A New Energy Strategy for the United States: Energy Independence

Stephen J. Moretto
2006 Independent Study
The Industrial College of the Armed Forces
National Defense University
Fort McNair, Washington, DC 20319-5062

ABSTRACT

"We hold these truths to be self-evident, that all men…are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty, and the pursuit of Happiness" (2nd Continental Congress, 1776). In 1776, our founding fathers declared independence from the oppression of a foreign power and took action to create a free nation to be true to their ideals. Today, this freedom is being threatened by US dependence on oil supplied by foreign powers. This dependence is increasingly encroaching on the general welfare of the nation, in terms of our national security and economic well-being. US dependence on foreign energy imports is at an all-time high and will likely increase if current policies and strategies do not change.

Since 2001, natural gas and oil prices have doubled largely due to lack of global capacity to supply world demand for energy. Fossil fuel prices will continue to rise over the next 20 years as world supplies of oil and natural gas struggle to keep up with rapidly increasing world demand and as countries compete for fossil fuel supplies. Energy supply and prices affect the cost of all products produced in the US. Furthermore, energy supply greatly impacts US strategic decision-making, influencing our decisions on how we confront international crises in terms of deciding which countries to ally with, and which countries to tolerate despite ideological differences.

Our standard of living, economic well-being, and national security will be compromised within the next 10 years, if current energy goals are not changed to address imbalances between global supply and demand of fossil fuels. It is important that new policies be implemented immediately because oil and gas prices have already greatly increased

due to a lack of excess supply and are already having an impact on our economy. With the growing gap between energy supplies and demand, the US will be increasingly dependent on energy-rich countries such as Saudi Arabia, Russia, Iran, and Argentina. Furthermore, competition with Europe and Asia for energy supplies will increase. The bottom line: The US standard of living, economy, and national security are likely to suffer due to dependence on energy from countries that influence world supply and demand. Therefore, the US should take decisive steps to greatly reduce dependence on oil and natural gas by 2015 and to achieve energy independence by 2025. The US should position itself as a leader of high technology energy solutions that can free it and the world from an unstable fossil fuel market, thereby alleviating or preventing an all-out world energy crisis. To address this global situation, US priorities should be directed toward increasing the supply of nuclear, solar and biofuel power.

Most Americans agree that the US must work toward energy independence, but they disagree strongly on methods to achieve that goal. Not only is it not clear to most Americans which methods are feasible and practical, the issue is further complicated by the actions energy industries take in competition for resources, markets, and favorable legislation. Industries and other constituencies undercut each other, slowing progress. Resource allocations and policy could be improved through an integrated, unbiased look at the world's energy systems.

This article examines the issue of US energy dependency from the perspective of an independent citizen looking at what would be best for the US. It analyzes the interdependencies of world supply, world demand, political implications, technologies, current policies, and recent strategies, and recommends an integrated national energy strategy that could make the US energy independent. First, the article reviews how competition for energy supplies is affecting the US, its allies, and the world. Next, the article discusses how other nations can and are using their energy resources for political gain, and demonstrates how increased dependence on energy limits the US's pursuit of its national interests. The article also examines in detail how, over the last ten years, Russia has masterfully honed its energy strategy as an instrument of national power and how this kind of "energy politics" will increase as other energy-producing countries learn how to exert the same sort of influence. The economic cost to the US and the world for energy independence and some benefits of moving toward energy independence will also be presented, to clarify which energy options for reducing energy independence are available and practical for the US. The article concludes with a recommended plan to curtail a potentially significant energy crisis in the 2015 timeframe and to end America's energy dependence by 2025. The plan focuses on America's current technical capabilities to produce energy that will generate jobs and increase economic prosperity for the nation.

WORLD POLITICAL AND ECONOMIC TRENDS, PROBLEMS AND IMPLICATIONS

US Trends

About one-sixth of current US energy supply is imported. Over the next 15 years, the US is projected to double its energy imports from foreign sources, assuming its current energy policy does not change (National Energy Policy [NEP], 2001). Most of the increased energy imports in the future will be related to supplying the transportation sector with gasoline (NEP, 2001 p 8-3), which comes from oil. The first bar in Figure 1 shows that 52% of our oil was imported in 1999. The second bar shows coal production, which indicates that the US is an exporter of coal. In fact, the US has the largest coal reserves in the world, and much of its electricity is generated by coal (EIA, 2006). The third bar shows natural gas production. Since 1999, the US has not increased domestic natural gas production, and imports have increased by almost 20% (EIAOOG, 2005). A discussion of how coal, nuclear power and the other energy sources listed below can reduce the US net energy imports appears later in the article.

Today, oil imports make up about 60% of total US oil consumption (EIA, 2006), nearly double what was imported during the 1970s when the oil crisis occurred (EIA, 2006). Figures 2 and 3 show the oil and gas consumption projections for the US. The lower lines show the amount of energy that can be produced domestically by the US. The highlighted areas represent projected shortfalls and indicate the amount of energy that must be imported to meet our energy needs. Figure 2 shows that the Energy Information Administration (EIA) estimates oil imports will increase from around 11 million barrels per day in the year 2000 to around 20 million barrels per day in 2020. In the 1970s, the US imported little natural gas.

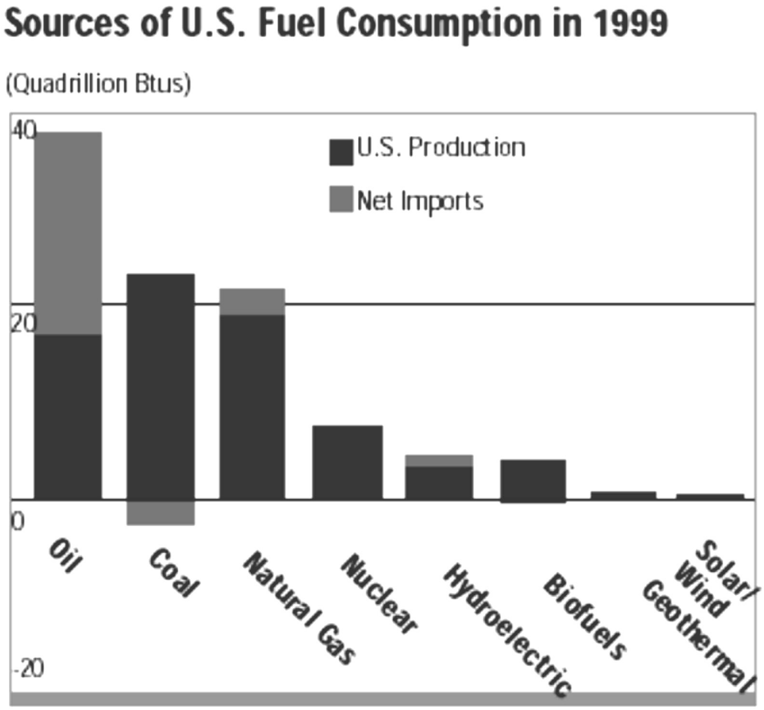
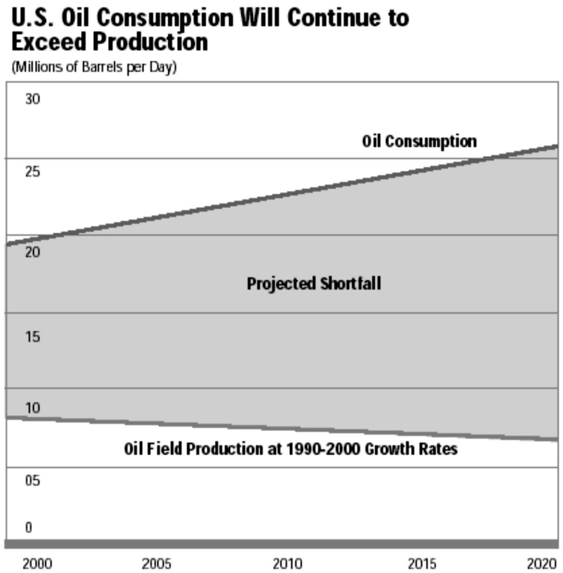


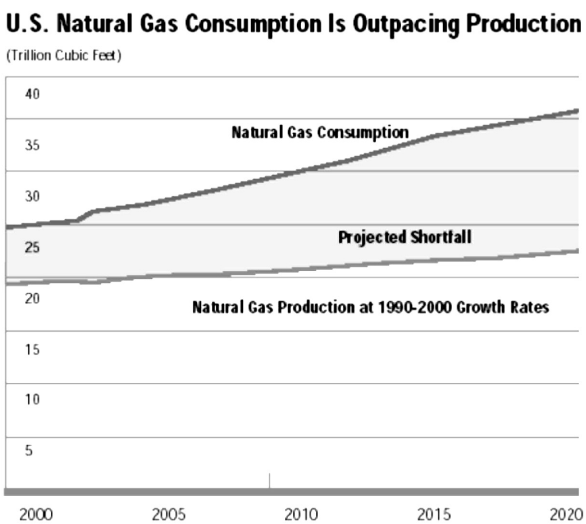
Figure 1. US fuel consumption in 1999.

The United States produced 72 of the 98 quadrillion Btus of energy that it consumed in 1999. We are self-sufficient in virtually all of our energy resources, except oil, where we import 52% of our net requirements, and natural gas where we import 15-16% net, primarily from Canada. (*Source: U.S. Department of Energy, Energy Information Administration*)

Since 1980, natural gas imports have tripled (EIAOOG, 2005). Figure 3 shows the projected increase in natural gas imports from 2000 to 2020. These two charts demonstrate that oil and gas imports will increase dramatically. While the increase of oil dependency is clearly part of a long-term US trend, increasing dependency on natural gas is another important trend to consider in formulating a national energy strategy.



Over the next 20 years, U.S. oil consumption will grow by over 6 million barrels per day. If U.S. oil production follows the same historical pattern of the last 10 years, it will decline by 1.5 million barrels per day. To meet U.S. oil demand, oil and product imports would have to grow by a combined 7.5 million barrels per day. In 2020, U.S. oil production would supply less than 30 percent of U.S. oil needs. (*Sources: Sandia National Laboratories and U.S. Department of Energy. Energy Information Administration*)



Over the next 20 years, U.S. natural gas consumption will grow by over 50 percent. At the same time, U.S. natural gas production will grow by only 14 percent, if it grows at the rate of the last 10 years. (*Sources: Sandia National Laboratories and U.S. Department of Energy. Energy Information Administration*)

Figures 2 and 3. Increasing shortfalls in domestic oil and natural gas production are met by increased imports to meet consumption demands (NEP, 2001).

US energy production trends over the last 20 years have shown a decrease in domestic oil production and increases in nuclear power, coal, and renewable sources. Figure 4 shows that domestic oil supply has steadily decreased since 1970. It also shows that domestic energy production from nuclear power, coal, and alternative energy sources has consistently increased since 1970. Natural gas supplies decreased from 1970 to around 1985 and have risen slowly from 1985 to 2000.

Electric power and transportation fuel are the main drivers of US energy consumption (IEO, 2005). Industrial and commercial consumption are increasing minimally because energy-consuming industrial products are increasingly produced outside the US. Figure 5 shows that oil used for transportation is the largest energy consumption category in the US (26.1 quadrillion Btus), almost twice the residential energy consumption (13.3 quadrillion Btus) which is second largest. Notably, oil (38.3%) and electricity (39.0%) consumptions are the top two areas,

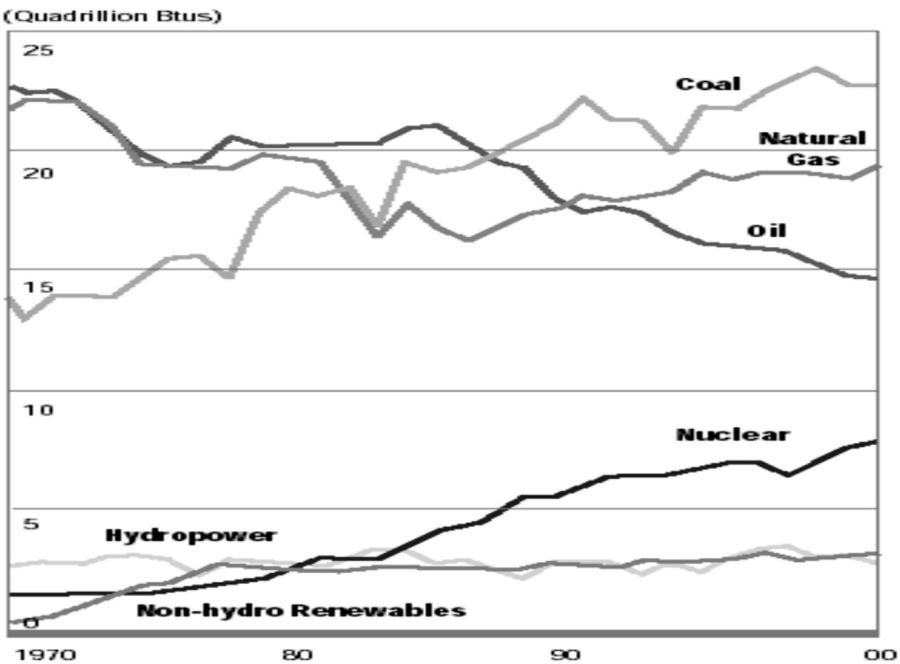


Figure 4. US energy production 1970-2000 (NEP, 2001).
Production of coal, the nation's most abundant fuel source, exceeded 1 billion tons in 2000. Electricity generation acounted for about 90 percent of U.S. coal consumption last year. (*Source: U.S. Department of Energy. Energy Information Administration*)

accounting for 77.3% of America's energy use in 2002. Since oil and electricity are the drivers of consumption in the US, these two categories will be used as a framework to examine alternative energy strategies later in the article.

