ENERGY CHOICES

America's Energy Choices *for* 2014

ASP White Paper

January 2014

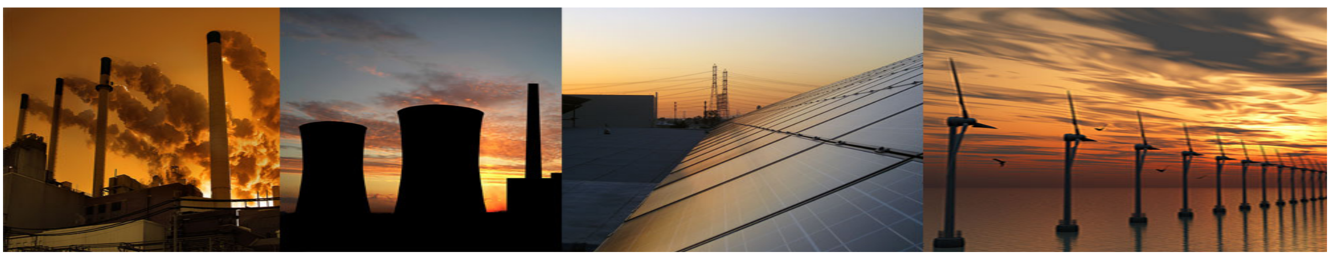
Introduction - Updating the Choices for 2014

Today, how America uses and produces energy remains hotly debated in Washington and around the country. At times, it appears the debate about energy has become yet one more example of a culture war between opposing political factions. In this political debate, conservatives cry "Drill, baby, drill," while liberals block any projects that emit greenhouse gasses or intrude on the habitat of any animal. The result of this is a stalemate in which changes to energy and environmental policy can only move forward by going around Congress.

This impasse is not much different than when ASP first released its version of "America's Energy Choices" in 2011. The political stalemate over energy means that there has been no movement at the federal level, and only halting moves at State and local levels.

However, the energy choices made years, or even decades ago, by politicians, businesses, and consumers have led to what can only be described as a revolution in how the U.S. produces energy.

The reality of change in America's energy system is far different from the stagnation of the political debate. In our first version of "America's Energy Choices" this revolution was beginning to make itself apparent, but in 2011, it had not yet had a major impact on politics.



Renewable energy sources, particularly solar and wind power, are seeing the largest proportional gains. Although this is partially a factor that they are growing from a small base, today the total volume of wind and solar is beginning change the system. Wind was the largest addition to electric capacity in 2012 and solar power – both large utility-scale installations and small systems on homes or businesses – has seen growth that is almost exponential. In some months of 2013, solar has been the only electric capacity added to the national grid.[1]

On the side of fossil fuels, the U.S. is seeing an unprecedented boom, as the impacts of the technologies and expertise around hydraulic fracturing and horizontal drilling have expanded America's accessible fossil fuel resources. When these technological advances were combined with persistently high oil prices, the production of oil began to grow. In absolute terms, the growth of natural gas and oil has been revolutionary.

We are also beginning to see a revolution in how Americans consume energy.

So called "Green Buildings" have gone from an expensive niche to the standard in many cities for new buildings – and they often end up saving money. New fuel efficiency standards put in place for automobiles and trucks are reducing the demand for liquid fuels, ensuring that – even as oil production increases – the demand for oil is decreasing. For a country that still wastes over 50% of its primary energy, there remain many opportunities to use energy more efficiently.

Put together, the combination of rapid growth in renewable sources of energy, a boom in production of oil and gas, and increasingly greater efficiency is having effects that even the most optimistic did not foresee only a few years ago.

The US is poised to become a major exporter of natural gas over the next decade – while less than a decade ago, energy companies were building natural gas import facilities. Greenhouse gas emissions have dropped since their US peak in 2006 due to a combination of greater efficiency, fuel switching from coal to gas for electric power, and the recession. A globalized market for solar photovoltaic production has caused a drop in installed prices of solar panels to less than $1 per watt. In a time of recession and low job growth, oil and gas extraction has proved to be a valuable tool of economic growth.

On the other hand, some are overselling the benefits of the energy revolution.

While the U.S. is reducing its dependence on imported oil, we will never be 'energy independent' because oil is a global market: so long as oil can easily cross borders, the price will be set beyond our shores. In renewable energy, some had predicted a boom in 'green jobs' from manufacturing products like solar panels – but instead of those jobs, we've seen the growth in installers while the panel manufacturing has gone to China.

These revolutions were a product of choices about energy made decades ago by politicians and business leaders.

Scientists, financiers, and entrepreneurs then sustained their investments in these choices through a variety of market conditions and predictions. Repeatedly, the story for today's energy revolutions start in the energy crisis of the 1970s – and while some investments from that time failed, others are bearing fruit today.

The future could hold similar energy revolutions, but we have to make the choice and sustain the investment today.

We should not make the mistake of assuming that the energy technologies of today will be the same in the future.

This report, for instance, includes fusion energy as a choice even though it is not a viable energy source today. One day, if we choose to make the investment, it will be viable. And, if America does not choose to make the investment, there are many global competitors waiting in the wings.

A Note about the Text and Sources:

With that introduction, a note about the following text. All of this change makes accurate prediction impossible. We simply do not know what energy demand or supply will look like in 2030 or 2050. Any prediction beyond the next decade will tell you more about the author of the report than it will tell you about the future. The best we can do is an educated guess about future markets. With that bit of humility, this report will use the US Energy Information Agency's (EIA) predictions.

Where possible, we will use monthly numbers from 2013, but annual numbers will necessarily be from 2012.

You can find them through their website, www.eia.gov

Assessing America's 21st Century Energy Choices

Today, the United States faces a series of choices that will determine how its economy is powered to meet the needs of the 21st century.

How America chooses to replace and expand its energy supply will affect the health of the world's environment, America's national security, and the well-being of the U.S. economy. However, the political debate does not have an effective vocabulary to discuss the costs and benefits of different choices.

Meanwhile, long term challenges remain. Even though it is still largely ignored in Congress, climate change is an issue that will not go away: we cannot argue with chemistry and nature, and the longer we wait, the worse it will get. Likewise, even though we suddenly have access to more oil and natural gas, the world's population continues to grow, and developing countries' economic growth is putting more pressure on energy than ever. The world will need sustainable alternatives to fossil fuels – and America can lead in the research and development necessary to get there.

Policymakers too often make arguments about energy based on which will 'sell' the best in order to fit a decision already made. Instead, policymakers should look at the options and weigh the trade-offs for each. This starts with the understanding that there is no one best energy source; all have drawbacks. Therefore, we need a common way of measuring for those who actually want to debate America's energy policy in order to make it better, instead of simply scoring political points.

Decision makers should not pretend there are silver bullets that will automatically bring cheap, clean, domestic energy to all.

This paper will attempt to outline a matrix of policy choices for the government, utilities, and the private sector to consider. It looks at a series of different options for how to fuel America's economy, each of which will be considered in light of three concerns:

(1) Energy Security;

(2) Economic Stability; and

(3) Environmental Sustainability.

Sometimes these terms are simply buzzwords, so it is important to specifically define each.

Energy Security

Analytically, 'energy security' is impossible to quantify. President Jimmy Carter defined energy security in a 1977 speech as "independence of economic and political action" in international affairs, meaning that the United States should be able to define its interests overseas independently from how it uses energy domestically.

Importantly, 'energy security' does not mean 'energy independence' in the sense that all of the energy used in the United States comes from within its borders without international trade. This is neither obtainable nor desirable in a globalized world. In addition, energy security does not depend on the percentage of supply that is imported. In a world of globally traded commodities, it is no longer possible to be truly energy independent: even domestically produced energy sources are subject to fluctuations in global commodity markets.

In any realistic view, the United States does not face traditional 'energy security' threat that are existential: we are not at war with a nation that could stop our access to global markets. Since the oil price crises of the 1970s, the risk of absolute supply shortages has been reduced significantly. The creation of the International Energy Agency (IEA) and its requirement that all member countries hold oil stocks capable of replacing 90 days' worth of imports acts as a buffer against disruptions in oil supplies.

Although speculators are sometimes blamed for inflating prices, the deepening of international futures trading markets allows price signals to give warnings of impending supply and demand imbalances. Today, then, for the United States, energy security concerns are no longer about physical disruptions in supply. These concerns stem from the possibility that actions in foreign policy will lead to price increases causing undue harm to economic growth.

Keeping this is mind, this paper defines energy security as the ability for a country to act in its foreign policy independently of how it uses energy domestically. In those terms, oil is the only major source of energy insecurity for the United States. However, changing energy production in the United States, combined with new technologies, affords the U.S. the ability to use energy to increase the energy security of friends and allies: this is the case in the newfound abundance of natural gas.

Obtaining energy security actually does not come from increased domestic production alone: it comes from flexibility, competition, and redundancy. If a source of energy supply is easily replaced by either a different fuel type or a different source, then a country is insulated from supply shocks. U.S. foreign policy should be determined by its interests, not by how it generates its energy.

Economic Stability

It seems clear that all decisions about energy policy must consider price. The United States, though, is one of the most energy intensive developed economies, which makes its economy vulnerable to price fluctuations.

Low prices at the expense of little buffer against fluctuations in price – both up and down – can be more harmful than a higher price that is stable over the long-term. Upward price shocks harm consumers by acting as a tax, but downward price shocks can harm producers as well by undermining long-term investments.

When prices are low, consumers are encouraged into dependency, only increasing the economic damage if prices spike upwards. The best example of this is that today, American drivers are feeling the pain of gasoline-dependency that years of low prices created.

When decision makers are deliberating about energy choices, the relative price of each decision is a critical component. However, short-term fuel prices cannot be the reason that long-term decisions are made. When deliberating on an energy choice, its economic stability – defined as how energy affects the health of the country's economy over the long term – should be an important concern. Producers and consumers should be able to make rational economic decisions independently of price fluctuations or negative externalities from energy.

Therefore, it is more important for an energy choice to be made that will provide long-term economic stability rather than providing only for low prices at any expense, particularly if those prices tend to be volatile.

Economic stability should be prioritized above low prices because the pursuit of low prices can give license to producers to ignore other costs. By ignoring these externalities, particularly pollution, the pursuit of low prices can cause non-economic costs to arise elsewhere, for example in reduced health from polluted air and water.

Environmental Sustainability

Climate change presents clear threats to both America's domestic and international security. Unchecked, it is not an exaggeration to say there is a clear risk that a changing climate poses existential threats to global security.

Even though there is no domestic law limiting carbon emissions, for almost a decade, the U.S. Government, under both Presidents Bush and Obama, has committed to a number of international agreements to cap and reduce emissions, expressed through statements at the G-7, the G-20, and the UN Framework Convention on Climate Change. Recent actions by the Obama Administration have made clear that they intend to put in place policies that promise to reduce greenhouse gas emissions by 17% below 2005 levels; meeting the voluntary commitment agreed to at the Copenhagen Climate negotiations in 2009.

