cost of ethanol are likely to persist as long as corn continues to be the dominant feedstock.

Corn ethanol has also been criticized for its energy and greenhouse gas profiles. To properly account for ethanol's costs and benefits, processing energy (usually in the form of natural gas but often enough from coal) and yield-boosting fertilizer inputs must be included in the equation. As more and more U.S. acreage is devoted to corn cultivation in order to satisfy demand for ethanol feedstock, there have been follow-on impacts on land use both in the United States and around the world. For instance, declining U.S. soybean acreage may have led to compensating production in previously untilled areas in tropical countries, with consequent releases of carbon into the atmosphere. If such land use contingencies are factored in, ethanol's environmental benefits may actually be less than zero.

Ethanol is also not a perfect substitute for gasoline. Gallon for gallon, it contains only two-thirds the energy of its oil-based counterpart; thus, all other factors being equal, a car running on ethanol will have to refuel more frequently. Moreover, pure ethanol's corrosive properties prevent it from sharing the pipelines and tanks used for gasoline distribution, and so each incremental gallon creates a need for an independent infrastructure, usually in the form or trucks and barges, which of course adds to the product's final cost.

The supply of increasingly cost-competitive and emissions-reducing biofuels is projected to eventually displace approximately 20 percent of total gasoline supply by energy content. For the near-term, however, biofuels must be understood, with perspective and proportionality, as blending components, rather than as one-for-one substitutes for gasoline. E-85 absorbs less than 1 percent of all biofuels produced, and because of the need for capital intensive infrastructure conversions, it is not a primary pathway to the alleviation of oil imports.

88 Renewable Fuels Association, "Industry statistics," http://www.ethanolrfa.org/industry/statistics/, last accessed 26 August 2008.
89 Oak Ridge National Laboratory (ORNL), Center for Transportation Analysis, "Table 2.7: Historic fuel ethanol production," http://cta.ornl.gov/bedb/biofuels/ethanol/Historic_Fuel_Ethanol_Production.xls, last accessed 26 August 2008.
90 Bernstein Research, "U.S. machinery & capital goods: EPA could waive ethanol quota shortly. Is this the end of corn-based ethanol?" 4 August 2008, 9.
91 Ibid., 4.

At the retail level, blended mixtures of 10 percent ethanol and 90 percent gasoline are compatible with existing distribution equipment and conventional cars, but the saturation level for 10 percent blending will be reached within four years if the current RFS mandate is fulfilled. The Department of Energy and EPA are midway through testing and performance validation of unmodified gasoline engines running on intermediate-level blends. If initial results are borne out, the existing vehicle stock will be able to use these blends without modification. For new vehicles, minor engine and fuel-line modifications would allow the use of all blends. For individual vehicles, these modifications are inexpensive, on the order of $100.

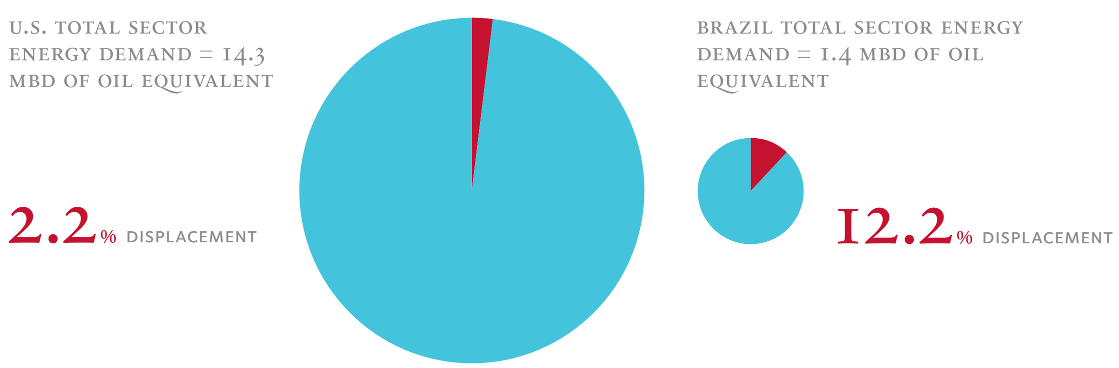
So-called third-generation biofuels have the potential to match the molecular structure and performance characteristics of hydrocarbon fuels, eliminating the corrosion and energy content issues and obviating the need for expensive infrastructure changes.

Advanced biofuels may alleviate many of the problems associated with corn-based ethanol. Cellulosic ethanol, classified as a second-generation biofuel, will leverage waste materials and other feedstocks that do not figure centrally in the food supply. Greater per acre yields achieved through processing of the entire plant (rather than through increased fertilizer consumption) could lead to marked improvements in ethanol's fossil fuel energy balance. No longer based on alcohol chemistry, so-called third-generation biofuels have the potential to match the molecular structure and performance characteristics of hydrocarbon fuels, eliminating the corrosion and energy content issues and obviating the need for expensive infrastructure changes. Processes such as Aqueous Phase Reforming (APR) do not require a fermentation cycle and may be able to leapfrog commercial production of cellulosic ethanol, which has been hampered by lagging development of critical enzymes.

In its 2006 *Recommendations*, the Council called for mandates and incentives to advance the development of an ethanol-compatible distribution infrastructure. With vehicle electrification emerging as a technologically feasible near- and medium-term strategy for dramatically reducing oil dependence, the Council has reassessed its position. National resources should be focused on electrification infrastructure needs, rather than on building a dedicated biofuels delivery network that will be superfluous if third-generation renewable fuels achieve their promise. In the meantime, ethanol should be blended with gasoline to offset oil consumption to the maximum extent possible while minimizing new infrastructure requirements.

By adding liquid fuels to the market, biofuels can reduce upward price pressure on their substitute—oil. Nevertheless, there is no plausible scenario under which the United States will be able to supply all or even most of its liquid fuel needs using ethanol or other biofuels. As long as liquid fuels still dominate the energy mix of the transportation sector, their price will be determined by the marginal gallon of fuel; this marginal gallon will be oil-based and chiefly determined by the price of oil in a global market.

DISPLACEMENT OF CONVENTIONAL FUELS BY ETHANOL (2007)*



— The U.S. and Brazil currently produce nearly the same quantity of ethanol. But since transportation fuel demand is so much greater in the U.S., ethanol displaces a far smaller share of oil use in the U.S. than in Brazil. Third generation biofuels, which will be compatible with today's energy infrastructure, may significantly improve on the ability of biofuels to displace oil consumption.

* EIA, AEO (2008), Table A35; EIA, *International Energy Outlook 2008* (June 2008), Table F18.; International Energy Agency, Medium-term oil market report (July 2008), 62.

RECOMMENDATION

Shift focus of biofuels deployment by concentrating on R&D and commercialization efforts on next-generation biofuels, fostering competition among fuels derived from differing feedstocks.

The federal government should expand research and development programs to expedite the eventual deployment of next generation biofuels. Many of the most promising third-generation fuels will obviate the need for expensive infrastructure changes required by ethanol, because the molecular structure of the fuels will not exhibit the especially corrosive properties of ethanol. At the same time, because the production of advanced biofuels is potentially much more efficient than the production of corn ethanol, advanced biofuels should offer a far more positive net energy balance. By developing and commercializing advanced biofuels, the United States can help reduce oil dependence in a cost-effective and environmentally sustainable manner that also increases the diversification of our energy supplies.

RECOMMENDATION

Require increasing production of Flexible Fuel Vehicles (FFVs).

New vehicles can be designed to run on E85 for a modest cost (roughly $100 per vehicle). The automotive industry should be required to steadily increase the production of FFVs by 10 percentage points per year so that all major production models are ethanol capable by 2017. Although the Council believes that third-generation biofuels will eventually eliminate the need for FFVs, mandating their production will provide near-term flexibility for various technological paths at a relatively small cost.

RECOMMENDATION

Accelerate Department of Energy and Environmental Protection Agency (EPA) testing and performance validation of unmodified gasoline engines running on intermediate-level, first- and second-generation biofuels blends.

Steady demand growth for alternative liquid fuels can be assured through progressively greater blending of biofuels into gasoline and diesel, steps that will require full certification of intermediate blends such as E-15 and potentially E-20. Today, every pump in America is certified to use blends up to E-15 safely and seamlessly and without any conversion costs. Similar testing is underway to validate E-20. Engine testing and certification will also be necessary, and DOE and EPA should be directed to accelerate their efforts in this regard.

RECOMMENDATION

Replace the 45-cents-per-gallon ethanol tax credit with a 'smart subsidy.'

Ethanol blenders in the United States, predominantly major oil companies, currently receive a tax credit of $0.45 per gallon. The subsidy is arguably unnecessary, since the ethanol industry has a guaranteed market as a consequence of the RFS. More important, the tax credit is divorced from specific production costs and feedstock technologies and thus fails to incentivize advanced technology producers or to guard against windfall profits. With respect to corn-based ethanol, the tax credit should be replaced with a variable subsidy that accounts for industry profitability by means of ratable reductions and eventually elimination when the benchmark price of oil rises above specified prices. Full access to the subsidy should be available if oil prices fall so far as to threaten the viability of the nation's biofuels industry.

RECOMMENDATION

Eliminate tariffs on imported ethanol over a period of three years.

Ethanol sold in the United States is protected from foreign competition by an import duty of $0.54 per gallon. As with ethanol subsidies, it is difficult to justify a policy that serves to increase the price of ethanol even when oil prices are high and the profitability of the domestic biofuels industry is not in question. Therefore, the tariff on imported ethanol should be eliminated.

PART II

Increasing Energy Access: Expanding Domestic Supply

The United States possesses significant reserves of oil and gas that can be developed in the coming years and used to directly offset imports and help fund a transition away from oil. Combined with measures to increase efficiency and diversify fuels in the transportation sector, producing more of our energy domestically will lead to enhanced energy security for the United States.

II. Increasing Energy Access: Expanding Domestic Supply

Today, every single barrel of spare world oil production capacity resides within OPEC, the overwhelming portion in Saudi Arabia. As world oil consumption continues to rise and OPEC production capacity fails to keep pace, the margin between supply and demand is slowly eroding, increasing the likelihood that a sudden supply interruption could destabilize the global economy. As urgent as this risk is to the United States and the world's oil consumers, the future outlook is perhaps even more alarming.

While OPEC countries today account for just over 40 percent of daily world oil production, the International Energy Agency (IEA) predicts that by 2030 their share will need to rise above 50 percent in order to meet rapidly rising world demand. Reaching this level of production will require trillions of dollars in oil and gas infrastructure investments and, moreover, a long-term commitment by OPEC to expand current production capacity. Even assuming such capital and commitment are mobilized, political risk and instability in key oil-producing nations such as Iraq, Iran, Nigeria and Venezuela add a substantial measure of uncertainty to the future of the global oil supply.

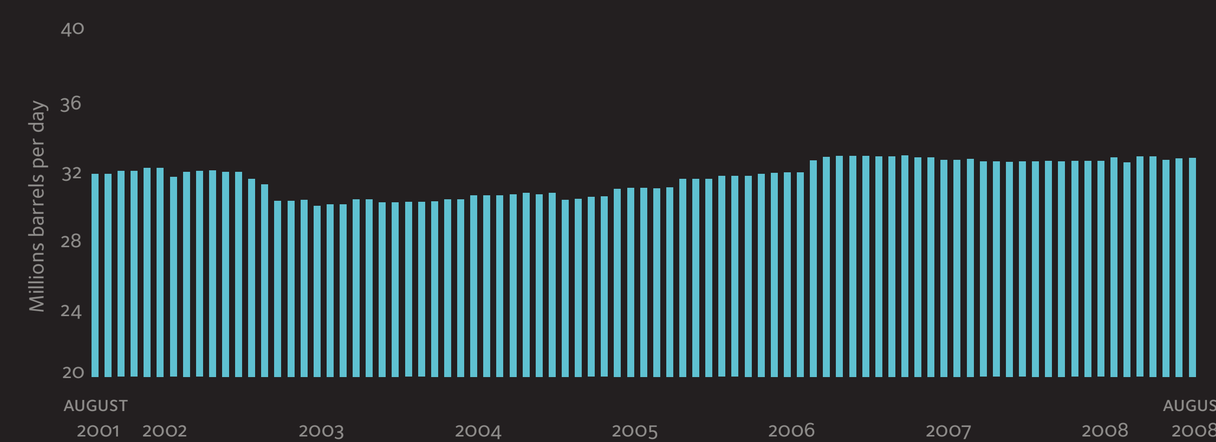
In 2006, the Council wrote that the United States faced an alarming threat from oil dependence. With each passing year, a variety of global trends were combining to increase the likelihood that this nation would face an energy crisis. Today, that energy crisis is upon us. It has come not on the heels of a major terrorist attack or as a result of war involving a major oil producer. Rather, the present energy crisis is the result of steadily rising worldwide demand for energy, weak annual growth in world oil production, rising infrastructure costs, and persistent political instability in a wide range of oil producing nations. These are fundamental characteristics of the global oil market and are likely to persist over the long term.

As world oil consumption continues to rise and OPEC production capacity fails to keep pace, the margin between supply and demand is slowly eroding, increasing the likelihood that a sudden supply interruption could destabilize the global economy. As urgent as this risk is to the United States and the world's oil consumers, the future outlook is perhaps even more alarming.

To be clear, mitigating—and eventually eliminating—the threat posed to the United States by its dependence on oil will require a multifaceted approach focused on reducing demand for petroleum products. Demand reduction on the scale required can only be achieved by implementing the transformative public policies that are outlined throughout this report. In particular, the promotion of advanced biofuels and vehicle electrification offer the greatest promise of ending U.S. dependence on liquid fossil fuels. While technological barriers remain to be overcome in both these areas, the Council is confident that research and development will yield the necessary technological advances and, moreover, that the commercialization timeframes for these technologies can be accelerated.

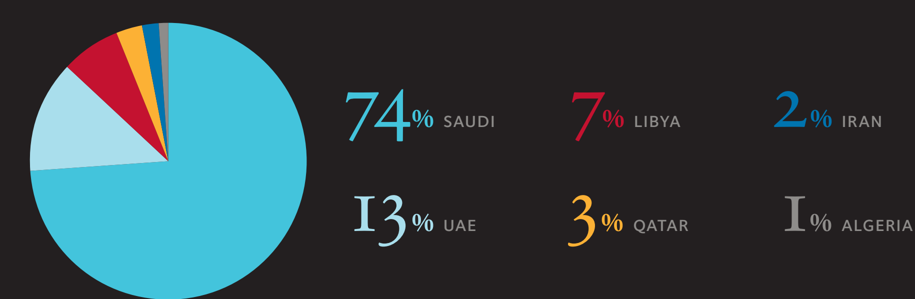
Despite possessing 75 percent of the world's conventional oil reserves, OPEC nations provide just 40 percent of daily global oil supply. OPEC investments in expanding production capacity have consistently fallen short of expectations. From 2001 to 2007, while world oil demand increased by 11 percent, production capacity from the OPEC-10 and Iraq increased by just 3 percent.

OPEC SUSTAINABLE PRODUCTION CAPACITY



IEA, *Oil Market Report*, (2001-2008)

EFFECTIVE OPEC SPARE CAPACITY*

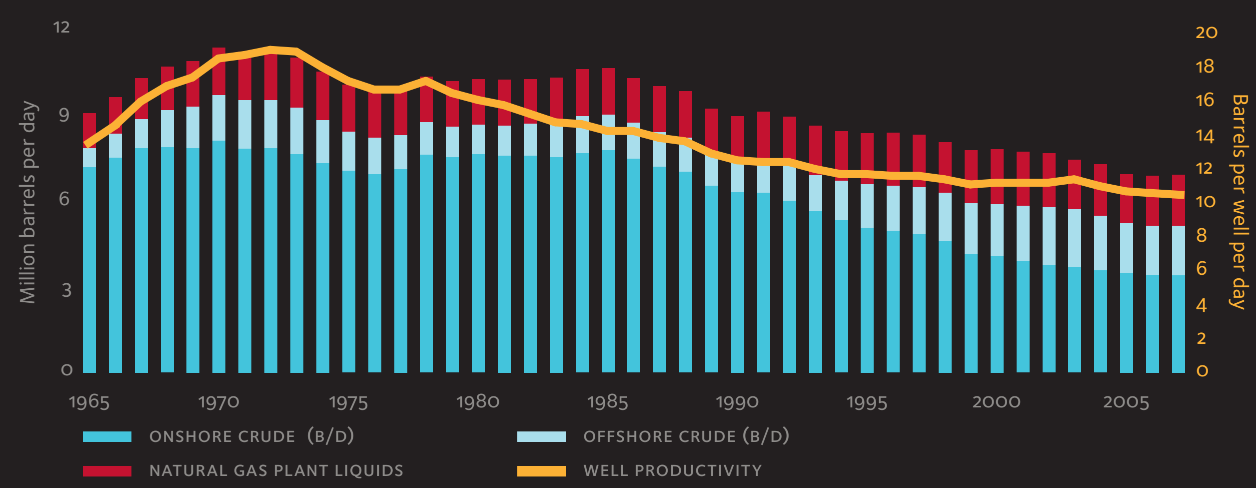


IEA, *Oil Market Report*, (12 August, 2008)

* Effective spare capacity includes only that capacity which could realistically be brought on line in 90 days.

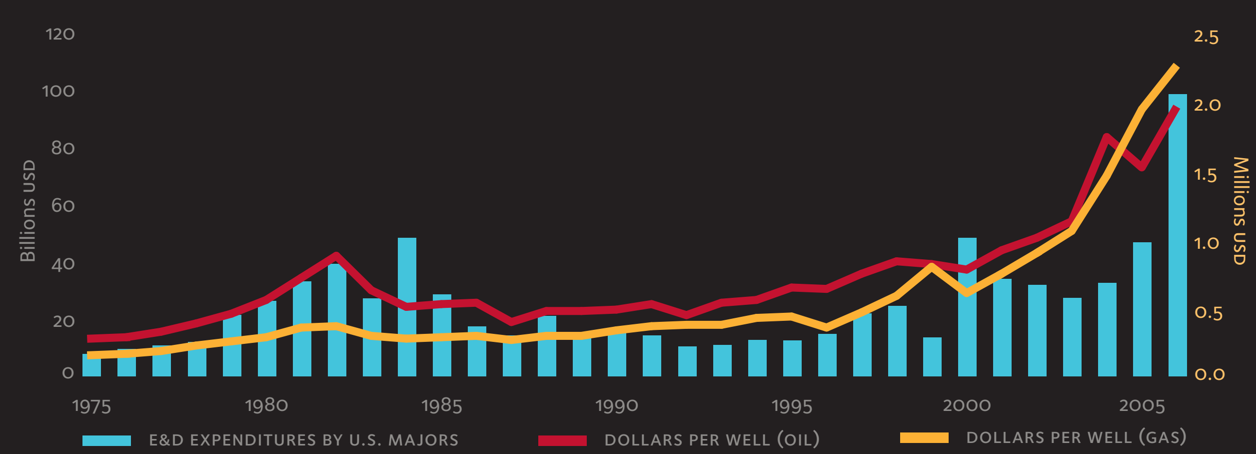
U.S. oil production peaked in 1970 at over 11 million barrels per day. Since then, well productivity has rapidly declined along with overall output. Moreover, U.S. oil and gas development costs have surged in recent years as 'easy' oil has proven difficult to find, and new areas for development are held off-limits.