COMPETITION FOR WORLD ENERGY SUPPLIES

Demand Trends and Energy Consumers: Europe, US, Africa, South America, and Asia

According to the Energy Information Administration (EIA), energy consumption in Europe, the US, Africa, and South America is expected to increase at a moderate and manageable pace over the next 15 years.

2002 Total US Energy Consumption (Quadrillion BTUs, EIA 2005)

	Transportation	Industrial	Residential	Commercial	**Total**
Oil	**26.1**	9.2	1.5	0.7	37.5
Natural Gas	0.7	8.9	5.0	3.2	17.8
Coal*	0.0	2.1	0.0	0.1	2.2
Electricity**	0.3	10.7	**13.9**	**13.3**	**38.2**
Heat		0.0	0.0	0.0	0.0
Renewables		1.8	0.4	0.1	2.3
Total	27.1	32.7	20.8	17.4	98.0

*19.8 Quadrillion BTUs for electricity generation is from coal and not included here

** includes BTUs to generate electricity from coal, nuclear, gas, renewables, and oil

2002 Total US Energy Consumption (%, EIA 2005)

	Transportation	Industrial	Residential	Commercial	**Total**
Oil	**26.6%**	9.4%	1.5%	0.7%	38.3%
Natural Gas	0.7%	9.1%	5.1%	3.3%	18.2%
Coal	0.0%	2.1%	0.0%	0.1%	2.2%
Electricity	0.3%	10.9%	**14.2%**	**13.5%**	**39.0%**
Heat	0.0%	0.0%	0.0%	0.0%	0.0%
Renewables	0.0%	1.8%	0.4%	0.1%	2.3%
Total	27.7%	33.4%	21.2%	17.7%	100.0%

Figure 5. US Energy Consumption (IEO, 2005).

Europe is currently effectively managing its energy demand through taxes, conservation and technology investments. As this article details later, one worrisome trend for Europe is that its increased natural gas requirements are likely to be met primarily by Russia and Iran (Cedaz, 2005; Smith, 2005). The primary concern for nations in Africa and South America is that energy may become unaffordable as world supplies of inexpensive energy become scarce, leading to economic downturns, instability, or the implementation of highly damaging environmental policies such as the destruction and use of rain forests as energy sources (Monbiot, 2005).

Perhaps most significantly, energy demand is increasing at a high rate in Asia, where strong economic growth in India and China will contribute to the biggest increases in world energy consumption. Based on estimates from the EIA, energy consumption in Asia will almost double between 2002 and 2015. Figure 6 shows that, by 2015, Asia will surpass the US in energy consumption, which will have some serious implications for the US.

World primary energy consumption by region

	2002	2015	2025
Asia	88.0	155.8	197.0
US	98.0	117.6	132.0
Other	226.0	229.6	315.0
WORLD	**412.0**	**503.0**	**644.0**

(EIA base case: Units are in Quadrillion BTU)

Figure 6. World primary energy consumption by region.

Some of the growth can be attributed to increased industrial operations that produce exports for the rest of the world; however, another key trend is increased energy consumption per person resulting from those in new industrial jobs who can now afford automobiles and electrical appliances. Sometimes overlooked, energy consumption per person is an important metric when projecting potential energy demands (EIA, 2005):

- China uses 9.9% of the world's energy and has 21% of the world's population.

- India uses 3.1% of the world's energy and has 16.6% of the world's population.
- The US uses 25% of the world's energy and has only 4.6% of the world's population.

Based on the above statistics, if China and India needed as much energy per person as the US uses today, they would need 200% of today's world energy supply—**twice as much as the world can produce today**. As China and India modernize over the next ten years, it is reasonable to expect that their energy demands will increase rapidly along with their desire to compete for their fair share of the world's energy supply. Figure 7 shows that energy consumption in India and China

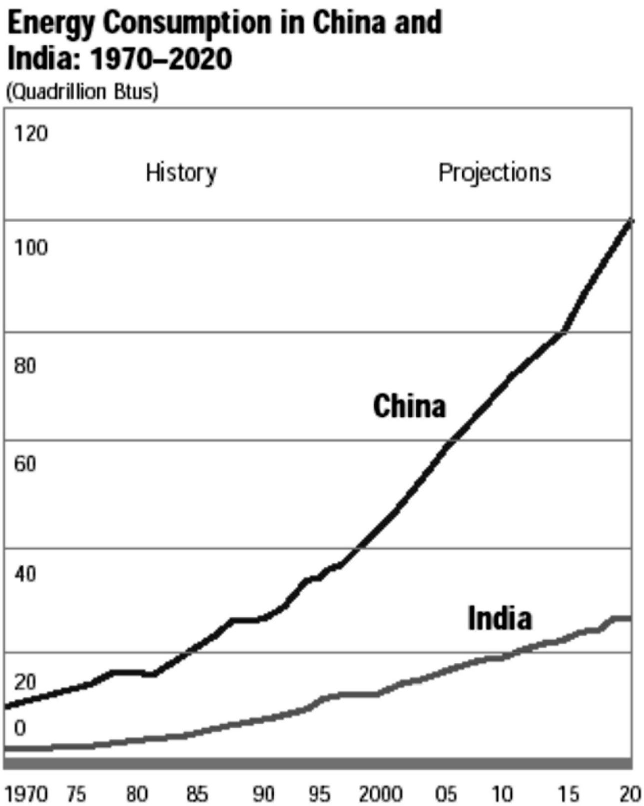


Figure 7. Projected growth in China's and India's oil demand. (US DOE, 2004). China and India account for the bulk of projected growth in oil demand in non-OECD countries. (*Source: U.S. Department of Energy. Energy Information Administration*)

has been increasing substantially since 1970 and that, over the next ten years, the demand is expected to increase even more rapidly. In terms of energy consumption, the US can be compared with the gluttonous dinner guest who eats one-fourth of a pie when there are 20 other guests wanting dessert.

Anticipation of future demand has caused China, Japan, and other Asian countries to be concerned with ensuring reliable sources of energy in the future. This, in turn, has resulted in conflicts between Asian countries for energy-rich islands, and competition for pipelines coming to the region (Smith, 2005).

Asia is not the only area of concern—Western Europe and Eastern Europe are becoming increasingly dependent on oil and natural gas from Russia. Russia has exploited Eastern Europe's energy dependency and is in a position to replicate its tactics in Europe and Asia. Later in the article is an in-depth discussion of Russia's strategy and recent actions that illustrates the trends, problems and implications associated with increased competition for oil worldwide.

SUPPLY TRENDS AND SUPPLIERS

Overall, suppliers of energy are becoming more sophisticated in their approach to meeting global demand. After experiencing a drop in oil prices caused by excess capacity in the 1980s, both oil companies and exporting countries carefully manage new investments in energy production capacity (*The Economist*, 2005). *The Economist's* April 2005 energy survey shows that spare capacity to supply the world's energy demand has declined to relatively low levels compared to most of the last 40 years. The black line in Figure 8 shows the decline in spare supply capacity from 25% in 1982 to around 2% in 1990, with capacity fluctuating around 5% since then. It also shows that low excess capacity from 1975 to 1980 preceded the highest-ever real price per barrel when it spiked in 1980. Real prices came down after high prices caused increases in capacity between 1979 and 1983. Some excess capacity was created by tapping sources that are only profitable when prices are high, which is one reason excess capacity dropped again in 1983 when real prices also receded.

The lack of spare capacity increases prices and leads to shocks when supplies are disrupted by events such as hurricanes and other

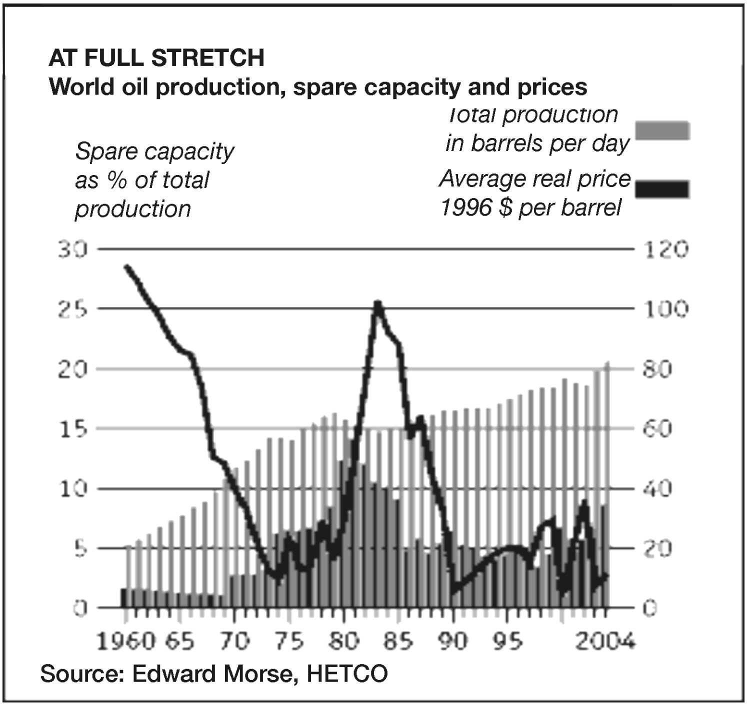


Figure 8. Declining spare oil production capacity (*The Economist*, 2005).

disasters. OPEC and Western oil companies have not invested in more capacity in order to prevent another unprofitable energy price collapse. Western oil companies are still able to supply energy from previous discoveries that were developed first, because less capital was required to make them productive than for more recent discoveries. As energy prices rise, it becomes profitable to make investments in the higher-cost sources of energy, but oil companies are cautious about new investments because those became unprofitable when prices decreased in the past. This led to the current situation where there is less spare capacity in older sources, and that contributes to price increases and supply crises. Because of this, it is not likely that the world will see a drop in energy prices due to overcapacity as in the past. In fact, cautious management of capacity may raise real energy prices higher than ever, because companies may underestimate demand and not be able to keep up with rapid increases in Asian energy demands.

Seventeen percent of US imported oil comes from neighboring countries such as Canada and Mexico, which pose no threat to U.S. interests. However, as Figure 9 shows, the US receives oil from countries that have conflicting interests with the US. Saudi Arabia, Venezuela, Iraq, and Columbia are major suppliers that have political and economic differences with the US that could lead to supply difficulties.

The biggest threat from these countries is that they could decrease supply and cause increasing prices. In the past, OPEC has tried to decrease supply to keep prices up, with mixed results. For example, Saudi Arabia, having by far the world's largest oil reserves, has a history of working with OPEC and Russia to restrict oil supply in an effort to keep prices up (Bergsten, 2005). In addition, Saudi Arabia (able to produce oil for less than $2 per barrel) is reaping the benefits of higher prices by selling only enough to satisfy its revenue requirements and to keep prices within target levels. Saudi Arabia is a key player in keeping world prices stable because it has changed its production levels to dampen the effects of changes in the supply demand of oil (Bergsten, 2005). In fact, it reduced its production in the past to keep prices up, while other OPEC countries increased production to keep prices affordable even after exceeding their allocation of production.