Climate change has deep implications for energy policy. The fossil fuels the United States uses, as 82% of its primary energy, are the main driver of climate change. Therefore, any plan that looks to reduce emissions will require either reducing the total amount of energy produced (either through gains in efficiency, or absolute declines in energy used) or replacing a large portion of energy production with emissions-free power.

Environmental sustainability is about more than climate change, however.

Local environmental effects of energy production are as important – or more – than climate change to how the United States makes its decisions about energy production. Decisions on how strictly to legislate and enforce pollution limits have significant impacts on decisions about how to produce energy. Environmental sustainability in energy generation and extraction are critical to the feasibility of any energy system.

The extraction, through mining or drilling, of fuels and minerals necessary for energy production can have negative effects on the local environment. These externalities include spills, water contamination, and air pollution – all of which can be harmful to the health of people living and working around extraction sites. How energy production affects local water supplies and local air quality will determine how the public accepts new energy developments.

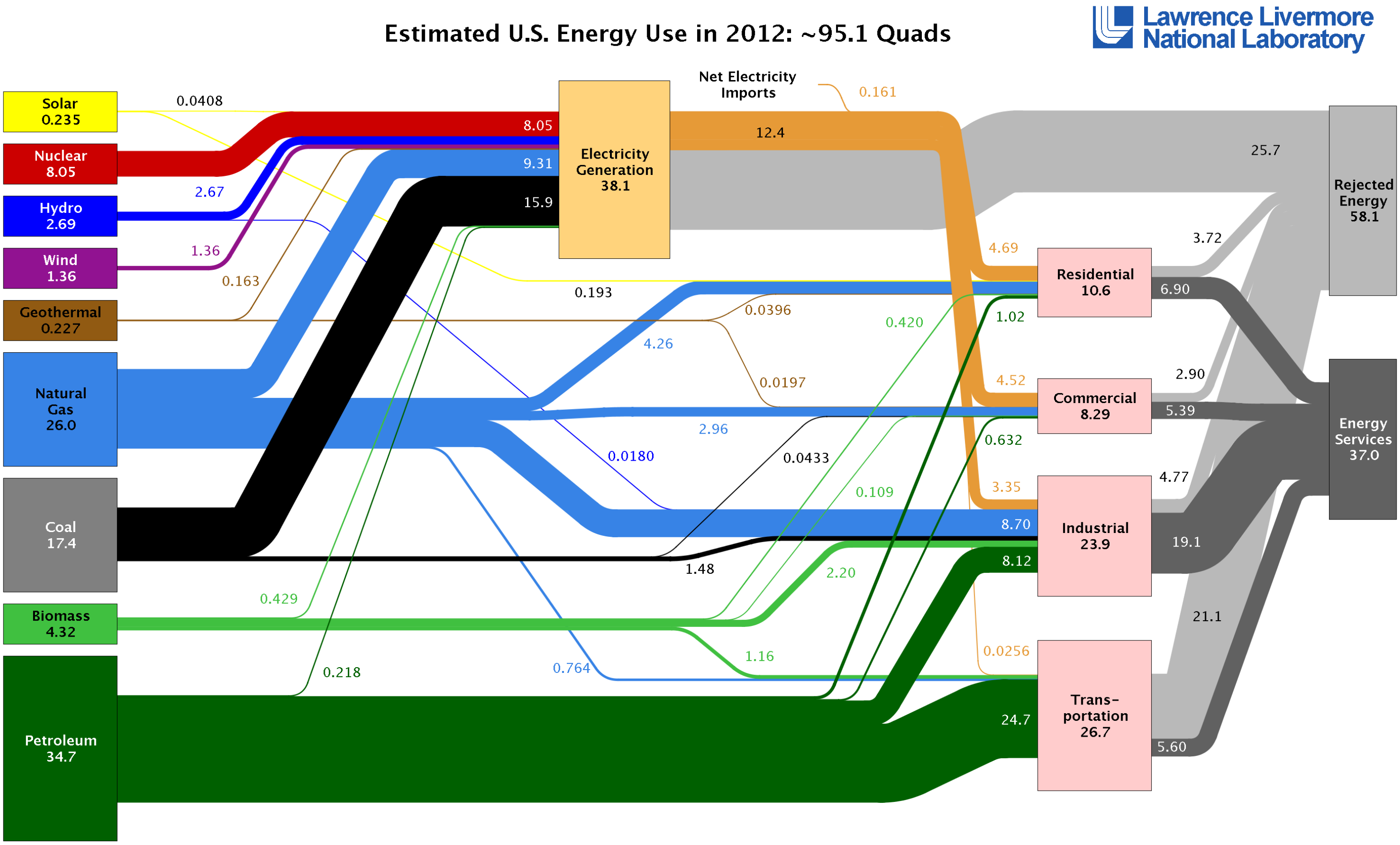
An energy source should be defined as environmentally sustainable if the production and use of it does not cause undue harm. Whether that harm is to local ecosystems, the global atmosphere, water systems, neighboring businesses, or human health, an energy source with substantial externalities is not sustainable over the long term.

Environmental sustainability and economic stability are closely linked over the long-term, because an energy choice that harms the environment will eventually cost more. It may be true that polluting can reduce costs, just as throwing garbage out an apartment window is cheaper than paying for garbage collection, but over the long-term both will prove unsustainable. This is because political, regulatory, and legal pressure will be brought against pollution sources to both reduce effluence and clean up any contamination.

When making a choice of how to power the American economy for the future, decision makers should clearly articulate how each potential source of energy affects national energy security, economic stability, and environmental sustainability.

Options for America's Energy Use

A description of America's future energy choices must begin with how the United States uses and produces energy now. Lawrence Livermore National Laboratory's flow chart (Figure 1) shows how the U.S. used energy in 2012. This chart shows the relative size and importance of each source of energy, as well as how each energy type is used. Analyzing the chart leads to some important conclusions, such as the separation of energy between that used for electricity generation and that used for transportation and the staggeringly high amount of 'rejected' (wasted) energy. The major drawback of the chart is that it is a static snapshot of energy use – it does not show growth or decline over time. Nevertheless, it provides an important baseline for the discussion of the different fuel types that follows.



Source: LLNL 2013. Data is based on DOE/EIA-0035(2013-05), May, 2013. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

I. Fossil Fuels

Fossil fuels make up the largest portion of energy production in the United States. Petroleum products, coal, and natural gas accounted for 82% of total energy production in 2012. Each has different physical properties that have given them very different roles in America's current energy mix.

It is not a mistake that fossil fuels are the dominant sources of fuel in the industrialized world. The combination of low prices and high energy density have made first coal, then oil and natural gas, the preferred choices for energy production for over 200 years. This long-term usage gives those fuels two centuries of built-in advantage in the form of infrastructure built to use and transport these fuels.

Rising global demand for all sources of fossil fuels is driven by population growth and the requirements of a burgeoning middle class in developing countries. Meanwhile, although geologists, economists, and analysts continue to argue about how much coal, oil, or gas remains beneath the ground, by definition, supplies of fossil fuels are finite.

Together, increases in demand coupled with constrained supply will inevitably lead to price increases. It is only a question of when fossil fuels are no longer the economical choice.

These three major fossil fuels all present significant, though different, challenges to American energy security, economic stability, and environmental sustainability.

Since the very beginning of the industrial revolution, when the cities of England were turned black by coal soot, it has been clear that burning fossil fuels have a cost to the local environment. This pollution is not only dangerous to ecosystems and wildlife; it has also proved to be detrimental to human health.

Over the last thirty years, advances in technology, such as the catalytic convertor on automobiles and advanced scrubbers in power plants, have reduced the amount of toxins released into local air and water supplies. However, it is also only within the last thirty years that scientists have begun to see evidence that the emissions from fossil fuels, especially carbon dioxide, are causing the climate of the entire Earth to change. So far, there is no technical fix to this: the only way to prevent fossil fuels from emitting greenhouse gases into the atmosphere is to not burn them at all; emerging technology would allow sequestration of the carbon from burned fuels, but that could be far in the future.

The result of two centuries of increasing fossil fuel use is that the concentration of carbon dioxide in the earth's atmosphere has risen by 4% from about 275 parts per million (ppm) to pass through a record 400 ppm for a time in 2013 and that the Earth's average temperature has risen by about one degree Celsius.

The United States has a responsibility as the second largest emitter of greenhouse gases in the world to reduce its emissions. Innovation and new technologies are increasing the efficiency of the engines and power plants that burn fossil fuels – meaning that less fuel and fewer emissions will produce the same amount of energy.

However, any efforts to reduce emissions must realize that you can only go so far with fossil fuels. If 82% of

America's energy continues to come from fossil fuels, then the earth would likely be stuck on a trajectory of warming 3 or 4 degrees above pre-modern levels – far beyond what climate scientists have deemed as a safe level.

1 Oil

Oil accounts for 35% of total primary American energy use, making it the single largest source of energy. Very little of that is used to produce electricity, it is the dominant fuel used in transport: 94% of the energy that powers American cars, trucks, trains, and planes is derived from the burning of fuels refined from crude oil.

The reason for this dominance is a combination of oil's unique physical properties and the history surrounding the internal combustion engine.

Physically, oil has a higher energy density than coal and is liquid at room temperature, which allows for comparatively easy transport. It can be refined into a variety of fuels servicing a wide array of needs, making it a remarkably versatile commodity.

Furthermore, the advent of the automobile—and the airplane after it— has provided oil with a first-mover advantage in the transportation sector. After a century of use, oil now holds a virtual monopoly in the locomotion of people and goods.

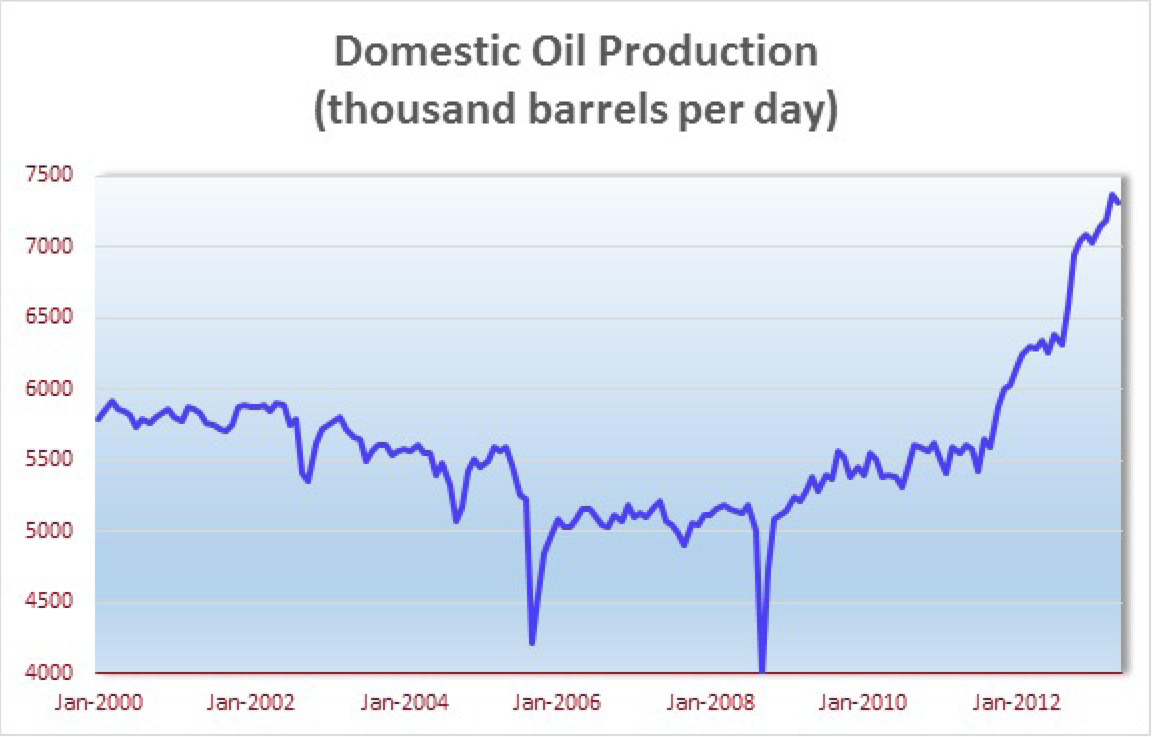
Industrialized society has built itself up around petroleum: pipelines, refineries, gas stations, airports, and roads all represent trillions of dollars of capital infrastructure built to support the internal combustion engine.