CRUDE OIL PRODUCTION AND WELL PRODUCTIVITY (1965–2007)



U.S. Department of Energy, *Annual Energy Review 2007; Annual Energy Outlook 2008*

U.S. COSTS OF DEVELOPMENT



U.S. Department of Energy, *Annual Energy Review 2007; Annual Energy Outlook 2008*

But even assuming rapid progress toward increased biofuels production and vehicle electrification, the United States will still require significant quantities of oil over the coming decades. In order to responsibly transition our national economy to a post-oil transportation sector and a low-emissions electricity sector, the Council is convinced that the United States must increase domestic production of oil and natural gas through innovative technologies and expanded access to off-limits areas. The supply side of the energy equation must be part of any meaningful strategy for energy security.

U.S. OIL PRODUCTION

From its peak of 11.3 MBD in 1970, U.S. oil production has fallen nearly 40 percent as older fields in Alaska, Texas, and Louisiana have experienced natural decline and new conventional discoveries have become increasingly rare and more costly to develop. Still, the United States continues to play a critical role in global oil production. In 2007, U.S. oil production was nearly 6.9 MBD, consisting of 5.1 MBD of crude oil and 1.8 MBD of natural gas plant liquids (NGLs).[92] At this level of output, the United States accounted for approximately eight percent of world oil production, ranking third behind only Saudi Arabia and the Russian Federation. U.S. production is all the more impressive considering that the nation possesses less than three percent of global proved reserves of conventional oil, compared to 6.4 percent for Russia and 21.3 percent for Saudi Arabia.[93]

Still, U.S. oil production is greatly outpaced by end-use consumption, which is in excess of 20 MBD. After accounting for domestic refinery gains, biofuels production, and other inputs, the United States imported 58 percent of its aggregate oil needs in 2007.[94] Nearly 20 percent of net U.S. imports originated from nations in the Persian Gulf region and 45 percent of imports originated from OPEC member-states.[95] Imports were necessary even before U.S. oil production reached a plateau and then began its decline; indeed, import levels have risen steadily for more than 50 years.

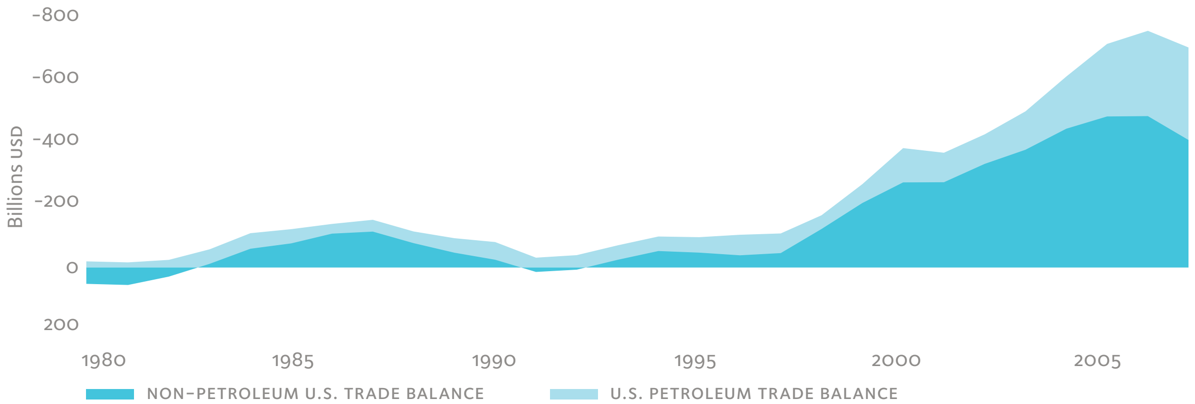
OIL IMPORTS AND THE ECONOMY

Oil is a fungible, global commodity. Prices are set in open markets, and individual customers pay the same amount for a given volume of a specific variety of crude. In this sense, there is essentially no such thing as 'foreign' oil. As world crude oil prices increase or decrease, they are paid by all countries, regardless of whether the oil is domestically produced or imported. If this were not the case, markets would quickly identify arbitrage opportunities and exploit them, eventually restoring price equilibrium.

But even though oil pricing is global, oil imports do present a unique set of dangers to the domestic economy. Over the past several years, oil imports have contributed to a significant widening of the U.S. trade deficit. In 2002, before world oil prices began their rapid ascent, oil imports represented just 22 percent of the total deficit. In 2007, net U.S. oil imports were valued at approximately $295 billion—more than 40 percent of the total deficit in goods and services.[96] In 2008, with world oil prices at historical records in both real and nominal terms, U.S. oil import costs are on pace to exceed any previous level by a wide margin. The total impact of these costs on the U.S. economy is difficult to measure, but without doubt high oil prices and rising import expenditures have contributed to a depreciating dollar and a weaker overall economy.

92 EIA, *AER* (2007), Table 5.1.
93 BP (2008)
94 Import data are from DOE, EIA. Oil import percentage is calculated as Net Oil Imports as a percentage of Product Supplied.
95 EIA, *AER* (2007), Table 5.4.
96 Ibid., Table 3.9.

OIL AND THE U.S. TRADE DEFICIT



U.S. Department of Commerce, Bureau of Economic Analysis; and DOE, *AER* (2007)

NATURAL GAS

Unlike the situation with oil, where imports outweigh domestic production, the United States today supplies 80 percent of its domestic natural gas demand. U.S. natural gas consumption in 2007 amounted to 23 trillion cubic feet (TCF). Net imports totaled 4.0 TCF, with 3.1 TCF sourced from North America and the rest—roughly 3 percent of U.S. natural gas consumption—being imported as liquefied natural gas (LNG). Over the coming decades, Department of Energy (DOE) base case scenarios hold U.S. natural gas demand relatively constant, with consumption peaking near 24 TCF in 2016 and then slightly declining to fall below 23 TCF in 2030. Current projections also hold U.S. gas production essentially constant near 19.5 TCF. As a result, 2030 imports remain just over 3.1 TCF.[97]

The nature and origin of U.S. gas imports, however, are expected to change in the coming years. Geology and regulatory delays are expected to contribute to a 65 percent decrease in U.S. gas imports via pipeline from Canada, resulting in a significant shift toward LNG imports. In DOEs base-case modeling, LNG imports reach 2.4 TCF in 2020 and 2.8 TCF in 2030—or approximately 13 percent of U.S. gas supply.[98]

U.S. oil production is greatly outpaced by end-use consumption, which is in excess of 20 MBD. After accounting for domestic refinery gains, biofuels production, and other inputs, the United States imported 58 percent of its aggregate oil needs in 2007. Nearly 20 percent of net U.S. imports originated from nations in the Persian Gulf region and 45 percent of imports originated from OPEC member-states.

These projections do not model the impact of legislation to regulate the emission of anthropogenic greenhouse gases. Many analysts look to natural gas as the future of low-carbon, cost-effective electricity generation in the United States, especially if the nuclear power and advanced coal with CCS options do not come on line at the required rate. Placing a cost penalty on high-carbon fuels could drive U.S. gas demand higher, ultimately leading to growing U.S. dependence on the global market for LNG. Without access to natural gas resources in Alaska and beneath the Outer Continental Shelf (OCS) or continued expansion in the production of unconventional shale gas, the United States could become dependent on a global gas market whose chief suppliers will be Iran, Russia, Nigeria, and a host of other countries in North Africa, Central Asia and the Middle East.

97 EIA, *AEO* (2008), Table A13.
98 Ibid., Figure 82.

While natural gas prices in the United States averaged $10 per million BTU in the summer of 2008, prices in Asia and Europe reached much higher levels near $15 per million BTU.[99] The high prices reflect the fact that many of the world's emerging economies are steadily increasing their use of natural gas but are without sufficient domestic resources. As a result, global demand for LNG is rapidly rising, with construction of gasification terminals far outpacing construction of liquefaction facilities. The slow expansion of liquefaction capacity partially reflects high capital costs, but it is also a function of the geopolitics of natural gas. Together, Russia and the nations of OPEC possess more than 75 percent of the world's gas reserves.[100] Just as with oil supplies, instability, corruption, mismanagement, and political imperatives have driven a wedge between natural gas production and the free-market ideal.

A NOTE ON RESERVES AND RESOURCES

Current U.S. proved conventional oil reserves are 29.4 billion barrels, or about 2.4 percent of the world total. Proved natural gas reserves are 204.4 TCF, or about 3.4 percent of the world total. These figures place the current U.S. reserves-to-production ratio at 11.7 years for oil and 10.9 years for natural gas. However, proved reserves alone present an incomplete and inaccurate picture of a nation's total resource potential. Reserves classification is a difficult and complex endeavor and depends heavily upon underlying assumptions regarding technology, energy prices, and government regulations.

NATURAL GAS (TRILLION CUBIC FEET)

		Inaccessible on Federal Territory	Total
Proved Reserves	All Sources		204.4
Onshore Conventional (UTRR)	Lower 48	25.9	166.8
	Alaska	55.5	126.8
Onshore Unconventional/ Continuous* (UTRR)	Lower 48	43.2	560.6
	Alaska	–	18.1
Offshore (UTRR)	Lower 48	76.5	287.8
	Alaska	–	132.1
Total		**201.1**	**1496.6**

OIL (BILLION BARRELS)

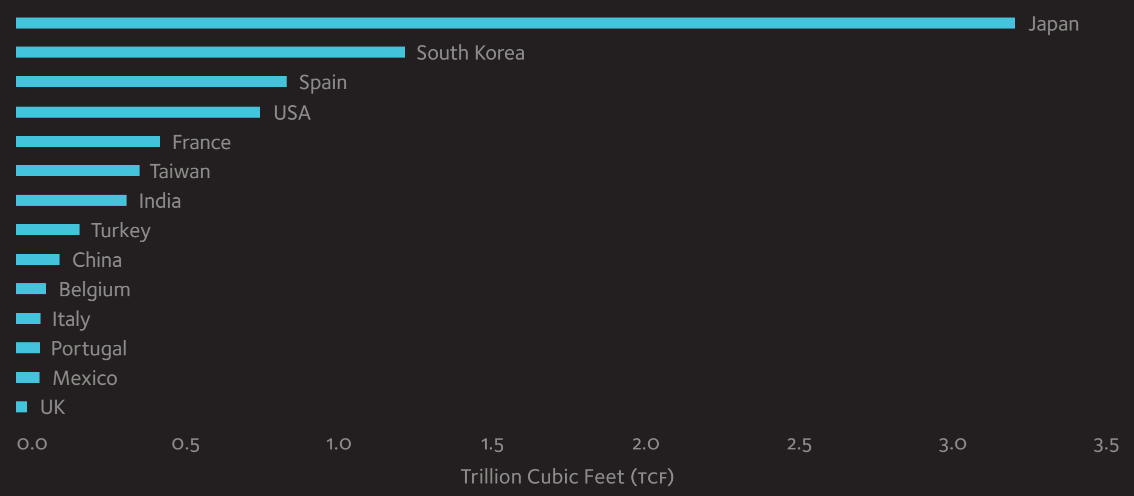
		Inaccessible on Federal Territory	Total
Proved Reserves	All Sources		29.4
Onshore Conventional (UTRR)	Lower 48	5.3	21.2
	Alaska	13.7	28.3
Onshore Unconventional/ Continuous** (UTRR)	Lower 48	0.6	7.3
	Alaska	–	–
Offshore (UTRR)	Lower 48	17.8	59.2
	Alaska	–	26.6
Total		**37.4**	**172.0**

Source: EIA, USGS, DOI et al, BP p.l.c.

99 ARC Financial, *Weekly Energy Charts*, 18 August 2008, Chart 27 and 31; Angela Macdonald-Smith, "LNG price may gain 80% on plant delays, export cuts," *Bloomberg Press*, 15 August, 2008.
100 BP (2008).
* Total includes gas from shales, coal bed methane, and tight gas sands.
** Total does not include 626 billion barrels of technically recoverable oil from shale deposits in the Western U.S. Viability of these resources will be highly dependent on a range of environmental, economic and technological constraints. Up to 80 percent of Western U.S.oil shales are beneath federal lands.

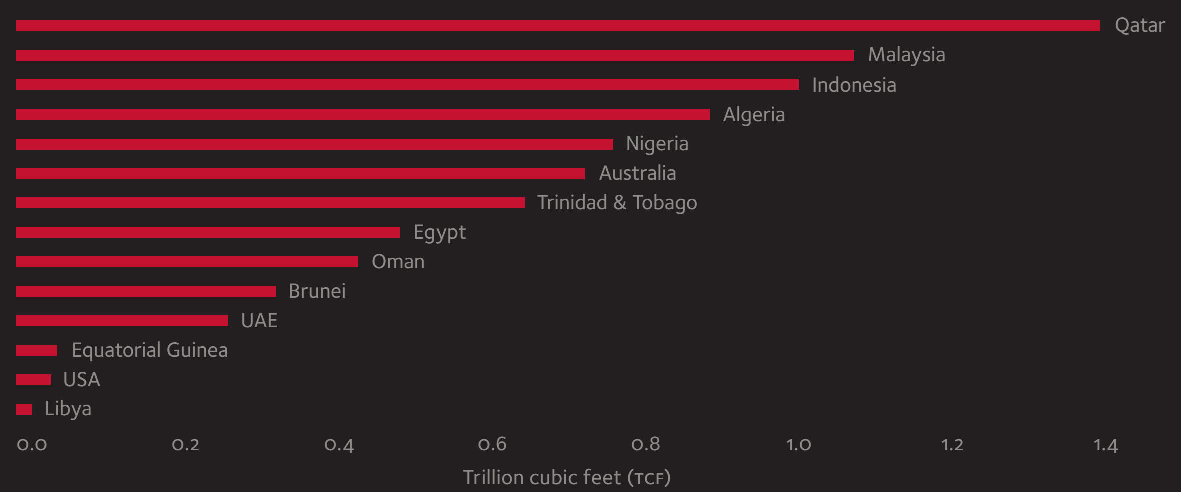
The U.S. is currently the world's fourth largest importer of LNG. As demand for natural gas rises, the U.S. could be forced to import larger quantities. This raises important strategic questions, as the global LNG market will be dominated by many of the same nations that supply oil in today's petroleum market.

TOP LNG IMPORTERS (2007)



BP p.l.c., *Statistical Review of World Energy* (2008)

TOP LNG EXPORTERS (2007)



BP p.l.c., *Statistical Review of World Energy* (2008)

In addition to its proved natural gas reserves, the United States possesses significant resources of unconventional natural gas trapped in low-permeability geological formations and absorbed into coal and other organic matter. As new drilling and recovery technologies have become available, and as the price of natural gas has risen, these resources have come to play an increasingly important role in U.S. natural gas production. In 2006, unconventional gas production accounted for more than 40 percent of the U.S. total, up from approximately one-fourth of total production just 10 years earlier.[101]

The United States also has significant unconventional oil resources, particularly oil shale. By some estimates, nearly 1 trillion barrels of in-place oil exist in the shallow reservoirs of the Green River, Uinta, and Piceance Basins near the common border of Colorado, Utah, and Wyoming. A 2007 report by the National Petroleum Council estimated that 626 billion barrels of this oil could eventually be recovered.[102] While current recovery technology for shale oil is not environmentally sustainable, emerging extraction techniques and the potential for carbon capture and storage systems may eventually allow these resources to significantly enhance the energy security of the United States.

Unquestionably, the United States possesses resources that could be used to halt the steady decline in domestic oil production and to ensure a future in which our electrical power needs are fueled by stable domestic energy supplies.. Accessing and developing these natural gas and oil resources will require a clear vision and direction from the federal government. Some of these resources are currently off-limits due to legislation, including offshore conventional resources beneath the Outer Continental Shelf and significant onshore resources in Alaska. Other resources will require a stable regulatory framework in which the private sector can make long-term investment decisions regarding technology and infrastructure. By establishing a clear regulatory framework, offering appropriate incentives, and expanding access to resources currently off-limits, government policy can foster an environment in which the best technologies and most efficient extraction techniques are matched with the best resources.

PRIMARY RECOMMENDATION

Target federal policy and resources to encourage the expanded use of CO_2 for enhanced oil recovery.

PROJECTED INCREASE FROM ENHANCED OIL RECOVERY (EOR): 1.0 MBD

Throughout its productive life, an oil reservoir transitions through three distinct recovery phases. In the primary phase, naturally existing gas pressure and gravity deliver oil to the wellhead where it can be pumped to the surface. Typically, primary recovery techniques yield 10 percent of the oil in place (OIP). During secondary recovery, the reservoir is subjected to water flooding or injection of additional natural gas to maintain pressure and continue the flow of oil to the wellhead. These secondary recovery techniques (which in practice are often utilized as primary recovery techniques) can increase the total recovery rate to as high as 40 percent. Still, this leaves at least 50 percent of the original OIP behind, or 'stranded'.

In an effort to develop the remaining 50 percent of OIP that exists after primary and secondary recovery, oil producers can turn to tertiary recovery, also known as enhanced oil recovery (EOR). EOR techniques attempt to reduce the viscosity of non-flowing oil by subjecting it to heat and pressure or by mixing it

101 Vello A. Kuuskraa, Advanced Resources International (ARI), "A decade of progress in unconventional gas," 24 July 2007, http://www.adv-res.com/pdf/ARI%20OGJ%201%20Unconventional%20Gas%20Progress%207_24_07.pdf, last accessed 27 August 2008.

102 National Petroleum Council (NPC), Global Oil and Gas Study, "Working paper #27: oil shales," 18 July 2007, 4.

with supercritical gases, increasingly CO_2. In 2008, total oil produced from all EOR projects in the United States averaged 643,000 barrels per day—about 10 percent of U.S. production.[103]

Historically, the injection of steam, known as thermal EOR, has been the most widely applied method. In 1990, there were 154 individual thermal EOR projects in the United States, yielding incremental production of over 450,000 barrels per day. Over time, as new and more effective methods have become available, thermal use has declined—in 2008 there were just 60 such projects yielding 250,000 barrels per day.[104]

Over the same time period, more advanced EOR methods have become available and put into practice. When subjected to increased pressure and temperature, CO_2 can retain the properties of a gas while reaching the density of a liquid. In this 'supercritical' state, CO_2 injected into a reservoir essentially mixes with liquid hydrocarbons, reducing viscosity and increasing flow to the wellhead. In 1990, there were 52 EOR projects in the United States utilizing this 'miscible' CO_2 technique, resulting in incremental oil production of 96,000 barrels per day. By 2008, the number of such projects had doubled and output reached 250,000 barrels per day.[105] Recent estimates place the amount of technically recoverable oil from CO_2 EOR at 84.8 billion barrels (more than 10 years of total U.S. consumption at the current rate and more than double current proved reserves).[106]

Unquestionably, the United States possesses resources that could be used to halt the steady decline in domestic oil production and to ensure a future in which our electrical power needs are fueled by stable domestic energy supplies. Accessing and developing these natural gas and oil resources will require a clear vision and direction from the federal government.

