Policies for a Secure Energy Future: Issues in Supply and Demand

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Policy interest in energy tends to ebb and flow. When prices are high or volatile, policy makers focus on actions to improve markets, diversify fuel and technology options, open up access to new resources, and improve the efficiency of how we use energy. When events cause high levels of pollution or natural resource damages related to energy production or delivery, the focus shifts to finding energy options with lower environmental risk. Typically, energy policy action occurs in the context of crises, not during calmer times that might allow for more measured consideration of the inevitable tradeoffs and balancing of interests.

In July 2007, for example, only three and a half years ago but a year before the global economic collapse would help to drive down energy prices, the National Petroleum Council's study, "Facing Hard Truths About Energy," opened with "The American people are very concerned about energy—its availability, reliability, cost, and environmental impact." Coming only two years behind the enactment of the comprehensive Energy Policy Act of 2005, the NPC report noted that energy was still "a subject of urgent policy discussions." By the end of 2007, Congress had enacted the Energy Independence and Security Act, designed to support those named goals by increasing the production of clean renewable fuels and the efficiency of products, buildings, and vehicles, by promoting research on and deployment of greenhouse gas capture and storage options, and by improving the energy performance of the federal government.

Just a few months later, in July 2008, wellhead prices of natural gas peaked at $10.79 per million cubic feet (mcf); by the end of 2010, prices were a third as high ($3.71 per mcf).[1] Overall energy demand dropped, of course, with the economic collapse, and by 2010 was still almost 5% lower than it was in 2007.[2] And while energy is still on the agenda of some policy makers, consumers and producers (a notable example being this past summer's oil spill in the Gulf of Mexico), energy is hardly the subject of "urgent" discussions in very many places.

Thus, this year's Aspen Institute Congressional Program explores our nation's energy security needs in the absence of a perceived crisis. Recent polls indicate that Americans do not list energy issues as among "important issues facing the country now."[3] In fact, there may be as much good news on energy security issues as there is bad, with recent developments in natural gas being the best example of a good news story. But the challenges are still real and the issues important. The papers and sessions at this year's meeting examine separate in-depth issues related to oil drilling, coal, transportation, green jobs, and adapting to climate change. The topic of this paper, then, is to examine the overall context for our energy economy, with more attention to issues not covered in other panels: natural gas, renewables, nuclear, and energy efficiency.

Setting the stage—some facts:

What are the energy resources that Americans depend upon, and where do they come from? There are some simple but important features of the U.S. energy landscape:

1. **Overall Energy Use:** Overall energy use has risen approximately 20% since 1980. (Figure 1). Before the recent economic decline which caused energy demand to fall in absolute terms, U.S. energy use from 1980 to 2007 had grown by 30%.

2. **Trends in Energy Use by Customer Type:** Households and industries use most of the nation's energy, with commercial customers not far behind. This may sound intuitively obvious, but this fact is inherently hidden in the traditional governmental data on energy use, which often depict "the power sector" and the "transportation sector" as users of energy, alongside of residential, commercial and industrial customers, muddying the fact that it is citizens and businesses who are the ultimate users of energy. (Figure 2). Considering that residential customers (households) currently make up over 1/3 of the transportation sector's energy use (in driving motor vehicles) and nearly 2/5 of all electricity (in their homes), and industrial customers use approximately 1/4 of all electricity and a substantial portion of energy used for transportation, then the data would show that these two sectors use most energy today. Commercial users' electricity use, however, is growing relatively fast (especially due to growth in electricity use in commercial buildings), so that commercial customers' overall share of total energy is slowly rising. In parallel, industrial customers' share of total energy is dropping the fastest over time, with industrial energy use having peaked in absolute terms in 1997 at a level 20% higher than it is at present. (Figure 3). Over time, electricity production and delivery takes up an increasing share of total energy.

3. **Household Energy Use:** Taking into account energy used in homes and motor vehicles, half of the typical person's direct energy use is electricity in buildings,[4] 30% is from driving cars, and the rest is for some other energy sources (e.g., natural gas or oil for heating homes).[5]

4. **Energy Use in Buildings:** Buildings (that is, residential and commercial buildings) and the activities inside of them (including heating, cooling, lighting, electrical equipment and appliances) now use approximately 43% of all energy in the U.S. economy, higher than in the transportation sector (29%) or the industrial sector (30%). And electricity in buildings now constitutes approximately 3/4 of total energy use in buildings.

5. **Manufacturing Use of Energy:** The largest manufacturing users of energy are petroleum and coal products (33%), chemicals (24%), paper (11%), and food (6%). Not counting use of non-fuel energy products by the petroleum/coal products group, natural gas is the dominant fuel used in manufacturing, and makes up just under 2/5 of energy used in manufacturing. Electricity, including on-site generation, makes up another fifth.

6. **More Efficient Use of Energy:** The U.S. economy has become more "energy intensive" over time: It takes less energy to produce economic output today compared to all other years in the last three decades. (Figure 4). This is a measure of underlying productivity improvements as well as the extent to which energy efficiency measures have been adopted by households, businesses and others, in buildings and motor vehicles. End-use efficiency is particularly important, since buildings use so much electricity and in light of the fact that *for every unit of fuel consumed in the production of electricity, 2/3 of its full energy value is lost to conversion inefficiencies (at the power plant) and delivery losses (on the wires).* Electricity, while vitally important to the economy, exacts an inefficient toll as fuel is turned into

power to run motors and computers, light up spaces, and perhaps a large number of tomorrow's cars.

7. **Fuel Shares:** The portion of U.S. energy supplied by different fuels has remained remarkably stable over the years. (Figure 5). In 2009, more oil was used than any other fuel (37% of total energy), with most oil used for transportation (except in the Northeast, where heating oil is important). Natural gas now provides 25% of total energy, with coal supplying 21% (almost entirely used for electricity), nuclear 9%, and renewables 7%. The shares were only slightly different in 1980, with 44% oil, 26% natural gas, 20% coal, but only 4% nuclear and 7% renewable. Fossil fuels continue to play the dominant energy role, providing 83% today, with nuclear, wind and biomass making up the growth in non-fossil energy in recent decades.

8. **Domestic Production of Energy—Part 1:** By far, the U.S. produces most of the energy its consumers use. (Figure 6). Imports make up 40% of total energy production and provide 30% of total energy use. The amount of oil imports has steadily increased (until the post-2008 economic downturn): roughly 3 out of every 5 barrels of oil now used in the U.S. economy come from outside the U.S. (Figure 7). Oil imports account for 92% of all energy imported into the U.S., and nearly 3/4 of the oil consumed in the U.S. goes to move people and things. The transportation sector, thus, is the most dependent on foreign energy sources.

9. **Domestic Production of Energy—Part 2:** By far, the two energy resources which have undergone significant growth in recent years are natural gas and renewable energy. Figure 8 shows the growth in production of natural gas relative to production of onshore and offshore oil in recent years. The trajectory for natural gas is significant, with new resources now economically available from shale gas and other unconventional gas areas. U.S. shale gas production has increased 14-fold in 10 years.[6] Additionally, domestic production of biofuels is strong, as is wind generation—which has dramatically increased, both in number and capacity of wind turbines and total output from these facilities. (Figure 9).

10. **Domestic Power Production:** Almost all of the nation's electricity comes from domestic energy resources,[7] with over 2/3 generated at power plants that use a fossil fuel: coal (45%), natural gas (23%); and oil (1%). (Figure 10). The remainder comes primarily from low-carbon fuels: nuclear (20%), conventional hydroelectric power (7%), and wind (2%). The last nuclear plant to come on line was in 1996, but "uprates" (or added capacity) at existing plants since then have totaled 4,582 MW (roughly the size of 4-5 large new reactors).[8] All of the nation's commercial nuclear energy and nine out of every ten tons of coal go into power production. By contrast, only 29% of U.S. natural gas produces electricity; the rest heats and cools buildings and runs industrial processes. The vast majority of power plant capacity added in the past decade is fueled by natural gas or wind, however. Given the combined effects of the cost advantage of natural gas, the policies supporting renewable energy, and the low cost to build a new gas-fired plant rather than a coal or nuclear facility, most of the new generating capacity likely to be added in the near term will be gas-fired and renewable capacity. By contrast, most of the oldest and least efficient generating capacity on the grid today burns coal; a third of coal-fired capacity is older than 40 years old. Half of the older plants have no pollution control equipment to address conventional air pollutants—like sulfur dioxide (contributing to acid rain), nitrogen oxides (contributing to smog), and mercury—and may face economic pressure to retire. The prospects for investment in nuclear plants are weak in the near term, especially in the absence of policies that

value low-carbon power production.

11. **Energy Prices:** Energy prices continue to exhibit mixed trends. (Figure 11). On the one hand, both oil and coal prices have risen recently, after having dropped with the economic collapse in 2008. Meanwhile, natural gas prices are much lower than their all-time highs in 2008, in part the result of significant improvements in technology that provide economical access to shale gas resources in the U.S. These countervailing trends tend to make natural gas all the more economically attractive—relative to other fossil fuels and new nuclear and renewable power plants as well.