Because of this, industrialized society is very sensitive to disruptions in our supply of oil. While we cannot ignore the system that currently exists, we can begin the arduous process of diversifying away from oil as the sole provider of transportation-related energy.

Energy Security

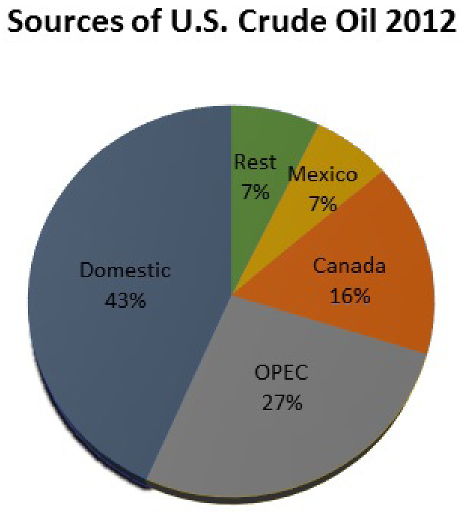
For the United States, dependence on oil for transportation—and thus the entire American economy—is a direct threat to national security. Concerns about the effect certain actions will have on the price of oil are always factored into foreign policy decisions, limiting policy flexibility and hindering our ability to pursue other non-oil-related goals.

In 2012, the U.S. imported 57% of its total crude oil. This gap was closed mid-2013 for the first time in almost two decades, with U.S. domestic production briefly beating out foreign imports by a few hundred thousand barrels per day.[2] This is an achievement for American industry and has brought with it considerable economic benefits.

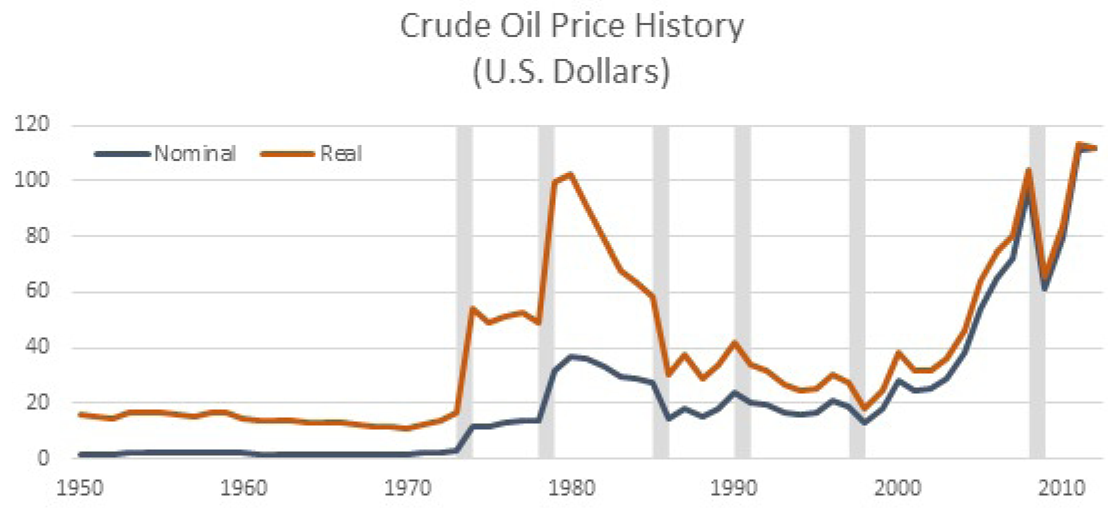


However, while domestic production is forecast to continue increasing over the coming decade, this does not solve the problem of energy security. The U.S. cannot drill, pump, or produce its way to "oil independence."

Even if the U.S. produced 100% of the crude oil it needed, the price of that oil would still be determined in the global marketplace. Oil is easily traded through pipelines and tankers, and oil producers will chase the highest global price. With the exception of temporary logistical cost differences between benchmarks, this means that there is effectively a single global price for crude oil. Thus, to ensure stable and relatively low prices for domestic consumption, the U.S. must secure the entire global oil system—a tall order.



Supply disruptions in the Middle East or rapid demand increases from the developing world would raise the global price of oil. For example, the Arab Spring 2011 revolution and civil war in Libya caused prices to rise due to a loss of Libyan production. This price shock was felt in the U.S. despite less than 1% of American imports coming from Libya. Similarly, when political upheaval rocked Egypt, global oil prices spiked simply



from the fear over potential issues with the Egyptian-controlled Suez Canal.

So long as 30% of global production comes from the Middle East (12% from Saudi Arabia alone) and so long as over 50% of the world's proven reserves are in the region, American foreign policy will continue to be intertwined with the region.

As would be expected, this securing of global oil production and supply lines comes at a hefty cost: estimates put the annual cost between $29 billion to $143 billion, depending on how broadly 'security' is defined.[3] Furthermore, the DoD is the single largest oil consumer in the world, accounting for 80% of the total energy used by the Federal Government. Between 2005 and 2011, despite reducing total petroleum consumption by 4%, overall expenditures rose from $4.5 billion to $17.3—an astounding 381% increase.[4]

Economic Stability

U.S. dependence on oil harms its economic stability as much as it harms its energy security. It perpetuates an environment of business uncertainty, reduces consumer discretionary spending, and contributes to our burgeoning trade deficit.

In addition to the long-term problems of supply and demand, oil suffers from the short-term problem of price volatility. Over the last five years alone, the global price of oil has fluctuated from an average per barrel price of $69 in 2007, to a peak of $147 in July 2008, back down below $35 in January 2009.

These drastic and sudden changes in price create an environment of uncertainty. This hurts American businesses that rely heavily on crude oil or its refined products for daily business. Trucking companies and airlines cannot predict their variable cost from month-to-month, which results in price increases to ensure a level of insurance for the business—this is why fear can drive prices as much as fundamentals. Increased domestic production does not shield America from the global factors that drive these incredible shifts in price.

Additionally, the price of oil seems to be rising as ever more technically difficult reserves are tapped. While the base of global supply is still being met by inexpensive conventional oil from the Persian Gulf, the price of the marginal barrel (the next new barrel brought to market) is trending upward.

Tight oil, oil sands, ultra-deep water, and the Arctic all hold tremendous volumes of oil, but the cost of retrieving it is greater. Compare the $5 a barrel extraction cost in Iraq to the upwards of $122 a barrel in the Canadian oil sands and the difference becomes clear. Between 2001 and 2010, the marginal barrel cost of the top 50 publically listed oil companies rose 229% and will reach over $100 per barrel next year.[5]

All this is happening while middle-class American household income is relatively stagnant. This means that a larger and larger portion of consumer spending is being diverted to gasoline and other refined petroleum goods, rather than education, healthcare, and American-made consumer durables. This increase in oil spending acts like a tax increase, putting added strain on an economy that is still recovering from the 2008 recession.

Another problem with America's addiction to oil is the effect it has on our trade balance. The U.S. consumes approximately twice as much oil as it produces, which means that it must purchase that oil from other countries.

In 2012, the U.S. consumed, on average, about 15 million barrels per day of crude oil. This translates to almost 5.5 billion barrels of oil in 2012, which amounts to over $560 billion in total expenditure. Of this total expenditure, 57%, or approximately $320 billion, was spent on foreign oil. While the U.S. has run a significant trade deficit for decades, over half of the current deficit is spent on oil imports. This is money that should be invested in American infrastructure and public services.

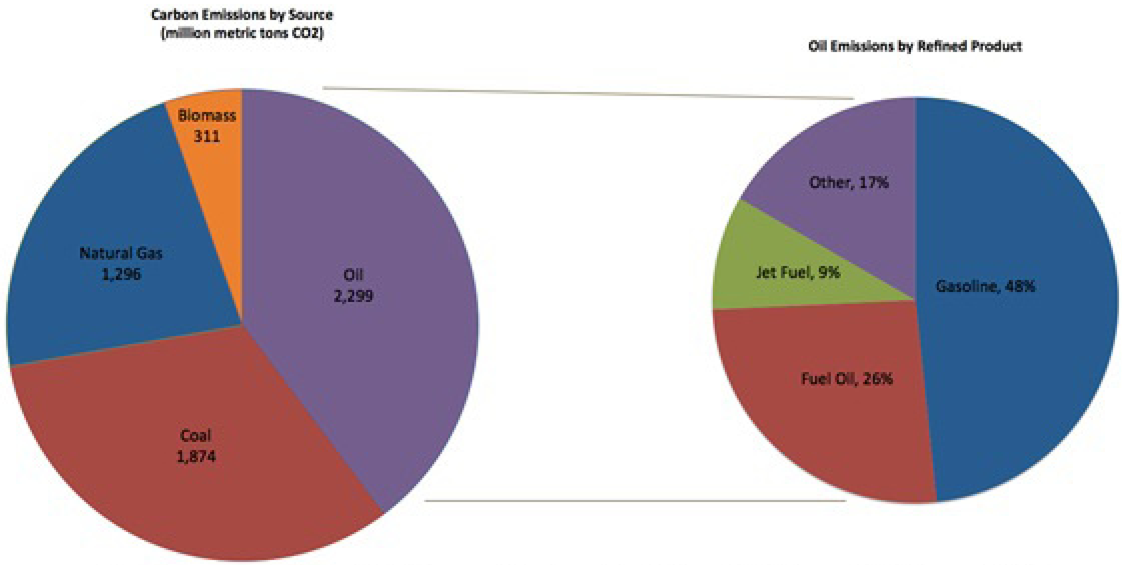
Environmental Sustainability

Oil—and products refined from oil—is the single largest source of carbon emissions in the U.S., representing approximately 40% of total American CO_2 emissions in 2012.