However, oil production using CO_2 EOR is currently restricted by its heavy reliance on naturally occurring reservoirs of carbon dioxide and a small but growing number of industrial gas plants designed to service the EOR market (mostly in the Permian Basin of Texas and New Mexico). Given the scale of the stranded oil resource base of the United States, a more robust market for CO_2 would likely lead to a significant increase in the number of CO_2 EOR projects and consequently to an increase in oil production from such projects.

Currently, most U.S. CO_2 EOR occurs in the Texas, where carbon dioxide is sourced from natural reservoirs in the western United States. Pipelines carry the CO_2 at pressure to oilfields where it is injected into the oil reservoir. This CO_2 is then produced along with the oil, from which it is separated. At this point the CO_2 can be vented into the atmosphere or reinjected into the reservoir and permanently stored for emissions mitigation.

EOR AND CARBON MITIGATION

There is no carbon emissions benefit from an EOR project that uses naturally occurring CO_2 to extend the productive life and improve the yield of an oil reservoir. However, if CO_2 is captured and transported from large-point anthropogenic emitters—such as power plants and certain industrial facilities—there is a potential for environmental benefits. Compared with oil produced from a conventional field, oil produced by means of an integrated EOR carbon capture and storage (CCS) system could have lifetime emissions that are between 40 and 80 percent lower.[107]

103 Oil and Gas Journal (OGJ), *Survey of enhanced oil recovery projects*, 21 April 2008, 47, Table 1 and 2.
104 Ibid.
105 Ibid.
106 ARI, report for the NETL, "Storing CO_2 with enhanced oil recovery," (2008), 27.
107 ARI, "Storing CO_2," 7; NPC, "Working paper #17: carbon capture and storage," (2007), 44.

The electric power sector, particularly coal-fired electric power plants, represents the most significant large-point source of CO_2 emissions in the United States. A conventional one-gigawatt coal plant produces roughly six million tons of CO_2 per year. Advanced combined cycle coal plants utilizing gasification technologies could provide a ready-made source of marketable CO_2 for storage in oil and gas fields as part of enhanced oil recovery. This CO_2 presents the United States with an important opportunity to increase energy security while addressing concerns about global warming.

The United Nations Intergovernmental Panel on Climate Change (IPCC) estimates that 99 percent of the CO_2 stored in appropriately selected reservoirs can be safely sealed and stored for more than one thousand years. The IPCC suggested that the global carbon dioxide storage potential for geological formations could range from 1,859 gigatons to 11,325 gigatons, depending on the viability of deep saline formations.[108] Ultimately, EOR utilizing CO_2 will only offer a small fraction of the required offsets in carbon emissions envisioned by most climate change abatement scenarios, but these projects can function as a learning and proving ground for more ambitious CCS technologies while significantly increasing oil production.

It should also be noted that the sale of CO_2 from advanced coal power generation facilities to EOR projects could offer a significant cost offset. While estimates vary according to assumed feedstock prices and capital costs, a number of recent analyses point to the benefits of EOR in offsetting lifecycle costs of CCS in power generation. For example, the IPCC estimates electricity production costs with CCS and EOR to be roughly equal to a reference plant without CCS, whereas CCS on its own increases costs by between 25 and 33 percent.[109]

ELECTRICITY PRODUCTION COSTS WITH CCS AND EOR COMPARISONS (US$/KWH)

Power Plant System	Natural Gas Combined Cycle	Pulverized Coal	Integrated Gasification Combined Cycle
Without capture (reference plant)	0.03–0.05	0.04–0.05	0.04–0.06
With capture and geological storage	0.04–0.08	0.06–0.10	0.05–0.09
With capture and EOR	0.04–0.07	0.05–0.08	0.04–0.07

Source: UN IPCC

CHALLENGES TO DEPLOYING EOR

Although a fully integrated carbon capture and storage project has yet to be demonstrated at the commercial level, each of the required components has already been developed beyond the research phase. Transport and storage technologies are integrated in the oil and gas industry (pipelines and EOR projects being the most obvious examples), and several demonstrated capture technologies are economical given current market conditions.[110] The most significant hurdles to more widespread deployment of CO_2 EOR are a lack of regulatory certainty regarding carbon policy, inadequate transport infrastructure from large-point emitters, and the high capital costs of both pre-combustion capture and carbon dioxide purchased at the field level.

108 United Nations Intergovernmental Panel on Climate Change, *Carbon dioxide capture and storage* (2005), 31.
109 Ibid., 9.
110 Ibid., 7.

CCS Technologies Feasibility Comparison Chart

CCS Component	CCS Technology	1*	2*	3*	4*
Capture	Post-Combustion	○	○	●	○
	Pre-Combustion	○	○	●	○
	Oxyfuel Combustion	○	●	○	○
	Industrial Separation (natural gas processing, ammonia production)	○	○	○	●
Transportation	Pipeline	○	○	○	●
	Shipping	○	○	●	○
Geological storage	Enhanced Oil Recovery (EOR)	○	○	○	●
	Gas or oil fields	○	○	●	○
	Saline formations	○	○	●	○
	Enhanced Coal Bed Methane Recovery (ECBM)	○	●	○	○
Ocean storage	Direct injection (dissolution type)	●	○	○	○
	Direct injection (lake type)	●	○	○	○
Mineral carbonation	Natural Silicate minerals	●	○	○	○
	Waste materials	○	●	○	○
Industrial uses of CO_2		○	○	○	●

*KEY 1. Research Phase; 2. Demonstration Phase; 3. Economically feasible under specific conditions; 4. Mature Market

Source: UN IPCC

At some point in the future, the market alone will foster the large-scale use of CO_2 captured from power plants for EOR. Unfortunately, the restructured FutureGen program announced by the U.S. Department of Energy early in 2008 allows CCS for EOR only after storage of one million tons of CO_2 in saline reservoirs. Federal programs focused on CCS deployment should place CCS for EOR on a level footing with CCS in saline reservoirs without an oil-recovery potential. At the same time, the federal government should offer loan guarantees and tax incentives for the construction of CO_2 pipelines from major economic and industrial centers to regions populated with oil and gas fields.

RECOMMENDATION

Support federal investment in technologies that can limit the adverse environmental impacts of oil shale and coal-to-liquids (CTL) production to ensure long-term viability before undertaking public investment in production.

OIL SHALE

Worldwide, it is estimated that there are roughly 3 trillion barrels of shale oil in place.[111] Unlike other unconventional oils, oil shale has not been degraded by chemical or microbial exposure, and is instead organic kerogen that has not been subjected to the necessary heat and pressure required for natural

111 NPC, *Hard truths: facing the hard truths about energy* (2007), 202.

conversion to conventional oil. Shale oil is typically found close to the surface in outcroppings or at depths of up to 3,000 feet. U.S. oil shale deposits, concentrated on federal lands in Utah, Colorado, and Wyoming, are estimated to contain recoverable oil in excess of 600 billion barrels.[112]

The most basic extraction technology for shale oil is surface mining followed by retort—a process in which the shale is subjected to intense temperatures approaching 1,000 degrees Fahrenheit for short periods of time. This process then yields low quality crude which requires additional upgrading. The economic and environmental costs of the mine and retort process are significant. A single 50,000 barrel per day mine and retort facility can require between $5 billion and $7 billion in capital outlays.[113] Massive quantities of spent shale rock require disposal, and CO_2 emissions are higher than those of conventional oil extraction techniques. The mine and retort process also consumes a substantial amount of water and uses natural gas as a processing feedstock.

In recent years, *in situ* technology has offered the promise of a cleaner, more efficient shale mining process. In situ extraction entails heating the oil shale while it is still in the ground at lower temperatures over longer periods of time (several months). This process yields higher quality crude, which, in pilot-scale tests, has not required additional upgrading. It also avoids the environmental costs associated with the disposal of spent shale. On the other hand, in situ conversion techniques can pose risks to aquifers located near shale deposits and also result in greater CO_2 emissions than conventional petroleum extraction. In pilot-scale demonstrations, successful containment of the shale process from adjacent aquifers has proven feasible.

To date, federal research and development has yielded important progress on both CCS and coal gasification techniques, mostly as components of clean coal power initiatives. As further R&D advancements are made, it will be critical to demonstrate the feasibility of integrated carbon capture and storage in a commercial-scale setting.

COAL-TO-LIQUIDS

With 28 percent of the global total, the United States has by far the largest domestic reserves of coal in the world. The 242 billion tons of coal reserves beneath U.S. soil result in a reserves-to-production ratio of 234 years.[114] Technologies that would convert these resources into liquid fuels (coal-to-liquids, or CTL) could theoretically allow the United States to displace a portion of conventional petroleum consumption. Estimates range as high as 20 percent of the total U.S. petroleum market to as low as 1 percent, depending on a wide variety of economic factors.[115]

However, CTL is significantly limited at its current stage of development both by cost (currently estimated at $1 billion for every 10,000 daily barrels of annual production capacity) and by emissions of CO_2 and other pollutants.[116] The well-to-wheels emissions potential of coal-derived liquid fuels is estimated to be double that of conventionally produced fuels. Moreover, with approximately 50 percent of current U.S. electricity generation coming from coal, the impact of CTL demand on U.S. coal prices will be an important consideration. With existing market fundamentals, U.S. coal prices

112 NPC, "Working paper #27," 4.
113 RAND Corporation, *Oil shale development in the United States* (2005), 15.
114 BP (2008).
115 NPC, *Hard truths*, 205.
116 Ibid.

more than doubled from late 2007 to mid-2008.[117] Added pressure on the demand side from CTL could have notable implications for consumer electricity prices.

THE NEED FOR CCS

The Council does not advocate restrictions on the use of private funds to pursue unconventional oil alternatives. However, uncertainty about future oil prices and carbon mitigation policies makes it difficult to justify the allocation of significant public funding for unconventional oil production that might not prove viable over the long term. While the Council recognizes the energy security value of increased domestic fuel production, we remain clear-eyed about the economic and environmental profile of unconventional fuels. The marginal barrel of fuel produced from CTL and oil shale using existing technologies will cost up to 5 times as much as a conventional barrel. Moreover, these unconventional fuels will generate significantly greater quantities of carbon dioxide. The government can work to improve the cost-benefit equation of unconventional oil and liquefied coal by: 1) setting a clear carbon policy; 2) accelerating pilot-scale demonstrations of advanced coal gasification technologies and integrated carbon capture and storage facilities; and 3) promoting research into technologies that limit environmental impacts.

To date, federal research and development has yielded important progress on both CCS and coal gasification techniques, mostly as components of clean coal power initiatives. As further R&D advancements are made, it will be critical to demonstrate the feasibility of integrated carbon capture and storage in a commercial-scale setting. Integrating carbon capture and storage may ultimately allow for the necessary economic and environmental improvements that will deliver unconventional fuels to a carbon-constrained market.

RECOMMENDATION

Increase access to U.S. oil and natural gas reserves on the Outer Continental Shelf (ocs) with sharply increased and expanded environmental protections.

PROJECTED INCREASE IN OCS OIL PRODUCTION: 1.0 TO 2.0 MBD

PROJECTED INCREASE IN OCS GAS PRODUCTION: 1.0 TO 1.4 TCF

The United States possesses significant amounts of undiscovered technically recoverable resources (UTRR) of both conventional oil and natural gas.[118] According to a Congressionally-mandated 2007 inventory of these resources, total (onshore and offshore) undiscovered recoverable conventional and unconventional natural gas resources are at least 1,100 trillion cubic feet. Undiscovered conventional oil resources are approximately 140 billion barrels.

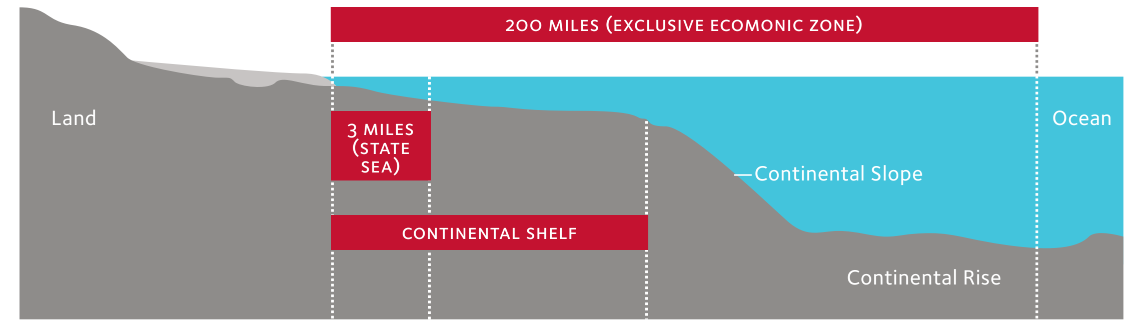
A significant portion of both undiscovered gas and oil rests beneath the waters of the federal Outer Continental Shelf—defined as that area of the seabed within the U.S. exclusive economic zone that extends from state waters out to 200 miles offshore. The U.S. Minerals Management Service (MMS) estimates mean OCS undiscovered recoverable oil resources to be 85.9 billion barrels and mean OCS natural gas UTRR to be 420 trillion cubic feet.[119]

117 DOA, EIA, "Coal news and markets," http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html#spot, last accessed 26 August 2008.

118 UTRR are defined as resources postulated, on the basis of geologic knowledge and theory, to exist outside of known fields or accumulations. These resources are capable of being produced by employing conventional primary and secondary recovery techniques. As undiscovered resources are ultimately explored, tested and proved to exist, they can become proved reserves.

119 U.S. Department of Interior (DOI), Minerals Management Service (MMS), *National assessment of undiscovered technically recoverable reserves of oil and gas*, (2006), 3.

FEDERAL OUTER CONTINENTAL SHELF (OCS)



Source: Congressional Research Service

In recent decades, offshore production in federal waters has come to play an increasingly important role in U.S. oil and gas production. As onshore conventional fields have gone into decline and offshore development has become more cost-effective, the percentage of U.S. oil and natural gas production coming from the federal OCS has steadily increased. In 1990, just 10 percent of U.S. crude oil production came from offshore federal waters. By 2004, the OCS share was averaging well over 28 percent in some months. Though the industry suffered significant damage and interruption during the 2005 hurricane season, by 2008 OCS crude production was once again responsible for over 25 percent of total domestic supply.[120] Moreover, as crude oil prices have increased and offshore technology has become more sophisticated, industry has achieved the flexibility to explore and produce at greater depths. In 1995, just 26.4 and 7.8 percent, respectively, of the crude oil and natural gas production on the OCS occurred at depths greater than 200 meters. By 2004, the numbers were 35.1 percent for gas and nearly 70 percent for oil.[121]

The offshore oil and gas industry has achieved this progress while maintaining a remarkable environmental record. According to MMS, the offshore oil and gas industry produced 10.2 billion barrels of oil between 1985 and 2007 with a spill rate of just .001 percent.[122] In recent years, as standards and technology have improved, the rate of incidents has steadily declined. A recent report by the Congressional Research Service found that the annual number of oil spills in U.S. coastal waters declined by 50 percent from 1995 to 2004. In fact, nearly two-thirds of the oil that enters the North American coastal waters each year comes from natural seeps, with only 5 percent coming from oil extraction and transportation.[123]

During the turbulent 2005 Atlantic hurricane season when Hurricanes Katrina and Rita tore through the Gulf of Mexico, approximately 75 percent of the 4,000 federal OCS oil and gas facilities in the Gulf of Mexico were subjected to 175 mile-per-hour winds and other hurricane conditions. Despite serious damage to 168 platforms, 55 rigs, and more than 560 pipeline segments, the U.S. Coast Guard and MMS reported no major oil spills.[124] Total OCS petroleum spillage from the two storms has been estimated at 14,676 barrels—about the size of a single Olympic swimming pool—of which the vast majority (90 percent) was released and dispersed during the storms.[125]

120 DOE, EIA, "Crude oil production," http://tonto.eia.doe.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_m.htm, last accessed 26 August 2008.

121 DOE, EIA, "Overview of U.S. legislation and regulations affecting offshore natural gas and oil activity," (2005), http://www.eia.doe.gov/pub/oil_gas/natural_gas/feature_articles/2005/offshore/offshore.pdf, last accessed 27 August 2008.

122 SAFE analysis; DOI, MMS, "Spills: statistics and summaries," http://www.mms.gov/incidents/spills1964-1995.htm and http://www.mms.gov/incidents/spills1996-2008.htm, last accessed 28 August 2008.

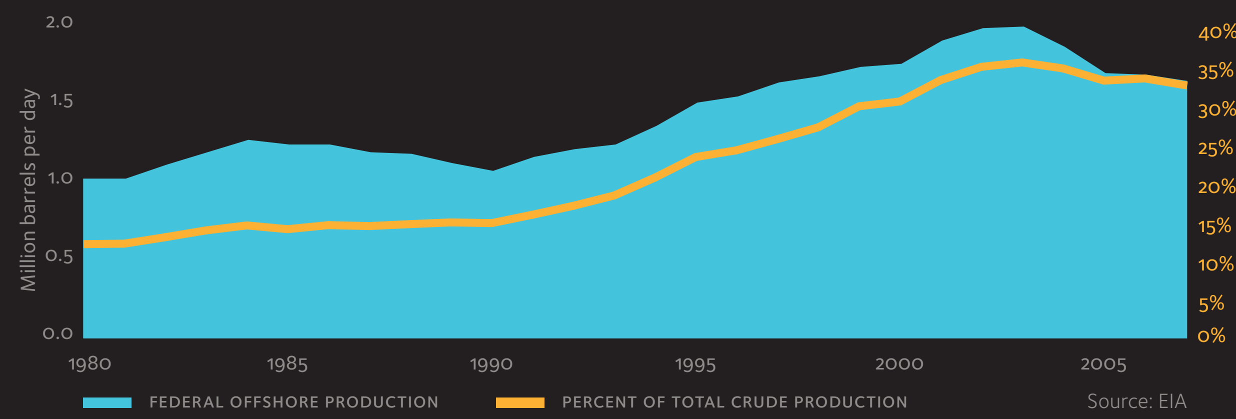
123 Congressional Research Service (CRS), "Oil spills in U.S. coastal waters: background, governance, and issues for Congress," 23 August 2007, 30, http://assets.opencrs.com/rpts/RL33705_20070823.pdf, last accessed 27 August 2008.