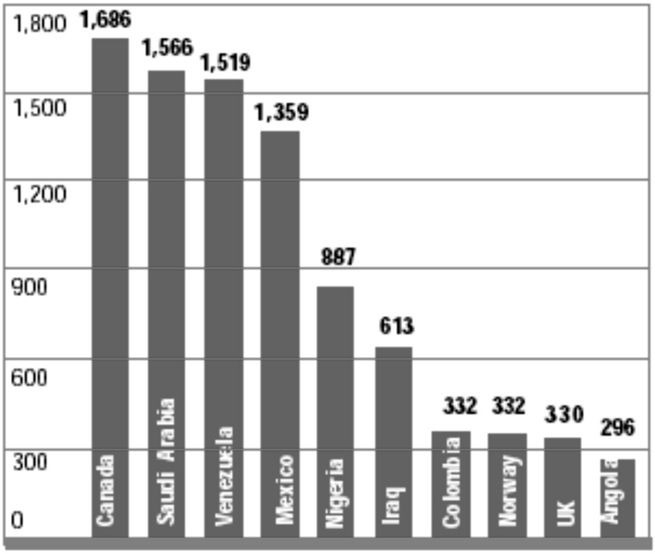


Figure 9. Top 10 US oil suppliers—2000.
In 2000, nearly 55 percent of gross U.S. oil imports came from four leading suppliers: Canada (15%), Saudi Arabia (14%), Venezuela (14%), and Mexico (12%). (*Source: U.S. Department of Energy, Energy Information Administration*)

Lowering production is no longer a needed strategy to stabilize price; in fact, world demand has increased so much that increased production is necessary to stabilize prices. Saudi Arabia is near its peak production capacity (*The Economist*, 2005) and is not able to respond to demand increases to prevent rapid increases in oil prices. Oil prices would be much less if Saudi Arabia could maximize its production and had excess capacity as it once had. Obviously, it is not in the interest of any oil-producing nation to have unstable oil prices, because high, unpredictable prices could have the undesired effect of forcing numerous countries to switch to other sources of energy. For example, in the 1800s when whale oil was the main supply of energy, unstable prices stimulated the switch to crude oil (Evans, 2004).

Other Alternative Energy Suppliers

More recently, some countries such as Brazil, having reacted to unstable prices in the past, developed significant alternative energy sources. Brazil has met most of its increased transportation demand over the last 20 years by developing ethanol production and distribution facilities, and currently exports a significant amount of ethanol to other countries. Brazil's ethanol production comes mostly from sugar cane as a raw material. Other countries, such as Thailand, Australia, Guatemala Peru, Argentina, and Paraguay have climates that can produce large amounts of sugar cane, which may make them future exporters of ethanol. France satisfies 80% of its energy needs with nuclear power and exports electricity to neighboring countries such as Germany. Iceland is using hydrogen for some of its transportation needs and is working to be the first nation with a hydrogen-based economy (Chapman, 2005).

RUSSIA'S ENERGY STRATEGY

Russia has become a key player in using its energy to accomplish its political ends. Russia will have more influence on world energy prices as the demand increases in developing countries such as China and India. As more countries become dependent on Russia's large gas supply, it is important to understand Russia's energy strategy because they will be able to extort military, political and financial concessions from energy-dependent countries.

Russia's recent political moves have been criticized for being counter to democracy and human rights, but a closer look reveals Russia's strategy is focused on increasing its ability to use energy as an economic instrument of national power across the world. Over the past 15 years, Russia has been preparing its energy infrastructure to exert influence over Europe, the Middle East, the Far East, and the US. So far, Russia has had some success in Eastern Europe, but has limited influence in other regions. Nonetheless, as world energy consumption rises with demand, Russia's strategy will increase its economic influence worldwide. Russia has made strategic tradeoffs to be able to use energy as a strong instrument of national power. Russia's and other countries' energy strategies will erode advantages that the US currently enjoys, such as an economic hegemony if the US does not implement its own aggressive strategy aimed at energy independence.

Russian Energy Reserves and Infrastructure

Most estimates show that Russia has over 30% of the world's natural gas reserves. Ninety percent of Russian gas is produced by Gazprom, Russia's state-run gas company. Gazprom is essentially under state control and serves to execute Russian energy strategies through operating and building natural gas pipelines (DOE-R, 2005) both inside and outside of Russia. Most of the gas produced in Russia comes out of the Yamal-Nemets Region, in the northwest part of Siberia near the Arctic Circle.

Russian President Vladamir Putin and the Russian government have stated on several occasions that their oil reserves are underestimated. Experts disagree on how much of the world oil reserves reside in Russia, with estimates ranging from 6% to 18% (Quayat, 2003). "Some oil executives believe that recent seismic tests…prove that Russia possesses more oil and gas than today's most optimistic estimates" (Smith, 2004, p. 8). The source of this disagreement is that much of Russia's oil-rich territory has not been fully explored in hard-to-reach areas of Siberia. There are vast prospective regions in Eastern Siberia that will take time to develop. The fact that Russia's production is not rising rapidly to capture near-term demand could payoff for them in the long run because as time goes on, Russia's oil will become more valuable as world energy supplies dwindle. Russia is likely to use the untapped oil and gas reserves in Eastern Siberia, near China, to exploit Asian nations that are competing for new energy supplies. World competition for scarce energy supplies is the key component of Russia's national energy strategy.

Current and Emerging Market Developments (European Dependency—Asia Will Be Next)

Current markets for Russian gas lie primarily in the 33 European countries to the west. Germany, Italy, Turkey, and France are the top four consumers of Russian gas exports (Russia Country Analysis Brief, 2005). Sixteen out of 33 European countries depend on Russia for 75% or more of their natural gas supply (Stern, 2002). Russia is in a powerful position to influence all of Europe, since only 5 out 33 European countries are not dependent on Russian energy imports. (Stern, 2002).

Emerging Russian markets lie primarily in the East, and include China, Korea, and Japan. Russia's influence in the East will increase as plans to build a pipeline to China and Korea are realized. China's demand is set to rise more than any other nation. Its current consumption of 4.1 million barrels of oil a day is estimated to rise to 10 million barrels per day in 2020 (Ivanov, 2004). Russia plans to reach Japan through direct pipelines that branch from pipelines leading to China.

Gas and oil pipelines from Russia to China and Japan could raise tensions in Asia. Anticipated energy shortages have made China and Japan concerned with ensuring reliable sources of energy, creating tension and competition between them (Rattlif, 2002), both wanting to be the first and sole destination of Russian pipelines. This situation is of particular concern because geologists estimate that Russia will not be able to satisfy the oil demands of both countries (Rattlif, 2004). Nonetheless, it is likely that Russia will build both pipelines to enhance its advantage in the world export market and to use competition as an economic instrument of power. Having both pipelines will intensify competition as demands increase over time, allowing Russia to raise prices and demand political and economic concessions from Asian nations.

Russian National Energy Strategy

As noted above, over the last 15 years, Russia has taken steps to ensure that its energy infrastructure is able to exert worldwide economic power. To date, it has used economic power with great success to gain control over other countries' energy infrastructures and achieve political goals. "Russians have realized that possession of atomic weapons confers only limited status…" and they "recognize that the country's strongest instrument for influencing foreign events is the energy card" (Smith, 2004, p. 16). Russia plans to use energy "to increase Russia's leverage in international security affairs and influence the political and economic policies of Russia's trading partners" (Smith, 2004, p. 16).

Russia has been pursuing a strategy to subject its energy infrastructure to government control. "Putin and his advisors…share the view that members of the Russian energy industry should operate as an instrument of state policy rather than autonomous international players, as…in the US and Europe" (Smith, 2004, p.14). Furthermore, Russia has been gaining control over competing neighbors' energy infrastructures through various strategies. One strategy has been for Russian-controlled companies to purchase controlling or blocking interests in foreign energy companies (Rattlif, 2004). Russia has nearly achieved its objective in gaining control of neighboring countries' energy infrastructure and is just a few steps away from ensuring state control of its domestic energy infrastructure.

Use of Energy as an Economic Instrument

Russia is making strategic moves in building its infrastructure so that it can fully exploit other countries' need for energy. It is also making strategic moves to make sure it has alternatives for energy transit, so that it will be less vulnerable to other countries' strategies. Russia has already used gas debts as an instrument of national policy by trading debt for assets and equity in areas of the energy sector where it wanted to acquire a controlling interest. "The massive power of the Russian energy industry is evidenced by its ability to acquire…majority (or blocking minority) financial stakes" (Smith, 2004, p. 7). In fact, Russia has succeeded in gaining a large stake in every major gas and oil company in Eastern Europe (Smith, 2004, pp. 32-33) by using energy revenues to buy controlling stakes in the companies.

Russia has also used its control of energy supply as a lever to acquire key energy industries in other countries. For example, in 2002, a Russian company demanded to buy the Latvian oil port of Ventspils. Latvia refused the demand, which resulted in Russia directing that its crude oil be carried by pipeline to be rerouted elsewhere for export. This rerouting caused a 50% reduction in oil exports going out of the Latvian port (Smith, 2004). A second example (Smith, 2004) occurred during 1998-1999 when Russia cut off oil shipments to Lithuania nine times in an attempt to force Lithuania to cede control of its pipelines to LUKOIL, a company controlled by the Russian State and used as "an instrument of Kremlin Policy" (Smith, 2004, p. v.). Russian strategy worked and Lithuania was eventually forced to sell control of energy assets to Yukos, one of Russia's largest oil companies. Yukos was able to buy 53.7% of Mazeikiu Nafta, an energy company that owns Lithuania's oil pipelines, the Bundinge terminal and the Maxeikiai Oil Refinery (the only oil refinery in the Baltic States) (Interfax Financial & Business Report, 2005). A final example was Russia's efforts to stop the completion of competing pipelines such as the Odessa-Brody pipeline from Ukraine (Smith, 2004), which would prevent some of the former Soviet States such as Turmemenistan from having alternatives to routing their energy though Russian pipelines. The pipelines were stopped, causing Turmemenistan and its neighbors in Southwest Asia to become dependent on Russian pipelines (Smith, 2004). Russia has used its location to a strategic advantage by gaining favorable terms from neighboring countries. Because pipeline alternatives were blocked and Russia refused consent to allow pipelines to be built through Russia, Turmemenistan had to settle for a 25-year deal with Russia to buy natural gas at set prices.

Russia is creating a strategic overcapacity for exporting its energy products. Construction of the Baltic pipeline system began in December 2001 (Rattlif, 2004). The Baltic Pipeline system (proposed construction of an undersea gas pipeline to Western Europe, an oil port in Primorsk, and pipelines to the Pacific and China) gives Russia options in exporting its energy. These pipeline options force competition among states that have pipeline routes which Russia does not control. While Russia's strategy has been costly in the near term, its aim is to ensure that little can be done to exert political or economic leverage on its energy strategy in the future (Smith, 2004).

Russia's planned completion of a pipeline though Belarus to Western Europe will greatly reduce the incentive for Russia to continue providing preferential energy prices to the Ukraine (Balmaceda, 2002). Russia's energy strategy will be strengthened if European stakeholders working with Gazprom approve the North European Gas Pipeline, a planned underwater pipeline from the Yamal region to Germany. This pipeline will increase Russia's export capacity and serve as an alternative to exporting Russian gas through other transit routes. If this pipeline is competed, it will allow Russia to cut off gas supplies in Eastern Europe without affecting its Western customers.

Russia has successfully forced major political concessions from Eastern European countries over the last 15 years because of their dependence on Russian energy. Below is a list of some of the major events that illustrate the number and magnitude of the concessions Russia has created with its energy strategy. It is important for the US to evaluate how this type of coercion could be exerted over the US and its allies in the future by energy-producing countries:

- In 2004, Gazprom cut off the gas supply to Belarus over a growing conflict over gas prices (Poland Business Review, 2004).
- Russia used energy discounts as leverage to keep the Ukraine from actively pursuing NATO membership and supporting pipeline routes that bypass Russia (Smith, 2004, p.6).
- Energy discounts discontinued in Estonia as a punitive measure for not aligning with Russia on several issues (Smith, 2004).
- Gazprom reduced its supply of gas significantly to the Ukraine just before a major summit meeting between Russia and the Ukraine in 1993. "The Russian delegation at the summit meeting stated that the gas debt could be cancelled if Ukraine would cede full control over the Black Sea fleet to Russia and turn over its remaining nuclear warheads to the Russian Strategic Rocket Forces" (Smith, 2004, p. 47). Russia was successful in getting the Black Sea Fleet and the nuclear warheads.
- In 1992 and 1993, Russia cut off oil to Estonia, Latvia, and Lithuania after demands were made to remove Russian troops from their countries. "Moscow…intended the cutoff as a warning to non-Baltic former republics of the USSR to think hard before defying Russia on economic or security policy" (Smith, 2004, p. v.).
- In 1995, Russia used energy tariffs and gas incentives to try to convince Ukraine and the CIS customs union to support the Russian position on the ABM treaty (Smith, 2004).
- In 1996/97, fuel loans were written off by Russia in exchange for support of the establishment of the Commonwealth of Russia and Belarus and for agreeing to allow the Yamal pipeline to be constructed through Belarus (Balmaceda, Clem, & Tarlow, 2002).