12. **Greenhouse Gas Emissions:** Finally, although greenhouse gas emissions from the energy sector have dropped in recent years in conjunction with lower energy use, energy activity (especially oil used for transportation and coal used for power generation) remains a key source of GHG emissions and other pollutants. And without additional policy action, the long-term trend indicates increasing emissions and increasing requirements for significant adaptation to climate change.

Some observations and issues:

Different lenses help to make sense of today's complex U.S. energy landscape. Each provides a different angle on the realities of energy in America: the structure of its markets, key patterns of production and use, their relationships to larger strategic issues in the nation, and their implications for policy. Because issues relating to the transportation sector and coal are addressed by others, the observations here focus on key themes in the overall context.

1. **Regional variations:** Major regional differences are central to understanding energy systems, politics and policy in the U.S. These regional variations affect the character of the energy economy in different parts of the nation—whether, for example, a region views itself as an energy producer versus a consumer, or what are the prevailing attitudes about different fuels and their value. Texas and Louisiana are oil-producing areas; Appalachia and the Rockies have large coal resources; Pennsylvania is an up-and-coming shale gas production region, with prospects for a small role for coal; the sunny Southwest and the windy Upper Plains states have renewable energy potential; the Northeast is increasingly a gateway to offshore wind resources and energy imports. These facts create challenges for energy policy. Those aimed at creating incentives to build new transmission to connect remote windy areas with distant population centers, for example, face major hurdles, in part because the new lines may need to cross areas with people who don't want or need the power. (Figures 12-14).

2. **Regional differences** in attitudes about coal versus gas for power generation provide another good example: "coal country" states (Figure 15) have economies that are based, in part, on access to relatively inexpensive power; these states tend to have higher than average energy consumption per capita. (Figures 16-17). States like California, Texas, and New York that have little coal in their energy mix, rely more heavily on gas and nuclear power; these areas' historically poor air quality made it hard to site new power plants (such as coal plants) with high air emissions. These are also places that have had high electricity costs and restructured their electric industries to introduce competition as a way to help lower energy prices. These regional variations mean that environmental regulations affecting coal plants pose significantly different impacts and politics in parts of the nation.

3. **Natural gas—especially shale gas—is perhaps the best energy story in decades.**[9] Changes in production technology ("directional drilling" and "fracking") have opened

up vast areas of U.S. shale gas formations for economical development. (Figure 18). According to the newly released *Annual Energy Outlook,* "The technically recoverable unproved shale gas resource is 827 trillion cubic feet (as of January 1, 2009)..., 480 trillion cubic feet larger than in [last year's] *Annual Energy Outlook...*The larger resource leads to about double the shale gas production and over 20 percent higher total lower 48 natural gas production in 2035, with lower natural gas prices, than was projected [last year]....Shale gas offsets declines in other U.S. supply to meet consumption growth and lower import need."[10] (Figure 19). This is such big news because it offers the promise of access to relatively low-cost, abundant and relatively low-carbon gas to consumers in industry, at power plants, and in homes and office buildings. It means relatively stable, non-volatile prices—something that was unheard of just five years ago. Shale gas reserves are located close to consumers, with implications for pipeline and storage infrastructure. Domestic and international gas and oil prices may no longer move in tandem; international gas resources may no longer be so strongly controlled by countries (like Russia) willing to use gas for strategic advantage. Low gas prices are putting pressure on old and inefficient coal plants to retire—with improvements in air emissions; but they also put pressure on new nuclear and renewable projects because when the gas alternative is so attractive, it is harder to justify investment in these other technologies that can't be supported by investment in the near term based on market prices alone. Also, access to shale gas resources involves large quantities of water, raising concerns about water supply, water quality and industry practices that more resemble manufacturing activities than traditional oil and gas extraction.

4. **Buildings are a big deal in the energy system.** They use a lot of energy (43% of total energy use). Since 1980, residential and commercial buildings' energy use grew 55% (compared to 21% overall growth in U.S. energy use, and 37% growth in transportation energy use). Commercial buildings' energy use, especially, has dramatically increased: up 71% in that period, in light of overall growth trends in commercial square footage, the heavy air conditioning loads of such buildings, and the proliferation of electrical equipment. Electricity use in buildings has grown 104%, and now constitutes approximately one-third of *all* energy used in the U.S. economy. This means that energy use in buildings is heavily responsible for driving growth in the power sector. And changes in buildings' use of energy (through such things as building codes, appliance efficiency standards, efficiency programs, and "demand response" pricing models) can have a profound impact on companies' total energy requirements, their expenditures on energy, and the environmental impacts associated with production and delivery of electricity.

5. **In fact, electricity itself is a big deal.** This is hardly news: around the globe and historically, economies evolve and develop as they electrify their energy systems. This is part of the reason for the establishment of the Tennessee Valley Authority nearly 80 years ago. Electricity is a powerfully flexible form of energy for consumers, but it also suffers from inherent inefficiencies in that considerable energy (2/3 of the total energy value of fuels used to produce power) is lost in the process of converting fuel (such as coal, or natural gas, or uranium) into electricity, and then delivering electricity to retail customers. This means that for each unit of electricity able to be "conserved," there are two units of fuel not consumed, thereby avoiding its emissions to the atmosphere. Future growth of electricity depends upon such things as the adoption rates for energy efficiency measures and appliance/building efficiency standards, additions of electricity-

using equipment (e.g., battery technology, electro-technologies), the pace of economic recovery, and the impact of future environmental policies. In fact, deep reliance on electric vehicles in the future might lead to even-faster growth in overall electricity requirements.

6. **Americans are becoming more energy efficient:** The trend shows considerable improvement in the productivity of energy in the economy. (Figure 4). "Since 1992, the energy intensity of the U.S. economy has declined on average by 2 percent per year, in large part because the economic output of the service sectors, which use relatively less energy per dollar of output, has grown at a pace almost 6 times that of the industrial sector (in constant dollar terms)." There is still a huge potential for further improvement, both in the existing buildings and in the energy use of new appliances, buildings, and manufacturing processes. Appliance efficiency levels are set by the U.S. Department of Energy; building codes tend to be governed by state and local policies, with considerable variation in efficiency levels and enforcement of standards. China sets a clear example of having aggressive overall efficiency targets for its economy as a matter of national policy: Since 2005, Chinese policies have led to the closure of inefficient factories and power plants and a major push on energy efficiency (in vehicles, buildings, appliances), leading to a nearly 15% improvement in overall energy intensity in five years.[12] China has recently proposed to reduce its energy intensity by another 17% by 2016.[13] By contrast, the EIA estimates that market forces and existing policies will lead the U.S. to reduce its energy intensity by 40% between 2009 and 2035.[14]

7. **The environmental footprint of energy production, delivery and use has improved in the U.S., but remains challenging.** This was obvious during the summer of 2010, as the Gulf of Mexico's natural resources and fisheries were hit by the oil spill resulting from the Macondo offshore incident. More routinely, combustion of fossil fuels emits pollutants affecting public health, natural systems, visibility, and global climate change. Extraction of shale gas requires significant quantities of water. Hilltop coal mining can lead to run-offs, affecting the quality in neighboring water systems. From a technology point of view, the game changers would be tied to:

   - improvements in the efficiency of power production, delivery and use;
   - the ability to develop or otherwise gain access to technologies and practices that produce electricity with lower greenhouse gas emissions, and lower harmful and hazardous air pollutants;
   - the development of storage devices to render low-carbon but intermittent renewable resources more steady sources of power;
   - the application of "smart" grid technologies (an array of hardware and software technologies and systems) that will allow current systems to be operated more reliably and at lower cost over the long run;
   - the ability to safely extract natural gas and oil safely and with minimum use of other natural resources like water;
   - processes to safely manage high-level radioactive wastes from nuclear generation.

8. **Energy infrastructure is very long-lived, and near-term investment decisions have long-lasting impacts.** Many of the nation's current energy facilities—natural gas pipelines, electric transmission lines, coal power plants, large hydroelectric and nuclear facilities, refineries, and other facilities—are old. Many are aging, having served decades beyond their original planned lives. Many will need to be replaced with more modern technology and materials. These investments will undoubtedly lead to efficiency gains but will come through investment

needed to just maintain the system, rather than to grow or improve it. From a short-term economic point of view, adoption of currently available technology to replace the old may minimize costs (and prices to today's consumers), but introduce long-term obligations for energy use with potentially large environmental and energy security impacts. Advanced technology (such as coal gasification with carbon capture, large and small-scale nuclear reactors, gasification systems that use various waste streams as a feedstock, energy storage systems to support more efficient grid operations, or off-shore wind supported by high-voltage transmission systems) may face significant hurdles in entering commercial markets, but offer improvements over current technology and long-term pay-off from an intergenerational point of view. The fact that a significant share of energy systems in the U.S. are supplied through competitive markets means that, although they provide many economic benefits to consumers, such markets also can make it harder for new advanced technologies to gain traction. Many, in fact, may require public support in one form or another in order to move into commercial demonstration projects in U.S. installations.[15] This may be particularly true in light of the otherwise "good news" about low natural gas prices, which raises the relative cost of other fuel/technology combinations. But such support may constitute a big bet that could pay off in the long-term for American economic, energy and environmental security, but involve costs in the near-term that may be hard to swallow in times of tight budgets and hopes for economic recovery.