124 The Coast Guard defines "major spills" as those in excess of 2,400 barrels.

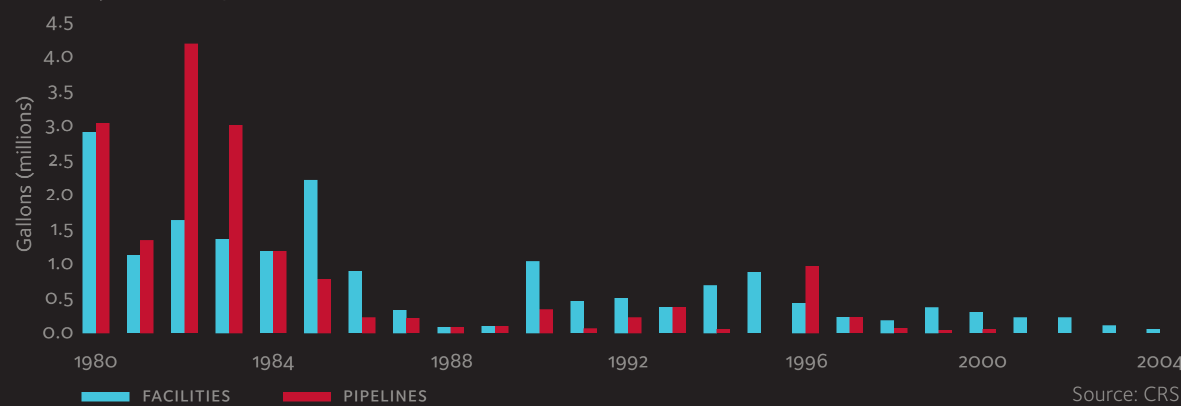
125 DOI, MMS, "Petroleum spills of one barrel or greater from Federal OCS facilities resulting from damages caused by 2005 hurricanes Katrina and Rita including post-hurricane seepage through December 2007," (2008), http://www.mms.gov/incidents/PDFs/HurrKatrinaRitaSpillageRev23June2008Comb(2).pdf, 27 August 2008.

Offshore production has accounted for a rising proportion of U.S. oil and gas supply in recent decades. With advances in technology and best practices, the industry has achieved an increasingly strong record of safety.

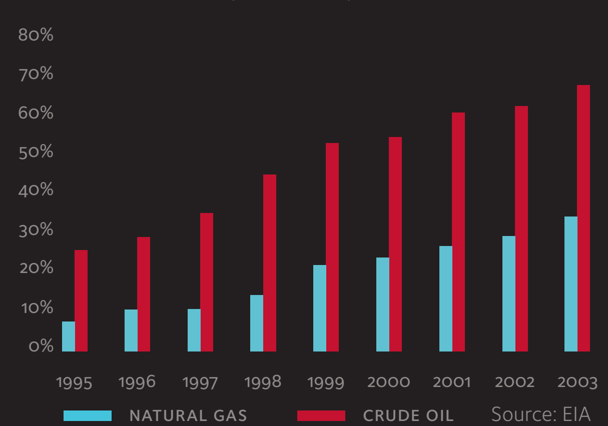
FEDERAL OFFSHORE CRUDE OIL PRODUCTION



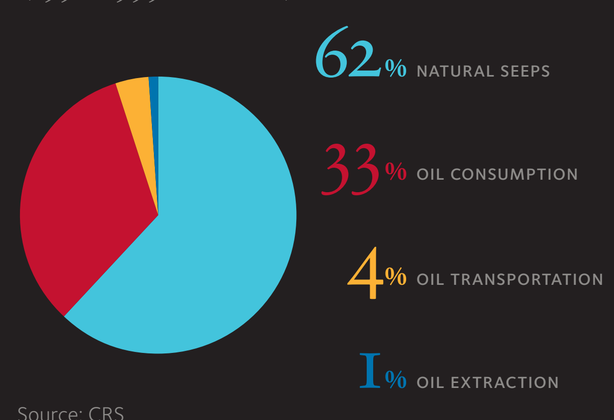
VOLUME OF OIL SPILLS INTO U.S. COASTAL WATERS FROM FACILITIES AND PIPELINES (1980–2004)



FEDERAL GULF OF MEXICO PRODUCTION SHARE FROM DEPTHS GREATER THAN 200 METERS (PERCENT)



OIL INPUTS TO NORTH AMERICAN COASTAL WATERS (1990-1999 AVERAGE)



Despite this record, and despite the growing importance of offshore resources to U.S. energy security, much of the OCS is off limits as a result of Congressional moratoria. Excluding waters off Alaska, the OCS comprises approximately 678 million acres. Of these, roughly 85 percent are unavailable for development. Currently, leasing is prohibited throughout the entire Pacific Coast, the entire East Coast and throughout most of the Eastern Planning Area of the Gulf of Mexico. Off-limits OCS areas are estimated to hold at least 77 trillion cubic feet of natural gas and nearly 20 billion barrels of oil. However, since most of this area has never been surveyed using modern three-dimensional (3D) seismic technology, the ranges of these estimates can vary by wide margins. High-end estimates for off-limits OCS oil are approximately 30 billion barrels and high-end estimates for off-limits OCS gas are nearly 120 trillion cubic feet.[126]

The outlook for the global oil market is fraught with uncertainty. Non-OPEC oil production has consistently lagged expectations. Production in developed countries (OECD) is decreasing due to natural field decline and the increasingly challenging environments in which oil is found. In developing (non-OECD) non-OPEC nations, such as those in the former Soviet Union, production is hampered by mismanagement, a lack of export infrastructure, and government corruption. In sum, while the world's non-OPEC suppliers provide 60 percent of the world's oil today, they will provide less than half by 2030.[127] As demand continues to rise in emerging markets in East Asia, the Middle East and Latin America, the world is poised to become increasingly reliant on OPEC nations for its energy supplies.

The offshore oil and gas industry has achieved this progress while maintaining a remarkable environmental record. According to MMS, the offshore oil and gas industry produced 10.2 billion barrels of oil between 1985 and 2007 with a spill rate of just .001 percent…During the turbulent 2005 Atlantic hurricane season when Hurricanes Katrina and Rita tore through the Gulf of Mexico, approximately 75 percent of the 4,000 federal OCS oil and gas facilities in the Gulf of Mexico were subjected to 175 mile-per-hour winds and other hurricane conditions. Despite serious damage to 168 platforms, 55 rigs, and more than 560 pipeline segments, the U.S. Coast Guard and MMS reported no major oil spills.

Opening the OCS to oil production will not generate enough oil to shift the global production balance in any meaningful way, but it will allow the United States to import less oil, just as reduced transportation sector demand will decrease the need for imports. The Council recognizes the tradeoffs entailed with accessing the OCS. However, given the magnitude of U.S. oil consumption and of the security threat confronting this nation, keeping upwards of 20 billion barrels off-limits to production is an untenable policy.

Similarly, opening the OCS will not on its own address the risk of U.S. reliance on the global LNG market in our electric power sector. But estimates of incremental production from opening the OCS areas currently off-limits range as high as 1.4 trillion cubic feet per year by 2025,[128] enough domestic production to offset approximately 50 percent of the LNG imports in Department of Energy forecasts.

The Council believes that it is sensible to increase access for exploration and production in the OCS so long as government and the oil and gas industry are willing to strengthen the legal and financial

126 DOI, MMS, "Planning area resources addendum to the 2006 national assessment," (2006), http://www.mms.gov/revaldiv/PDFs/2006NationalAssessmentBrochure_update.pdf, last accessed 27 August 2008.

127 International Energy Agency (IEA), *World Energy Outlook 2007* (2007), 43.

128 ARI, "Estimate of the potential economic benefits from the leasing and development of oil and gas resources in OCS moratoria areas," (2006), 3.

penalties that can be imposed on those who damage the environment. In terms of specific suggestions for improvements, the Council recommends the following:

— Increase the size of surety bond requirements for offshore producers.
— Establish/strengthen Citizens' Advisory Groups, equipped with financial autonomy, to advise the Department of Interior during environmental evaluation phases of the lease permitting process.
— Specify stricter liability provisions to reduce the likelihood of protracted litigation.
— Increase vessel liability caps.
— Protect coastal vistas using provable line-of-sight calculations to measure the actual impact of offshore production facilities.
— Provide/increase funding for existing federal programs dedicated to researching the environmental impacts of offshore oil and natural gas drilling.
— Accelerate the maximization of the Oil Spill Liability Trust Fund until it reaches its cap of $2.7 billion.
— Increase funding for NOAAs Office of Response and Restoration.

The outlook for the global oil market is fraught with uncertainty. Non-OPEC oil production has consistently lagged expectations. Production in developed countries (OECD) is decreasing due to natural field decline and the increasingly challenging environments in which oil is found. In developing (non-OECD) non-OPEC nations, such as those in the former Soviet Union, production is hampered by mismanagement, a lack of export infrastructure, and government corruption. In sum, while the world's non-OPEC suppliers provide 60 percent of the world's oil today, they will provide less than half by 2030.

ROYALTY REVENUE FROM OCS OIL AND GAS DEVELOPMENT

The federal government collects significant royalties from the extraction of oil and gas resources in federal waters. In 2007, the Minerals Revenue Management Service, a division of MMS, reported $6.4 billion in royalty receipts plus an additional $580 million in lease rents and bonuses associated with bids.[129] While estimates vary widely depending on assumptions, expanding access to the OCS areas currently off-limits should significantly increase the revenue flow from royalties. One recent study, which assumed full access to all OCS waters by 2012, estimated cumulative increased royalties at $41 billion by 2025.[130]

Regardless of current disputes, the Council clearly sees the value of royalty requirements for all offshore leasing activity and supports a structure that factors the current price of oil into the MMS process for determining royalty requirements. Moreover, rather than depositing the federal share of OCS royalty payments in the general fund of the Treasury, these revenues should be dedicated to energy research, development, and deployment. Transportation electrification should be a priority, with funds available for both consumer incentives and manufacturer assistance.

129 MMS, Minerals Revenue Management Service, www.mrms.mms.gov, last accessed 26 August 2008.
130 ARI, "Estimate of the potential economic benefits."

RECOMMENDATION

Increase access to U.S. resources in the Arctic and Alaska.
PROJECTED INCREASE IN ALASKAN PRODUCTION: 0.7 MBD

In addition to reserves of oil and gas held off-limits on the Outer Continental Shelf, the United States possesses significant reserves in onshore federal lands which are also not available for production. The Energy Policy and Conservation Act of 2000 directed the Department of Interior to conduct a comprehensive review of all onshore oil and gas resources and to identify the impediments to their development. In 2008, a multi-agency process that integrated analyses from the Departments of Interior, Energy, and Agriculture, as well as the Environmental Protection Agency, produced an inventory of the entire onshore United States.[131]

The study estimated total UTRR beneath federal lands to be approximately 30.1 billion barrels of oil and 230.1 trillion cubic feet of natural gas. Of these totals, 62 percent of the oil and 41 percent of natural gas resources were fully inaccessible due to regulatory restrictions. Moreover, an additional 30 percent of the oil and 49 percent of the gas resources were subject to timing limitations that only permit development activities during certain windows throughout the year.[132] In total, federal regulations restrict or limit access to 28.2 billion barrels of oil and 207.4 TCF of natural gas.[133]

As Prudhoe Bay has gone into natural decline and potential replacement resources have been held off-limits, total ANS crude oil production has quickly trended downward, falling below 800,000 barrels per day in 2007—just 14 percent of total U.S. crude oil production. Opening limited areas of Northern Alaska to oil and natural gas production can reverse this trend and improve U.S. energy security.

The Council fully recognizes the value of preserving the sanctity of pristine wilderness environments. As such, we do not recommend lifting leasing restrictions throughout the vast majority of the onshore United States. Many of the reserves surveyed by the federal government coincide with ecosystems and natural geological structures of tremendous scientific and national significance. Just as in the case of offshore development, the need for increased energy security derived from increased production of onshore oil and gas resources must be balanced with the broader environmental priorities of the nation. Nonetheless, the Council is convinced of the merits of lifting restrictions in certain onshore areas likely to yield large quantities of conventional resources while limiting the acreage ceded for production access. In particular, of all the areas surveyed by the federal government, Northern Alaska is notable for possessing extremely large resources in a relatively confined space. While off-limits lands in the Northern Alaska Study Area represents just 11 percent of the fully inaccessible federal territory, these lands hold more than two-thirds of the inaccessible onshore UTRR oil resources (13.3 billion barrels).[134]

131 DOI, "Inventory of onshore Federal oil and natural gas resources and restrictions to their development," (2007), http://www.blm.gov/pgdata/etc/medialib/blm/wo/MINERALS__REALTY__AND_RESOURCE_PROTECTION_/energy/EPCA_Text_PDF.Par.18155.File.dat/Executive%20Summary%20text.pdf, last accessed 27 August 2008.
132 Ibid., 114.
133 On 18 July 2008, the Bureau of Land Management, U.S. Department of Interior, released a Record of Decision for leasing certain areas of the Northeast Planning Area of the National Petroleum Reserve-Alaska. Oil and gas resources in these areas were assessed as "inaccessible" in the Federal Onshore Inventory.
134 DOI, "Inventory," 117.

Historically, crude oil production from the accessible areas of Alaska's North Slope (ANS) has played an important role in overall U.S. output. Production began in the late 1970s and peaked in 1988 at more than 2.0 MBD, much of this from the mammoth Prudhoe Bay oil field, which had estimated oil in place of at least 25 billion barrels and cumulative production of approximately 13.5 billion barrels.[135] As Prudhoe Bay has gone into natural decline and potential replacement resources have been held off-limits, total ANS crude oil production has quickly trended downward, falling below 800,000 barrels per day in 2007—just 14 percent of total U.S. crude oil production.[136]

Opening limited areas of Northern Alaska to oil and natural gas production can reverse this trend and improve U.S. energy security. Specifically, of the 13.3 billion barrels of technically recoverable federally restricted oil in the Northern Alaska Survey Area, 7.7 billion barrels fall within the 1.9 million acres of the 1002 Area of the Arctic National Wildlife Refuge (ANWR).[137] An additional 2.7 billion barrels are on state and native lands within the 1002 Area.[138]

The Arctic presents oil and gas producers with some of the most difficult operating conditions in the world, including permanent ice in many areas. The technology to survey, extract, and transport Arctic oil and natural gas reserves is only now emerging and is not fully developed. Still, the United States must be vigilant in ensuring its right of access to Arctic resources off the coast of Alaska.

In 2008, an analysis by the Department of Energy posed three cases for development of oil and natural gas resources in the Coastal Plain of the Arctic National Wildlife Refuge. The estimates were derived from USGS survey data. The mean resource case assumed 10.4 billion barrels; the low resource case assumed 5.7 billion barrels; and the high resource case assumed 16.0 billion barrels.[139] In the mean resource case, DOE estimated increased U.S. incremental oil production from opening ANWR would be 780,000 barrels per day (BD) in 2027 and 710,000 in 2030. Total Alaska production would be over 1.0 MBD in 2030 compared to just 300,000 BD in the base case. The increased production would significantly extend the life of the Trans-Alaska Pipeline System, which has a minimum flow rate of 300,000 BD.

Political symbolism and the ideological battle surrounding the issue of ANWR have unfortunately blocked the advancement of a sound national production policy that could reduce our oil dependence and improve our energy security. This impasse is not acceptable given the size and nature of the energy threat facing the country. The Council is convinced of the merit of its recommendation to increase environmentally responsible production in Alaska. For a limited period of time, this incremental output would improve U.S. energy security. Nevertheless, the value of this recommendation must be measured against the greater and more enduring benefits that can be achieved through implementation of our other recommendations, including electrifying the transportation sector, continuing to improve the fuel

135 DOE, NETL, "Alaska north slope oil and gas: a promising future or an area in decline?" (August 2007), Fig. 3.1 and Table 3.1, http://www.netl.doe.gov/technologies/oil-gas/publications/EPreports/ANSSummaryReportFinalAugust2007.pdf, last accessed 27 August 2008.

136 DOE, EIA, "Crude oil production," http://tonto.eia.doe.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_m.htm, last accessed 26 August 2008.

137 ANWR was created by the Alaska National Interest Lands Conservation Act (ANILCA) of 1980. Section 1002 of ANILCA deferred a decision on the management of oil and natural gas exploration and development in the coastal plain of ANWR. The coastal plain area—the 1002 Area—represents about 8 percent of the total area of ANWR.

138 DOE, EIA, "Analysis of crude oil production in the Arctic National Wildlife Refuge," (May 2008), 1, http://www.eia.doe.gov/oiaf/servicerpt/anwr/pdf/sroiaf(2008)03.pdf, last accessed 27 August 2008.

139 Ibid.

economy of light-duty and commercial vehicles at the "maximum feasible" rate, and increasing access to U.S. reserves on the OCS.

THE U.S. ARCTIC

The seabed beneath the waters of the Arctic Circle is believed to hold large quantities of oil and gas. In June of 2008, the U.S. Geological Survey released its Circum-Arctic Resource Appraisal identifying technically recoverable reserves of oil and gas within 33 geological provinces of the Arctic. The report estimated mean technically recoverable oil reserves of 134 billion barrels (including NGLs) and 1,699 trillion cubic feet of natural gas. More than 70 percent of the mean undiscovered oil resources were estimated to occur in only five of the provinces and more than 70 percent of the undiscovered natural gas was estimated to occur in three provinces. Roughly 84 percent of total resources were in offshore areas.[140]

Nations with territorial claims to the Arctic include Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden, and the United States. International marine boundaries beyond each nation's 200-mile Exclusive Economic Zone are currently determined by a United Nations treaty known as the Law of the Sea. Not all countries participate in the Law of the Sea—the United States is not currently a signatory—and the treaty raises questions regarding national sovereignty. However, in the absence of a final consensus on Arctic territory, some of the Arctic nations have begun staking claims to areas of the seabed believed to possess oil and gas reserves.

The Arctic presents oil and gas producers with some of the most difficult operating conditions in the world, including permanent ice in many areas. The technology to survey, extract, and transport Arctic oil and natural gas reserves is only now emerging and is not fully developed. Still, the United States must be vigilant in ensuring its right of access to Arctic resources off the coast of Alaska. If the Law of the Sea requires unacceptable national security tradeoffs, a suitable alternative should be pursued. Current informal bodies, such as the Arctic Council, are important arenas for multilateral compromise, but there is still a need for a credible bilateral framework for establishing territorial rights in the Arctic.

RECOMMENDATION

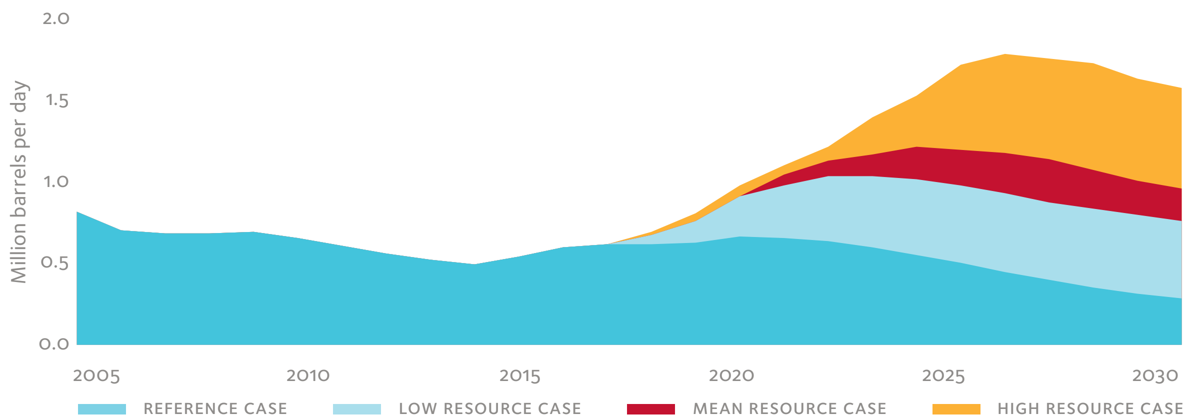
Federal support for construction of a natural gas pipeline from Alaska to the continental United States.