Clearly, Russia is well on its way to ensuring that its energy can be used effectively by the state. Russia has secured control of its gas industry, and one can argue that government action to prosecute Mikhail Khodorkovsky (the owner of Yukos, one of Russia's largest oil companies) was a strategy for Russia to gain control of its privatized oil sector. While the action against Yukos and its owner is viewed negatively internationally, it was a strategic political move by Russia's President Vladimir Putin, and for Russia's Energy Strategy. Putin went after Khodorkovsky and Yukos because the company owed billions in taxes, was engaged in criminal activity—including alleged murder (Economic Intelligence Unit, 2005), and was buying politicians and a political infrastructure to overthrow Putin. While the action was not viewed well internationally, it was well received domestically: It improved Putin's approval ratings from 70% to 80% with Russians (Goldman, 2004) and was a tangible result of his promise to rein in the oligarchs. In addition, it created a climate wherein oligarchs would be more likely to pay taxes, curb their illegal activities, limit their political activity, and bend to government authority. Finally, the action created a climate that made it easier for Putin to get controlling interests in the remaining Russian oil companies.

Following the Yukos takedown, Russia has made offers to buy parts of the other domestic oil companies. This is a big step forward in Russia's energy strategy for limiting the influence of foreign ownership of Russian energy companies. It positions the government to operate unchecked in the use of energy as an instrument of national power, which is consistent with Putin's long-term plans. Once this strategy is complete, the Russian government will have a blocking interest in every domestic energy company, and be able to exercise state authority, while allowing some foreign ownership. With this move, it is hard to refute the claim that "Putin has been successful in consolidating state control over the Russian energy sector and eliminating any competing source of influence that might come from privatized energy firms" (Smith, 2004, p. iv).

Implications for World and Regional Security

Russia has proven to be persistent and strategic in pursuing its national energy strategy. It has also been a master in gaining strategic advantages through the use of power it has gained from its favorable energy situations. Clearly, the US needs to position itself to benefit from Russia's abundant energy supply, but also should protect itself from the increasing economic power that Russia will be able to exert in the future.

As the world becomes more dependent on energy imports, other energy-exporting countries will be able to emulate Russia's success in using its energy as an instrument of national power. As a result, the US's relative power and hegemony will be eroded. It is possible that some European countries' lack of support for invading Iraq could be related to Europe's dependence on Russian and Iraqi energy. Iran, with the most natural gas reserves in the world (EIA, 2006), is in a position to benefit greatly from a buyer's market, such as avoiding international sanctions for their misdeeds, such as their nuclear program. Countries such as India and China cannot help but look toward Iran as a solution to meeting their energy needs, which will likely put them at odds with supporting sanctions or other policies toward Iran that the US promotes. European and Asian dependence on Russian and Middle Eastern oil has hampered US efforts to counter threats in Iraq and Iran. As dependence on energy imports increases over the next 20 years, the US's ability to build coalitions and solve problems multilaterally will become more difficult, resulting in political and economic costs that are intolerable.

COSTS OF OIL DEPENDENCY—IMPLICATIONS FOR THE US AND THE WORLD

As previously stated, scarce energy supplies increase the cost of all US products. Dependence on oil has made a big difference in strategic decision making, causing the US to accept allies with ideologies, values and political systems that run counter to our own. It is important to elaborate on the extent to which energy dependency weakens the US's ability to exert diplomatic power over countries that supply energy to the US and its allies. Lovins (2004), in his book *Winning the Oil End Game*, talks about a great number of political compromises the US has made that were driven by our dependency on foreign energy. Oil dependency, he asserts, constrains US actions, principles, ideals, and diplomatic effectiveness by:

- **distorting** relationships with, and appearing to apply double standards in dealing with oil-producing states;
- **undermining** the nation's moral authority by making every issue appear to be "about oil" and national policy in thrall to oil interests. This is arguably one of the most important contributors to rampant anti-American sentiment in much of the world—hostility that has itself "become a central national security concern";

- **injecting**…irritants into relations with current partners, such as Europe and Japan, and potential ones, such as China and India, whose long-term friendship is a key to robust counter-terrorism collaborations and many other elements of global stability;

- **intensifying** competition over oil with all other countries, ultimately including China and India—a likely path not to friendly relationships but to geopolitical rivalries akin to those that helped to trigger World War II.; and

- **setting** the stage for billions of people to blame their poverty and oil shortages on what demagogues could portray as America's uncaring gluttony" (pp. 150-152).

Because of US dependency on energy imports and the greatly increasing world demand for energy, more frequent armed conflict over energy-related issues is anticipated, directly affecting our national security. Lovins (2004) lists some national security implications as well. US energy dependence, he writes, erodes US national security by:

- **engaging** vital national interests in far-off and unfamiliar places where intervention causes entanglement in ancient feuds and grievances, and even in oil wars;

- **requiring** military postures—such as deployments in the midst of proud traditional societies—that reinforce Islamist arguments and Islam/West friction, arousing resentment and inciting violence among some of the world's 1.3 billion Muslims; thereby turning American citizens and assets worldwide into symbolic targets;

- **requiring** increasing oil prices and hence the unserviceable Third World debt: In 2001, 154 low- and middle-income countries' fuel (mainly oil) imports equaled two-thirds of their new borrowings (pp. 146-155).

Besides the cost of armed conflicts, there are also some serious economic impacts for the US. Lovins (2004) goes into some of the details asserting that energy dependence weakens the national economy by:

- **imposing** huge deficit-financed burdens on the U.S. for military forces able to protect and secure access to oil and to deter mischief in oil-related regions;

- **extracting** from unduly influenced legislators ever larger deficit-financed domestic oil subsidies (which distort markets by suppressing fair competition and retarding cheaper options that could reduce national costs);

- **creating** major environmental liabilities both at home and abroad, increasing social and economic pressures, raising health-care costs and lost labor productivity.

Governor Donald Kohn of the Federal Reserve Board remarked at the Fifteenth Annual Hyman P. Minsky Conference on April 22, 2005, that the important imbalance in the US economy was the growing gap between what the US spends and what it produces.

In short, energy is contributing to the increasing difference between what is spent and produced in the US. While the energy sector is only a part of the overall economy, it is a critical economic and strategic driver. Energy pervades the economy; every single product and service in the US has energy as a component in its manufacturing, production, and delivery. Oil is used in the chemical industry, which relies on crude for 90% of its products, including plastics and refrigerants. While demand for petroleum products in the chemical industry has increased by 700% since 1949, 90% of a barrel of crude oil still goes to liquid fuels such as gasoline or diesel (Armstrong, 2002).

Simply put, the US energy situation drives its economic destiny. In his economic assessment of the US, economist Frank Bergsten asserted that energy is a threat to both US and global prosperity and that energy is one of the key strategic sectors in the world to consider over the next 20 years with world energy demands increasing faster than supply (Bergsten, 2005).

While inflation has been low overall for most personal consumption expenditures, the rising cost of energy has been contributing to increasing core inflation. Natural gas and oil prices have doubled since 2001. According to the EIA, this increase was attributed to increased demand and weak production. Considering Asian demand trends and low *excess production capacity* which was discussed earlier, it is fair to say that the world energy supply and demand situation for the next 10 years is going to get much worse, leading to further drastic price increases and having broad negative effects on the US economy.

WHAT SHOULD US ENERGY STRATEGY BE?

In light of the previous discussion, the US should make eliminating dependence on outside energy sources a vital priority. It should also begin to invest in exportable energy technologies that mitigate the scarcity of world energy supplies. By helping other countries increase their energy supplies, the US can reduce the ability of exporting countries to exert coercive power over our allies and the world. The following discussion proposes how the US should satisfy its energy demand in the future, use its national resources more effectively, and achieve energy independence. Also discussed are relevant environmental, safety, and political factors that are important in the formulation of an integrated national energy strategy.

As previously mentioned, electrical power generation and transportation fuels make up about 78% of energy consumption in the US. We will next examine electrical power generation and discuss major issues associated with the use of coal and natural gas in generating electrical power for the US. We will discuss how increased nuclear power generation is the preferred strategy for meeting our future electrical power generation requirements. Use of solar power will be addressed in the context of how it can supplement the electrical power supply without adding to national power grid requirements. In addition the article examines how petroleum imports can be reduced by investing in biofuels and what strategies should be put in place to eliminate future petroleum imports. Finally, the article demonstrates how coal and other prospective fuel supplies can be converted to transportation fuels, to reduce petroleum imports.

Electric Power Generation

Electric power is a key variable in formulating a national energy strategy because of its versatility. As natural gas and oil prices go up, electric power will increasingly be used to heat homes, power cars, and generate hydrogen for future vehicles. The 2002 National Energy Policy cites successful deregulation efforts in Pennsylvania and Texas that encouraged increases in power generation. It also notes California's less successful efforts when the state encouraged utilities to divest power generation and focus on competitively buying power, leading to its recent problems such as loss of power and high prices. These limited and mixed results suggest that state and federal policies are not robust enough to consistently ensure reliable and inexpensive electricity supplies, so a fresh look at the national electric power generation strategy is needed.

Because electrical power generation requirements are hard to predict, and past energy policies related to electric power generation have had unintended environmental and economic consequences, better policies need to be put in place regarding energy policy at both state and federal levels.

Environmental Emissions Relating to Electric Power Generation

As discussed, the US consumes more electricity than any other energy source. The nation generates electricity from primary energy sources such as coal, natural gas, and nuclear power, and from renewable sources such as hydroelectric power, and solar power. Figure 10 shows how much power was generated by each energy source and consumed by the US in 2002.

2002 Electricity Consumption (EIA, 2005)		
	Percent	(Quadrillion BTU's)
Coal	51.8%	19.8
Nuclear	21.2%	8.1
Natural Gas	15.2%	5.8
Renewables	9.4%	3.6
Oil	2.4%	0.9
Total	100.0%	38.2

Figure 10. US energy consumption in 2002. (IEO, 2005)

The environmental consequences of reliance on fossil fuels to generate electricity are gaining scrutiny. A build-up of greenhouse gases appears to be causing a warming of the climate, which could cause changes in weather patterns, disrupting farming and other industries worldwide. Much of the greenhouse effect is attributed to carbon dioxide. Worldwide emissions of CO_2 from burning fossil fuels total about 25 billion tons per year. About 38% is from coal and about 43% from oil.

(Nuclear Energy Institute [NEI], 2006). Figure 11 shows that coal is the largest emitter of carbon dioxide and that natural gas is the second largest.

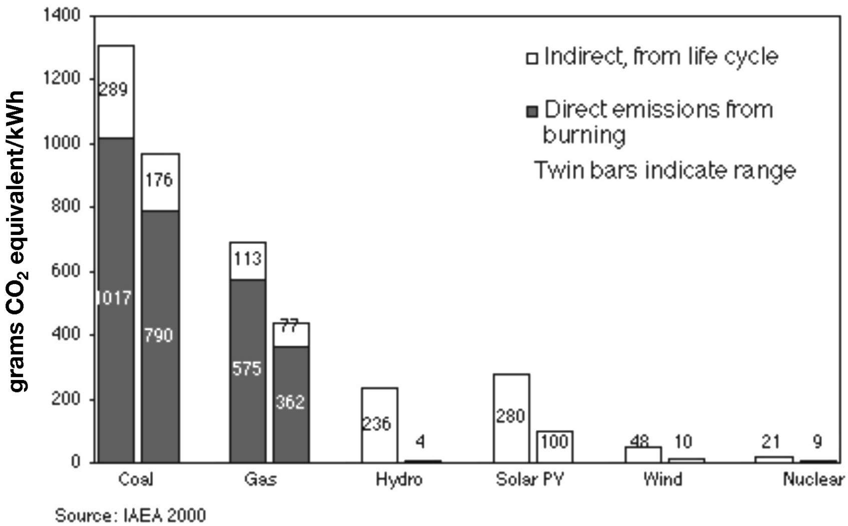


Figure 11. Greenhouse gas emissions from electricity production (IAEA, 2000).

As shown in Figure 12, one alternative strategy the US has pursued for the last 10 years was designed to use natural gas to increase future electricity production (Simon, 2006). One reason the natural gas option was pursued is that it is less polluting than coal which emits about twice as much carbon dioxide per Btu. (EIA-D, 2006). Even so, over 1.2 million metric tons of carbon dioxide emissions were still emitted from natural gas use in the US in 2002. Also, strategists did not consider the limited supply of natural gas in North America. Natural gas prices doubled from 2001 to 2006 because of weak production and high demand caused by increased use of gas for electric power generation (EIA Brochure, 2005).