Some policy issues and suggestions:

These observations point to several potential priorities in U.S. energy policy:

- First is ensuring that the opportunities afforded by America's vast shale gas resources are realized with minimum-to-no bad surprises. This means adoption of practices and policies to support safe exploitation of the gas supply with acceptable risks to natural resources and the environment. Several studies are underway to assess industry practices and identify the trade-offs associated with new forms of regulation by state or federal environmental authorities (or both). The goal should be to find a workable combination that supports prudent development of the shale-gas resource potential for near- and long-term strategic advantage for the U.S.
- Second is tapping deep reserves of energy efficiency and demand reduction in existing buildings and industrial processes, and to adopt standards for efficient electrical and other energy use in new buildings, appliances and equipment. Statutory authorities supporting energy efficiency reside in many places within federal and state jurisdictions, including under the Department of Energy, policies of the Federal Energy Regulatory Commission and state public utility commissions, state building codes, market rules and practices of grid operators, practices of energy efficiency service providers, public housing authorities, city and town governments, and countless others.
- A third suggestion is to find and adopt policies to improve the pathways to develop and deploy modern and advanced energy technologies. Some of these may include tapping the purchasing power of large entities, such as the Department of Defense with its long-term strategic interests in improving the efficiency of its energy use and securing alternative fuels, and in reducing taxpayers' payments for energy.
- Other ideas may involve relying on utilities as agents to accomplish larger public policy objectives, through providing long-term contracts to support investment in renewable energy projects, or small-scale nuclear plants, or access to natural gas fields.

- Another option is to support the implementation of environmental regulations of traditional air pollutants under existing law that will, in combination with low natural gas prices, encourage some of the oldest and least efficient coal plants to retire. This could allow for the introduction of more modern power plants, yielding a more efficient fleet of plants, producing new construction jobs related to replacement capacity, and reducing unhealthy levels of air pollution.

- Other options involve developing mechanisms to map out and fund investment in advanced energy research, development and deployment (RD&D), such as was recently recommended by the President's Council of Advisors on Science and Technology.[16] PCAST recommended a substantial increase in federal support for RD&D and identified the importance of "roadmaps for key energy technologies" and the assessment (and where appropriate, elimination) of existing energy subsidies and incentives. Similar recommendations were offered this past year by the American Energy Innovation Council,[17] which recognized two reasons for a governmental role in accelerating energy innovation:

  First, innovations in energy technology can generate significant, quantifiable public benefits that are not reflected in the market price of energy. These benefits include cleaner air and improved public health, enhanced national security and international diplomacy, reduced risk of dangerous climate change, and protection from energy price shocks and related economic disruptions. Currently, these benefits are neither recognized nor rewarded by the free market. Second, the energy business requires investments of capital at a scale that is beyond the risk threshold of most private-sector investors. This high level of risk, when combined with existing market structures, limits the rate of energy equipment turnover. A slow turnover rate exacerbates the historic dearth of investments in new ideas, creating a vicious cycle of status quo behavior.

Endnotes

National Academy of Sciences, "America's Energy Future," 2009.

Energy Information Administration, Annual Energy Outlook, 2011.

International Energy Agency, "Energy Technology Perspectives," 2008.

National Petroleum Council, "Facing the Hard Truths About Energy," July 2007.

President's Council of Science Advisors, "Accelerating the Pace of Change in Energy Technologies Through an Integrated Federal Energy Policy," November 2010.

American Energy Innovation Council "A Business Plan for America's Energy Future," June 2010.

References

1 Natural gas wellhead price data from the U.S. Energy Information Administration ("EIA"). For prices through October 2010, see http://www.eia.gov/dnav/ng/hist/n9190us3m.htm; for prices; for quarterly prices, see the Short Term Energy Outlook, January 11, 2011, Table 1, http://www.eia.gov/emeu/steo/pub/steo_full.pdf.

2 Energy Information Administration ("EIA", Short Term Energy Outlook, comparing information for the four quarters of 2007 (from the March 2008 STEO) with the four quarters of 2010 (from the January 2011 STEO).

3 Bloomberg National Poll conducted by Selzer & Company. Dec. 4-7, 2010. N=1,000 adults nationwide. Margin of error ± 3.1. Energy did not appear in the top priorities mentioned by those surveyed. The results were: Unemployment and jobs (50%); federal deficit and spending (25%); health care (9%); war in Afghanistan (7%); immigration (5%); other or unsure (4%).

4 This figure is based on a view of energy use that assigns energy for production and delivery of electricity to the end users who purchase/consume electricity.

5 This is based on 2008 data for (a) total energy consumption in residential buildings (reflecting both primary use of energy directly in residential buildings, retail sales of electricity to residential customers, conversion and delivery losses associated with electricity production, transmission and distribution of electricity); and (b) energy consumption in passenger vehicles. See EIA Annual Review of Energy, and data on number of passenger vehicles from the Bureau of Transportation Statistics, http://www.bts.gov/publications/national_transportation_statistics/,

6 Howard Gruenspecht, EIA, "Shale Gas and the U.S. Energy Outlook - Recent Developments," presentation to The Energy Council, Global Energy and Environmental Issues Conference, Santa Fe, New Mexico, December 10, 2010.

7 U.S. nuclear plants use uranium produced at U.S. and foreign mines. In 2009, over 80 percent of uranium delivered to U.S. reactors was from foreign sources. http://www.eia.doe.gov/cneaf/nuclear/umar/summarytable1.html

8 Source: Nuclear Energy Institute, cumulative uprates 1996-2010, http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/graphicsandcharts/usnuclearindustryyearlypoweruprates/

9 See John Deutch, "The Good News About Gas: The Natural Gas Revolution and Its Consequences," *Foreign Affairs*, January/February 2011.

10 EIA, "Annual Energy Outlook: 2011," Early Release Overview, December 2010, page 1.

11 EIA "Annual Energy Outlook 2011," Early Release Overview, page 7.

12 http://www.wri.org/publication/uscc-testimony-green-energy-policy-in-china.

13 http://af.reuters.com/article/energyOilNews/idAFTOE69C00X20101013.

14 EIA, "Annual Energy Outlook 2011," Early Release Overview, page 7.

15 See James Fallows, "Dirty Coal, Clean Future," The Atlantic, December 2010.

16 "Our most important recommendation is that the Administration establish a new process that can forge a more coordinated and robust Federal energy policy, a major piece of which is advancing energy innovation. Many Executive Branch agencies and departments must be engaged, with leadership from the Executive Office of the President. This is needed because "energy policy" is an amalgam, and often derivative, of policies for environment, competitiveness, security, finance, land use, and more. The President should establish a Quadrennial Energy Review (QER) process that will provide a multiyear roadmap that lays out an integrated view of short-, intermediate-, and long-term energy objectives; outlines legislative proposals to Congress; puts forward anticipated Executive actions coordinated across multiple agencies; and identifies resource requirements for the development and implementation of energy technologies." PCAST, "Accelerating the Pace of Change in Energy Technologies Through an Integrated Federal Energy Policy," November 2010, pages 1-2.

17 The AEIC's members include Norm Augustine, former chairman and chief executive officer of Lockheed Martin; Ursula Burns, chief executive officer of Xerox; John Doerr, partner at Kleiner Perkins Caufield & Byers; Bill Gates, chairman and former chief executive officer of Microsoft; Chad Holliday, chairman of Bank of America and former chairman and chief executive officer of DuPont; Jeff Immelt, chairman and chief executive officer of GE; and Tim Solso, chairman and chief executive officer of Cummins Inc.