Alaska has abundant natural gas resources that remain unexploited due to the absence of a pipeline to move gas to the Lower 48. As increasing demand for power generation from natural gas strains U.S. domestic supply in the future, an Alaska gas pipeline will become a critical component of U.S. energy infrastructure. In 2004 the Alaska Natural Gas Pipeline Act established an $18 billion loan guarantee program for the construction of a pipeline. The value of the loan guarantee was limited to 80 percent of the project's cost. A final commitment to construct a pipeline remains elusive, however, for several reasons.

First, the final route of the pipeline remains in dispute, with some parties supporting a subsea line under the Beaufort Sea that would come ashore in Canada and connect to the North American natural gas pipeline network in Alberta. Others prefer an overland pipeline that runs through Alaska and that would

140 U.S. Geological Survey, "Circum-Arctic resource appraisal: estimates of undiscovered oil and gas north of the Arctic Circle," (2008), http://pubs.usgs.gov/fs/2008/3049/fs2008-3049.pdf, last accessed 27 August 2008.

ALASKAN CRUDE OIL PRODUCTION SCENARIOS



Source: EIA

have the benefit of providing local gas supply where needed. It also appears that construction of a pipeline is not supported by all three of the major companies that own the Alaskan natural gas.

Second, some gas producers in the Lower 48 are concerned that the addition of significant volumes of Alaskan gas to the nation's supply will act as a drag on prices and reduce the incentive to produce gas in the Lower 48 and on the OCS. This concern has gained additional momentum as gas production in the Lower 48 has risen significantly over the past few years and technologies have matured allowing for the production of gas from shale.

Finally, since the Alaska Natural Gas Pipeline Act was passed in 2004, the price of steel has risen significantly, potentially leaving the initial loan guarantees insufficient to support construction of the pipeline.

At this point in time, given the growing level of production in the Lower 48, it is not clear that the market wants or needs Alaskan natural gas. However, in order to ensure that the government is not an obstacle to its construction when the market is finally ready, Congress should increase the cap on the size of the loan guarantee to $30 billion, maintaining the limit on the size of the loan guarantee to 80 percent of the cost of the project. Thus, when the market is ready to build the pipeline, the government will stand prepared to assist without the need for additional federal financial support.

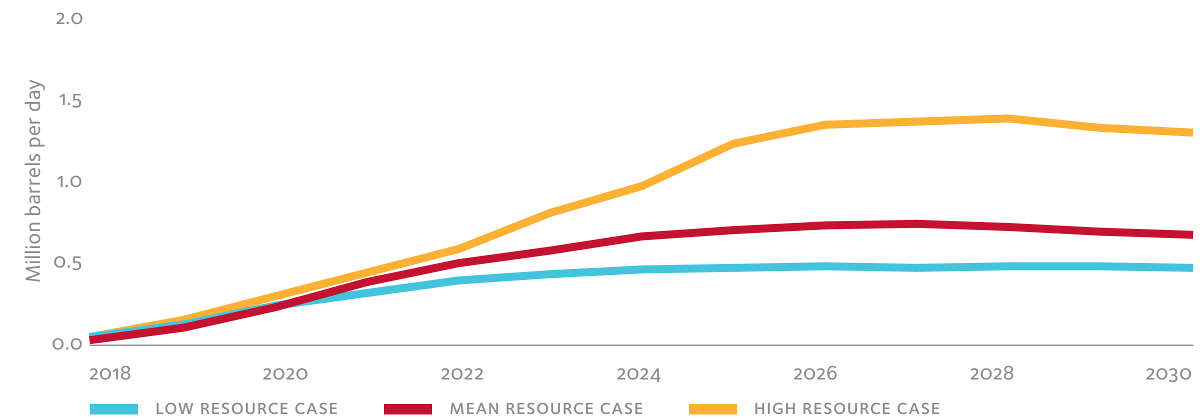
RECOMMENDATION

Expand federal R&D initiatives studying the opportunities to exploit methane hydrates, including the initiation of small-scale production tests.

While global estimates vary considerably, the energy content of methane occurring in hydrate form is immense, possibly exceeding the combined energy content of all other known fossil fuels.[141] However, future production volumes are speculative because methane production from hydrate has not been documented beyond small-scale field experiments.

141 DOE, Fossil Energy, "Methane hydrate – the gas resource of the future," http://www.fossil.energy.gov/programs/oilgas/hydrates/index.html, last accessed 29 August 2008.

INCREMENTAL ALASKAN CRUDE OIL PRODUCTION IN THREE SCENARIOS



Source: EIA

In recent field tests, researchers have demonstrated the capability to predict the location and concentration of methane hydrate deposits using reprocessed conventional 3-D seismic data, and new techniques, including multi-component seismic, are being tested. Small-volume production tests in the U.S. and Canadian Arctic suggest that commercial production is possible using depressurization and thermal stimulation from conventional well-bores. Large-scale production tests are planned in the Canadian Arctic in the winter of 2008 and in the U.S. Arctic in the following year.

The Department of Energy believes that demonstration of production from offshore deposits will lag behind Arctic studies by three to five years, because marine deposits are less well documented and marine sampling and well tests are significantly more expensive.

Although this is high-risk research, it holds out the promise of extremely large benefits. Currently, DOE is spending between $10 and $12 million per year to address the two major technical constraints to production: 1) the need to detect and quantify methane hydrate deposits prior to drilling, and 2) the demonstration of methane production from hydrate at commercial volumes. In order to take full advantage of this potentially valuable resource, DOE should expand its research and development budget for methane hydrates by $10 million per year until it reaches $100 million.

PART III

Accelerating the Development and Deployment of New Energy-Related Technology

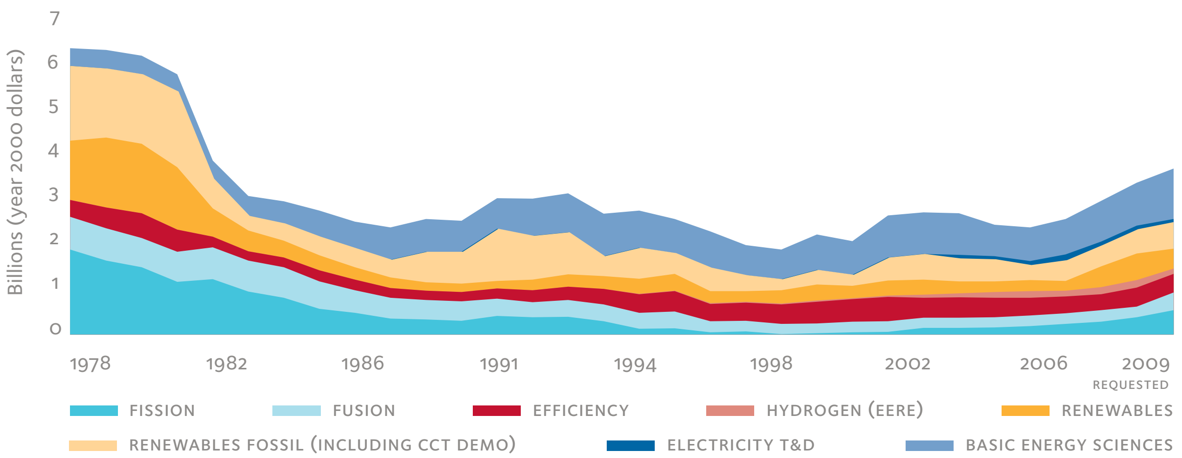
From its historical peak of approximately $6 billion in 1978, Department of Energy spending on research in renewable, fossil and nuclear energy has fallen to $1.4 billion in 2008. Meanwhile, investments in energy RD&D by U.S. companies fell by 50 percent between 1991 and 2003. These expenditure levels are not commensurate with the seriousness of the energy security challenges facing America and the world. Government must increase its commitment to RD&D, combining dramatically expanded financial support with fundamental reforms.

III. Accelerating the Development and Deployment of New Energy-Related Technology

U.S. investment in energy research, development, demonstration and commercialization/deployment must be significantly enhanced. The challenges must be adequately communicated to the public through their elected representatives. And investment strategies must be shaped to clearly pursue the goal of providing adequate, affordable and reliable energy for consumers while minimizing greenhouse gas emissions, spurring economic growth, and increasing energy security.

Worldwide government R&D spending has fallen by 50 percent in the last 25 years, to a level of $10 billion per year.[142] Two countries, the United States and Japan, account for 80 percent of this investment. However, U.S. government energy R&D accounts for a mere 3 percent of total government research and development spending. More research, development and deployment (RD&D) spending is needed, both in the public and in the private sector, and experts have characterized this needed change as "urgent."[143]

U.S. DOE BUDGET AUTHORITY FOR RESEARCH, DEVELOPMENT AND DEMONSTRATION



Gallagher, K.S., "DOE Budget Authority for Energy Research, Development, and Demonstration Database", Energy Technology Innovation Policy, John F. Kennedy School of Government, Harvard University, June 2008.

Even some proponents of climate-change legislation have recently begun forcefully arguing that "to restrain emissions without a fundamentally new set of technologies… will end up stifling economic growth, including the development prospects for billions of people."[144] They correctly point out that simply pricing carbon dioxide will not be sufficient to pull advanced technologies into the market place. The market success of technologies such as carbon capture and storage for fossil-fuel combustion power generation, wide-spread deployment of plug-in hybrid vehicles, and concentrated solar-thermal power generation will depend on a confluence of factors, including the availability and quality of ancillary infrastructure and important regulatory, legal, and liability developments.

142 Throughout this chapter, the phrase R&D will be used broadly to cover the full spectrum on the basic research to commercialization continuum. Where distinct phases of that continuum are at issue, they will be identified.
143 Neil Hirst, testimony prepared for U.S. Senate Committee on Energy and Natural Resources, hearing on "Challenges to meeting future energy needs and developing technologies for meeting increased global energy demand in the context of addressing global climate change," 110th Cong., 1st sess., 25 June 2008.
144 Jeffrey D. Sachs, "Sustainable developments: keys to climate protection," *Scientific American* (April 2008), quoted in *New York Times*, 6 April 2008.

In order to preserve the political support necessary to sustain the spending required to meet energy security and environmental goals, increases in investment must be accompanied by significant structural and programmatic reforms. New institutions and new tools may be needed as well, although reforms in existing institutions and better use of existing tools are also important. Most important, a new sense of mission, urgency, and purpose must be cultivated within relevant federal agencies, national laboratories, universities, and the private sector.

The Challenge

In response to the oil crises of the 1970s, the United States quickly expanded investments in energy R&D—at times with negative consequences that reverberate today. In part due to notable failures of government-directed R&D projects as well as ideological or philosophical beliefs about the role of government in promoting commercial activities, U.S. policy-makers shifted their focus from direct R&D investment to using policy and market-based tools such as the tax code to indirectly influence technology development. Today, the United States ranks 22nd among developed nations in the fraction of GDP that is devoted to non-defense research.[145]

As the governmental share of U.S. R&D spending has declined from two-thirds to one-third of the total, industry has taken up the slack—yet by spending development, not research dollars.[146] The failure to focus on the research side of the R&D equation has had predictable consequences. Only four American companies made the 'top ten' list for patents issued in 2005. Not coincidentally, the U.S. trade balance in high technology manufactured goods went from positive $40 billion in 1990 to negative $50 billion in 2001.[147] Within the energy sector, the picture is even bleaker. Shortly after the energy crisis of 1973, U.S. energy R&D soared from $2 billion annually to more than $14 billion, with public-sector investment peaking at just under $8 billion and private-sector investment topping out at nearly $6 billion.[148] By 2004, private-sector energy R&D funding was below $2 billion and government funding had dropped to roughly $3 billion. This steady decline in support for energy R&D has raised concerns about whether new classes of energy technologies will be approaching commercial viability when they are needed. The Global Energy Technology Strategy Project puts it well:

> With decades-long lead times not uncommon for the research, development, and deployment of new energy technologies, current trends raise serious questions about the need to create an enduring change in the perceived return for energy R&D investments to ensure… a steady stream of technological innovation…[149]

This trend must be reversed. Given the importance of energy to our collective quality of life, the Council recommends that the U.S. research, development, demonstration and commercialization/deployment investments be at least on par with public health-related research. For public funding alone that would entail a ten-fold increase, as the 2008 enacted program level for the National Institutes of Health was $29.4 billion.

145 Norman R. Augustine, *Is America falling off the flat earth?* (Washington, D.C.: National Academies Press, 2007), 55.
146 Ibid., 56.
147 Ibid., 20.
148 Battell Memorial Institute, *Global energy technology strategy*, (May 2007), 121.
149 Ibid.

RECOMMENDATION

Annual public investment in energy R&D should be increased by roughly an order of magnitude to approximately $30 billion.

In an era of 'pay-go' rules, concerns about deficit spending, and a looming entitlements crisis, the Council recognizes that proposing dramatically increased spending in this area will be controversial. Some portion of this new spending can be offset by revenues raised through the implementation of other Council recommendations, notably the smart biofuels subsidy and royalty revenue from new oil and natural gas production. Further, the Council is aware of proposals to establish a direct tax on carbon or a 'cap and trade' regulatory system for reducing greenhouse gas emissions that will involve, to varying degrees, the auction or government sale of permits to emit greenhouse gases.

Given the importance of the energy sector for greenhouse gas management, the Council strongly believes that revenues generated through the imposition of a carbon policy should be devoted to developing and deploying energy technologies that have both climate change and energy security co-benefits. These funds should not be diverted to the general fund of the federal budget. At the same time, the Council also firmly believes that these R&D investments must move forward at robust levels with or without offsetting revenue increases. Just as individuals and businesses make investments representing current year outflows for future year savings, so, too, government should be investing tax dollars in energy technologies that will generate savings in the future. Investments made today will pay dividends in the future.

Another concern is whether dramatic increases in investment can be managed intelligently. Not without some justification, federal R&D spending, in particular by DOE, has been routinely derided for catering to "regional and industry special interests" that often diverge from technological and economic realities.[150] Recent efforts to rationalize DOE R&D spending and better coordinate energy investment among federal agencies are laudable, yet few would dispute that the investment process remains suboptimal due to a variety of factors.

Because of the magnitude of the challenge, many have called for a Manhattan or Apollo project to make the United States energy 'independent', while simultaneously combating climate change. But however well meaning, these advocates miss a key point. In constructing a nuclear weapon and putting a man on the moon, the United States undoubtedly mastered many engineering and science challenges, but our success came in large part because financial and local concerns were subordinated. But in energy systems, affordability for consumers and the need to involve multiple layers of government in siting are unavoidable complicating factors.

Caution is also appropriate when examining the utility of the Defense Advanced Research Projects Agency (DARPA) as a model for energy R&D. Like DARPA, the so-called Advanced Research Projects Agency – Energy (ARPA-E) program may well be successful at performing basic research. But ARPA-E cannot guarantee commercialization success, which in fact will depend on buy-in by the private sector and consumers. DARPA also operates from a more stable political and ideological position, for while R&D for national security missions enjoys strong support at all levels of government, many policy-makers question the need for direct public support for private-sector functions such as providing energy to consumers. Last but not least, proponents of DOE R&D routinely engage in the practice of congressional earmarking that would have doomed DARPA to failure had it been prevalent in that program.

While DOE can and must have an important role in managing the nation's R&D investments, new institutions and new ways of doing business are also required. These reforms will reflect the demand-driven, cost- and

150 Peter Ogden, John Podesta, and John Deutch, Center for American Progress, "A new strategy to spur energy innovation, issues in science and technology," *Issues* (January 2008), 2, http://www.issues.org/24.2/ogden.html, last accessed 27 August 2008.

market-oriented nature of energy R&D, rather than the performance-driven, non-market orientation of the Manhattan or Apollo projects.

Given the importance of the energy sector for greenhouse gas management, the Council also firmly believes that these R&D investments must move forward at robust levels with or without offsetting revenue increases. Just as individuals and businesses make investments representing current year outflows for future year savings, so, too, government should be investing tax dollars in energy technologies that will generate savings in the future.

COMMERCIALIZING ENERGY TECHNOLOGIES

Commercially-oriented R&D in a market economy is generally within the purview of the private sector. Where social benefits of R&D outweigh benefits than can be captured by innovating businesses through sales, then government support of basic and applied R&D is appropriate—and, in the energy sector, crucial. This support must be tailored to needs that vary across a time continuum that can be broken down into five stages:

Step 1. Basic research
Step 2. Applied research with lab scale demonstration
Step 3. Pilot-scale demonstration (that may include further elements of research)
Step 4. Larger-scale demonstration to prove out cost-effective scalability
Step 5. Initial commercialization or so-called "first mover" deployment

Each of these steps has distinct and shifting roles for the public and private sector. One constraint on effective investment has been a near-ideological belief—reinforced by notable "failures" in large-scale energy technology demonstrations in the 1970s—that the government role should diminish along the continuum just slightly past the basic research stage. [151]

The large capital expense of some energy systems (e.g., centralized, stationary power-generation facilities) and a regulatory structure that limits rates of return combine to make it difficult to attract private equity and debt financing. While public utilities commissions (PUCs) are charged with ensuring that investor-owned utilities receive a reasonable rate of return, in practice the PUC analysis often devolves to a simple question of near-term least-cost providers. Projects in both regulated and unregulated markets face competition from natural gas 'peakers' and from imported generation. Finding equity partners and lenders willing to commit funds for projects costing more than a billion dollars when they will not see returns for several years is difficult in any fiscal environment. After the sub-prime mortgage meltdown and the associated liquidity squeeze, conditions have worsened considerably in this regard.

In the liquid-fuel arena, it was once the case that the ability of petroleum-producing nations to quickly increase production, combined with the sunk cost of the prevailing distribution infrastructure, deterred investors from supporting R&D in alternative fuels. Even the expensive subsidy for conventional corn-based ethanol initially resulted in little market penetration. The conventional ethanol market only began to grow with the removal from the market of a substitute blending product (methyl tertiary butyl ether,

151 Ibid. Commentators often point to the Clinch Breeder Reactor, Solvent Refined Coal, and the Barstow (California) Central Solar Power Tower as unsuccessful DOE demonstration projects.

or MTBE) due to groundwater and health concerns and because of the large production mandates contained in energy legislation passed in 2005 and 2007. Current high fuel prices and some investors' concerns about "peak oil" have clearly made private sector R&D more attractive, but first mover facilities at large scale are only starting to be proposed. A strong government role is necessary as new alternative fuels move through steps four and five in the commercialization process.