Because many Americans depend on natural gas to heat their homes, the government at one point shifted its strategy away from natural gas. This change particularly benefited the elderly on fixed incomes who were being hurt by rapid and sustained price increases that the strategy was causing. Figure 13 shows electric power generation by fuel, with coal use ramping up sharply, which indicates that the new strategy is to use coal to satisfy new electric power requirements over time.

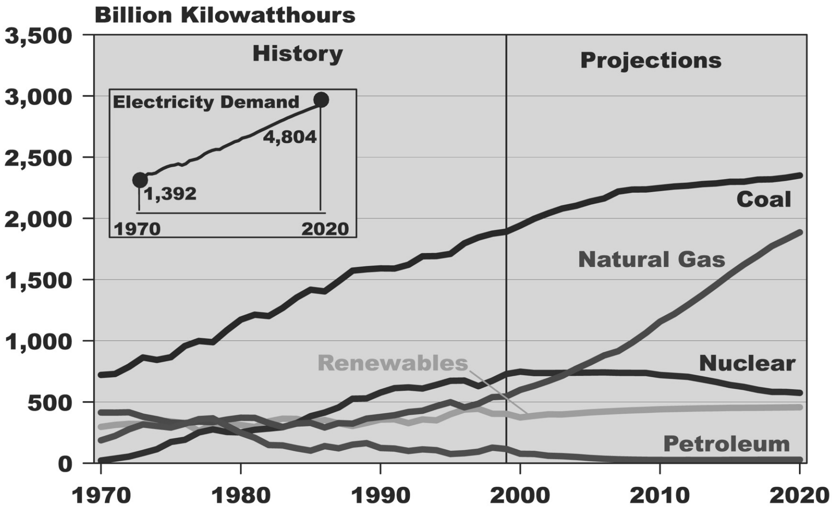


Figure 12. Electricity generation by fuel—2001 projection (Simon, 2006).

Currently, coal is used to power more than 50% of our electricity (EIA, 2005). Coal is abundant in the US, so it is possible to greatly increase electric power generation without increasing energy imports; however, a number of environmental and other issues with coal make this strategy undesirable over the long term.

Coal has a number of production issues associated with public health, safety, property and the environment (NEP, 2001). Regulation of coal mining has not kept up with the intense-extraction mining technology. New longwall and mountaintop removal mining techniques are having unintended consequences, such as vibrations from mining operations, damage to homes, and noise pollution (Kunz, 2001). Coal is gaining the attention of environmentalists and property owners because of associated damage to air, water, and land resources (*Appalachian Voices*, 2002; *Pollution*, 2001). These risks to streams, wetlands, wells, springs, and aquifers suggest that environmental regulations associated with coal mining need to be strengthened and enforced.

Another concern with coal is environmental emissions (Kunz, 2001). Burning coal for electricity causes the most environmental damage compared to other energy sources. Coal emits a variety of harmful compounds into the air, which is why there is much current discussion regarding making investments in new "clean coal" technologies.

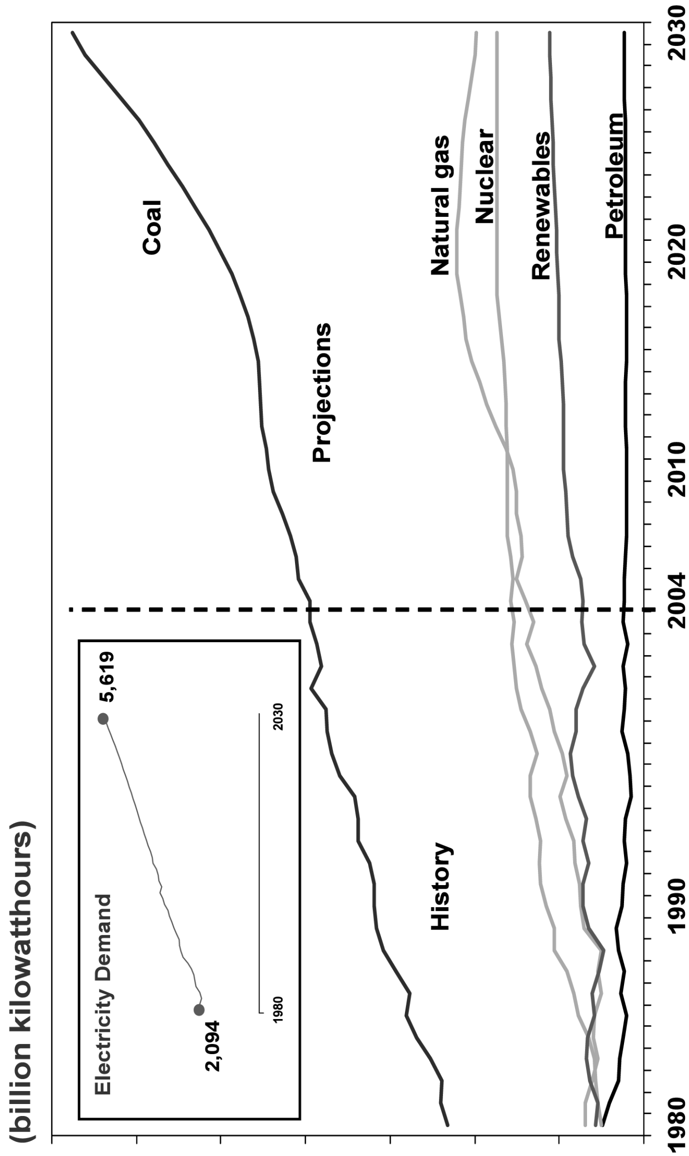


Figure 13. Electricity generation by fuel, 2006 projection (Simon, 2006).

Increasing coal use to satisfy future electricity demand is not the best strategy because there are better non-polluting options for producing electricity. Using coal for electricity is unavoidable in the near term, but over the long term, using coal for transportation fuel is a much better strategy for the US. Technological opportunities and uses for coal will be covered later in the transportation fuels section of this article.

Electrical Transmission Loss, the US Power Grid, and Solar Power

Electricity must travel long distances through a power grid to reach its source, causing a large amount of power to be lost (transmission loss). Currently, many power grids are reaching capacity, which has caused problems such as brownouts and blackouts in parts of the country. One benefit of solar power is that it is consumed close to its source, so transmission losses are minimized, and requirements for upgrades to the power grid can be reduced. Additionally, solar water heating systems can reduce consumption of natural gas and electricity used to heat water.

One constraint on solar power is the unaffordable cost to install a complete system. While the cost of solar power cells has come down by a factor of 20 over the last 25 years, it is not affordable to most citizens. Continued development is needed to reduce solar power system costs and power yields. One study indicates that at present efficiency levels, it would take about 10,000 square miles of solar panels to satisfy the nation's electricity requirements (Parfit, 2005). To illustrate the magnitude of the effort, installing 10,000 square miles of solar panels would equal about 900 square feet on 300 million buildings (Parfit, 2005).

The best approach to decreasing costs and increasing solar power performance is to create a large enough market where companies can compete for business. Another benefit of participating in the market for solar power is that competition will lead to the development and deployment of better solar power systems. The government can support this effort by putting in place stronger incentives for solar power adoption. Current incentives are not enough for consumers to justify making the upfront investment. Increasing current tax incentives by a factor of five is needed for the average homeowner to consider solar cell installation. Federal regulations should be considered to require solar power installations on new homes. The nation would greatly benefit by pursuing "a man on the moon" goal of having 50 million rooftop systems by 2015 and 300 million by 2025. However, strong incentives are needed to achieve such a goal. For example, a power generation tax on fossil fuel plants could subsidize increased tax breaks for solar power installations. Economic benefits would be generated as jobs are created to manufacture, install and maintain solar cell systems. The US should also put in place incentives such as competitions for companies to install solar power systems. One idea would be to award $1 million for the first million megawatts that a solar power company installs.

Even if robust incentives were implemented, another hurdle must be crossed to expand the use of solar power—the availability of raw materials to make solar cells. Currently, most solar cells are made from silicon left from inefficiently manufacturing computer chips. New methods, such as using conductive polymers and nanotechnology are maturing, and may lead to better options for rooftop solar power. Triple-junction thin film technology may become an affordable alternative for rooftop power in the future (NEP, 2001).

Nuclear Power

In a stunning turnaround, Greenpeace founder Patrick Moore spoke in favor of nuclear energy at the U.N. Climate Change Conference. "There is now a great deal of scientific evidence showing nuclear power to be an environmentally sound and safe choice," Moore said, adding that calls to phase out both coal and nuclear power worldwide are unrealistic. "There are simply not enough available forms of alternative energy to replace both of them together. Given a choice between nuclear on the one hand and coal, oil and natural gas on the other, nuclear energy is by far the best option, as it emits neither CO_2 nor any other air pollutants" (NEI, 2006).

There are 104 nuclear power generating plants in the US, supplying just over 20% of the nation's electrical power (EIA, 2005). In this section, the article will outline factors supporting the increase of nuclear power generation as a key part of the US energy strategy. Not only is nuclear power arguably the best environmental choice for electricity production, but it has great potential for reducing our dependence on foreign energy products.

The US can add as much nuclear power generation capability as it wants since there are ample supplies of nuclear fuel in North America (NEI 2020, 2006). The price of nuclear energy is not subject to economic market manipulations, and there is an existing stockpile of nuclear material left over from the Cold War to support expanded power generation for decades. In fact, nuclear power is the lowest in cost compared with other sources, as shown in Figure 14. Since there is ample nuclear fuel supply, and the cost is lower than fossil fuels, nuclear power has great potential for reducing US dependence on foreign oil.

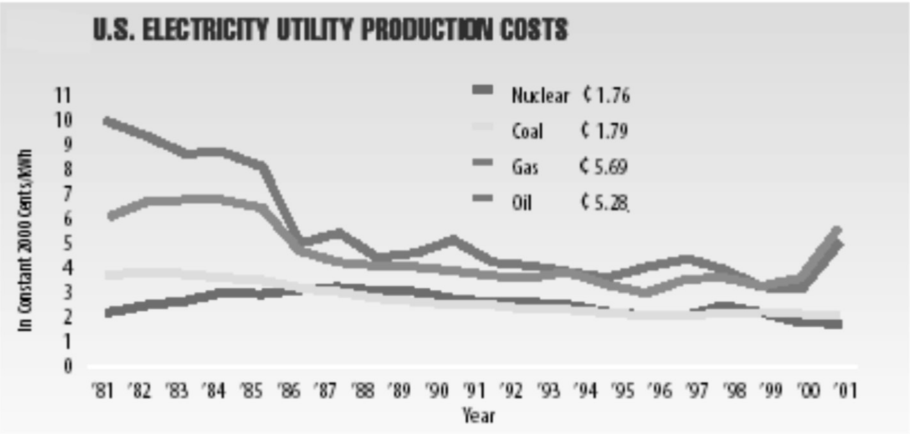


Figure 14. Electrical utility production costs (NEI 2020-E, 2006).

Safety and Security Issues: Over the last 30 years, growth in nuclear power generation slowed as a result of environmental and safety concerns arising from the Three Mile Island and Chernobyl nuclear accidents. Environmental groups have raised issues with safety, mining, enrichment and storage of fuel and waste. Many of these concerns have been addressed in the regulatory processes and disciplined operational procedures, which has enabled the nuclear industry to achieve one of the best safety records of any energy industry (NEP, 2001).

The table includes accidents that have occurred outside the US and shows that nuclear power results in far fewer fatalities than those associated with other fuels.

Safety concerns relating to nuclear power's vulnerability to terrorist attacks similar to the 9/11 attacks and other vulnerabilities are currently being addressed. The Electric Power Research Institute (EPRI) study showed that US nuclear reactors can withstand the full impact of a fully fueled Boeing 767 (EPRI, 2004). Containment buildings are heavily guarded, making nuclear power America's safest energy source.