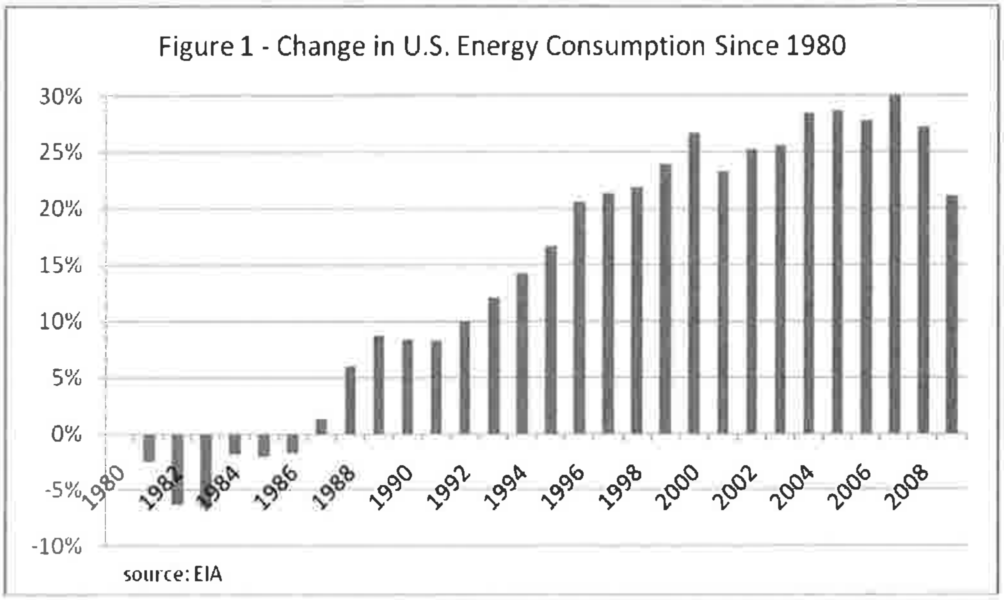

Figure 1 - Change in U.S. Energy Consumption Since 1980

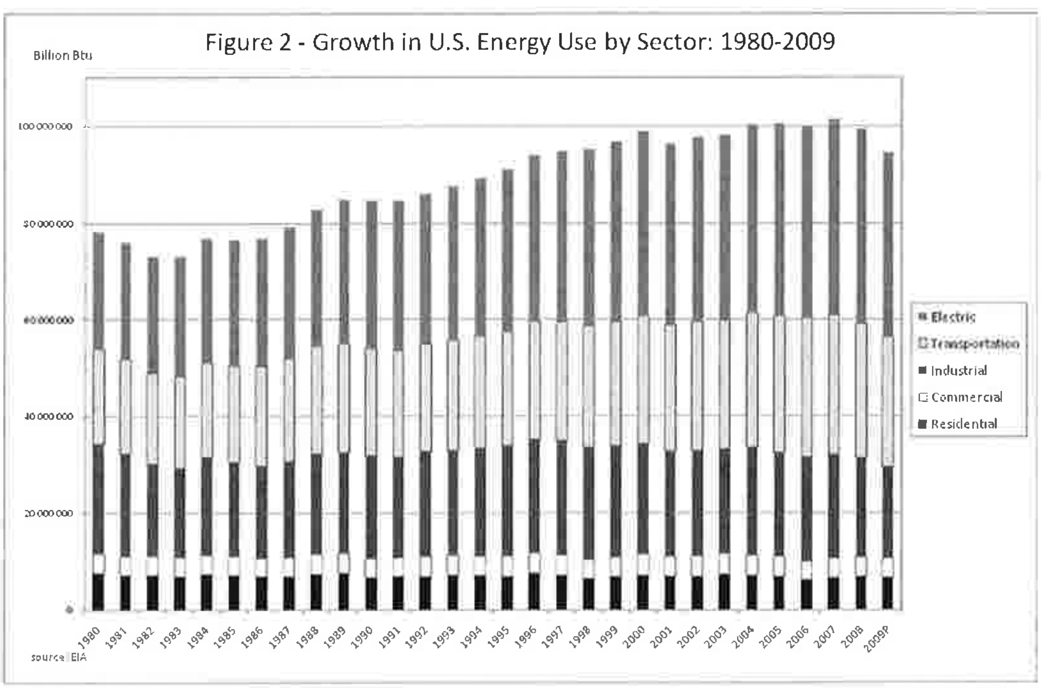

Figure 2 - Growth in U.S. Energy Use by Sector: 1980-2009

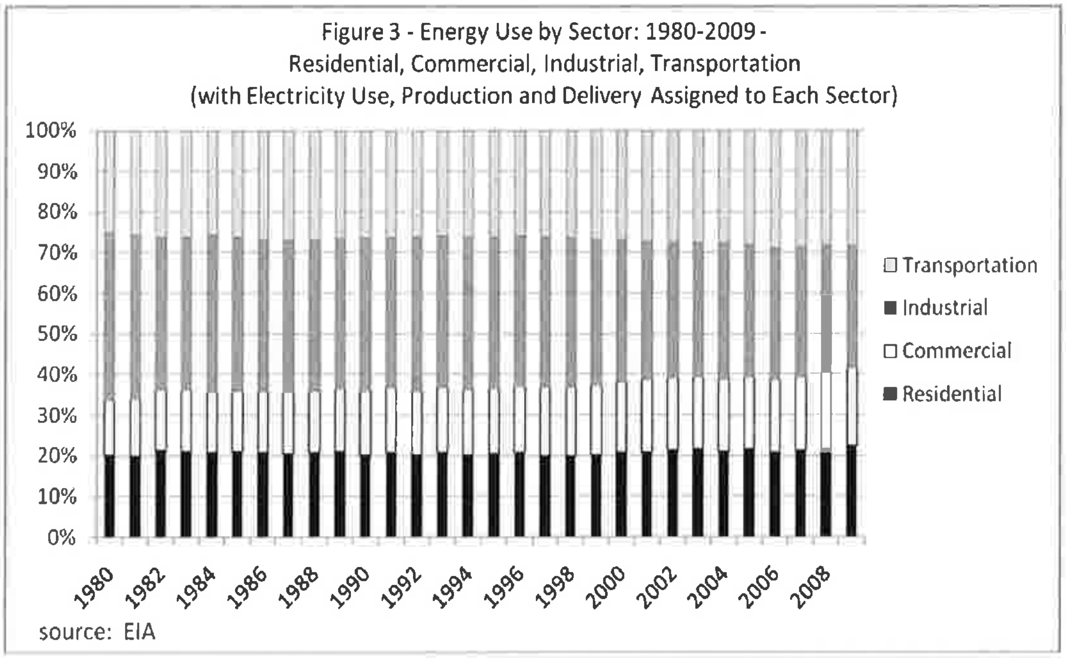
Figure 3 - Energy Use by Sector: 1980-2009 -
Residential, Commercial, Industrial, Transportation
(with Electricity Use, Production and Delivery Assigned to Each Sector)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Transportation
Industrial
Commercial
Residential
source: EIA

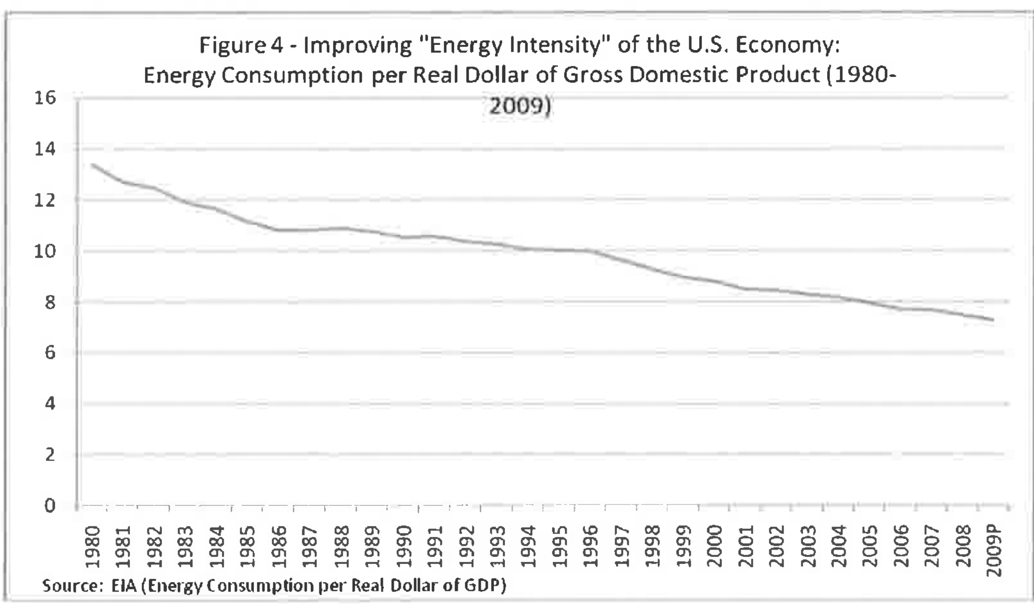
Figure 4 - Improving "Energy Intensity" of the U.S. Economy:
Energy Consumption per Real Dollar of Gross Domestic Product (1980-2009)
16
14
12
10
8
6
4
2
0
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
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1996
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1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009P
Source: EIA (Energy Consumption per Real Dollar of GDP)