Many have called for a Manhattan or Apollo project to make the United States energy 'independent', while simultaneously combating climate change. But however well meaning, these advocates miss a key point. In constructing a nuclear weapon and putting a man on the moon, the United States undoubtedly mastered many engineering and science challenges, but our success came in large part because financial and local concerns were subordinated. But in energy systems, affordability for consumers and the need to involve multiple layers of government in siting are unavoidable complicating factors.

Energy technology start-ups and the venture capital firms need concentrated support by government during the periods of fundamental research and commercialization, with lower levels of funding being acceptable and even preferable during pilot testing.[152] On an individual energy technology basis, government investment is critical in the basic and applied research phases but can ramp down in the pilot phase (somewhere between 1 and 10 percent of expected commercial-scale production) as venture firms step in to invest in promising technologies. At the large-scale demonstration phase, where production will still be roughly an order of magnitude lower than commercial scale, government needs to partner with the private sector to help reduce risk during the scale-up process. The cost of a commercial-scale facility (step five) will be much greater than that of the pre-commercial demonstration (step four), but direct government investment in any individual project can be minimized by leveraging loan guarantees and employing tools such as purchase agreements and production tax credits.

BARRIERS TO EFFECTIVE PUBLIC-PRIVATE PARTNERING

Private investors are not interested in 'one-off' projects. Instead, they seek the market approval that comes with the ability to license or otherwise deploy technologies on a widespread scale. Current policies related to intellectual property that seek to give the Department of Energy or a lab a share of the rights can and have deterred investors from partnering with the government. For corporations seeking to maintain their own R&D portfolio, the intermittency of the R&D tax credit is a challenge.

Rigid procurement requirements (particularly as they may relate to sizing pilots and demonstrations), fuel choice, geographic location, or other non-performance related attributes can also deter participation and delay technology maturation. These exclusionary requirements are increasingly imposed not by the executive branch, but through the congressional earmark process, whereby otherwise performance-based R&D programs are transformed into a series of home-state projects that may or may not be related to the overall program mission. In fact, the American Academy for the Advancement of Science reported in January 2008 that DOE was one of the two "most heavily earmarked domestic R&D agencies, while the National Institutes of Health (NIH) and the National

152 Private communications and meetings with SAFE staff.

Science Foundation (NSF) remain earmark-free."[153] This trend is not confined to periods of divided government, but it has been exacerbated by the deterioration in relations between the executive and legislative branches in general.

For demonstration projects that require major capital expenditures and multi-year construction horizons, the annual appropriations process and balky state and federal permitting process present additional hurdles for investors. The former challenge faces only those who seek government funding, whereas the latter applies to both types of projects. Recent efforts to establish the loan guarantee program authorized in EPAct 2005, and the more recent restructuring of the so-called "FutureGen" integrated gasification combined cycle power plant project, exemplify the challenge of building big energy infrastructure—a challenge that has long prevailed in the transportation world.

As a major global energy consumer, the United States has a responsibility to lead—and has led—in this energy R&D and commercialization. Leadership in energy technology is also in our economic self interest. Good policies and strategies will spur growth in two ways. First, overall manufacturing and service productivity rise when energy prices are stable and supplies are reliable. Second, the commercialization of new technologies to enhance energy security while minimizing greenhouse gas emissions will serve as a key new export market in a time of grave concerns about our balance of trade.

STRUCTURAL AND PROGRAMMATIC REFORMS

Policymakers have a clear choice: either to be mission-focused and run the risk of some failures along the way, or to continue on a path of short-term investments that are micromanaged and subject to the vagaries of political cycles and home-state politics. The Council believes these recommendations can provide structural and programmatic support to policy makers working for an improved R&D process.

RECOMMENDATION

Reform the existing institutions and processes governing federal R&D spending.

Reform Congressional Earmarking

Congress should eliminate earmarking for home-state energy projects. By placing local constituent interests above the broader national interest, earmarking has directly contributed to the balkanization of energy R&D funding. In an analysis spanning seven fiscal years of earmarks in the appropriations bill that funds DOE, the Congressional Research Service found 12,531 separate earmarks, totaling more than $37 billion.[154]

Investment strategies must be shaped to clearly pursue the following goal: adequate, affordable and reliable energy for consumers that increases U.S. national security, spurs U.S. economic growth, and minimizes greenhouse gas emissions. Congress should focus on providing centralized long-term funding and support for R&D projects with the goal of fostering a stable climate of investment in innovation. Congress should also work to ensure that agencies are meeting performance goals and should tie continued or increased funding of individual programs to the attainment of those goals.

153 American Academy for the Advancement of Science, "R&D funding update: R&D earmarks total $4.5 billion in 2008," 7 January 2008, http://www.aaas.org/spp/rd/earm08c.htm, last accessed 26 August 2008.

154 CRS Appropriations Team, CRS Memorandum, "Earmarks in Appropriations Acts: FY1994, FY1998, FY2000, FY2002, FY2004, FY2005," 26 January 2006, http://www.fas.org/sgp/crs/misc/m012606.pdf, last accessed 26 August 2008.

Consolidate Executive Branch R&D

Additional streamlining can be achieved in the executive branch by eliminating the overlap among the myriad of federal agencies that carry out energy-related R&D. Energy research programs at the Departments of Agriculture, Interior, Transportation, Health and Human Services and the EPA could be consolidated within the DOE. Alternatively, R&D budget development could be coordinated under the stewardship of a National Energy Council installed at the White House (See recommendation in Risk Management section). Under this approach, individual agencies would continue to perform energy R&D, but categories and scopes would be coordinated to eliminate redundancy and achieve synergies.

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Increase Accountability

Congress or the President should ensure that DOE is both empowered and accountable directly to both the President and the authorizing and appropriating committees by circumscribing the role and influence of the Office of Management and Budget (OMB) in the annual R&D budget process. OMB has a valuable role to play in enforcing budget limits set at the agency level and in ensuring that agencies implement presidential priorities, but has neither the expertise nor the resources to evaluate individual programmatic priorities.

Currently, agency R&D budgets must clear two separate and often conflicting hurdles: an internal and opaque OMB budget 'review' process and an external, open, and accountable congressional appropriations process. These duplicative procedures divert resources from primary performance goals. OMB review should be limited to audits of agency program performance evaluations and top-line budget level enforcement and OMB should be without power to seek reallocations of internal agency program and sub-program budgets. Congress is the constitutional entity entrusted with making authorization and appropriations decisions and should employ the annual appropriations process (in conjunction with more frequent authorization oversight hearings) to assess agency performance against published goals.

RECOMMENDATION

Develop a more effective federal R&D investment strategy.

Incentivize the R&D Process

National lab contracts and university grants should be performance-based. Incentive pay and bonuses should be offered to research laboratories and universities for supplementing public sector research efforts with grassroots innovation. Until recently, contracts and grants were not tied to actual outcomes and performance and were viewed by critics as more akin to sinecures or tenured arrangements than competitive, results-oriented vehicles for innovation. Recent reforms at DOE link lab contract terms to performance outcomes, and energy technology oriented contracts and grants could include incentives linked to future commercialization or deployment of technologies. These incentives would compensate non-profit entities without reserving or impairing the intellectual property rights that are attractive to the private side of public-private partnerships. Labs and universities receiving federal funds are in a different position than private entities putting their own funding at risk. Thus, the risk-reward calculus is not the same for both parties, and milder incentives for publicly-funded entities are appropriate.

Protect Property Rights

Conversely, intellectual property rights should be guaranteed to private-sector investors to minimize risk aversion, enhance private-sector due diligence, and encourage long-term partnerships that encompass both successes and failures. Private investors are not interested in 'one-off' projects, but they are willing to make a broad range of portfolio investments in the pursuit of big winners that counterbalance the inevitable losers. Investors and their financial partners seek the market approval that comes with the ability to license or otherwise deploy technologies on a widespread scale. Current policies related to intellectual property—which seek to give the Department of Energy or a government lab a share of the property rights—can, and have, deterred investors from partnering with the government.

Target Federal Dollars Appropriately

Investment should be targeted to the appropriate stage of the R&D process and deployed at a magnitude commensurate with the demands of each stage (i.e., smaller dollars early, larger dollars later, and leveraged dollars last). Here again, public-private partnerships can co-exist with varying levels of public investment. Sustained and stable funding of national labs and universities can reap benefits at relatively modest levels on a per technology component or subcomponent basis. Private partners can then fund the most promising components or systems at the pilot stage with little government investment. At the larger pre-commercial demonstration phase, where projects may require hundreds of millions of dollars to prove scale and address technology risk, greater government investment is appropriate. Subsequently, vehicles such as purchase requirements, loan guarantees, and tax credits can substitute for direct federal investment and can be leveraged across sectors in ways that reduce risk to the taxpayer while ensuring rapid commercialization.

Reform the Subsidy Process to Match Desired Outcomes

All subsidies beyond basic research/pilots should only be employed on a least-cost-per-unit basis (e.g., through a reverse auction). In most cases, subsidizing commercial energy technologies is only necessary to address the cost-differential between cleaner or more secure sources and other conventional technologies whose external costs are not reflected in the price. Current market conditions as well as existing market mandates obviate the need for subsidies for conventional ethanol or petroleum products.

As advanced biofuels and coal with carbon capture and storage projects begin to move forward, loan guarantees represent the wisest type of federal investment and, indeed, can be actual revenue raisers offsetting earlier-stage R&D. For those pilot projects that require more direct federal assistance, competitive processes that require project sponsors to commit to a certain output per federal dollar invested are most appropriate to ensure that federal investments are cost effective.

Congress should establish an Energy Security Trust Fund to fund early-stage energy-related R&D at levels significantly higher than their current levels of funding. The federal government should [also] establish an Energy Technology Authority (ETA) of the United States as a market-driven source of private financing and public-private partnering for the most promising energy technology innovations.

Extend and Modify the Various Tax Incentives

As noted above, Congress should extend and modify the existing suite of tax credits that apply to alternative energy projects, such as R&D, investment, and production tax credits. For corporations seeking to maintain their own R&D portfolio, the intermittency of the R&D tax credit is a concern. A long-term durable and predictable tax policy will allow the supply chain to fully develop, which will lower the capital cost through rational supply chain management and economies of scale. It is appropriate to review these incentives on a regular basis through the congressional oversight process. Any tax credit that appears to be superfluous, represents a windfall, or requires adjustment can be modified through the legislative process. Requiring regular congressional action to keep effective and appropriate tax credits in place has proven to be a failed approach and should be discarded.

RECOMMENDATION

Establish new institutions to provide funding for early-stage R&D and for later-stage deployment and commercialization.

Establish Energy Security Trust Fund to Fund Early Stage R&D

Congress should establish an Energy Security Trust Fund to fund early-stage energy-related R&D at levels significantly higher than their current levels of funding. Further, the fund should be funded directly by statute without requiring appropriated funds. Bypassing appropriations will not only help insulate the funds from the earmarking process, it will also ensure a reliable stream of funds that can be used to fulfill multi-year commitments to R&D programs. The trust fund should supplement, and not replace, those R&D funds that are currently distributed through the program offices in order to avoid a political dispute over the effectiveness of those departments.

Congress should establish a new office within DOE to coordinate the expenditure of R&D dollars available in the Energy Security Trust Fund. The office should identify six broad areas of energy research within which all research would fall: (1) improved efficiency/electrification of transportation, (2) alternative fuels, (3) carbon storage, (4) enhanced fuel production techniques, (5) improved power production, and (6) power distribution. For each area, the office should solicit grant proposals twice a year and then convene a committee of experts (from within DOE, elsewhere in government, academia and industry) to review and score the proposals based solely on their merit. DOE would then fund the grant proposals, starting with the proposal with the highest score, and funding those with lower scores until money for the time period ran out.

Establish an Energy Technology Authority of the United States

The federal government should establish an Energy Technology Authority (ETA) of the United States as a market-driven source of private financing and public-private partnering for the most promising energy-technology innovations. In conversations with current government officials, it has become clear that the most successful model for such an institution would be quasi-governmental investment organizations similar to the Overseas Private Investment Corporation (OPIC) and U.S. Export-Import Bank (EXIM). The ETA would possess the full backing of the United States government, but would be managed and organized like a private corporation. After an initial capitalization, the corporation would be self-sustaining, generating revenue through projects, interest, and fees, thereby minimizing future appropriations.

The ETA's core mission would be to accelerate and scale capital formation for clean and renewable energy production and distribution. The ETA could bring emerging technologies to market much more quickly than would occur under normal market conditions by providing leverage for energy projects, thereby mitigating the upfront risks for private-sector partners.

RECOMMENDATION

Invest in the next-generation workforce for the energy industry.

The energy sector of the economy directly employs more than one million people, half of whom are older than 50 years of age and eligible to retire within the next decade. Among those retiring will be the engineers and scientists needed to sustain and transform the energy sector. Furthermore, fewer students are training to enter the industry. Enrollment in petroleum engineering and geosciences programs, for instance, has fallen by 75 percent over the last twenty-five years. With declining enrollments, many university programs that trained students for the energy industry have themselves closed, complicating the effort to rebuild the industry's workforce.

To meet this shortcoming, the Congress should establish a scholarship program through the Department of Energy that should fund annually 1,000 undergraduate and 500 graduate students studying engineering, geosciences and other energy-related fields. If we fail to train the next generation of energy experts we will be unable to sustain and transform our energy future. Such a program would cost less than $75 million.

PART IV

Reducing Demand for Oil: Improving Efficiency

The Energy Independence and Security Act of 2007 directs the Department of Transportation to make much-needed changes in the Corporate Average Fuel Economy standards first implemented in the mid-1970s. In order to maximize long-term oil savings, government must implement ambitious market-oriented standards for all ground transportation.

IV. Reducing Demand For Oil: Improving Efficiency

As part of a comprehensive strategy for reducing its exposure to rising crude prices and an increasingly volatile global oil market, the United States must steadily curb its demand growth while it transitions away from using oil as its primary transportation fuel.

RECOMMENDATION

Aggressively implement fuel-economy standards established in the Energy Independence and Security Act of 2007 (EISA).

Ensure the National Highway Traffic Safety Administration's (NHTSA) rule-making process for cars and light trucks is done at the maximum feasible rate to provide the nation with the greatest oil savings.

In keeping with the Council's 2006 Recommendations, the EISA enacted comprehensive increases in the fuel-economy standards for cars and light trucks for the first time in more than 30 years. The full fleet of new light-duty vehicles sold in the United States will be required to reach 35 miles per gallon by 2020, with current standards increasing at an average rate of 3.3 percent per year (the Council had recommended 4 percent). The existing CAFE system was also reformed so that standards will be determined on the basis of vehicle attributes. Under this approach, fuel-economy standards will be formulated for each manufacturer based on the footprints of the vehicles they sell. In other words, instead of a one-size-fits-all average for all automakers, each manufacturer will face a customized standard tailored to its production slate.[155]

Beyond 2020, the legislation calls for NHTSA to increase fleet-wide fuel-economy standards at the "maximum feasible" rate. This rate will be determined within NHTSAs rule-making process. The Council advocates expediting the process to set standards so that we can benefit from the oil savings as soon as possible.

In its 2002 study of CAFE's effectiveness, the National Academy of Sciences (NAS) concluded that the fuel economy of large U.S. passenger cars could be cost-effectively raised by as much 27 percent within a decade using available and emerging technologies to increase the efficiency of engines and transmissions. For the largest light trucks, the potential improvement was 42 percent. The implied potential fuel economy for the entire fleet given the existing mix of vehicles was 30.3 MPG.

The NAS study was by no means overly optimistic. The authors assumed only existing and emerging technologies and applied a gasoline price of only $1.50 per gallon. A retail gasoline price of $2.50 per gallon raises the expected cost-effective fuel economy of the entire fleet to 33.9 MPG. At $3.55 per gallon, the figure rises to 37.6 MPG, which equates to annual fuel economy increases of approximately 4.6 percent year for 10 years.

155 There is an anti-backsliding provision that limits manufacturer flexibility.

Significantly, the NAS study "gave little consideration" to the fuel-economy benefits of hybrids and advanced diesels.[156] Within the last five years, however, these technologies have dramatically raised the near-term bar on fuel economy. For example, Toyota's Prius gasoline-electric hybrid averages 46 MPG (2008 EPA combined mileage), giving it a fuel-economy rating that is 59 percent higher than its conventional sister-model, the Toyota Corolla.[157] And another wave of technological innovation is on the way. Diesel-hybrid concept cars—not compacts, but full-size family sedans—have been rated at 70 to 80 MPG.[158] Cutting-edge materials such as carbon fiber were developed for national defense, but they can also trim vehicle weight without compromising strength or safety and boost fuel economy to over 100 MPG.

Moreover, by conservatively valuing the externalities of gasoline consumption in its fuel-economy rulemakings, NHTSA has dismissed many feasible fuel-efficiency technologies as unacceptably expensive. But while externalities such as defense costs, future conflict over resources, and the empowering of hostile regimes are hard to quantify, they are nonetheless real and must be borne by society. The Council believes that Congress must give NHTSA explicit direction in how to more comprehensively value the benefits of reduced oil dependence. Without this policy guidance, the standard-setting process will continue to systematically undervalue the benefits of lower fuel consumption.

By conservatively valuing the externalities of gasoline consumption in its fuel-economy rulemakings, NHTSA has dismissed many feasible fuel-efficiency technologies as unacceptably expensive. But while externalities such as defense costs, future conflict over resources, and the empowering of hostile regimes are hard to quantify, they are nonetheless real and must be borne by society.

At the conclusion of the National Research Council's ongoing update of its 2002 study on the effectiveness of fuel economy standards, Congress should reevaluate the EISA standards to determine if they are sufficient given changes in the economy and technology since December 2007.

EISA directed the Department of Transportation to contract with the National Research Council to study the new fuel-economy standards. Congress called for the report to be concluded in 2013. The Council recommends accelerating delivery of the report by three years and then reconsidering the EISA standards based on the conclusions in the report. Moreover, in conducting its analysis, the National Research Council should employ an analytical framework that measures the true cost of U.S. oil dependence, including the cost of externalities that are not incorporated into the cost of oil.

156 Paul R. Portney , testimony prepared for House Committee On Science and Technology, "Improving the nation's energy security: can cars and trucks be made more fuel efficient?" 109th Cong., 1st Sess., 9 February 2005.

157 http://fueleconomy.gov/.

158 Amory B. Lovins, E. Kyle Datta, Odd-Even Bustnes, Jonathan G. Koomey, and Nathan J. Glasgow, *Winning the oil endgame: innovation for profits, jobs, and security* (Snowmass, CO: Rocky Mountain Institute, 2005), 50 ff.

Ensure that the National Highway Traffic Safety Administration (NHTSA) pursues an aggressive and expeditious rule-making process with regard to medium- and heavy-duty trucks as part of implementing EISA 2007 and, where possible, phase, consolidate, and streamline statutorily-required processes to result in maximum oil savings at the earliest possible date.