The majority of Americans support more nuclear power, including some prominent environmentalists. A new public opinion survey in

Table 1. Comparison of accident statistics in primary energy production. (NEI, 2005)

Fuel	*Immediate fatalities 1970-92*	*Who?*	*Deaths per TWy* electricity*
Coal	6400	workers	342
Natural gas	1200	workers & public	85
Hydro	4000	Public	883
Nuclear	31+	workers	8

*Typical weather years

Source: Bell, Roberts & Simpson, Research Report #20, Centre for Environmental & Risk Management, University of East Anglia, 1994; Hirschberg et al, Paul Scherrer Institute, 1996; in: IAEA, Sustainable Development and Nuclear Power, 1997; Severe Accidents in the Energy Sector, Paul Scherrer Institute; 2001.

the US shows that 83% of Americans living within 10 miles of a nuclear power plant favor nuclear energy, and 76% are willing to see a new reactor built near them. Also, 85% give the nearest nuclear power plant a "high" safety rating, and 88% are confident that the company operating the power plant can do so safely (NEI, 2006). Ann Stouffer Bisconti, Ph.D., President, Bisconti Research Inc. states, "U.S. public support for nuclear energy reached record highs in May 2005, continuing an upward trend. Now, 70% favor nuclear energy. Even more significant is the widening gap between those who strongly favor and strongly oppose nuclear energy, because persons with strong opinions are most likely to take action one way or the other. Those who strongly favor (32%) nuclear energy outnumber those who are strongly opposed (10%) by a 3-to-1 margin." (NEI, 2006).

One major benefit associated with nuclear power is that, unlike other energy sources, it is not subject to disruption by adverse weather like hurricanes or climate changes. This is an important long-term consideration when thinking about the amount of oil refinement capacity that was taken offline and how gas prices increased in the wake of Hurricane Katrina. Also, considering the potential for a series of bad weather years for agriculture or global climate change (Pittenger, Gagosian, 2003), it is a wise strategy not to be over-reliant on energy supplies such as wind and biofuels. Nuclear power can be used to decrease the use of petroleum by generating electricity for vehicles, and homes, and hydrogen for use in hydrogen power vehicles and water desalinization. Nuclear plants can also be used as a heat source and source of power to recover oil from oil shale, and produce diesel fuel from coal. Furthermore, increased nuclear power generation will satisfy future power requirements, which were to be filled by natural gas that now has become unaffordable. Increased nuclear power generation reduces overall natural gas usage for electrical power generation. Using natural gas for electricity generation is one of the key reasons gas imports have tripled since 1985 and prices doubled since 2001. With 25 years of safely providing 20% of the nation's electricity, there is a strong case to make for expanding nuclear power generation.

To conclude this discussion on nuclear power generation, this article recommends that the US should triple its nuclear power generation by 2020 and triple it again by 2030 to cover increases in US electric power consumption. Facilities should also be designed and built to use waste heat from nuclear power to assist in Fischer-Tropsh processing of coal into biodiesel, recovery of oil from tar and oil shale fields, the production of biomass ethanol fuel.

Transportation Fuels

Two-thirds of all oil consumed in the US is used for transportation fuels. Biofuels, methane hydrates, natural gas, hydrogen, and fuels produced by the Fischer-Tropsh chemical process are all alternatives to the use of oil for transportation. Of these four options, biofuels have the most potential for supplying fuel in significant quantities over the next ten years. The other alternatives require the development of new technologies, factories and infrastructure to such an extent that they must mature over several decades before they can become significant sources of fuel for the US.

Biofuels—American Fuels Made by American Farmers

Biofuels are an energy source that can be produced in the US and should be seen as a way to greatly reduce our dependency on imported oil. Biofuels are derived from animal or plant products. As long ago as the 1800s, whale oil was used for lamps (Lovins A., 2005). Both biodiesel and ethanol were used in the early 1900s to power automobiles, but were replaced by petroleum products because they cost less. Today, with increasing demand for oil, a decreasing supply of inexpensive oil, and better technologies to produce biofuels, the US is again interested in ethanol and biodiesel.

Brazil and Europe have already demonstrated that producing and using significant quantities of biofuels is a viable option. Europe and Brazil did, however, pay an economic price through subsidies, research and development (R&D) programs, and taxes to achieve their capabilities and levels of production. During the oil crisis in the 1970s, Brazil was hurt economically and reacted by developing a large ethanol production capability enabled by government subsidies and regulation. Brazil has met most of its increased transportation demand over the last 20 years by developing ethanol production and distribution facilities. Brazil has significant export capacity for ethanol that was underutilized in the 1990s when oil prices were low. It produced about 11 billion liters of ethanol in 2000, and about 15 million liters in 2004 (Unica, 2005), near its peak in the 1980s when it produced as much as 16 billion liters in a year (Johnston, 2006). Brazil's ethanol production comes mostly from sugar cane as a raw material. Brazil can make ethanol for about $1 a gallon (Johnston, 2006), less than the wholesale price of gasoline today. Currently, the cost of producing ethanol in Brazil is much less than what can be achieved elsewhere. Part of its success is attributed to efforts of Brazilian scientists at the Centro de Tecnologia Canavieria, a research lab funded by sugar growers, who decoded the DNA of sugar cane, helping them select varieties that were more pest-resistant and produced more sugar (Luthnow, 2005). Another factor in its success is that sugar canes produces sugar that can be converted directly to ethanol. Crops such as corn, which is abundant in the US, must go through an intermediate step to be converted to sugar (glucose), making ethanol more expensive to produce in the US.

The biofuels industry is currently emerging as an important factor in national security. Ethanol production facilities have been used to produce alcohol for commercial uses and as a fuel additive, but only recently have they been seriously considered as a potential replacement for gasoline imports. New technologies and production methods are evolving from the biotech industry to make ethanol cost competitive with gasoline. One technology is converting plants (cellulose) into glucose by using enzymes. Iogen Corporation has developed a prototype production facility that demonstrates that the technology is mature enough for full production (Elias, 2006). Biotechnology research efforts are underway to find ways to improve the conversion of cellulose to ethanol. Researchers are studying yeasts (Jepson, 2004) and bacteria

(Kompala, 2001) in search of better ways to convert biomass material to ethanol. Other ongoing research includes searching for naturally occurring bacteria that can be genetically adapted to producing ethanol. Craig Venter, who mapped the human genome, has recently completed a worldwide trip collecting genetic material in hopes of developing microorganisms that can produce an ethanol from cellulose and produce a steady stream of hydrogen (Rosenwald, 2006). In summary, there is great potential for biotechnologists to reduce the cost of ethanol production by creating better plants and microorganisms that convert the plants to fuel. The problem is that the cost of gasoline will soon exceed the price of ethanol, and we will not have the industrial infrastructure ready to meet the demand for ethanol.

Biodiesel Production—Current and Maturing Technologies

Early in the century, biofuel was produced from oilseeds and used in diesel engines, but production faded as diesel fuel became more affordable. Europe is the world leader in biodiesel, producing 17 times more than the US. Europe produces more biodiesel because its tax policies and regulations have stimulated demand for the product. Europe uses rapeseed to produce biodiesel. Rapeseed is better suited for biodiesel production than soybeans that are the primary source used to produce biodiesel in the US (Wikipedia, 2006). Soybeans are grown primarily for food products, and excess crops are used for biodiesel production. Besides soybeans, many other crops can produce biodiesel. Oil content and yield per acre are important factors that relate to how much biodiesel can be produced from crops. Appendix A outlines the oil content of various crops and yield per acre for crops. Developing specialized crops to increase biofuel production efficiency is an area of opportunity for US biotech companies that should be pursued. Algae biofuels may have the most potential as a primary transportation fuel because of the possibility for scaled-up production without proportional requirements for land. There are potential synergies with gas and coal electric plants that produce carbon dioxide emissions that could be used to support algae-based biofuel production.

Current and Future Capacity to Produce Biofuels

One concern relating to biofuel production is related to having enough land and water resources to meet production needs. The US has the most arable land per capita in the world (Armstrong, 2002). Several studies show that the US can safely produce large amounts of biodiesel and ethanol to provide a significant percentage of America's transportation fuel. The USDA (2005) completed a feasibility study concluding that the US can produce 1.0 to 1.3 billion dry tons of biomass per year for use in producing ethanol. The National Resources Defense Council (NRDC) estimates that "165 billion gallons of biofuels per year could be produced by 2050 just from land that is currently used for cultivation, while still meeting our current agricultural demands" (Green, 2005, p. 4) and that "between 54% and 94% of our gasoline needs can be met in 2050" (Green, 2005, p. 34). The US Office of the Biomass Program (OBP) in its multiyear plan estimates that 10% of transportation fuel will be biomass derived by 2020 and that up to 30% of our transportation fuel needs could be met by transforming biomass to ethanol (EERE-OBP, 2003). The NRDC estimate is based on the implementation of its recommendations that basically provide a number of financial and regulatory incentives to enable efficient use of most of our agricultural resources and deployment of production facilities to produce biofuels. The key difference between the NRDC estimates and the OBP estimates is that the OBP assumes that future incentives will not change from the status quo. (EERE-OBP, 2003).

Environmental, Safety, and Weather Considerations Relating to Biofuels

Overall, biofuels are better for the environment and safer than coal, gas, gasoline and diesel. A rigorous study recently compared the relative costs and benefits of various transportation fuel options. The model used evaluated fuel cost, fuel location (available infrastructure), environmental emissions, and safety. The bottom line was that biodiesel and ethanol came out on top, and conventional fuels on bottom. Environmental emissions were evaluated in terms of emissions per mile (Queddeng, 2005). An Australian study found that use of E10 (a mixture of 90% gasoline and 10% ethanol) decreased emissions for CO by 32%, HC emission by 12%, butadiene by 19%, benzene by 27%, toluene by 30%, and xylene by 27%. Biodiesel came out on top over ethanol, natural gas and petroleum products because OSHA considers biodiesel to be non-toxic and non-flammable. Biodiesel reduces emissions of carbon monoxide (CO) by approximately 50% and carbon dioxide by 78% (Sheehan, 1998). Biodiesel contains fewer aromatic hydrocarbons—benzofluoranthene offers a 56% reduction, and Benzopyrenes a 71%

reduction. It also eliminates sulfur emissions (SO_2), because biodiesel does not contain sulfur. Biodiesel is biodegradable and non-toxic. Tests sponsored by the US Department of Agriculture confirm biodiesel is less toxic than table salt and biodegrades as quickly as sugar. In the US, biodiesel is the only alternative fuel to have successfully completed the Health Effects Testing requirements (Tier I and Tier II) of the Clean Air Act (1990) (Wikipedia 2006).

Impact to Water, Biodiversity, and Natural Habitats

Environmentalists are concerned about the effects of biofuel crops on water resources, biodiversity, and natural habitats. Malaysia and Indonesia are starting pilot-scale production from palm oil, but these projects have been criticized by some environmental advocates. Friends of the Earth have published a report asserting that clearance of forests for oil-palm plantations is threatening some of the last habitat of the orangutan (Monbiot, 2005). These concerns should be addressed as soon as possible to minimize opposition to increased biofuel production. The NRDC report also addresses environmental issues such as erosion and runoff in a report that outlines how biofuels can help end America's oil dependence. The NRDC recommended growing switchgrass as an environmentally sound choice for use in producing ethanol in the US (Green, 2004).

One drawback to biofuel production is that it is dependent on weather conditions. In 1996, bad weather significantly reduced ethanol production (Dipardo, 2002). One study done at the National Defense University (Pittenger and Gagosian, 2003) discusses how current melting of the polar icecaps, caused by global warming, could change ocean currents which would rapidly change climates and greatly disrupt the production of both agricultural and biofuel crops over many years. It is important for the US to address probable variations in ethanol supply as it becomes more dependent on ethanol as a fuel source.

In the final analysis, there are enormous economic benefits to the nation relating to biofuels replacing imported oil products. First, the US trade imbalance would be improved, resulting in benefits to the national economy. Bergsten estimates that the world economy would benefit by half a trillion dollars, and "250 billion dollars per year would be gained by the US for reducing and stabilizing world energy prices" (Bergsten, 2005, p. 57). Another benefit is that farmers would enjoy higher and more stable crop prices, increasing their income more than 30% according to a NRDC Report (Green, 2004) and alleviating economic harm that higher energy prices are causing them (see Figure 15).