Oil produces 164,000 pounds of carbon dioxide emissions per billion British thermal unit (Btu) of energy—40% more than natural gas, but 21% less than coal.

The largest contributor to oil demand, and thus the largest emitter of greenhouse gases, is the gasoline that powers America's vast fleet of automobiles.

The U.S. government has instituted policies, such as the increase in Corporate Average Fuel Efficiency (CAFE) standards, which will reduce the amount of greenhouse gas emissions per mile traveled. This policy mandates innovation in automakers that wish to sell their cars in the American market. By creating the impetus for innovation, CAFE standards allow companies the freedom to pursue the required mileage standards in a competitive way.



While the increase in domestic production has been good for the economy, it brings with it many potential environmental costs. Drilling for oil can produce oil spills, like the explosion of the Deepwater Horizon platform in 2010 which killed 11 workers, shut down fishing across the Gulf of Mexico, and is estimated to cost upward of $20 billion to clean up.

As exploration for oil expands into more difficult-to-access areas, such as deep underwater, in the Arctic, or in the oil sands of Alberta, Canada, it is clear that there will be a greater risk of environmentally damaging spills due to the technical complexity of operating in these areas.

This increased production has also put tremendous strain on existing transportation infrastructure. Pipelines are overloaded, especially in in areas like North Dakota where oil production is a relatively new phenomenon. To alleviate this congestion, oil is shipped by rail.

The transportation of oil by rail and by pipeline also comes with a cost, however, each with its own benefits and costs. Two recent reports found that pipelines tend to be safer but have a higher spill rate, while rail transport has a higher rate of injury but a better spill record.[6] These different costs need to be weighed in assessing whether projects like the proposed Keystone XL are truly in the national interest.

To mitigate the risks associated with the transportation of oil, government must ensure that proper safety standards are enforced. Pipeline spills like ExxonMobil's Pegasus pipeline in Arkansas this past March and the train derailment in Lac Mégantic, Quebec in July serve as cautionary tales as to the dangers this industry can bring.

The American public will have to make a choice of whether it accepts the risks of environmental damage from increased drilling and the movement of oil across the country that comes with it. Future accidents will occur; that is the nature of any industrial activity. However, government can help reduce the risk of future incidents by aggressively ensuring that basic safety standards are met and that many levels of redundancies are in place to account for inevitable human error.

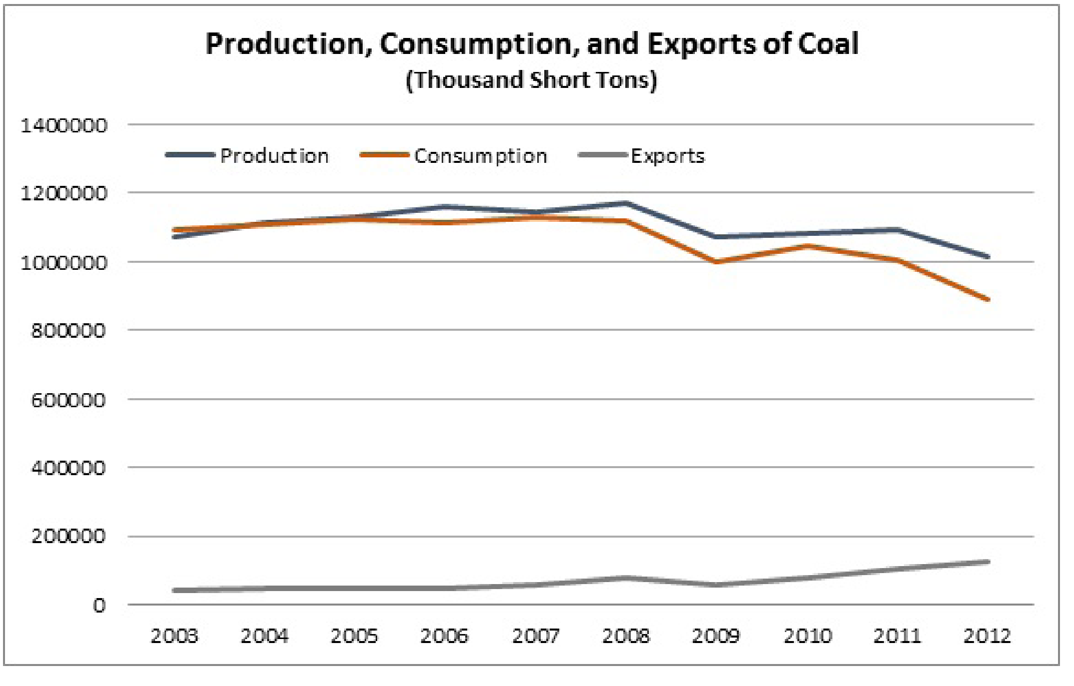
2. Coal

Coal provides 18% of total energy use in the United States and is the single largest source of electric power, providing 37% of total electricity generation. However, coal's share of electricity production has been steadily falling for the past five years due to the surge in domestic natural gas production.

Domestic production is also highly concentrated, with over half of all U.S. coal coming from Wyoming and West Virginia. Coal is arguably America's most secure and readily available source of energy, but this comes at a cost.

Energy Security

The coal that the U.S. consumes, unlike oil, is almost entirely produced from domestic mines, and thus is not susceptible to foreign security



threats. Moreover, unlike oil or even natural gas, coal is not an easily tradable commodity due to its size and weight, and thus the market price is inherently local when compared to other fossil fuels.

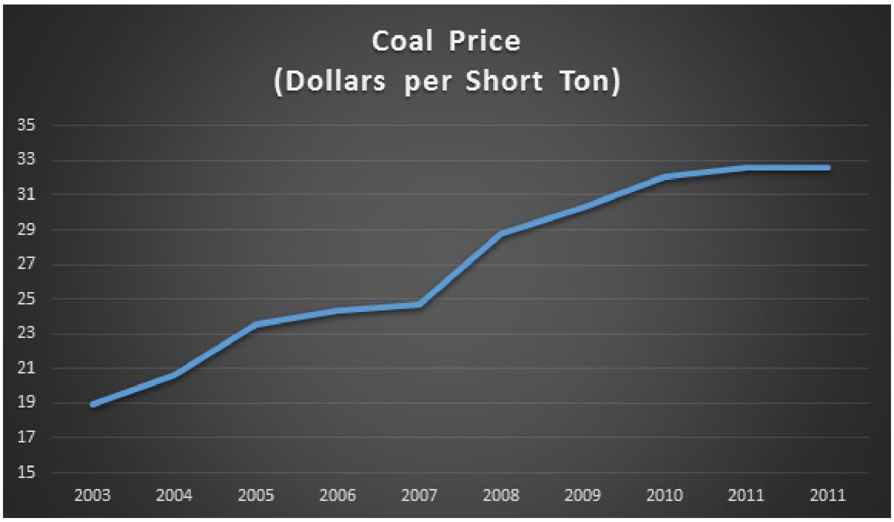
The value of coal to American energy security is evident from the high priority that presidents from both parties gave it during the 1970s energy crises: Presidents Nixon, Ford, and Carter all initiated policies that favoured domestic coal production for electricity generation.

The United States is estimated to have almost 250 years of recoverable coal reserves at present rates of consumption. If security was one-dimensional, coal would be an optimal choice and America would be energy-secure for the production of electricity. However, there is more to security than simply the price and the supply, and coal's heavy environmental costs outweigh the short-term security it provides.

Economic Stability

The dominance of coal in utility-scale generation is a reality because the mining and transportation of coal has historically been cheap. Coal is essentially the oil of electricity generation, with a first-mover advantage and a massive infrastructure built up to support its use. Due to the long lifecycle of coal-fired plants, this history also serves to perpetuate future demand.

Since the 1970s, technological advancements allowed for the construction of large, high-volume, coal power plants with higher thermodynamic efficiency than older models. This enables more energy to be converted to electricity and less wasted as heat, allowing us to get more out of the coal we use.



For example, the largest coal power plant in the country—the Rockport plant in Spencer, Indiana—is capable of producing 2600 MW of electricity, twice the capacity of an average American nuclear power plant. It uses over 9 million tons of coal per year.

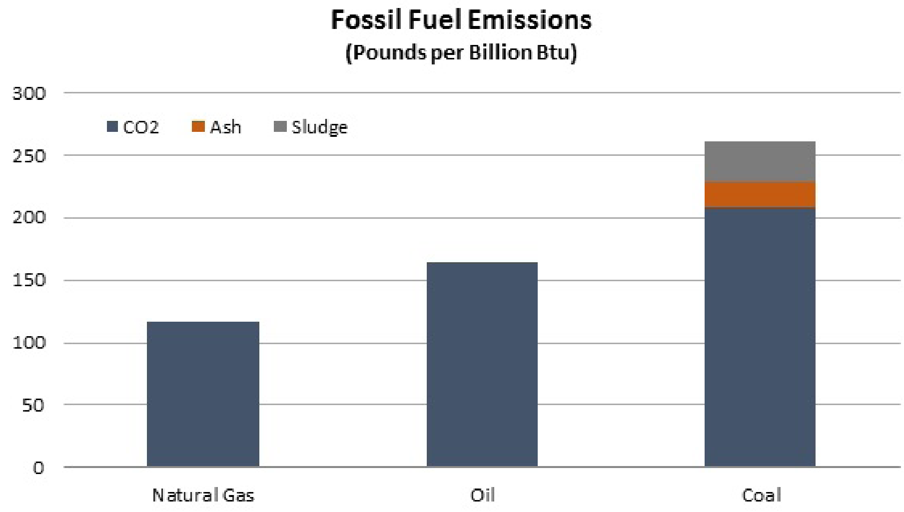
However, the cost of coal as an electric feedstock is increasing. Due to its weight, railroads have historically been the primary source of transportation from the mine to the coal plant. Railroad services are increasing in demand and many companies are securing larger profit margins from the transport of oil in the absence of pipeline competition. This translates to an increased cost of coal transportation, and thus the cost of coal-fuelled electricity; for some coal deliveries, transportation accounts for as much as 50% of the end-price.

Environmental Sustainability

The true cost of coal becomes apparent when you examine its environmental profile. The mining of coal literally displaces mountaintops and takes a significant toll on the health of those who live near coal mining operations. It is also extremely dangerous and coal mining remains the 7th most dangerous job in the U.S.

Coal is the dirtiest of the fossil fuels, producing a staggering 208,000 pounds of carbon dioxide emissions per billion Btu. Coal also contains other pollutants, including mercury, lead, and sulphur. Many of these pollutants can be removed in the smokestack by modern scrubber technologies. However, there is not yet a technological fix for reducing greenhouse gas emissions.

There are pilot projects in Norway and Germany that are testing carbon capture and sequestration (CCS) technology as a way to remove greenhouse gas emission and sequester them underground. They have not yet demonstrated that this is a safe, long-term option. It also is possible that the energy lost by capturing and sequestering the carbon dioxide will make coal power plants with CCS technology more costly and inefficient than competing power plants.