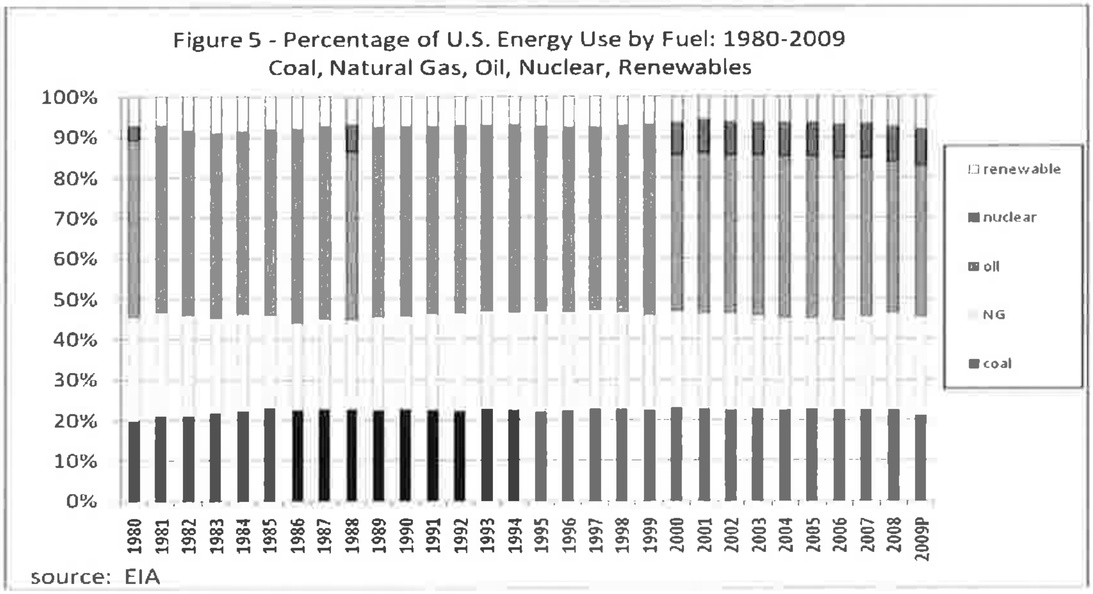


Figure 5 - Percentage of U.S. Energy Use by Fuel: 1980-2009
Coal, Natural Gas, Oil, Nuclear, Renewables
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
renewable
nuclear
oil
NG
coal
1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009P
source: EIA

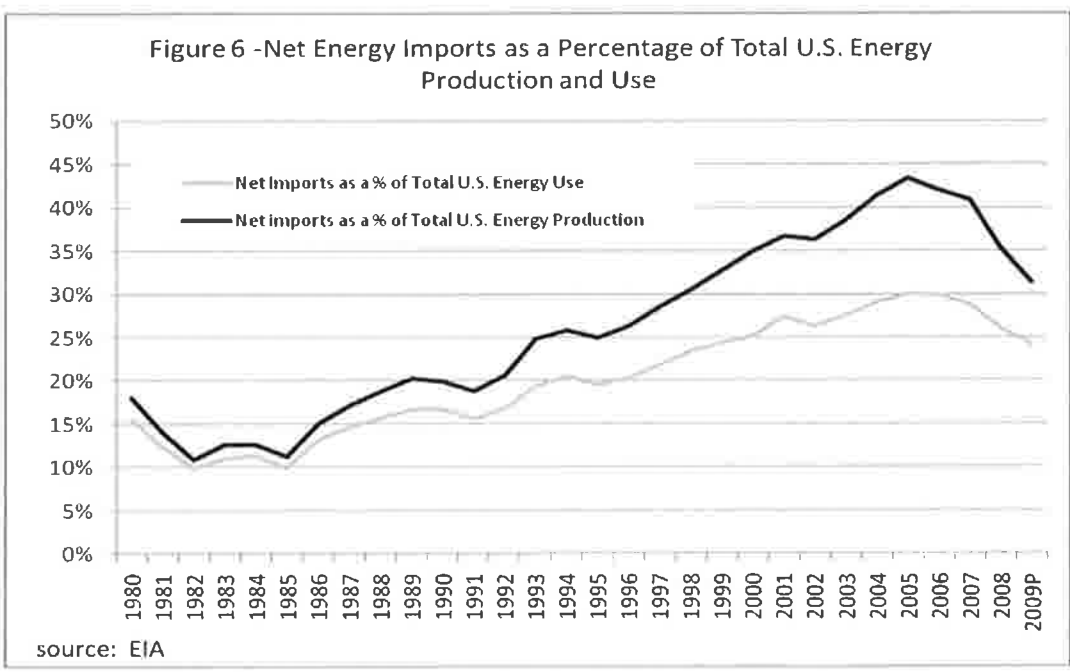


Figure 6 -Net Energy Imports as a Percentage of Total U.S. Energy Production and Use
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Net Imports as a % of Total U.S. Energy Use
Net imports as a % of Total U.S. Energy Production
1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009P
source: EIA

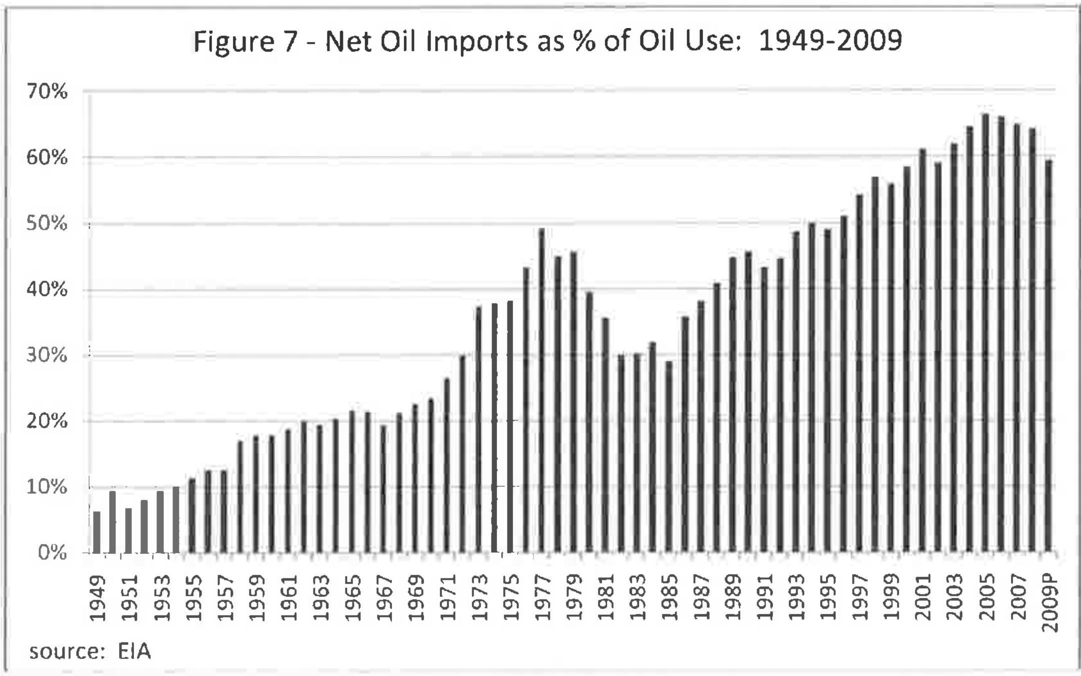


Figure 7 - Net Oil Imports as % of Oil Use: 1949-2009

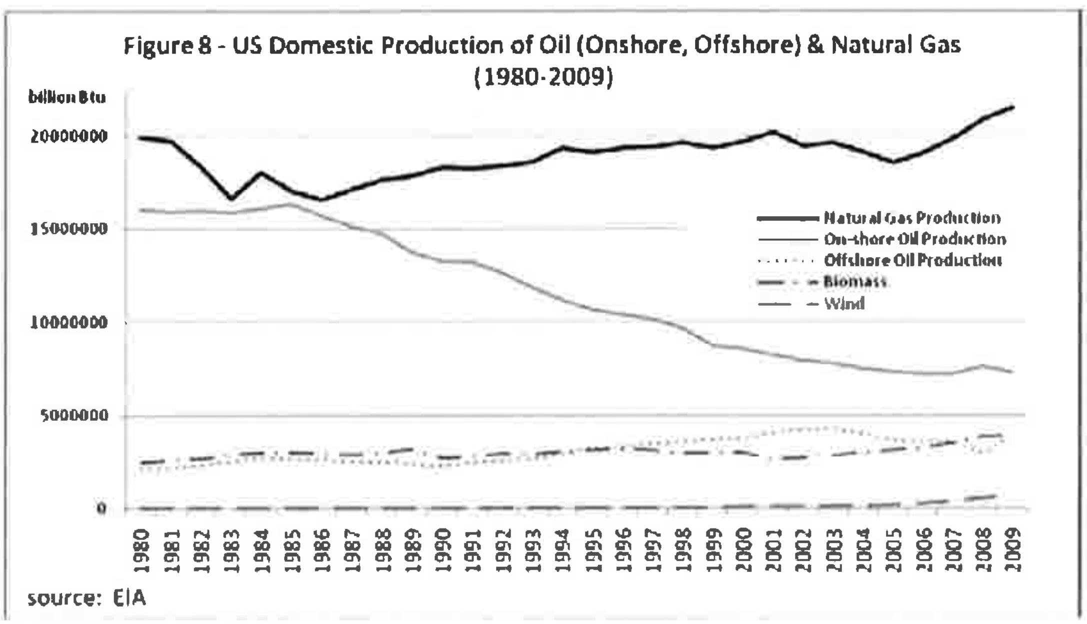


Figure 8 - US Domestic Production of Oil (Onshore, Offshore) & Natural Gas (1980-2009)