With more full use of land, the US government would save over 10 billion dollars a year that it pays out in farm price support subsidies. Another benefit would be the creation of over a million jobs for American workers. Job creation associated with the 34 ethanol plants now under construction will support "the creation of 153,725 jobs in all sectors in the economy this year" (Urbanchuck, 2006, p. 3). Increased jobs and production from the plants would, in turn, gain

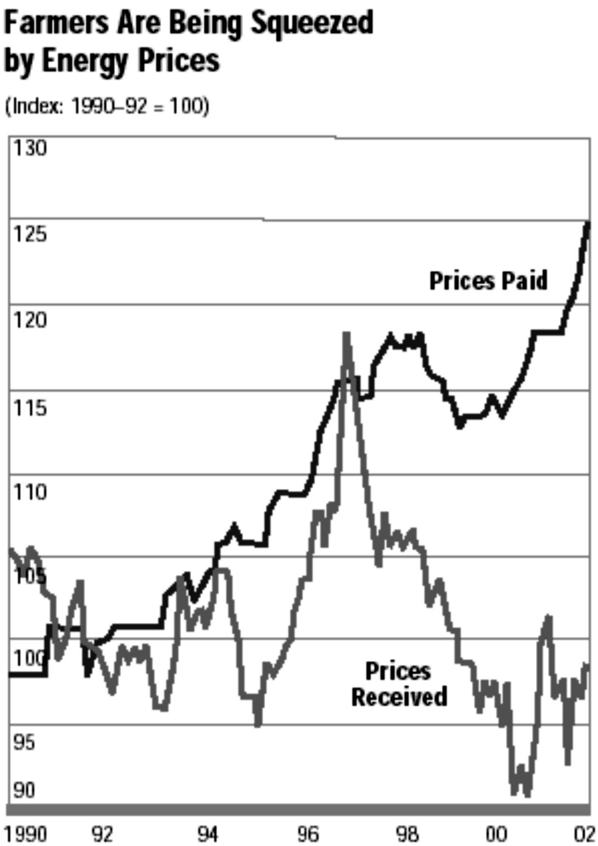


Figure 15. Impact of rising costs of energy and weak demand for farm products (USDA, 2004).
Costs for fuel, fertilizer, and electricity have boosted total prices paid by farmers, while prices farmers receive for their products have remained weak. *NOTE: Prices paid are for goods, services, interest, taxes, and wages; prices received are for all farm products.* (*Source: U.S. Department of Agriculture*)

state and federal governments over $3.5 billion dollars in tax revenue. (Urbanchuck, 2006)

Biofuel Policy

The biofuels market hit $15.7 billion globally in 2005 and is projected to reach $52.5 billion by 2015 (Lapedus, 2006). Over the next ten years, competition for imported energy may cause prices to rise dramatically, hurting the US economy. The US should have a vital interest in dramatically increasing its biofuel production capacity to lessen the adverse effect on the economy that extremely high oil prices will cause. Because of the political and economic advantages of producing biofuels domestically, it is in the best interest of the US to pursue new strategies to dramatically increase biofuel production. Biofuels are a key long-term strategy for reducing our petroleum dependency. The 2006 energy bill establishes the annual use of 7.5 billion gallons of ethanol and biodiesel by 2012. This is not enough. Additional legislation is needed to have ethanol mixed with gasoline and distributed at the pump, and to have biodiesel combined with regular diesel for both transportation and home heating. Legislation should specify increasing from a 10% content in the near term, to 50% by 2015 and 80% by 2020.

Biofuel technology is undergoing revolutionary changes due to higher prices for oil, and biotechnologies are reducing the price of biofuels. The biofuel industry is set to grow, driven by increasing world energy demand. This growth will create opportunities for new companies to enter the market with new biofuel crops, bio-organisms, technologies and production facilities. US policy should be to accelerate its biofuel production so that the political, environmental, and economic benefits can be realized sooner while at the same time avoiding large economic costs associated with rising petroleum prices.

It is clear that, with the benefits biofuels have to offer and strong public support to reduce our dependency on oil imports, now is a great time to implement the following recommendations.

The US should endeavor to increase production of biofuels so that the industry can provide at least 15% of transportation fuel consumption in the near term and 50% by 2025. The NRDC lists policies to build a biofuel infrastructure and market which includes methods such as competitions, prototype production facilities, tax incentives, regulations, subsidies, loan guarantees, bond insurance, and efficacy insurance (Green, 2005). In addition to ongoing incentives and policies, the list below should be adopted to accelerate biofuel production and use in the US:

- The President should direct that government vehicles use biofuels as the fuels of choice. Biodiesel should be the fuel of choice in the US military, because of its higher safety, non-toxicity, lower emissions, and ability to mix with conventional diesel. (Queddeng, 2005). This could be implemented with a Presidential Directive or Order. The directive or order would increase the demand for biofuels and form a foundation for growing a national industrial base that can contribute to achieving independence from foreign oil. This idea is similar to that proposed by the Energy Future Coalition in its 1/18/2003 report of the Bioenergy and Agriculture Working Group. Other benefits associated with the building and operation of biofuel production plants are the jobs that would be created in every state.
- The government should invest in prototype facilities to produce biofuels with new technologies, to use the facilities to produce fuel for government fleets, and to further research development. Government and military agencies should hold competitions for biofuel supply contracts. Contracts should be based on an evaluation of environmental impacts, fuel properties, and yield per acre, to encourage development of better biofuel production technologies and use of land.
- Guidelines, metrics, goals, and legislation should be put in place to encourage all vehicles to use E85 or biodiesel within the next 10 years.
- Increase loan guarantees, bond insurance, and efficacy insurance to increase biofuel innovation and production facility construction.
- Modify the farm bill to encourage the production of better and environmentally responsible biofuel feedstock. Hold competitions for the right to grow biofuel feedstock on federal land. Award those who have minimal environmental impact and highest yields for the areas to be planted.
- Adopt renewable fuels standards and flexible fuel requirements.
  — Require that all new gasoline-powered cars be E85 compatible.

— E10, a blend of 10% ethanol and 90% gasoline, should be phased in as the standard at all gas stations within the next 4 years. E85, a blend of 85% ethanol and 5% gasoline, should be made available at all gas stations within the next 10 years.

- Increase corporate average fuel economy standards.
- Increase tax credits for biofuels to increase demand for E85 and biodiesel.
- Increase gasoline taxes yearly in order to increase biofuel demand, encourage fuel conservation, and pay for incentives and subsidies to increase biofuel infrastructure and production.

CONTINUE ONGOING INITIATIVES: BALANCE NEAR-TERM AND LONG-TERM EFFORTS

Gas Liquification of Coal

In addition to increasing power supply through nuclear power, solar power, and the use of biofuels and other methods described above, the US should reduce petroleum and natural gas consumption through use of gas liquefaction of coal. The US has the largest amount of coal in the world—the equivalent of the entire world's oil reserves (PAE, 2006). Germany developed a Fischer-Tropsch process to liquefy coal into fuel in 1923 by flooding coal with steam to turn it into a gas which then ran through cobalt pipes to turn it into a liquid. "Germany got as much as 15% of its motor fuel from coal to liquids plants according to Texas A&M professor Anthony Stranges" (Gold, 2005). In the 1970s, projects were started by the US government to produce liquid fuel from coal, but those ended after the oil crisis (Shorgren, 2006).

For the US to produce large amounts of liquid fuel using coal, it needs to divert use of coal from electrical power generation and satisfy its electrical power generation needs with other sources such as nuclear and solar power. There are some companies like Rentech Inc. that have announced plans to build a coal gasification plant in Illinois. Since the US has enough coal to satisfy its own fuel needs, it should set the goal of becoming an exporter of liquid fuel to stabilize the world fuel market over the long term. The US should encourage additional near-term production of liquid fuels from coal through tax incentives, government use of the product, and loan guarantees. Some consider fuel derived from coal a biofuel. The US military should contract with domestic producers to satisfy all its fuel consumption requirements with biofuels by 2010. Contracts should secure stable prices and supplies for the US military through 2020. The US military should prepare to have all its assets run on domestically produced biofuels by 2012.

Methane Hydrates and Natural Gas

Methane hydrates are a potential long-term replacement for the natural gas that the US imports and can be converted to diesel fuel using the Fischer-Tropsch process. Large amounts of methane are frozen deep under the oceans near North America. Experts estimate that there is more energy stored in these deposits than all the natural gas and oil in the world (USDOE, 1999). The problem associated with methane hydrates is that mining techniques are not yet developed to tap this great resource. Also, there may be some great environmental risks associated with ocean floor instability that must be understood and addressed to safely mine this natural resource. Since it is expected to take 15 years just to study the issue (USDOE. 1999), it is likely that it will be more than 50 years before methane hydrates are produced in any significant quantities. Hydraulic fracturing has increased natural gas production and reduced costs. Landowners are concerned about ground water integrity and the potential contamination of drinking water. Producers who contaminate ground water may be exposed to future liability from people whose health is compromised by drinking water.

Hydrogen Economy

While hydrogen has been called a solution to the nation's energy needs, it should be viewed as a potential long-term (50 plus years) solution to reducing environmental emissions. It should not be viewed as more economical than other options or as a solution to our energy dependency problems. It is clear from reading the "Hydrogen from Coal Multi-year Research, Development and Demonstration Plan" (USDOE, 2005) that there are many technical barriers to producing and using hydrogen. Hydrogen-powered vehicles are not likely to be more economical than alternative vehicles because of the technical limitations of using hydrogen in domestic vehicles. Hydrogen-powered buses have been shown to cost much more than other alternatives even when future improvements and environmental benefits are considered. (Owen, 2005).

Hydrogen's first limitation is that it costs much more to produce than other fuels. Hydrogen today is produced primarily from fossil fuels (Wikipedia-HE, 2006). It is produced in small quantities using electricity from other energy sources. Using fossil fuels to generate hydrogen doesn't solve our energy dependency problems.

Hydrogen's second limitation is that it is a gas, and an excessive amount of energy and money are needed just to compress it into a fuel tank. Even with better technologies in the future, hydrogen will still have a lower energy per unit volume than liquid fuels like gasoline. As a result, hydrogen vehicles will require much larger fuel tanks that tend to reduce the range and fuel efficiency of vehicles (Physicsweb, 2002).

Hydrogen's third limitation is transfer, storage, and a lack of logistical infrastructure to deliver the product on a large scale. There are safety issues associated with compressed hydrogen and technical issues associated with hydrogen-degrading storage tanks (Wikipedia-HE, 2006). Also, because hydrogen is not compatible with the current liquid transfer infrastructure, a whole new distribution infrastructure would need to be developed and capitalized, which is unlikely without strong government incentives. Other storage methods such as liquid ammonia storage, metal hydrides, and nanotechnology have limitations that may or may not lead to a good solution to the hydrogen transfer and storage problem (Wikipedia-HE, 2006).

The DOD conducted a study that ruled out using hydrogen for many military applications (Coffey, Hardy, Besenbruch, Schultz, Brown, Dahlurg, 2003). The study identified several methods for generating hydrogen that held promise, one of which involved nuclear-related technologies to split water (Coffey, Hardy, Besenbruch, Schultz, Brown, Dahlurg, 2003). The study also discussed using the Fischer-Tropsch process to convert hydrogen to liquid fuel for military applications. Converting hydrogen gas to diesel fuel holds some promise. South Africa uses the technology to produce transportation fuel from coal, and found that natural gas could be converted to diesel fuel as well. Currently, $17 billion is being invested in Qatar to build a facility to convert natural gas to clean diesel fuel (Gold, 2005). US research efforts related to hydrogen should be focused on developing more efficient techniques to produce hydrogen and environmentally friendly technologies that can convert hydrogen to liquids that are compatible with existing storage and transportation infrastructures.

Public Support of US Energy Strategies

According to a survey commissioned by the Energy Fuel Coalition, 88% of Americans support financial incentives such as tax breaks to encourage the use of renewable energy. The survey also found that 92% of Americans support standards encouraging renewable energy usage by corporations. (Bodio-Memba, 2006). Tom Friedman (2006) eloquently frames the issue and characterizes the current outlook of the American people:

> "Currently our federal gas tax is 18.4 cents a gallon and has not been increased since 1983. According to the latest *New York Times* news poll, most Americans are willing to accept a gasoline tax if some leader would just frame the stakes in the right way. The poll said most Americans would support a higher gas tax to reduce dependence on foreign oil and to reduce global warming. If the gas tax were raised to keep the pump price of gasoline above $3.50 a gallon, it would cause demand for more fuel-efficient cars and cars that run on biofuels. Oil-financed autocrats—Venezuela, Russia, Iran, Nigeria, Burma, and Saudi Arabia—have all the money in the world now to turn back the democratic tide. And you think doing nothing to reverse that is patriotic? Shame on you...you unpatriotic wimp. Green is the new red, white and blue, Pal. What color are you??" (p. 1)

Summary and Prioritization of Recommendations

The US should immediately begin to reduce its dependence on outside energy sources by increasing production of domestic energy sources. This strategy will help the trade deficit by reducing imported oil and gas and through export of energy-producing technologies to other energy-dependent countries. By reducing US energy dependence and increasing other countries' energy supplies, world energy prices can be stabilized. This strategy would reap substantial benefits for the US and the world. Bergsten estimates that "$250 billion per year would be gained by the US for reducing and stabilizing world energy prices" (Bergsten, 2005, p. 57) and that here would be a half-trillion-dollar benefit to the world economy.