Burning coal also produces non-carbon dioxide emissions. Both coal ash and coal sludge (slurry) are produced in the mining, processing, and burning of coal. While some of the ash is used in products like concrete and asphalt, the vast majority of these by-products are stored indefinitely behind dams or other artificial barriers, adding to coal's environmental footprint. These stores are hazardous waste and are a danger to the local ecosystem and human population. In 2008, the threat these ponds pose was demonstrated when a containment dike ruptured in Tennessee and released 1.1 billion gallons of coal ash and sludge into the Emory River.

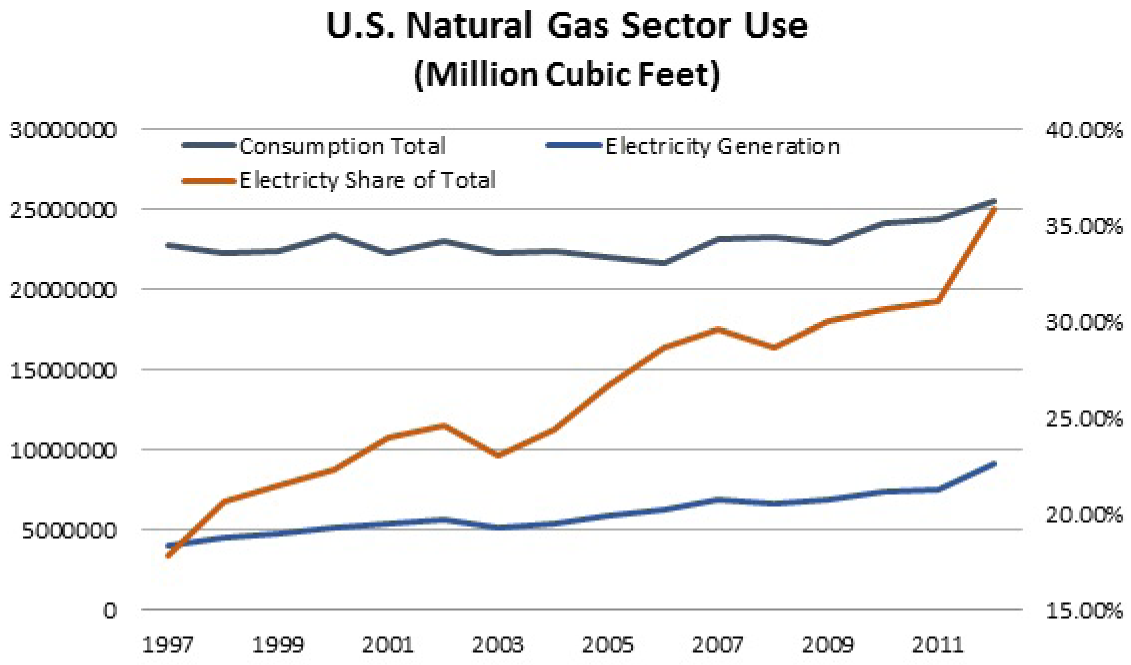
Coal may also be the worst option for the environmental and human damage it causes when it is mined. Coal mining releases toxic sulphuric acid into local groundwater supplies, destroys local ecosystems, and harms human health. The full environmental costs of America's coal use must be considered when discussing the price of cheap coal-fuelled electricity.

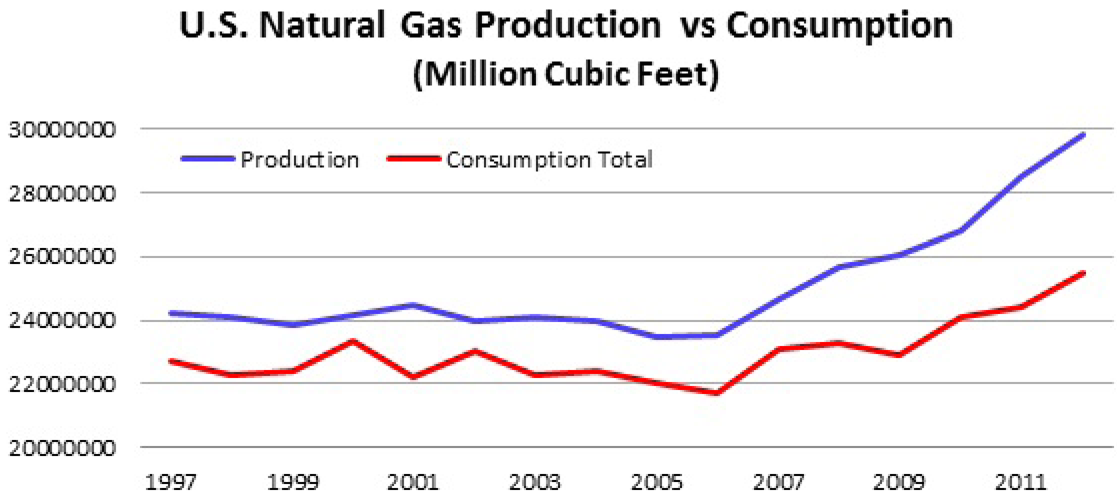
3. Natural Gas

Natural gas accounts for 27% of total primary energy in the United States. While it is still primarily used for heating and industrial purposes, electricity generation's share of total natural gas end-use has doubled over the past decade. It has also moved to displace other electricity generation feedstocks, growing from 17% of total electricity generation in 2003 to 31% today.

In the last decade, new technology, particularly the commercialization of hydraulic fracturing ('fracking'), has revolutionized natural gas production in the U.S. Fracking pushes highly pressurized water, sand, and select chemicals deep underground, fracturing underground tight rock formations (most notably is shale). This frees gas previously trapped in those formations, which is then captured, stored, and sold to consumers.

This has led to natural gas production in areas of the country, such as Pennsylvania and Colorado, where it was not previously economically viable. Due to this technological revolution, the rate of U.S. natural gas extraction has increased 27% from 2005 through 2012.





Energy Security

While oil 'independence' is a fallacious idea, natural gas independence is virtually a reality. The US produces 17% more natural gas than it consumes, only importing the gas when it makes geographic sense. The US imports 12% of the total gas it consumes and 95% of that comes from Canada, a historic ally.

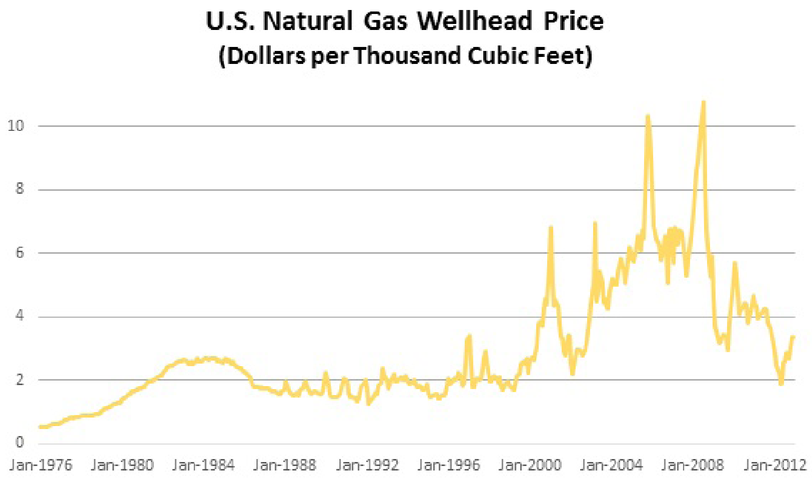
Furthermore, this is not short-lived security. The US possesses a potential resource base of 2,689 trillion cubic feet[7]; that amounts to a 105-year supply based on current consumption levels.

Before this natural gas boom was apparent—as recently as 2006—there was pressure from major natural gas consumers to build more liquefied natural gas (LNG) import terminals. Now, the pressure has reversed. The prevailing industry opinion is that US gas production will continue to rise and LNG export terminals should be constructed to facilitate the sale of US gas on global markets.

Economic Stability

Natural gas is not as easily transportable as coal or oil because it is a gas at room temperature. It requires significant infrastructure investments in pipelines, LNG facilities, and fuel tanks in order to transport it across even small distances. The result of this natural barrier to trade is that there are no unified gas markets like there are for oil. Prices of natural gas vary significantly around the world and have historically been extremely volatile.

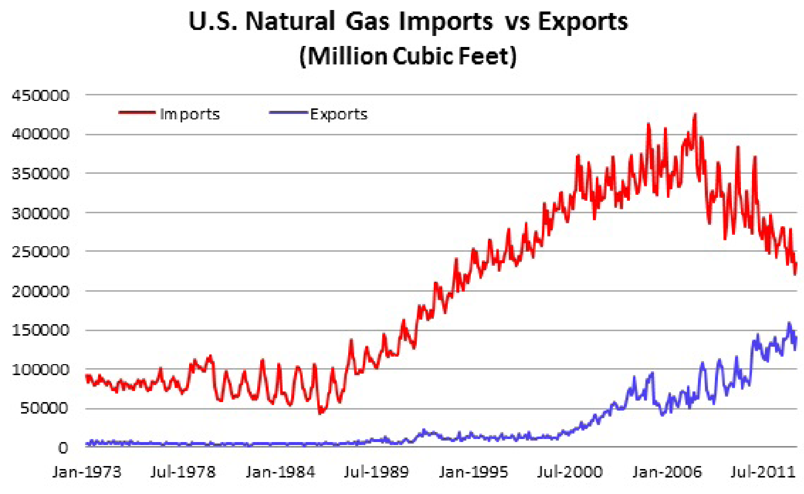
This uncertainty surrounding natural gas prices has utilities concerned about making long-term commitments to using natural gas as a base-load power source. Their reluctance stems from the fact that they are often prevented by state laws and utility commissions from increasing consumer electricity rates when fuel prices rise. Instead, gas power plants have been used to satisfy peak demand capacity, which supply extra electricity to the grid when demand is highest.



Price volatility hurts producers as well. In mid-2012, many companies saw the market price of natural gas drop below their cost of production. In response, many of them simply stopped drilling.[9] This start and stop drilling behavior further exacerbates price volatility and contributes to a business environment of uncertainty.

If LNG export terminals were available, these companies could sell their product to international markets when domestic prices plummet. This reduces price volatility, which, in turn, allows for less risky investment.

While some fear that LNG exports would dramatically increase domestic natural gas prices, the natural barriers to trading natural gas are expensive to overcome. It has been estimated that LNG exports will only increase prices in the short-term by \$0.00 - \$0.33/Mcf and in the long-term (5+ years) by \$0.22 - \$1.11/Mcf.[10]



If current trends hold, the United States will produce an ever-increasing volume of natural gas annually. It can be harnessed as a powerful tool that can stimulate the American economy, providing fuel for electricity generation, converted natural gas vehicles, and petrochemical industries. While natural gas has historically been prone to radical price shocks, plans to export the gas globally will serve to even out this volatility.

LNG – a New Tool of Geopolitics?