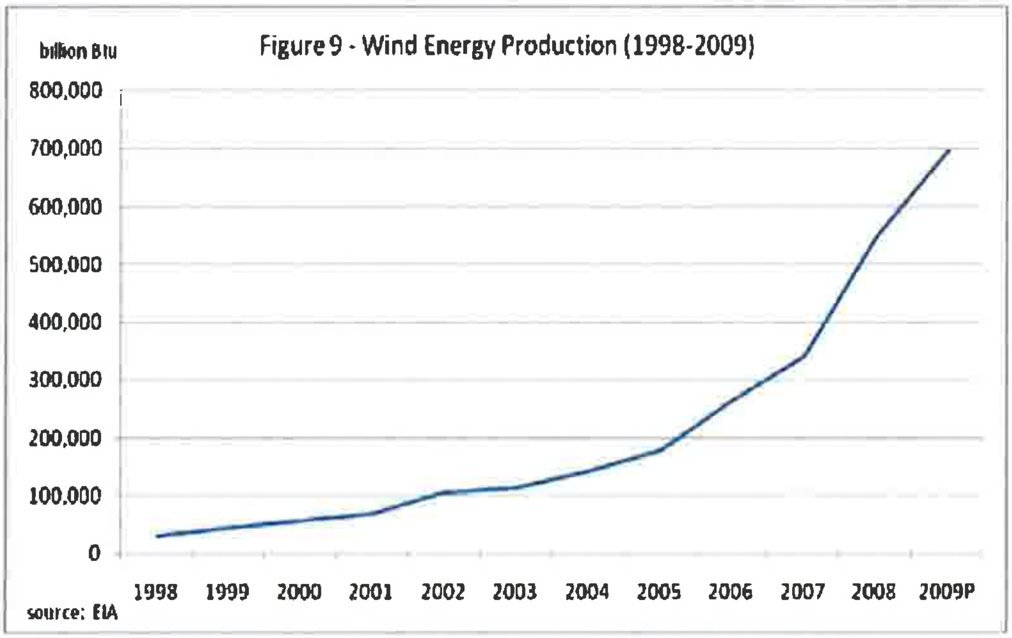


Figure 9 - Wind Energy Production (1998-2009)
billion Btu
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009P
source: EIA

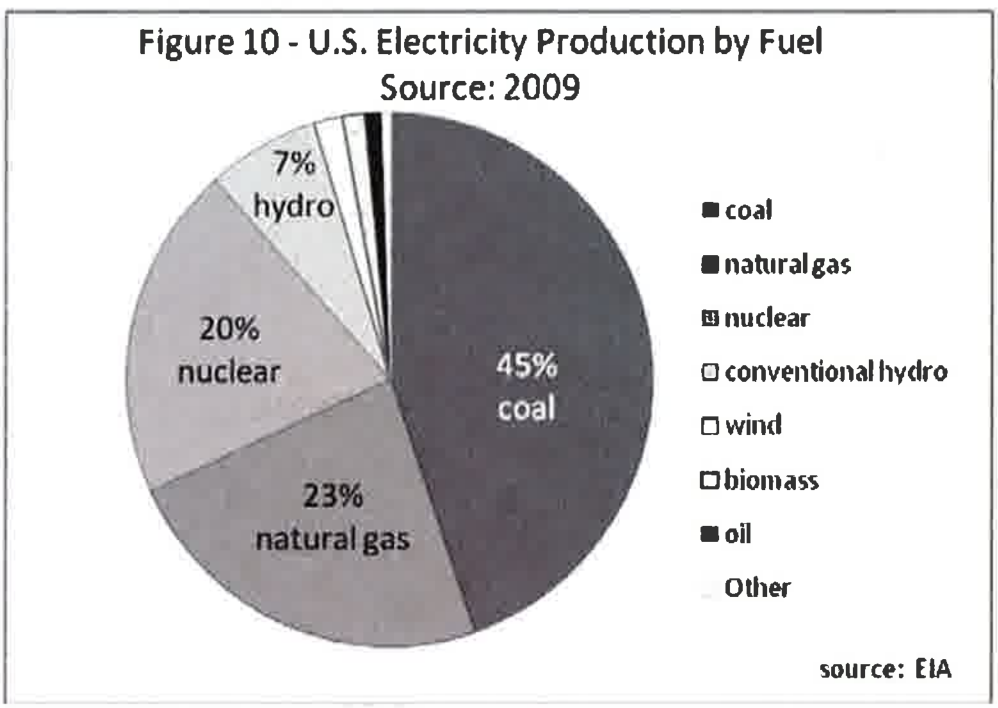


Figure 10 - U.S. Electricity Production by Fuel
Source: 2009
45%
coal
23%
natural gas
20%
nuclear
7%
hydro
coal
natural gas
nuclear
conventional hydro
wind
biomass
oil
Other
source: EIA

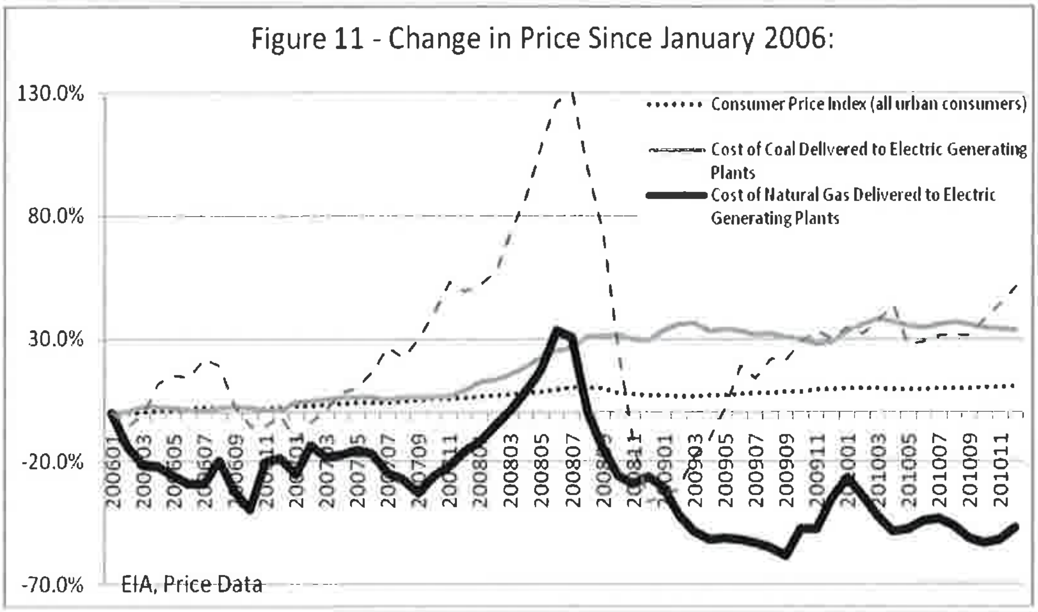


Figure 11 - Change in Price Since January 2006:

Figure 12 - Wind Tends to Be Located Where People Are Not

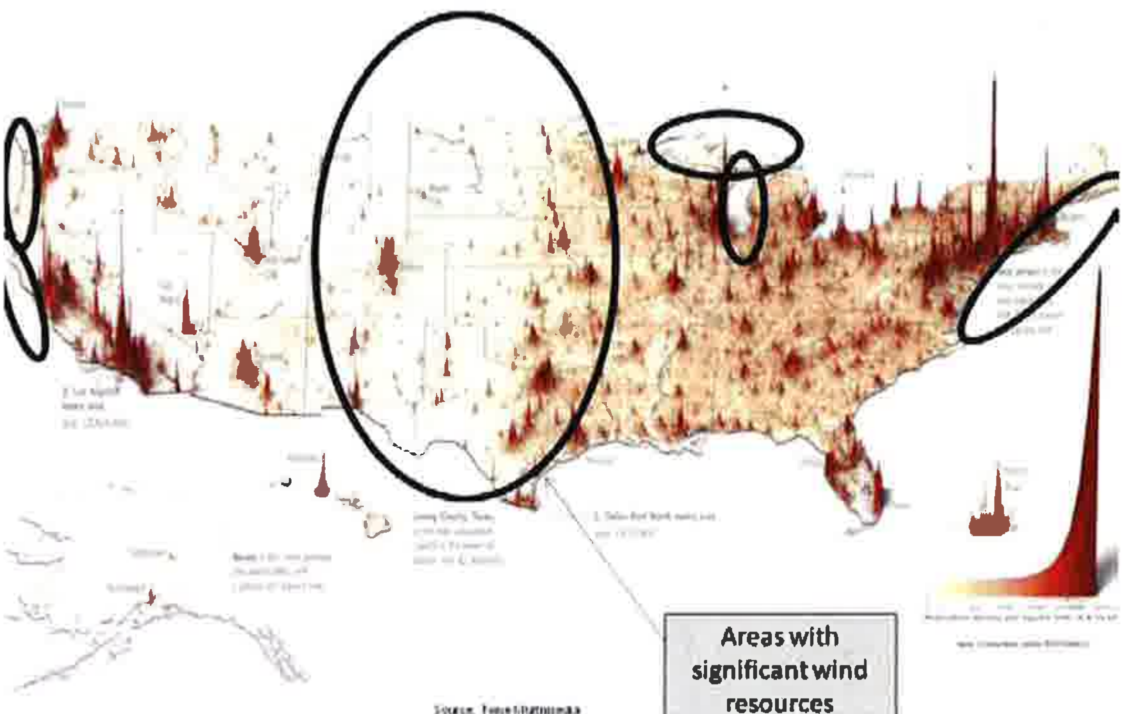
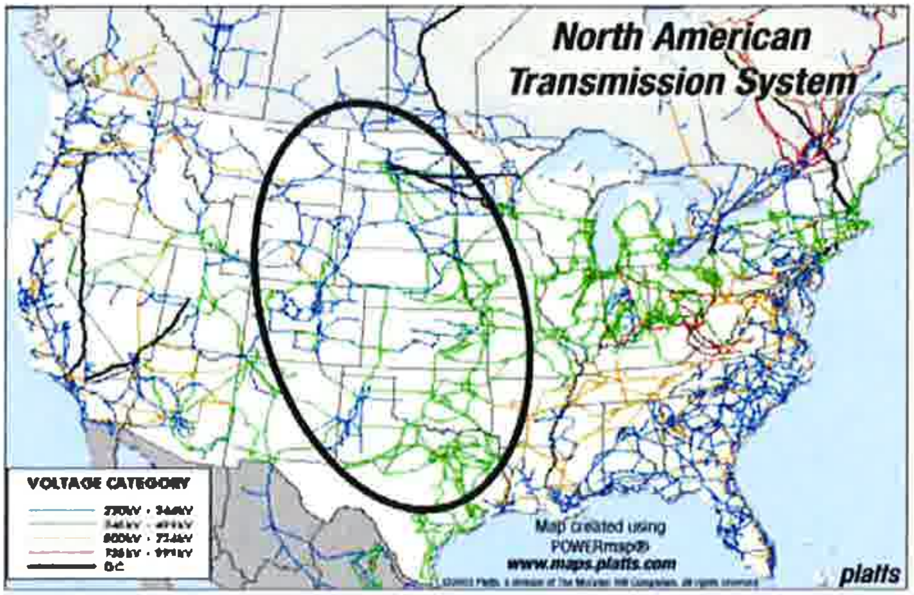


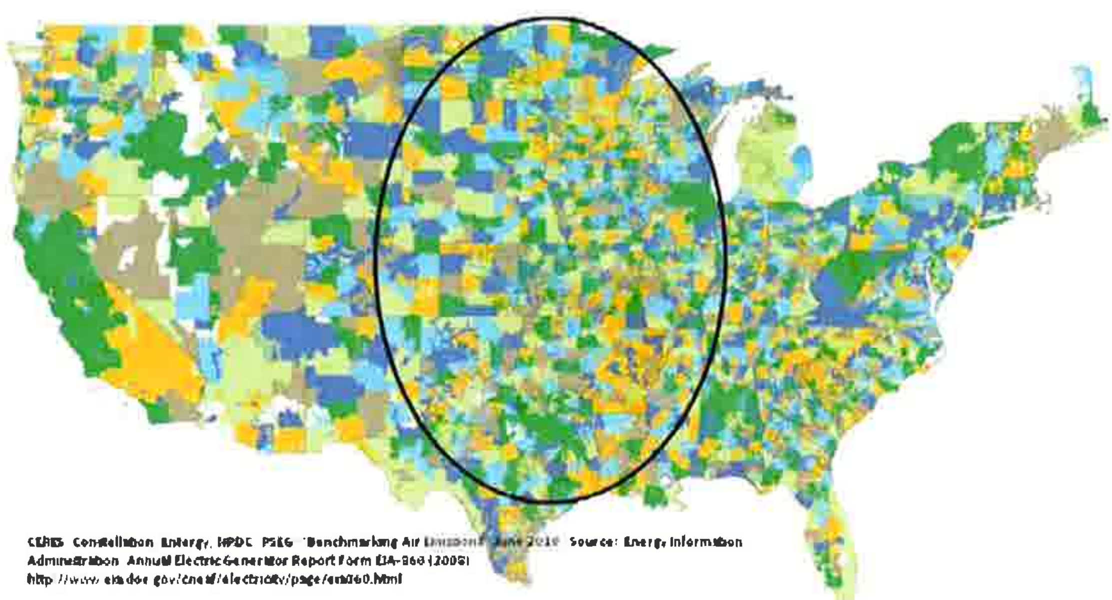
Figure 13 – The Electric Grid is Weakest in Areas
Where the Best Wind Resources Are Located



Source of maps: Platts

Tierney – Energy Security Figures – Aspen Congressional Program, 2011

Figure 14 – To Connect Wind Resources to Consumers,
New Transmission Lines Must Cross Multiple Electric Utility Service Territories and States



CERES, Constellation, Entergy, NRDC, PSEG "Benchmarking Air Emissions" June 2010. Source: Energy Information Administration, Annual Electric Generator Report Form EIA-860 (2008) http://www.eia.doe.gov/cneaf/electricity/page/eia860.html