In accord with the Council's 2006 Recommendations, EISA mandated the issuance of fuel-economy standards for medium- and heavy-duty trucks for the first time in U.S. history. This structural reform is of great importance for reducing fuel demand in the transportation sector. However, the legislation did not set specific standards for these vehicles, as it did for cars and light trucks. Instead, the bill left NHTSA with statutory authority for setting the medium- and heavy-duty fuel-economy standard as part of its rule-making process.

Because medium- and heavy-duty trucks account for nearly one-fifth of transportation fuel demand, setting appropriately aggressive standards has the potential to achieve significant oil savings. In order to allow us to achieve those savings as soon as possible, NHTSA should proceed with the rulemaking process on as accelerated a timetable as possible, while ensuring that the rule-making process is soundly rooted in an analytical framework that measures the true cost of U.S. oil dependence. The Council believes that 4-percent annual improvements in medium- and heavy-duty truck fuel economy are both technologically and economically feasible. Such a rate would also be consistent with NHTSA's recent rule-making for cars and light trucks, as well as with DOE and DOT studies detailing the technical potential for cost-effective improvements in the fuel economy of medium and heavy-duty trucks.[159]

RECOMMENDATION

Increase allowable weight to 97,000 lbs. gross vehicle weight for tractor-trailer trucks that have a supplementary sixth axle installed but which replicate current stopping distances and do not fundamentally alter current truck architecture. In addition, government should study further the safety impacts of significantly longer and heavier tractor-trailers used in conjunction with slower speed limits.

Regulations limit the weight of trucks in the United States to well below Canadian and European levels. Given the demonstrated safety of longer and heavier trucks abroad, the Council recommends that the government increase allowable weight to 97,000 lbs. gross vehicle weight for tractor-trailer trucks that have a supplementary sixth axle installed but which replicate current stopping distances and do not fundamentally alter current truck architecture. Moreover, the Council continues to recommend that the government study the safety impacts of significantly longer and heavier tractor-trailers used in conjunction with slower speed limits. If safety can be proven, implementation could generate major efficiencies while simultaneously reducing road congestion and other non-fuel costs.

159 DOE, EIA, A. Vyas, C. Saricks and F. Stodolsky, "The potential effect of future energy-efficiency and emissions-improving technologies on fuel consumption of heavy trucks," (August 2002), http://www.ipd.anl.gov/anlpubs/2003/03/45815.pdf, last accessed 27 August 2008; DOE, Argonne National Laboratory, "FreedomCAR and vehicle technologies heavy vehicle program FY 2006 benefits analysis: methodology and results – final report," (2005), http://www.ipd.anl.gov/anlpubs/2006/01/55326.pdf, last accessed 27 August 2008; DOE, Argonne National Laboratory, F. An, F. Stodolsky, A. Vyas, R. Cuenca, and J. Eberhardt, "Scenario analysis of hybrid class 3-7 heavy vehicles," (March 2000), http://www.osti.gov/bridge/servlets/purl/750634-10KujN/webviewable/750634.pdf, last accessed 27 August 2008.

RECOMMENDATION

Require the Federal Aviation Administration (FAA) to implement and fund improvements to commercial air-traffic routing in order to increase safety and decrease fuel consumption.

U.S. airlines incur substantial additional operational costs for every minute of flight delays, with a considerable share of the increased costs going to cover incremental fuel costs. Improved air traffic control procedures could reduce flight delays and improve flight times, thereby decreasing aviation fuel consumption.

By doubling the number of usable altitudes between 29,000 and 41,000 feet, the Domestic Reduced Vertical Separation Minima (DRVSM) implemented in 2005 are believed to have saved 500 million gallons of jet fuel in their first year alone, equivalent to nearly 12 million barrels.[160] That was over 2 percent of all the jet fuel consumed in that year by U.S. commercial carriers. Additional savings could be achieved through rationalized routing. Area Navigation Procedures (RNAV), which allow aircraft to improve the efficiency of climbs, descents, and other movements by supplementing ground navigation information with GPS data and computer analysis, would also yield substantial efficiencies upon full implementation. Other advances with major fuel savings potential are airspace optimization programs like the one recently instituted in south Florida, better oceanic flight protocols, and state-of-the-art tools to permit flight controllers to predict conflicts and minimize the need for drastic course alterations.

The Council believes that 4-percent annual improvements in medium- and heavy-duty truck fuel economy are both technologically and economically feasible. Such a rate would also be consistent with NHTSA's recent rule-making for cars and light trucks, as well as with DOE and DOT studies detailing the technical potential for cost-effective improvements in the fuel economy of medium and heavy-duty trucks.

Ultimately, the nation will require the Next Generation Air Transportation System (NEXTGEN).[161] This new infrastructure will utilize digital, satellite-based technologies to provide the capacity and efficiency necessary to keep pace with growing demand in air traffic services. Incidentally but by no means inconsequentially, NGATS might yield oil savings of as much as 0.4 MBD by 2030. The Council supports these improvements in air-traffic routing and calls on Congress to end the political stalemate that has prevented funding for this important advance.

160 Of course, not all of the 42 gallons in a barrel can be used to yield jet fuel; discussions with John Heimlich, Chief Economist, Air Transport Association of America, various dates. See Federal Aviation Administration (FAA), "Aerospace forecasts FY 2005–2016," Table 25, http://www.faa.gov/data_statistics/aviation/aerospace_forecasts/2005-2016/media/Table25.PDF, last accessed 26 August 2008.

161 FAA, "NextGen goal: performance-based navigation," 24 June 2008, http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=8768, last accessed 27 August 2008.

PART V

Managing Risks and Global Issues

The Department of Defense, the State Department, and the various branches of the intelligence community must consciously focus on issues of energy supply as part of their comprehensive pursuit of national security. Working in concert, they must develop policies and strategies that protect the global infrastructure, secure key geographic transit areas, and mitigate political instability in energy-supplying countries.

V. Managing Risks and Global Issues

The security of the global oil market depends on a vast network of oil production and transport infrastructure, much of which is vulnerable to sabotage, attack and political manipulation. In spite of efforts to diversify transportation fuels, reduce oil demand and increase domestic supply, any disruption to this vital infrastructure could result in a sudden and debilitating rise in oil prices.

In July 2008, the International Energy Agency estimated that OPEC spare production capacity would average 2.5 million barrels per day in that year and warned that spare capacity could fall as low as 1.0 MBD within 5 years.[162] At such dangerously low levels, OPEC spare capacity would easily be overwhelmed by a range of highly plausible scenarios, which in turn would cause significant economic damage for all oil-consuming countries in a short period of time. Oil ShockWave™, a scenario exercise conducted by SAFE, found that the temporary loss of even 2 percent of daily world oil supplies could cause prices to quickly spike by as much as 80 percent.[163] Given the wide range of threats to global petroleum supply, it is imperative that the United States and its allies take proactive steps to manage the risks associated with near-term dependence on an increasingly unstable world market.

RECOMMENDATION

Direct the Department of Energy to develop workable guidelines for the use of the Strategic Petroleum Reserve and evaluate its proper size based on those criteria.

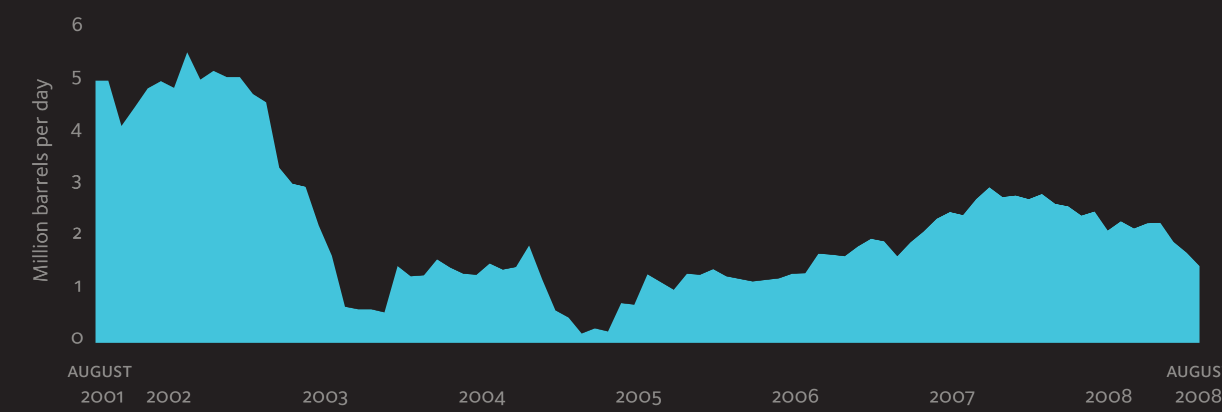
The Strategic Petroleum Reserve (SPR), a government-owned crude reserve, was established in the mid-1970s in the wake of the 1973-74 Arab Oil Embargo as our nation's first line of defense against future oil supply interruptions. Since 2000, the reserve has been expanded from 540 million to 700 million barrels of oil. Moreover, in the Energy Policy Act of 2005, Congress directed the Department of Energy to expand the capacity of the SPR to 1 billion barrels and to fill it to that level. As prices rose past $100 per barrel in the summer of 2008, Congress passed legislation stopping the president from continuing to fill the SPR.

Congress should direct the Secretary of Energy to initiate a process to develop clear guidelines for use of the SPR. Given the development of the market since the 1970s, establishing parameters for use of the SPR presents a significant challenge. The reserve is currently large enough to enable temporary responses to physical supply disruptions related to acts of war, terrorism, or natural disasters. However, today's reserve is far too small—and probably could never be made large enough—to respond meaningfully to a catastrophic loss of oil resulting from a crisis involving a long-term interruption in the flow of Persian Gulf oil. Likewise, the SPR is not an economic reserve that can moderate the price of oil over a sustained period of time.

162 IEA, *Medium-term oil market report* (July 2008), 5.
163 SAFE, *Oil ShockWave: simulation report and summary of findings* (2007).

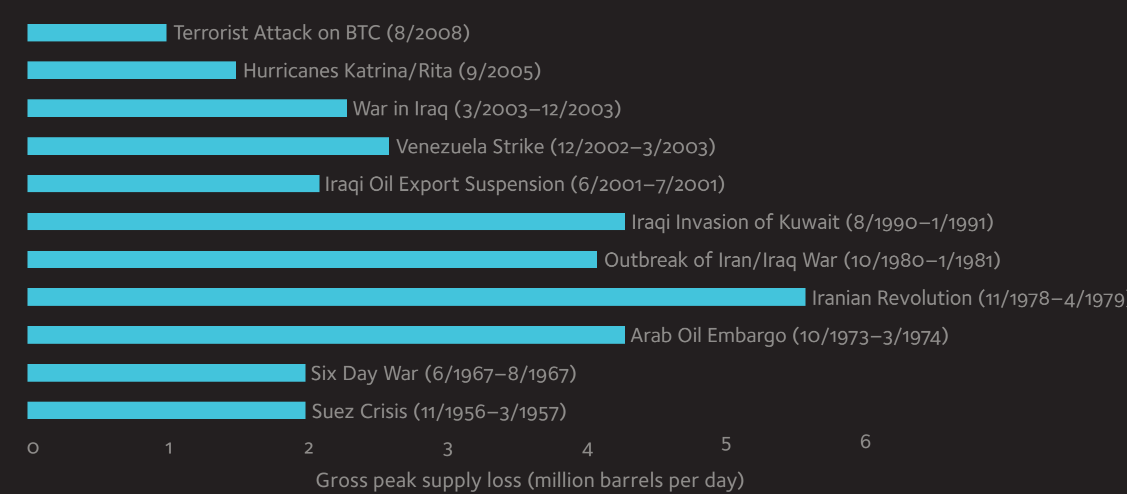
Over the past several years, steadily rising demand for oil has placed mounting strain on energy producers to increase output. But non-OPEC supply growth has proven to be more geologically challenging than anticipated, and corruption, instability and political manipulation have constrained production investments within OPEC. The result has been low spare capacity. In the event of a significant oil supply disruption, today's level of spare capacity could be overwhelmed.

OPEC SPARE CAPACITY



IEA, *Monthly Oil Market Report* (2001-2007)

MAJOR OIL SUPPLY DISRUPTIONS



IEA, *Oil Supply Security* (2007), 19.

Given the uncertainty over its proper use, Congress should direct the Department of Energy to initiate a process to establish criteria for use of the SPR. Once completed, the Secretary should then initiate a study to determine the appropriate size for the SPR, and based on the outcome of that process, offer new recommendations to Congress regarding both the SPR's size and proper use. Until that point, the SPR should not be used as a tool to reduce oil prices.

RECOMMENDATION

Work with foreign governments to eliminate fuel subsidies.

According to a recent study by Morgan Stanley, half the world's population receives fuel subsidies. Gasoline and diesel are heavily subsidized in much of Asia and Africa, not to mention in most OPEC countries. In Venezuela, for instance, gasoline cost 10 cents per gallon in the summer of 2008.[164] Fuel subsidies create significant problems for most countries that offer them, and these effects can spill over to the global oil market as well. In particular, subsidies shield consumers from the true market costs of fuel consumption, artificially supporting higher demand levels than would be the case without the subsidies. When these policies are implemented in large oil consumers such as China and India, there are substantial consequences for the entire global oil market. Higher demand levels in these countries support higher oil prices around the world.

To address this market failure, the government should engage in a diplomatic effort to assist countries that subsidize fuel costs in reducing or eliminating their subsidies. In instances where it may be too difficult or destabilizing to allow low-income consumers to pay the market price for fuel, the United States could suggest that they eliminate fuel subsidies so that all consumers face the market price of fuel thus having an incentive to conserve fuel, and offer direct aid to low-income households to offset some of their fuel costs. This approach has two benefits relative to direct fuel subsidies. First, forcing all consumers to pay the market price for fuel will encourage them all to conserve, even if they receive a direct payment to compensate them for some of their fuel costs. Second, restricting payments to lower income families will eliminate the cost of subsidizing fuel for those who can afford its non-subsidized price.

RECOMMENDATION

Promote a robust China-U.S. partnership on carbon capture and storage that focuses on private-sector collaboration and sharing of best practices.

The world's two largest consumers of electricity, the United States and China, should increase collaboration on clean power initiatives that are consistent with geopolitical stability and global energy security. In 2007, the International Energy Agency reported that China had passed the United States as the world's largest emitter of energy-related carbon dioxide, despite the fact that China's GDP was still just 20 percent of U.S. GDP. This seeming disparity has arisen because coal provides over 70 percent of the energy consumed in China each year, compared with only 20 percent in the United States. As the most carbon-intensive fuel, coal is a significant factor in increasing global

164 IEA, *Monthly oil market report* (July 2008), 14.

carbon emissions. However, given its wide availability in both China and the United States, coal will likely remain a large part of the energy mix in both countries.

The Council is aware of several ongoing initiatives led by the Departments of Energy, Treasury and State and believes that joint private sector research and development initiatives represent the most likely means for success in such collaboration. With both nations possessing huge reserves of coal, a robust partnership to develop carbon capture and storage technologies for use with coal-fired power generation is certainly in order.

RECOMMENDATION

Establish a National Energy Council at the White House to coordinate the development of the nation's energy policy and to advise the president with regard to energy policy.

Given the scope of the energy-related challenges facing the nation, and the range of government agencies involved in formulating energy policy, the president should establish an interagency National Energy Council at the White House. The council would operate as a co-equal to the Domestic Policy Council and the National Economic Council with a mandate to be responsible for energy issues. The office can be established by the president without a change in the law.

Half the world's population receives fuel subsidies. Gasoline and diesel are heavily subsidized in much of Asia and Africa, not to mention in most OPEC countries. Subsidies shield consumers from the true market costs of fuel consumption, artificially supporting higher demand levels than would be the case without the subsidies. When these policies are implemented in large oil consumers such as China and India, there are substantial consequences for the entire global oil market. Higher demand levels in these countries support higher oil prices around the world.

The establishment of a National Energy Council will demonstrate the president's commitment and attention to the issue of energy-related economic transformation and establish a new seriousness of purpose as our nation moves to address this challenge. Government policies and programs related to energy fall within the interest of many federal agencies which often have competing views. An interagency council can help ensure that conflicts are resolved in a manner that is consistent with our nation's overall energy goals.

RECOMMENDATION

The National Intelligence Council should complete a comprehensive National Intelligence Estimate on energy security that assesses the most vulnerable aspects of the infrastructure critical to delivering global energy supplies and the future stability of major energy suppliers.

The first step to more effectively managing risks to the United States' energy supplies involves a comprehensive assessment of the world's critical infrastructure and energy reserves. As the lead organization responsible for strategic analysis within the intelligence community, the National Intelligence Council (NIC) should take the lead in providing policymakers with a comprehensive risk assessment on the nation's energy security. In 2007, the NIC completed a National Intelligence Assessment on the national security implications of climate change. Building on that experience, the NIC should now complete an assessment that provides the next president with the foundation of information upon which to base his energy security policies over the next four years.

The intelligence community should also collect information on the motivations and capabilities of groups who seek to attack infrastructure and work to provide policymakers with current information on major infrastructure projects that could impact the future of American energy supplies. The National Geospatial Agency, for example, has previously provided analysis of commercial imagery data on oil pipelines under construction and in operation in Russia and the Caucasus to track progress and security of oil pipeline projects. This cooperation and support must be made systematic.

RECOMMENDATION

Working with the Department of State, the Department of Justice should bolster programs designed to train national police and security forces to defend and secure energy infrastructure in key countries.

The United States military alone cannot provide the type of omnipresent security coverage that would prevent or mitigate attacks against key energy infrastructure located around the world. Pipelines, for example, cross thousands of miles of terrain in countries in which the United States does not have a security presence.

Where they are perceived as representing foreign influence or economic and political inequality, pipelines are often the prime targets of saboteurs or terrorists. For example, the Armed Forces of Columbia (FARC), a Marxist military group, has often attacked the pipelines of Chevron and Chevron's ally, Petroecuador. In the Niger Delta, recent attacks on Chevron and Shell petroleum pipelines by the Movement for the Emancipation of the Niger Delta (MEND) halted production that resulted in a decline of Nigerian output by about 650,000 barrels per day. The impact of these disruptions is significant, as Nigeria ranks as the fifth-largest supplier of U.S. oil imports.

With countries like Nigeria in mind, the United States should bolster programs to improve the capacity of domestic security forces that have the responsibility to protect critical infrastructure. Additionally, the United States should attempt to improve the ability of its partners to mitigate the impact of attacks and disruptions.

The United States can build on the experience gained while helping Colombia develop a quick-response capability. Since 2002, the United States has provided almost $100 million in technical assistance to Colombia with the goal of securing key oil pipelines. These efforts have significantly reduced the impact of attacks on supply.

RECOMMENDATION

As called for in its recent Maritime Strategy, the U.S. Navy should leverage the maritime forces of other countries to provide protection against terrorists and pirates for oil tankers in vulnerable regions.