The benefits of the natural gas boom will not be felt solely by the U.S. Exporting natural gas has and will continue to help foreign nations diversify their energy sources. This is of particular value to trading partners and strategic allies that monopoly gas producing countries that use natural gas as a tool to achieve foreign policy goals.[8]

The Shale Gas Revolution could provide the United States with a new tool of geopolitics, if the government chooses to allow it: natural gas exports. Unlike oil, the market for natural gas is not truly global. Rather, natural gas is priced differently in different parts of the world. This is due to the nature of natural gas – it is not easily transportable.

This means that there are geopolitical opportunities from allowing LNG exports to move forward. Permitting new LNG export capacity in the United States will provide more liquidity to the global LNG market, provide alternative sources of energy for our allies, and accelerate the trend away from the oil-linked pricing system in Asia and Europe. LNG export capacity will undermine the ability of major energy suppliers to use energy as a political weapon.

LNG exports will help American allies in two key regions - Europe and Asia - by undercutting the political clout of dominant producer states and by expanding the quantity of total energy supplied to allies starved of energy. LNG exports could improve the energy security of America's closest allies. Exporting LNG can help America's allies around the world bridge from dirtier sources of energy, like coal and oil, to cleaner, carbon-free sources of energy.

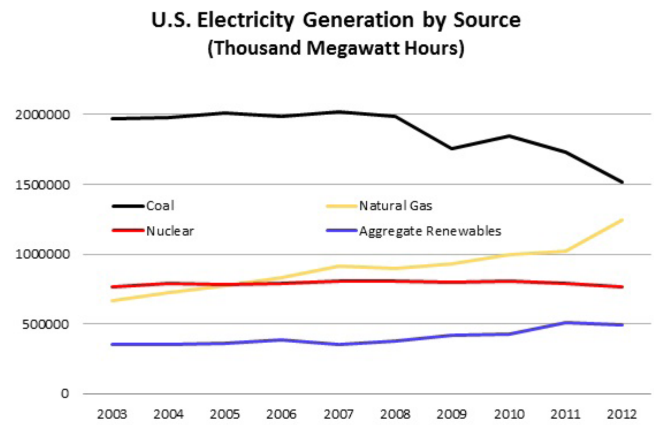
U.S. LNG exports would create a more liquid market, with deliveries based on supply and demand fundamentals. This would allow America's allies to diversify their energy sources, reduce the burden on their economies, and free themselves from dependence on unfriendly countries.

If natural gas exports do in fact become economically feasible over the next few years, the additional global supply could have effects beyond energy markets. In this regard, the U.S. has national security interests at stake. Natural gas exports can support our allies around the world by helping them diversify their energy sources.

Environmental Sustainability

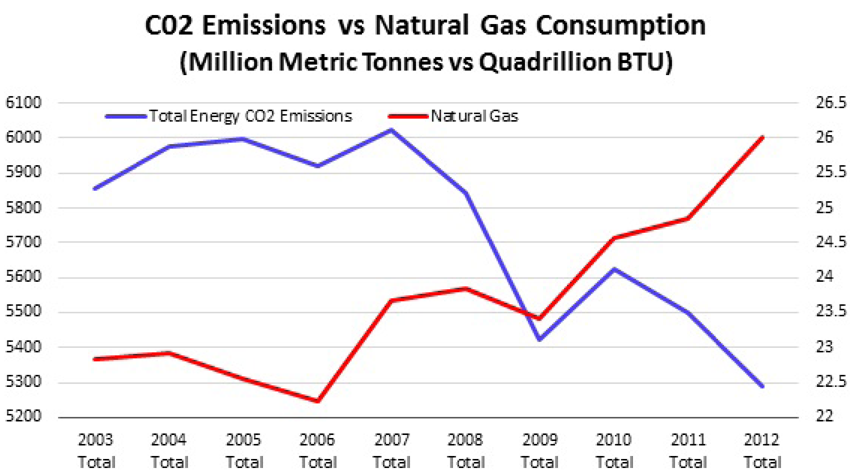
Burning natural gas is more environmentally friendly than any other fossil fuel because it burns cleaner with less pollutants and no mercury. Its greenhouse gas emissions are 117,000 pounds of carbon dioxide per billion Btu, 44% lower than coal and 30% lower than oil. This means that if all electricity generation currently fueled by coal were switched to gas, total U.S. greenhouse gas emissions would drop by about 10%.

In addition, natural gas power plants are excellent partners to renewable generation. Renewable energy, especially wind, is by its nature intermittent. It is essential to have back-up capacity to step in when the wind stops blowing and this is where natural gas excels.



Coal plants can typically increase (ramp) or decrease (cycle) their generation by between 1.5% and 3% a minute. Natural gas plants, on the other hand, can ramp up their generation by 8% a minute, making them far better suited for being paired with renewable capacity.[11] For these reasons, natural gas has been called a 'bridge fuel' to enable greater use of renewable power in the grid.

Due to relatively low prices, natural gas has seen an increased share of the electricity input-fuel market; this has led to dramatic reductions in coal use. Because of this substitution, the United States has seen dramatic reductions its greenhouse gas emissions. While renewables have been increasing over this timeframe, the reduction in greenhouse gas emissions and coal use is mostly attributable to a combination of the shale gas revolution and the recession.



Although burning natural gas is relatively clean, there is an ongoing debate about how dangerous fracking and other extractive methods are to local health and water supplies. There is justifiable fear, and some evidence, that the chemicals in the fracturing fluid will leach into water supplies. Properly executed, the chemicals should not be a risk for water supplies because the fracturing takes place far below the water table.

With more than 460,000 natural gas wells operative in the United States, however, it is important that high standards are maintained across the country. Further study, increased transparency, tight oversight, and strict enforcement at all stages of the drilling process should be embraced by both regulators and industry.

II. Nuclear Power

Nuclear power is the expression of Einstein's famous equation: E=MC2, or Energy = Mass x Speed of Light, squared. This means there is a tremendous amount of energy locked in the nucleus of every atom. This energy can be released in one of two ways: by splitting the atom (fission) or by fusing two atoms together (fusion).

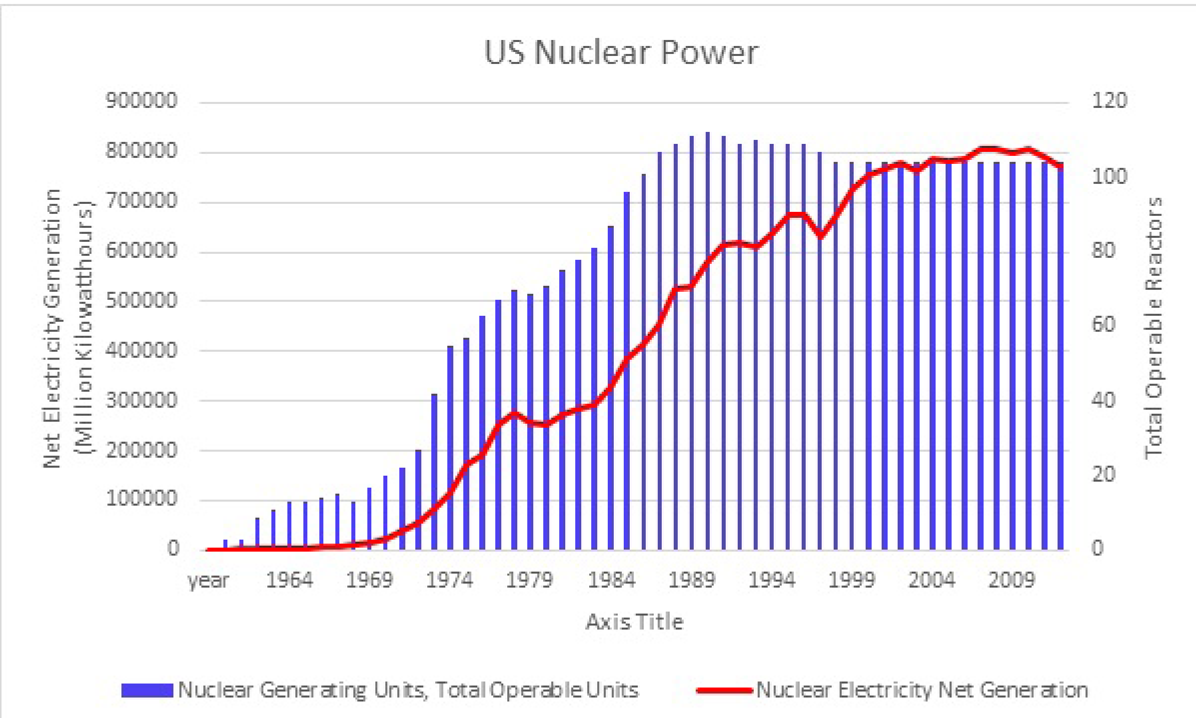
Humanity first unleashed the full power of the atom with research that led to the building of the first atomic bombs in 1945. Shortly thereafter, in 1952, a thermonuclear hydrogen bomb was tested by the United States – resulting in the first man-made (though uncontrolled) fusion reaction.

After the world saw the devastation that the atomic bomb could bring, some foresaw that the same power unleashed by nuclear weaponry could be harnessed for peaceful purposes. In this hope, President Eisenhower began the 'Atoms for Peace' program, with a 1953 speech to the United Nations saying, "the miraculous inventiveness of man shall not be dedicated to his death, but consecrated to his life."

4. Nuclear Fission

American civilian nuclear power began in 1955, when the Atomic Energy Commission asked for proposals from to build nuclear reactors to produce electric power from nuclear fission. By 1960, 3 civilian power reactors were in operation. Twenty years later, by 1980, 87 reactors were in operation around the country.

However, the 1979 accident at Three Mile Island, in which a nuclear reactor's core melted down, and questions about the cost and efficiency of nuclear power, slowed new construction. After 1980, over 100 reactor orders were canceled and fourteen already operational reactors were permanently shut down.



Today, a total of 104 reactors are operational around the country, with a capacity of 101.0 gigawatts. In 2012, nuclear energy provided about 20% of the country's total electricity generation and 9% of total energy.

There are four nuclear reactors currently under construction in the U.S. – three more than were under construction in the original edition of "America's Energy Choices." Others are awaiting permitting and financing, but forecasts of a 'nuclear renaissance' have not yet come about. One area that could see growth in nuclear reactor construction is small modular reactors (SMRs). The Department of Energy has instituted a program to help develop and deploy these smaller scale (and cheaper) reactors. The number of these types of nuclear power plants could increase since financing will be easier to come by and construction will not take as long.

Energy Security

From a traditional energy security point of view, increasing use of nuclear fission reactors for electricity would give a strong boost to national energy security: its fuel (uranium) is either available from domestic mines, or from decommissioned nuclear weapons.

However, nuclear power does present more traditional threats to security. Nuclear power plants close to population centers, such as New York's Indian Point reactor, are potential terrorist targets. Moreover, the production of more nuclear energy power plants around the world poses proliferation risks, as a nuclear power program is an important prerequisite for a nuclear weapons program.

Economic Stability

Originally, nuclear power was envisioned as a cheap source of plentiful electricity – most memorably, it was described in 1954 by the head of the Atomic Energy Commission, Lewis Strauss, as "too cheap to meter." Unfortunately, that has not proved to be the case.