Investment strategies should be coupled with taxes on energy consumption. Bergsten says, "A substantial increase in carbon taxes is a necessary ingredient in any serious U.S. Energy Policy" (Bergsten, 2005, p. 25) and it would provide revenue for the investment strategy. Also, energy policy will require full integration with foreign policy (Bergsten, 2005, p. 13). A substantial increase in carbon taxes would also have the impact of reducing demand for energy in the US—a desired outcome. However, large tax increases would increase inflation, and negatively impact industries that use a lot of energy, like the chemical industry. Travel-related industries would be negatively affected by higher prices for gas and airfare. A small to moderate consumption tax would have less negative impacts on industry but less overall benefits. A better approach to take on a consumption tax would be to have higher taxes in areas where consumption is sensitive to price, and lower taxes in areas that would suffer negative impacts to industries and jobs.

Another approach to reducing carbon energy consumption would to be to stimulate investment in alternative energy supplies at the consumer level through tax credits. This approach would also cause industry to innovate and compete for consumer demand that would be created by the tax credits. The US should also sponsor contests with rewards to those who successfully make breakthroughs in energy generation and conservation technologies. Another strategy is to increase government spending on development of nuclear power plants to increase electric power supply domestically and internationally.

The US should pursue all paths—taxation of consumption, tax credits, contests, and nuclear power—while continuing its current funding of research. Pursuing all paths is recommended because the approaches will work synergistically, enabling the US to increase its domestic energy supply and reduce dependence on foreign energy. Reduced energy dependence will allow the US to be less constrained and influenced by foreign energy producers. Leading the world in non-carbon based energy supply technologies will also allow the US to exert more influence on foreign energy consumers.

Implementing the strategies within this article will allow the US to eliminate its dependence on petroleum products, and create an industrial base to be a strong exporter of energy technology and refined energy products.

CONCLUSION

In the final analysis, the US has the technology and resources to be energy independent. The US has been incurring significant costs diplomatically, militarily, and economically related to its dependence on foreign energy imports. These costs are expected to rise significantly as world competition for oil and gas supplies heats up due to record demand over the next 10 years. A more aggressive strategy is needed to alleviate the high costs associated with dependence on fossil fuels. For the strategy to address this global situation, US priorities should be to increase the supply of nuclear, solar, and biofuel power supplies, greatly decrease our dependence on oil and natural gas, and become an exporter of energy technology and refined energy products. Additionally, our long-term strategies should focus on increasing energy supplies, using energy more efficiently, and protecting the environment. US priorities for funding should be related to increasing nuclear, solar and biofuel supplies because the payoff is in fielding maturing energy sources. Funding for mature fuels like oil and gas should be reduced since there is more potential for higher returns on investments in emerging energy sources. The US should declare a goal of energy independence using this strategy, and take decisive steps to reach this goal by 2025.

References

Armstrong, R. (2002). From Petro to Agro: Seeds of a New Economy. Defense Horizons.

Center for Technology and National Security Policy. National Defense University.

Appalachian Voices. (2002). Mountain Top Removal Coal Mining. www.appvoices.org

Balmaceda, M., Clem, D., & Tarlow, L. (2002) *Independent Belarus, Domestic Determinants, Regional Dynamics and Implications for the West*. Cambridge: Harvard University Press

Becker, B., Kielling, L., (2002) *Russia's Role in the Shifting Oil Market*. Harvard University.

Bennet, C. (2004). Sustainable Oil. 5/25/04.

Bergsten, F. (2005) US and the World Economy: Foreign Policy for the Next Administration. Institute for International Economics.

Bodio-Memba, (2006) Survey Respondents favor alternative fuels. Free Press. 3/9/2006.

Coffey, T., Hardy D., Besenbruch G., Schultz K., Brown L., Dahlurg J. (2003). Hydrogen as a fuel for DOD. Defense Horizons November 2003. A publication of the center for technology and national security policy.

DOE-R. (2005). Russia Country Analysis Brief. http://www.eia.doe.gov./emeu/cabs/russia.html, 2/2005

Dipardo J. (2002). Outlook for Biomass Ethanol Production and Demand. EIA forecasts.

Economist. (2005). A Survey of Oil. *The Economist* (4/30/2005)

EERE-OBP. (2003). Office of Energy Efficiency and Renewable Energy. Office of the Biomass

Program. Multiyear plan 2004 and beyond. Draft November 6 2003

EIA. (2005). EIA: Base Case Data international energy outlook 2005 table A14. http://www.eia.doe.go/)

EIA Brochure. (2005). Residential Natural Gas Prices 2005. www.eia.doe.gov/oil_gov/natural_gas/analyis_publications/natbro/gasprices.htm
EIA-D. (2006). Derived from EIA Tables D1, B12 and B13.
EIA-GP. (2005). Residential Natural Gas Prices: Information for Consumers (2005) http://www.eia.doe.gov/oil_gas/natural_gas/analysis_publications/natbro/gasprices.htm
Elias, P. 2006. Using bugs to gin up alcohol. Paul Elias. Associated Press 2/12/2006.
Economic Intelligence Unit. (2005). *Country Report* June 2005
EPRI. (2004). Strength of Nuclear Plants against Nuclear Attacks. Electric Power Research Institute Study Dec 2002. www.world-nuclear.org./news/resistance.
Fee, F. (2003). Russian and Iranian Gas and Future US Energy Security, MEES Vol. XLVI, No. 37, 9/15/2003. http://www.mees.com/postedarticles/oped/a46n37d01.htm
Friedman. T. (2006) Who's Afraid of the Gas Tax. *New York Times* 3/1/2006
Green, N. (2004) Growing Energy. How Bio-fuels Can Help End America's Oil Dependence.
National Resources Defense Council. (December 2004)
Green, N. (2005) Bringing Bio-fuels to the Pump. An Aggressive Plan for Ending America's Oil Dependence. National Resources Defense Council. (July 2005).
Goldman, M. (2004) Putin and the Oligarchs. *Foreign Affairs*. NY Vol. 83, Iss. 6; p33
Gold R.(2005). Power Play: In Qatar, Oil Firms Make huge bet on Alternate Fuel; *Wall Street Journal* 2/15/05.
Interfax Financial & Business Report. (2005). 7/1/2005.
International Energy Agency (2002). *Russia Energy Survey*. p.11-20
IEO. (2005). International Energy Outlook, July 2005 Table D1, Report # DOE/EIA-0484
Ivanov, V. (2004). *The Energy Dimension Russian Global Strategy*. The James A. Baker Institute for Public Policy of Rice University.
Jepson M. (2004). *Metabolic Engineering of Xylose-Utilising Saccharomyces cerevisiae Strains*. Lund University, Doctoral Dissertation.
Johnston, S. (2006). Selwyn Johnston on-line office. Search for Selwyn Johnston and ethanol.
Kompala D. (2001) Maximizing Ethanol Production by Engineered Pentose Fermenting Zymomanas mobilis. Department of Chemical Engineering. University of Colorado, Boulder.
Kohn, D. (2005) Remarks by Governor Donald L. Kohn at the 15th annul Hyman P. Minksky Conference, the Levy Economics Institute of Bard College, Annandale-on-the Hudson, New York. April 22, 2005
Kunz S. (2001). The costs of coal in Pennsylvania. Pollution Update, 2/28/2001.
Lapedus M. (2006) Renewable Energy BiZ to Hit 167 Billion. EETimes online.
Lovins A. (2005) *Winning the Oil Endgame American Innovation for Profits, Jobs, and Security*. By Amory B. Lovins, E. Kyle Datta.
Luthnow D. (2005). As Brazil fills up on ethanol, it weans off energy imports. By David
Luhnow and Geraldo Samor. *Wall Street Journal* 1/9/2006.
NEI. 2006. Nuclear Energy Institute Reference. http://www.world-nuclear.org/education/ne/ne6.htm
NEI 2020. (2006). Vision 2020 Nuclear Energy and the Nations Prosperity. Nuclear Energy Institute
NEI 2020-E. (2006). http://www.nei.org/documents/Vision2020_Folder.pdf
NEP. (2001). National Energy Policy, Report of the National Energy Policy Develop-

ment Group, May 2001.
Monbiot G. (2005). Worse than fossil fuel 6/12/2005.
Owen A. and Cockroft. (2005). The Economics of Hydrogen Fuel Cells. Dec 2005.
PAE. 2006. Partners for Affordable Energy. http://www.affordable-energy.org/key_points/dependance.asp.
Parfit. M. (2005). Future Power. *National Geographic*; Aug 2005, Vol. 2008 Issue 2, p 2-31.
Pittenger F., Gagosian R. (2003). Global Warming could have chilling effect on the Military. Defense Horizons. Center for Technology and National Security Policy. National Defense University.
Physicsweb. (2002). The Hydrogen Economy Blasts Off, July 2002.
Poland Business Review, (2004). Gasprom cuts gas supply. 2/23/2004.
Pollution. (2001). Pollution Update. Raymond Proffitt Foundation. 28 Feb 01. www.rayproffitt.org.
Queddeng E. (2005) Decision Analysis Using Value-Focused Thinking to Select
Renewable Alternative Fuels. Masters Thesis presented to the Department of Systems and Engineering Management at the Air Force Institute of Technology. Eric A. Queddeng, Captain, USAF. March 2005.
Quayat D., (2003) The Russian Oil Sector and the Global Oil Economy: A Prospectus. *SAIS Review* 23.2 p.1-22 The John Hopkins University Press.
Rattlif, W. (2004). Russia's Oil in Americas Future: Policy, Pipelines, and Prospects. Hoover
Press Rev 3.
Rosenwald M. (2006). J. Craig Venter's Next Little Thing. Washington Post.com. 2/27/06.
Russia Country Analysis Brief. (2005) http://www.eia.doe.gov./emeu/cabs/russia.html, 2/2005.
Smith, S.C. (2004). *Russian Energy Politics in the Baltics, Poland, and the Ukraine, a New Stealth Imperialism*. CSIS Report.
Stern, J. (2002) *Security of European Natural Gas Supplies*. London: Royal Institute of International Affairs.
Simon B. (2006). *Progress Towards a New National Energy Policy*. Energy Briefing. Democratic Staff Director. Committee on Energy and Natural Resources. US Senate 2/21/06.
Unica (2005). *Brazil as a Strategic Supplier of Fuel Ethanol*. January 2005.
USDOE. (1999). National Methane Hydrate Multiyear Research and Development program plan. USDOE. Office of Fossil Energy. June 1999.
USDOE. (2004). "International Energy Outlook 2005" Energy Information Administration. http://www.eia.doe.gov
USDOE. (2005). Hydrogen from Coal Program. Research, Development and Demonstration
Plan, External Draft for Review. September 26, 2005.
USDA. (2005). Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The technical
feasibility of a billion ton annual supply. April 2005.
Urbanchuck C. (2006) Contribution of the Ethanol Industry to the Economy of the US.
US Energy Bill (2005).
Wikipedia-HE. (2006). Hydrogen Economy.

ABOUT THE AUTHOR

Mr. Stephen J. Moretto serves the US Navy as the Littoral Combat Ship Production Business Manager. He prepares and manages the execution of the ship production department's budget that exceeds $40M per year.

Mr. Moretto earned an MS in national resource strategy from National Defense University, 2006; Stanford Executive Program, 2002; an MS in engineering administration, Virginia Tech, 1998; and a BS in industrial engineering, SUNY at Buffalo, 1990.

His certifications include Program Management, DAWIA Level 3; Business, Cost Estimating, and Financial Management, DAWIA Level 3; Science & Technology Management, DAWIA Level 3; and Systems Engineering, DAWIA Level 3. (DAWIA Level 3 is the Department of Defense's highest level of certification.)

He served as the US Navy's Engineering and Science Community Manager in the Bureau of Personnel where he advised senior Navy leadership on strategic human resource management issues relating to the Navy's 40,000 civilian engineers and scientists.

Mr. Moretto was Director of Analysis and Evaluation in the Office of Naval Research Planning and Evaluation Office. He led the Cost Engineering and Analysis Division's Aircraft Carrier Cost Engineering Process Team. He wrote the first Aircraft Carrier Total Ownership Cost Management Plan that laid out the process to reduce aircraft carrier costs by several billion dollars per ship, receiving several awards for these efforts.

Mr. Moretto has published articles in the *Defense Acquisition Journal*, *Program Manager Magazine*, and the *ASE/ASNE Journal*.

He can be contacted at: 202-781-4173 (work); 703-861-7994 (cell); email: stephen.moretto@navy.mil.