In 2008, a report by the U.S. Government Accountability Office (GAO) questioned whether the U.S. Coast Guard had adequate resources to protect tankers and loading facilities. Another GAO report in 2007 concluded that the United States government has not conducted sufficient research on the impact of an attack on tankers.

Tankers now transport about half of the oil produced in the world. More than 90 percent of the United States' energy imports arrive via tanker. The increase in the demand for natural gas will continue to increase the number of LNG tankers and LNG import terminals. The large number of tankers traversing the globe, and the importance of tankers in delivering global energy supplies, make them an attractive target for groups intent on attacking U.S. interests.

Al-Qaeda has attempted to attack large oil tankers. The first successful attack occurred in 2002, when a small boat rammed into the *Limburg*, a French vessel. The tanker suffered about $45 million worth of damage and 90,000 barrels of oil were lost. More important, the attack also caused a short-term collapse of traffic through the Gulf of Aden.

Terrorist organizations are not the only threat to tankers. Pirates and politically motivated groups also regularly attempt to attack or disrupt tanker shipments. According to the International Maritime Bureau's Piracy Reporting Center, there were 49 attacks on tankers in the first quarter of 2008, up from 41 attacks in the same period in 2007.

The areas where tankers are most vulnerable to attack are the Red Sea, the western Indian Ocean, the western approaches to the Strait of Malacca, and the South China Sea. The littoral countries of these regions have various degrees of commitment and capability to protect shipping. The U.S. Navy has developed concepts for cooperative international maritime action to protect lawful use of the seas and suppress illegal use. The United States, through foreign military assistance, maritime cooperation and other means, should strengthen international capability to police these maritime regions without assuming responsibility for doing so on its own.

RECOMMENDATION

The Department of Defense should engage NATO and other allies in focused negotiations with the intention of creating an architecture that improves the security of key strategic terrain.

The United States contributes more than any other nation to protecting global oil infrastructure. And while the United States has never shirked this responsibility, the time has come for other nations and institutions to expand their own efforts. The United States should attempt to build on well-developed models for international cooperation, such as the efforts promoted by the Navy's Fifth Fleet through Task Force 150, to create lasting and sustainable agreements that will provide the American military with needed support in policing international waterways.

Key energy infrastructure, particularly loading terminals and oil platforms, is located along the coasts of nations who supply large volumes of energy to the world market. The importance of these facilities has increased the demands placed upon the American military, the Navy in particular, to provide security. In order to improve the sustainable security of these facilities, the United States should focus on building the capacity of local national navy and coast guard forces to secure their coastlines.

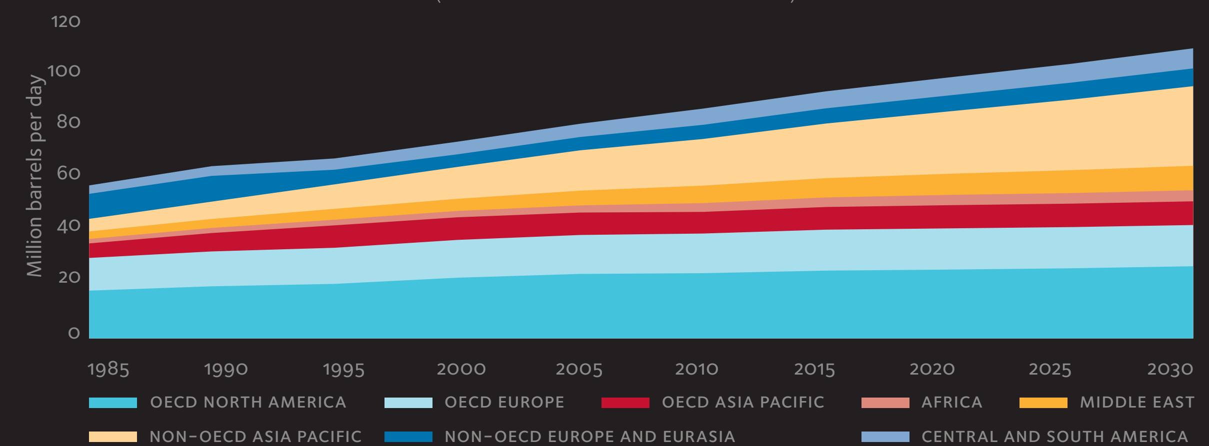
Conflict not only affects energy supplier states, but potential transit countries as well. For decades, war has prevented the construction of a pipeline across the territory of Afghanistan. All major pipelines transporting Central Asian energy currently go through Russia. Because diversifying export routes is important to energy security, the lack of stability in Afghanistan is problematic. More recently, the Russian incursion into South Ossetia and Georgia threatened the security of the Baku-Tbilisi-Ceyhan (BTC) pipeline.

Improving the capacity of local maritime security organizations will be particularly important in developing countries (e.g., Nigeria and Angola) that will provide a larger share of U.S. energy supplies in the future. Many energy analysts forecast that oil supplies from West Africa will grow from 15 percent of America's total consumption to 25 percent. And with the growing importance of West African energy supplies, the requirement for security has also increased. From 2004 to 2006, the U.S. Navy increased its presence off the coast of West Africa from 12 days to more than 180 days. In addition, the U.S. Navy's Sixth Fleet has successfully worked with local national forces in West Africa over the past several years to build the capacity of West African governments. The United States should build on this success by providing additional resources and enlisting the support of our allies.

Global demand for oil is expected to rise by more than 30 percent over the next two decades, driven by rapid economic growth in emerging markets. Meeting this demand will fall mostly to the members of OPEC and the countries of the former Soviet Union.

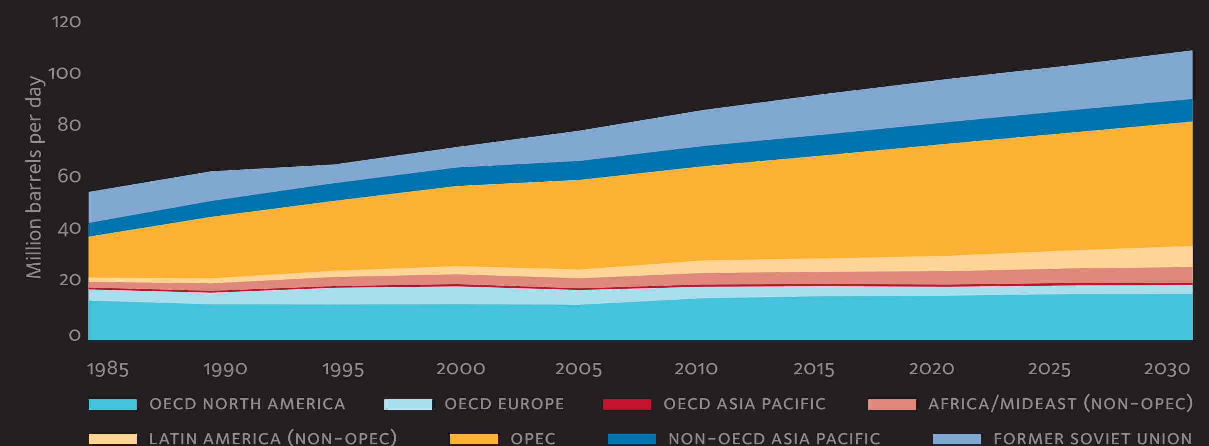
Many of the most important oil-producing nations are beset by violence, instability, and corruption that deter investment in energy. In other cases, the critical infrastructure that delivers oil to markets each day is vulnerable to sabotage and political manipulation. Identifying the most pressing threats will allow U.S. policymakers to work in concert with allies to mitigate risks.

WORLD OIL CONSUMPTION (HISTORICAL AND FORECAST)



U.S. Department of Energy, *International Energy Outlook* (2008); and BP p.l.c. *Statistical Review of World Energy* (2008)

WORLD OIL PRODUCTION (HISTORICAL AND FORECAST)



U.S. Department of Energy, *International Energy Outlook* (2008); and BP p.l.c. *Statistical Review of World Energy* (2008)

RECOMMENDATION

The intelligence community should bolster collection and analysis capabilities on potential strategic conflicts that could disrupt key energy supplies. The State Department should improve its capacity to intervene diplomatically in conflicts that impact U.S. energy security.

In addition to securing key global infrastructure and transit corridors, the United States must also focus on mitigating both the risk posed by political instability and conflict in producer countries and the ability of suppliers to leverage energy supplies to achieve political goals.

Political stability is critical to guaranteeing the production and transport of energy supplies. During times of military conflict or political crisis, production fields are not able to function at full capacity and the components of a state's energy infrastructure become targets for attack. Oil production fell dramatically, for example, in Iran after the 1979 Islamic revolution, and in 1991 when the Soviet Union collapsed.

The historical volatility in Iraqi oil production clearly demonstrates the negative effect of political crisis. Severe drops in production occurred in 1980, 1991, and 2003, which coincided with the start of the Iran-Iraq war, the first Persian Gulf War, and the U.S. invasion of Iraq. By some estimates, there were more than 400 attacks on Iraq's energy infrastructure between April 2003 and May 2007. The inability of Iraqi leaders to provide clear guidance on the future of Iraq's oil and gas industry has prevented Iraq from returning to pre-war oil production levels.

Conflict not only affects energy supplier states, but potential transit countries as well. For decades, war has prevented the construction of a pipeline across the territory of Afghanistan. All major pipelines transporting Central Asian energy currently go through Russia. Because diversifying export routes is important to energy security, the lack of stability in Afghanistan is problematic. More recently, the Russian incursion into South Ossetia and Georgia threatened the security of the Baku-Tbilisi-Ceyhan (BTC) pipeline.

RECOMMENDATION

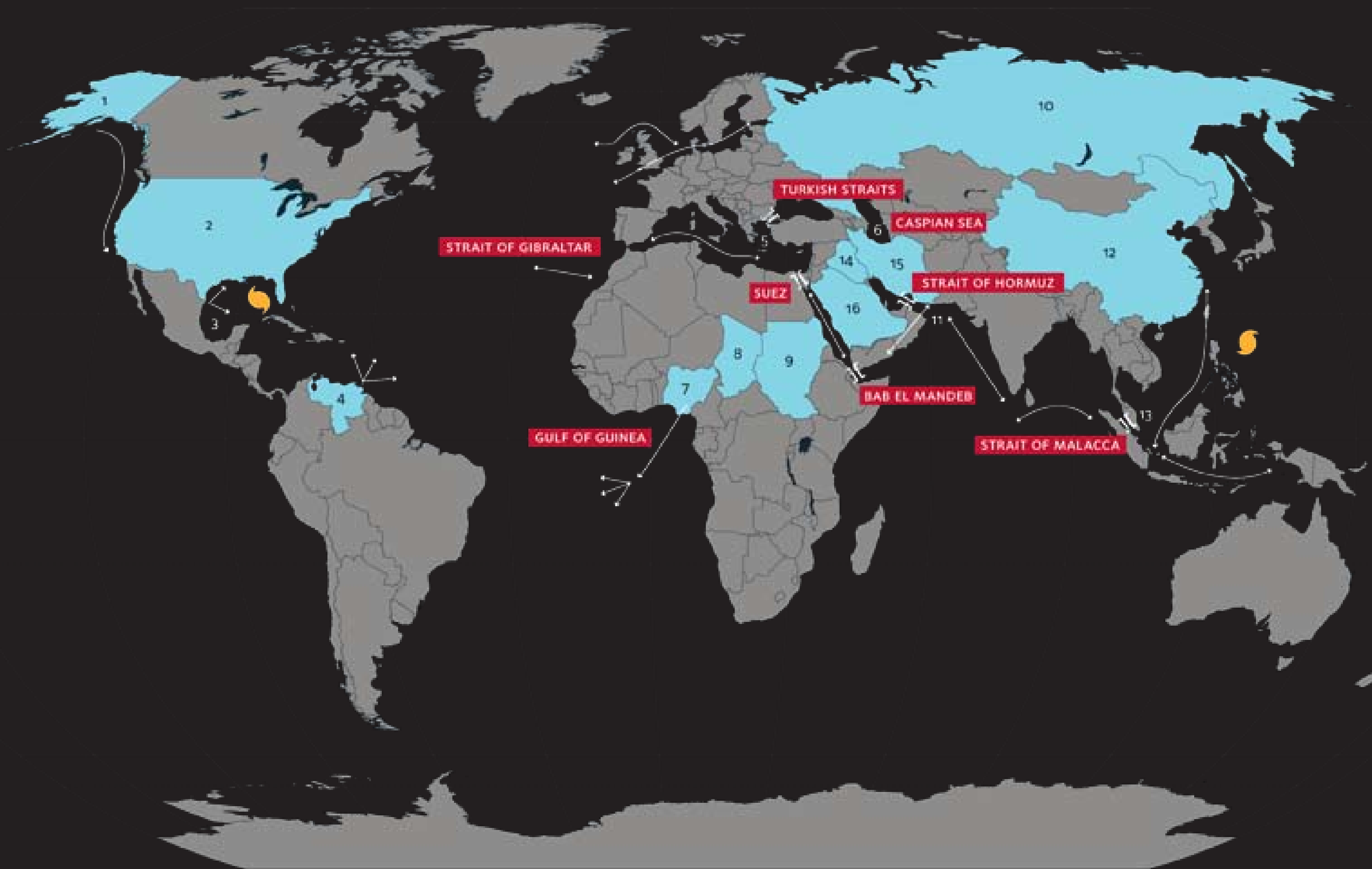
The intelligence community should expand the collection of intelligence on national oil companies and their energy reserves in order to allow policymakers to make better decisions about future alliances and the nation's strategic posture on energy suppliers.

In order for policymakers and U.S. companies to develop long-term energy policy and investments, they need consistent and accurate information about the volume of world reserves. The vigorous debate over peak oil is fueled by the lack of solid public information regarding the state of the world's oil supply. Oil companies and producing nations report their own reserves numbers, frequently without any outside auditing.

Saudi Arabia, for example, is often accused of overstating or misjudging its future production capability. It is almost impossible to obtain information about the world's biggest oil field, Ghawar, because Saudi Aramco and the Saudi government closely guard their production figures. Turkmenistan provides another example. It has promised to supply natural gas to Russia, China, Iran, and the European Union, but, until very recently, had not allowed any external auditors to confirm the extent of its natural gas reserves. This has great implications for consumers of Turkmen gas. By not revealing its true reserves, Turkmenistan benefits from the agreements it makes, while potential consumers of Turkmen natural gas are left questioning whether Turkmenistan will have enough gas to be able to fulfill its contractual obligations.

The lack of clarity regarding proven reserves will make competition for the remaining energy resources that much more fierce, especially as the demand for energy increases in developing countries such as China and India. Both countries are making a concerted effort to sign energy deals throughout Asia and the Middle East. Uncertainty and suspicions about the true state of the world energy balance can only stoke dangerous geopolitical tensions.

Instability in major oil-producing countries, a volatile investment environment, the threat of terrorism, a decrease in spare capacity, and high demand growth are straining the global oil supply system, causing high and volatile prices, and creating very real economic and national security vulnerabilities for the United States.



MBD—million barrels per day; B/D—barrels per day. Figures represent a country's or region's production in 2007. This map depicts only some of the widespread instability in the global oil market.
Source: BP p.l.c., EIA

1. PORT OF VALDEZ AND TRANS-ALASKA PIPELINE
The Trans-Alaska pipeline accounts for roughly 14 percent of U.S. crude oil production. Sabotage a serious concern.

2. UNITED STATES: 6.9 MBD
World's largest consumer, accounting for about 25 percent of global demand despite having only 3 percent of world reserves.

3. GULF OF MEXICO: 1.5 MBD
Infrastructure inherently vulnerable to natural disasters. In 2004 and 2005, hurricanes were responsible for the single greatest losses of energy output.

4. VENEZUELA: 2.6 MBD
President Chavez frequently threatens to "cut off the oil," noting economic consequences for U.S. In late 2002 and early 2003, labor strikes and general unrest reduced output by more than 60 percent.

5. TURKISH STRAITS
About 2.5 MBD flow through this chokepoint en route to Mediterranean Sea and world markets. One of world's busiest shipping lanes and only a half-mile wide at its narrowest point.

6. CASPIAN SEA AND THE CAUCASUS: 2.3 MBD
Ethnic conflicts, frequent unrest, and rampant corruption threaten export growth.

7. NIGERIA: 2.4 MBD
Ongoing political instability, including militant attacks on oil infrastructure, has reduced output.

8. CHAD: 200,000 B/D
President threatened to shut down production in dispute with World Bank. Government under attack from rebels.

9. SUDAN: 450,000 B/D
Violence threatens investment. China has resisted or blocked U.N. sanctions.

10. RUSSIA: 9.9 MBD
Uncertainty remains in wake of Yukos affair and other recentralization efforts. World's second largest producer.

11. STRAIT OF HORMUZ: 17 MBD
Roughly 20 percent of the world's total supply flows through the Strait of Hormuz. If blocked, only a small portion could be transported along alternate routes.

12. CHINA: 3.7 MBD
Rapidly growing demand due to economic development; recently became world's second largest consumer. Efforts to secure supplies will only intensify.

13. STRAIT OF MALACCA
Carries 15 MBD between Persian Gulf and key developing markets in East Asia. Narrowness makes navigation difficult; piracy a regular occurrence.

14. IRAQ: 2.1 MBD
Terrorists frequently target oil facilities. Currently producing well below pre-Gulf War capacity levels.

15. IRAN: 4.4 MBD
Fears persist over nuclear showdown with West.

16. SAUDI ARABIA: 10.4 MBD
Rife with terrorist threats and political tensions; current spare production capacity much lower than in past.

Conclusion

With each passing year, the global oil trends now at work—rising consumption, reduced spare production capacity, politicized capital investment strategies, and high levels of instability in key exporting countries—all increase the likelihood of an oil crisis. The odds in favor of a crisis are further heightened by the rise of terrorist movements expressly committed to targeting critical elements of the world's vulnerable oil production and delivery infrastructure and hostile state actors willing to use oil as a strategic weapon against the United States.

Many of the solutions we have put forth for consideration will require decades to mature. Market forces alone will not sustain their development, especially if the world experiences a temporary return of lower oil prices. Instead, government engagement will be necessary to align private interests in the service of the nation. We are confident that Americans will support a bipartisan and open-minded campaign for increased energy security. Let the campaign to reduce oil dependence be the first test of this patriotic belief.

About the Project

Securing America's Future Energy (SAFE) is a nonpartisan, not-for-profit organization committed to reducing America's dependence on oil and improving U.S. energy security in order to bolster national security and strengthen the economy. SAFE has an action-oriented strategy addressing politics and advocacy, business and technology, and media and public education.

The Energy Security Leadership Council, a project of SAFE, is an intensive effort by a collection of prominent business leaders and retired senior military officers to build support for a comprehensive, long-term policy to reduce U.S. oil dependence and improve energy security. Members of the Council are united in the belief that a fundamental shift in energy policy can prevent an unprecedented economic and national security calamity. In bringing together representatives of the business community and retired senior military officers, the Council is focused on breaking the longstanding energy policy stalemate.

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