Unlike fossil fuel-powered electricity generation, most of the cost for nuclear power is fixed, in up-front infrastructure costs. Once a plant is complete and running, the variable cost of fuel only adds a small amount to the price of electricity generated.

History has shown that the budget for new nuclear reactors, already high, is very often exceeded. An assessment of 75 of America's existing reactors showed predicted costs to have been $45 billion, but the actual costs were $145 billion. The country with the most recent nuclear power construction experience, India, shows that costs of its last 10 reactors have averaged 300% over budget. Once built, however, a noted benefit of nuclear power is that the price of electricity is stable and predictable.

Spent fuel is also a drain on government resources. Under the 1982 Nuclear Waste Policy Act, the U.S. government was to create a permanent storage site for radioactive spent nuclear fuel by February 1998. Sixteen years later, the federal government is no closer to meeting this requirement; as a result, utilities have filed dozens of lawsuits for over $6 billion in claims. Department of Energy statistics show that new lawsuits and other costs could eventually push the government's legal liability to over $16 billion.

Environmental Sustainability

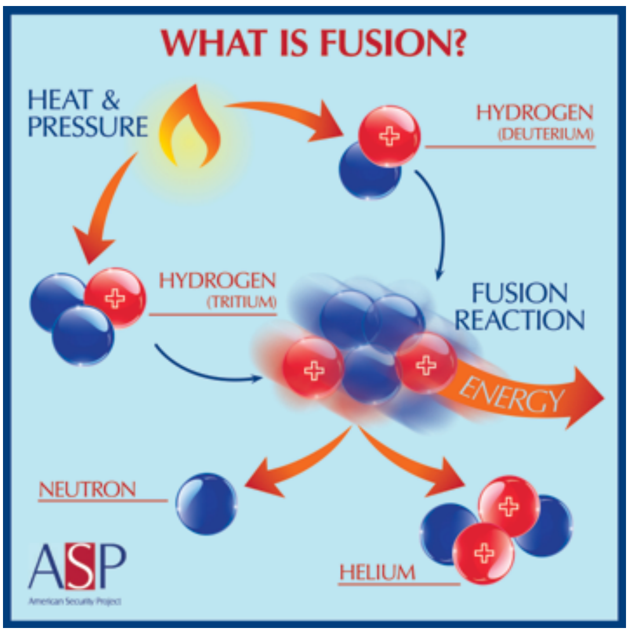
Nuclear power, both from fission and fusion, does not produce greenhouse gases. For this reason, some environmentalists most worried about climate change have shifted from their traditional opposition to nuclear power. If the United States produced the same percentage of its electricity from nuclear power as France does (77%), it would produce 19% fewer greenhouse gases.

Although there are no polluting emissions from existing (fission) nuclear power, that does not make it completely clean. Spent nuclear fuel, which can consist of radioactive uranium, plutonium, or thorium, presents long-term threats from radiation contamination. After spent nuclear fuel is removed from the reactor, it is placed in temporary water cooling pools within the reactor facility. This was not intended to be permanent, but the government's failure to find a long-term strategy for storing spent nuclear fuel means that most of America's radioactive spent fuel – 63,000 tons of nuclear waste – is stored on-site.

5. Fusion

Fusion has not seen the same success as a source of energy. The basic fuel for fusion is hydrogen, and energy is produced by forcing together the atomic nuclei of deuterium and tritium (two forms of hydrogen) to form helium. A great deal of energy is released by this reaction: one pound of fusion fuel is capable of yielding as much energy as is contained in 10 million pounds of coal.

The first patent related to fusion energy was issued in the United Kingdom in 1946. Since then, there have been a number of significant breakthroughs, including controlled fusion reactions. Up to now, the problems of how to contain the intense heat and pressure need for a sustained fusion reaction have prevented fusion reactions from achieving the point where more energy will be released from the reaction than is being used to initiate and control it.



Recent advances in laser and magnetic technology, however, have raised hopes that fusion could become a new source of electricity over the medium-term. In 2013, ASP published a 10 year plan to developing fusion energy, detailing the steps needed to make significant advances.

Scientists have been researching fusion energy for several decades. They have made great advances in producing and harnessing fusion energy, but budget cuts and annual fluctuations in funding levels have slowed progress. Given current support for fusion, commercializing fusion power remains decades away. However, with sustained scientific research and development, fusion scientists are convinced that they can make substantial breakthroughs over the next decade that would lead to a demonstration fusion power plant in the following decade. On the time scale important to energy infrastructure, the 2030s are not far away.

Energy Security

Fusion power has the potential to alleviate concerns about energy security. Fuel to power fusion power is available in seawater.

The downside risk on energy security comes from not investing in research and development. If other national efforts in other countries, particularly competitor countries like China, are successful in commercializing fusion reactions, then they will sell the technology abroad, at the expense of the U.S.

Importantly, dependence on technology and infrastructure do not raise the same energy security concerns as dependence upon imported fuel does, but they will certainly exert a cost.

Economic Stability

Bringing fusion power to a level that it is commercially viable will require significant research and development spending, estimated at about $30 billion over a 10-year period (or $3 billion per year, sustained over a decade). This is a significant outlay, but for comparison, the cost of the Manhattan project was approximately $22 billion in current dollars over 5 years, and the Apollo program was $98 billion over 14 years.

Once commercialized, power plants are likely to require a high initial construction cost and low operating costs. Fusion has the potential to be a long-term source of energy, but it will require significant and sustained investment in order to meet the engineering and scientific needs required.

Environmental Sustainability

Fusion power does not produce radioactive waste at nearly the same level as fission. In fact, developing fusion may actually help to solve the problem of spent nuclear fuel. Physicists at the University of Texas at Austin have designed a new system that, when fully developed, would use fusion to eliminate most of the waste produced by fission nuclear power plants.

Pairing fission and fusion reactions would also allow the dangerous radiation to be absorbed by fusion reactions, thereby using the harmful radiation from fission reactions to power fusion reactions. In this way, fusion could help the long-term environmental sustainability of existing U.S. nuclear power plants.

III. Renewable Power

Before the widespread adoption of fossil fuels two hundred years ago, renewable sources of power were the only energy sources available. Many towns were built on or near rivers in order to take advantage of the power of running water, while windmills dotted the landscape.

Wind was the prime mode of power for water transportation. Biomass is just a more technical name for burning wood for heat or light. In the 21st century, in an effort to build an energy system that is more sustainable, limitless, and is less likely to provoke conflict, humanity is returning to its original sources of energy. This time, though, scientists are using the combined technology and innovation of the 21st century in order to better harness these sources.

Renewable power includes power generated by water, wind, the sun, plants, or the natural heat of the earth. Together, these five power sources – hydro, wind, solar, biomass, and geothermal – account for 8.2% of total energy generation in the United States, and 10.8% of electricity generation.

While the different fossil fuel or nuclear sources of energy each present separate challenges or concerns about energy security, economic stability, and environmental sustainability. However, the positives and negative for these three criteria are largely shared across each of the five types of renewable energy source. For that reason, this chapter will first engage in a discussion of the shared concerns about renewable power for energy security, economic stability, and environmental sustainability, followed by a short overview of each type of renewable power.

6. Hydropower

Hydropower is the largest renewable source of energy in the United States. It produces 7% of the country's electricity power – in 1950, it produced 30% of the country's power. The Grand Coulee Dam on the Colombia River in Washington is the largest electricity power plant in the country, capable of generating 6.9 gigawatts of electricity.

However, there is little room for growth. Hydroelectric plants can only operate where rivers provide suitable amounts of potential energy, and most of the best sites have already been developed. Consequently, conventional hydroelectric generation grew steadily through the 1970s, peaked in 1997, and has been declining for the last decade.

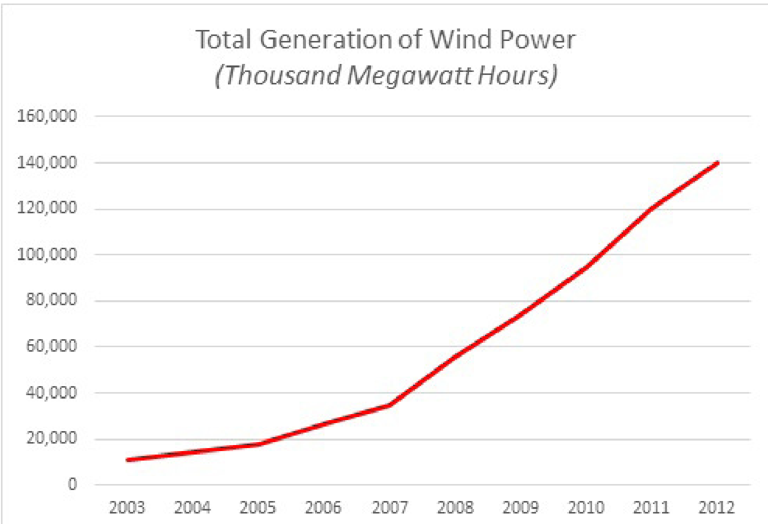
There are other forms of hydro generation, like underwater 'run of the river' turbines, their maturity does not approach the level of traditional hydropower, and their development is speculative.

One area of hydropower that could prove to be an area of growth is tidal power. Like conventional hydropower, it generates electricity using the kinetic energy contained in water currents. There are several mechanisms for generating tidal power, ranging from barrages that look like traditional hydroelectric dams to stream generators that act almost like undersea wind turbines to floating buoys that use wave movements to generate power. The largest currently operating generator is in Sihwa Lake, South Korea with a 254MW output capacity. In the U.S. there are estimates that there is enough wave and tidal potential to power 15-30% of America's energy demand, but cost and siting are challenges that will need to be overcome.

7. Wind

Wind power over the past decade has been the fastest growing source of American energy. For the ten years to 2012, wind had an average annual growth rate of 33%. Today, it accounts for 4% of electricity generation, twice the share it had in 2011.

Large scale wind farms are being installed across the country. Offshore wind farms are being installed rapidly in some European countries, but in the United States, only two are in the planning process and none have begun construction.

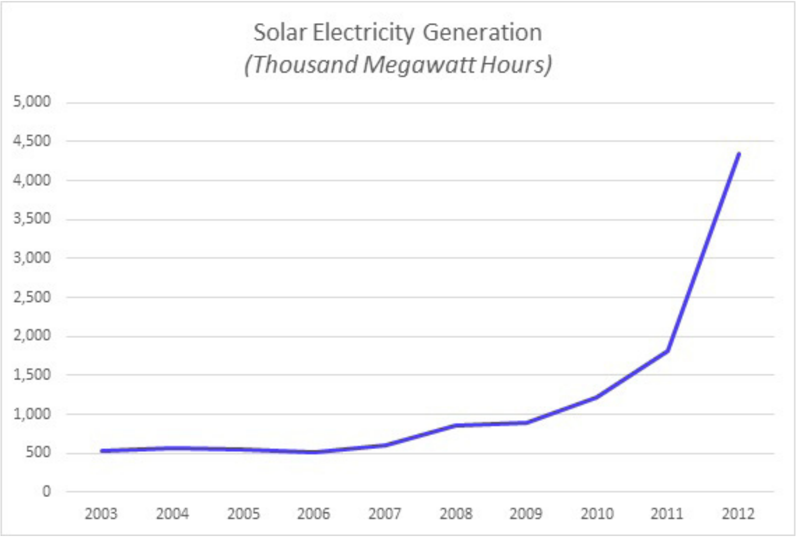


8. Solar

Solar power is less utilized than wind in the United States, but is growing faster than any source of power.