Tierney – Energy Security Figures – Aspen Congressional Program, 2011

Figure 15 - Coal Country – Resources and Power Plants

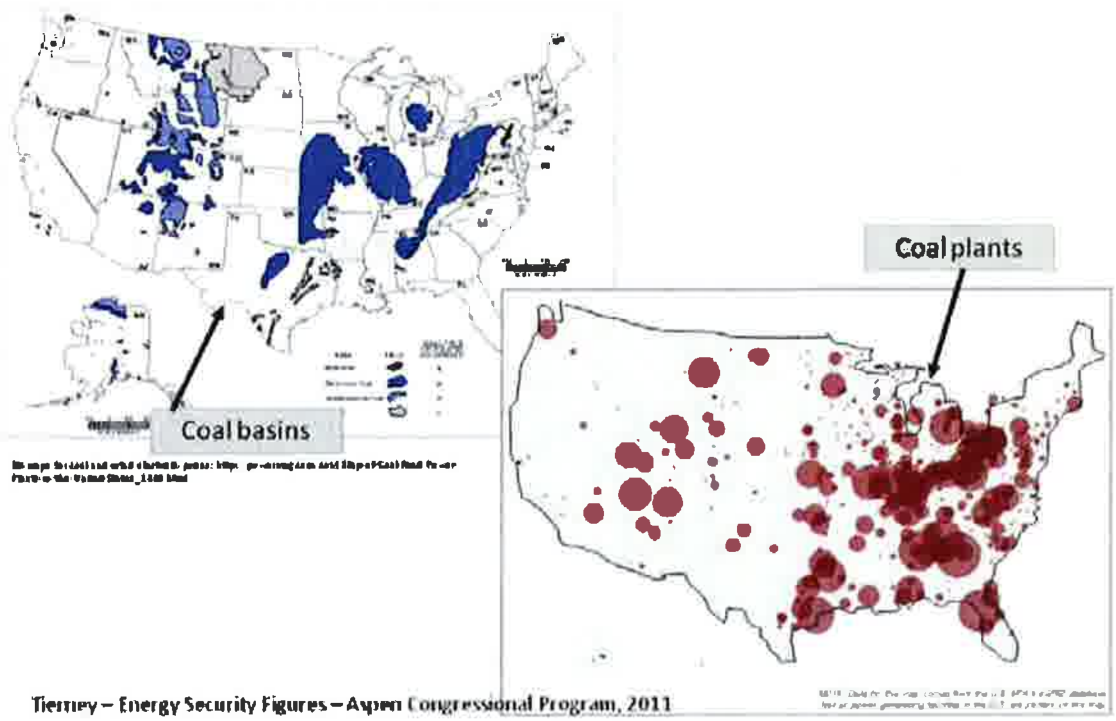


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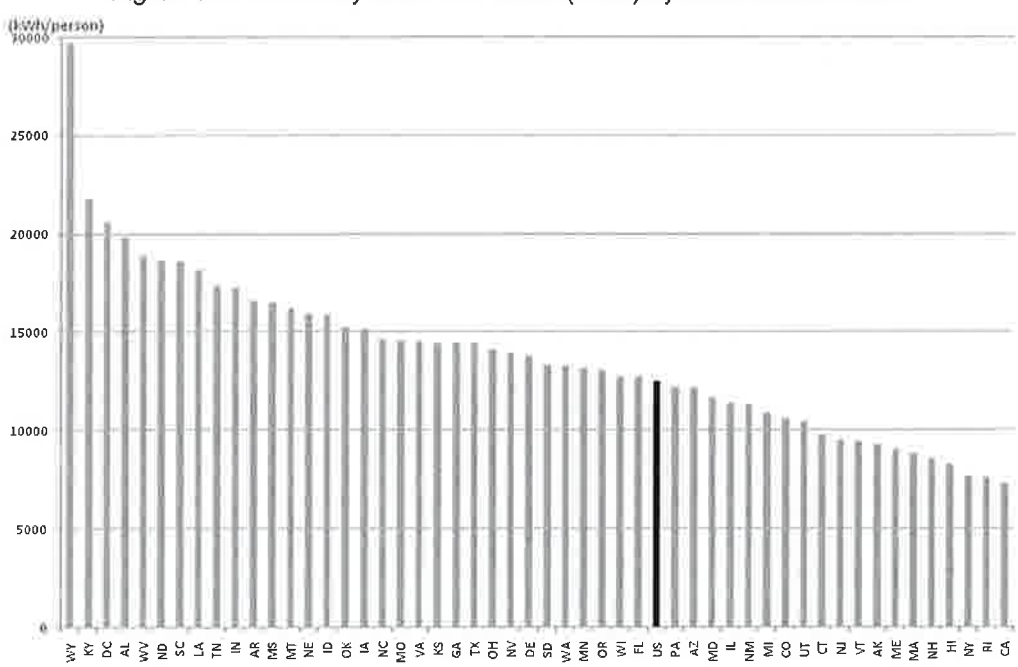
Figure 16 – Electricity Use Per Person (KWh) by State and US: 2007



Data: Energy Information Administration, State Energy Data System (most recent annual data available as of 3-12-10)

Tierney – Energy Security Figures – Aspen Congressional Program, 2011

Figure 17 – Percentage Coal in a State's Electricity Generation Mix

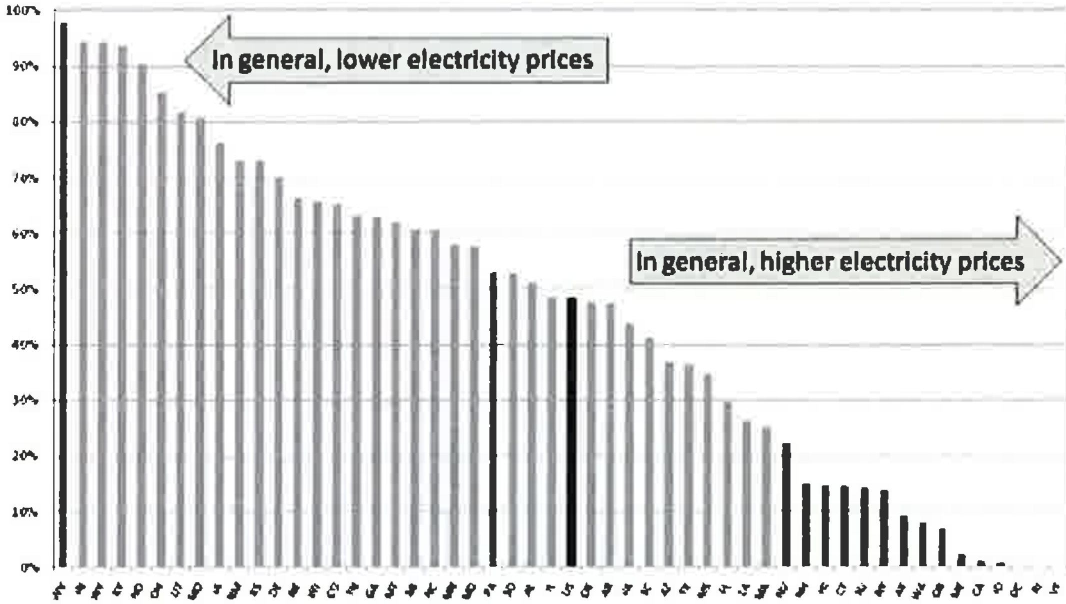


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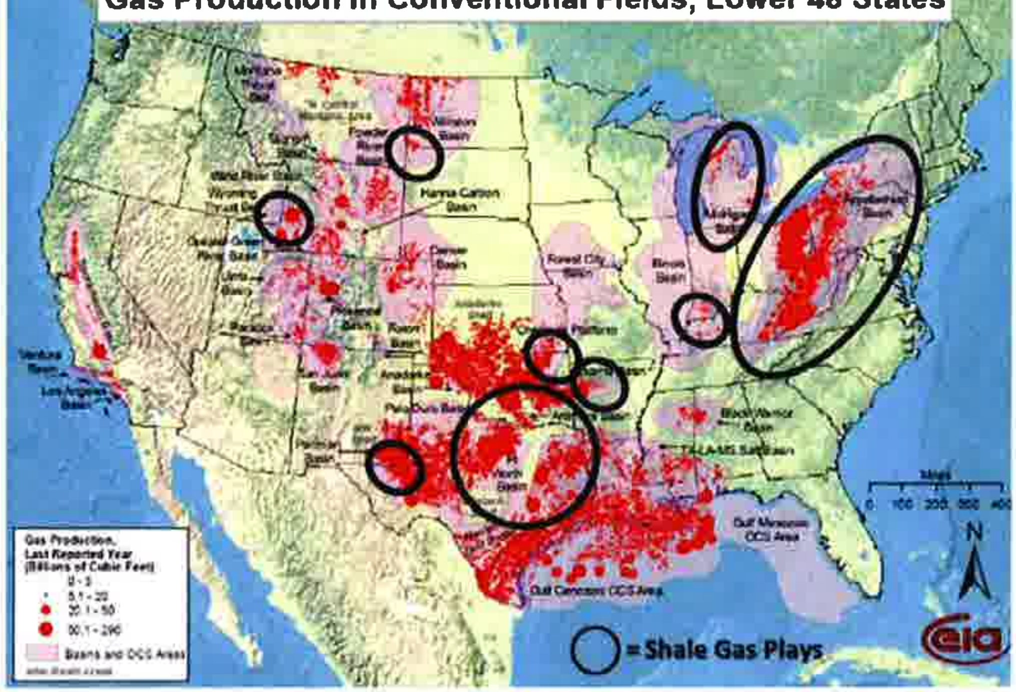
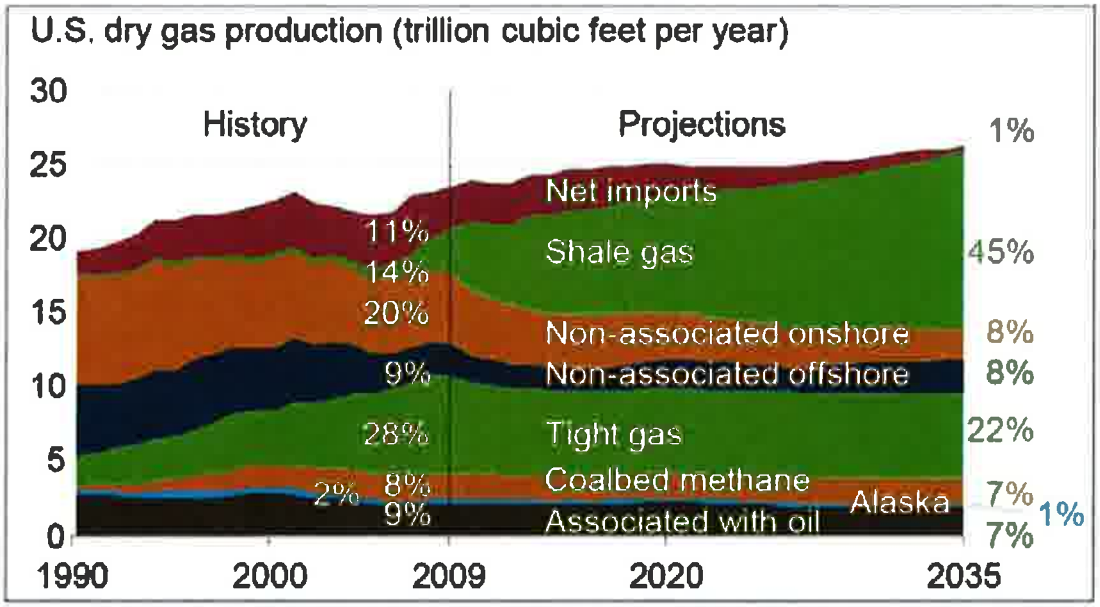
Figure 18 - Location of Shale Gas Plays and Gas Production in Conventional Fields, Lower 48 States



EIA, March 2010. http://www.eia.doe.gov/oil_gas/rpd/shale_gas.pdf

Tierney – Energy Security Figures – Aspen Congressional Program, 2011

Figure 19 – Increasing Role of Shale Gas in U.S. Dry Gas Production



Source: EIA Annual Energy Outlook Early Release Overview

Tierney – Energy Security Figures – Aspen Congressional Program, 2011