Utility-scale electricity generation in the United States from solar cells was once a far-off dream, but today, in some months, more new solar power generating capacity is opening than any other source.

There are two main ways to produce electricity from the sun. The first is through photovoltaic cells that capture sunlight on silicon and transform it into electricity. The second is called concentrated solar thermal. In this method, specialized mirrors are used to focus the heat and light of the sun on a central core that is heated. The heat from this core is then used to generate steam, turning a turbine and creating electricity. The benefit of this form of solar thermal power is that the heat of the central core can be maintained so that power can be generated even when the sun goes down.



9. Biomas

Generating energy from biomass is using plants for fuel. This can be as simple as using waste-wood from sawmills or paper factories in residential heating systems or it can refer to the process of refining corn into ethanol that is then blended into gasoline.

Ethanol is the most important of these fuels in the United States, but other countries have made biodiesel made from oilseeds and palm oil significant parts of their transportation fuels. Given generous subsidies, corn-based ethanol, blended into gasoline, provides about 10% of U.S. fuel supply by volume.

10. Geothermal

Geothermal power comes from the Earth's natural heat. Residential geothermal systems include simple heat pumps that use the soil's constant temperature to help keep houses warm in the winter and cool in the summer.

Geothermal on a utility-scale is a stable, long-term source of energy, but only in certain areas where the crust of the earth is thin and volcanic or seismic activity is high. The United States currently has the most installed geothermal electricity generation capacity internationally, with approximately 3.1 gigawatts of online capacity.

Geothermal electric power generation is occurring in nine U.S. states: Alaska, California, Hawaii, Idaho, Nevada, New Mexico, Oregon, Utah, and Wyoming. The largest producer of geothermal energy is California, with 83% of national generating capacity.

Energy Security

Any form of renewable power presents few concerns about energy security because they do not use a fuel that has to be imported.

Some complain about dependence on imported solar panels or other energy-producing goods from China, but this is not the same as energy security. Unlike dependence on a commodity like oil, importing solar panels – for example – constitute a one-time-only fixed cost. Once the cost is borne, there is very little variable cost for generating renewable energy. The same is true when concerns are raised that importing lithium for advanced batteries will only replace imports from unstable Venezuela or Iraq with imports from unstable Bolivia. This is likewise a false argument, because batteries should be termed as a fixed investment cost, not a variable cost, like fuel. While there are good economic arguments for not being reliant on imports of minerals or renewable energy materials, there are few valid security arguments.

An economy that relies on renewable power for its energy needs will be able to manage its foreign policy independently of how it utilizes energy. However, given the separation in fuels between electricity generation and transportation, policymakers should not be deluded into thinking that increasing renewable electricity generation will automatically increase energy security. There also needs to be a coherent strategy to use more renewable power in transportation. Only by giving consumers a choice about how to fuel their cars will policymakers be able to break the grip that oil has on transportation.

In the United States, transportation is primarily by automobiles, so any proposal to use more renewable energy in transportation must begin by either electrifying the auto fleet or significantly increasing the availability and use of ethanol and advanced biofuels.

Economic Stability

Renewable power receives subsidies, and in some cases, very generous ones. Of the five types of renewable power, only conventional hydroelectric is consistently competitive on cost of generation with fossil fuels. However, the demonstrated benefits of generating electricity without using a polluting fuel are a benefit that the government has an interest in promoting. Recent technological and market developments have dropped the cost of both wind and solar generation to the point where they begin to make economic sense in some markets.

The problem with the renewable production tax credit and any other subsidies is not that the government is 'picking winners and losers,' but that its choices are inconsistent. For businesses and utilities to make multi-year investments in large-scale renewable energy, they need more certainty than the consistent bipartisan brinksmanship over whether to extend these subsidies for one more year.

In areas of the country with consistent and strong winds, installing new wind turbines is already price competitive with new fossil-fuel generation, without subsidies. However, wind power presents two problems of economic stability: variability and grid stability. To overcome these problems will require the electricity grid to modernize from its 19th century roots into a modern 'smart grid.' With a smart grid, installed energy storage facilities, such as batteries or flywheels, will store electricity for times when it is most needed and computers can direct electricity along long-distance high-voltage lines from areas where the wind is blowing to areas that need electricity.

This smart grid should be paired with natural gas turbine power plants that can easily increase power to match fluctuating load levels. Hydroelectric power can also be easily stored for times of peak load.

Solar power's economic benefit is its compactness and versatility. It does not require large, expensive solar arrays to generate power. Instead, small units can be installed to offset the costs of electricity. With proper legal regulations (not implemented in all states), consumers can install solar power on their property – likely on their roof – and defray the monthly cost of electricity. At times of low household usage, they can even sell the electricity back to the grid.

Environmental Sustainability

In general, renewable power produces no greenhouse gas emissions. However, that does not mean that they are without environmental controversy.

America's ethanol program, for example, is coming under intense scrutiny. There are significant questions about the lifecycle emissions of ethanol. Even though it comes from plants, heavy inputs of fertilizer and use of fossil fuels to produce and transport it mean that the minimal benefit in reduced greenhouse gas emissions may not be worth the subsidies ethanol production receives. Cellulosic ethanol, which is derived from grasses or other sorts of herbaceous plants, is not yet in widespread use. Once it commercially viable, this technology should address the environmental sustainability and the economic concern about using food for fuel.

The main environmental problems with renewable power come from the size of its footprint and its impacts on local wildlife and ecosystems. The Grand Coulee Dam, for example, flooded a 125 square mile area, displacing thousands and permanently ending the annual salmon run up the Colombia River.

Large solar power plants planned for the California deserts are currently coming up against opposition from environmentalists who want to protect endangered wildlife from human encroachment.

The environmental opposition to the sites of some renewable power plants comes down to prioritization. Is the health of local ecosystems more important than promoting new technologies that could prevent the many dangers associated with climate change?

Conclusions

Over the last four years, the United States has seen the beginning of a great change in how it uses and produces energy. Part of this is due to government policy, particularly the impact of the 2009 stimulus on accelerating clean energy. The other part, however, is due to the impacts of new technologies, especially hydraulic fracturing and horizontal drilling, which have expanded America's accessible fossil fuel resources.

Because of these changes, this report analyzes different choices than a similar report from as recently as 2006 would have. In fossil fuels alone, the narrative has changed from being about rising oil imports, declining resources, and increased prices to questions about how to manage abundance.

However, two things have not changed: first, consumer energy prices, petroleum products particularly, have remained high. Second, the Middle East remains the most important center of energy affairs: small changes in the regional balance of power have caused two sustained oil price spikes in the past two years. Until the U.S. no longer depends solely on oil for transportation, questions of energy security will always begin with Middle Eastern oil.

Meanwhile, long term challenges remain. Climate change is an issue that will not go away: we cannot argue with chemistry and nature, and the longer we wait, the worse it will get. Likewise, even though we suddenly have access to more oil and natural gas, the world's population continues to grow, and developing countries' economic growth is putting more pressure on energy than ever. The world will need sustainable alternatives to fossil fuels – and America can lead in the research and development necessary to get there.

To meet these challenges will require policymakers to make some decisions and set some priorities that will not always be popular. But, in the long-term, we need a common set of facts in order for policymakers to determine the best interests of the country.

About the Authors

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Andrew Holland is the American Security Project's Senior Fellow for Energy and Climate. He is a Washington-based expert on energy, climate change, and infrastructure policy. He has over seven years of experience working at the center of debates about how to achieve sustainable energy security and how to effectively address climate change.

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Rory has worked as a strategic consultant in the Ontario electricity industry and hopes to consult on energy security policy in the future.

Further Reading

PERSPECTIVE: The U.S. Tight Oil Boom: Geopolitical Winner or Long-Term Distraction?

Advancements in hydraulic fracturing and horizontal drilling have already unlocked vast new natural gas resources from shale rock. Drillers are using the same innovations that brought about the "Shale Gas Revolution" for oil, leading to a surge in shale oil (or "tight oil") production. ASP's Perspective Paper, "The U.S. Tight Oil Boom: Geopolitical Winner or Long-Term Distraction?" highlights these contradictions – the U.S. tight oil boom has short-term geopolitical benefits, but over the long-term it does not provide real energy security.

FACT SHEET: DOD Installation Energy

Military installations are important for preparing, training and housing warfighters. These bases are the staging grounds for emergency response scenarios such as responding to natural disasters. They are therefore critical to national security. DoD is undertaking ambitious efforts to install renewable energy and energy storage at its military installations. This fact sheet details some of the military's efforts to improve resiliency and redundancy on its bases through clean energy.

PERSPECTIVE: The Geopolitical Implications of U.S. Natural Gas Exports

Low prices for natural gas in the U.S., and high prices in Asia, have sparked calls to allow American drillers to export LNG. Thus far, the debate surrounding LNG exports has focused on the economic impacts. This paper examines the geopolitical benefits of removing restrictions on LNG exports to two key regions – Europe and Asia.

International Progress on Fusion Energy – How American Leadership is Slipping

ASP's fact sheet, "International Progress on Fusion Energy" outlines the steps other countries are taking in developing fusion energy. Meanwhile, the U.S. is considering budget cuts to its fusion program, which will cause irreparable harm to the development of fusion power.

WHITE PAPER: Fusion Power – A 10 Year Plan to Energy Security

Fusion energy holds great promise to meet America's energy needs. Energy from fusion is clean, safe, secure and abundant. ASP's new White Paper report provides a detailed plan on how to accelerate the development of fusion power.

FACT SHEET: What is Energy Independence ?

ASP's fact sheet "What is Energy Independence?" explores the reasons why energy independence is the wrong goal to be working towards. Instead, a comprehensive goal of "energy security" – access to energy that is secure, economically stable, and sustainable.

PERSPECTIVE: Cause and Effect – U.S. Gasoline Prices

This paper examines the causes of America's soaring gasoline prices. The paper underscores that the price of gas is intimately interconnected with crude oil prices, which are set by global markets. The paper cautions that although America's oil production has surged in recent years, it has not lowered gas prices.

WHITE PAPER: Advanced Biofuels and National Security

ASP's White Paper report, "Advanced Biofuels and National Security" builds on ASP's long history of demonstrating the importance of reducing oil use for national security and highlighting the work of the Department of Defense in promoting alternative fuels. This report demonstrates that developing advanced biofuels are important in reducing America's dependence on oil; this dependence presents real national security threats to the United States and the American military.

Report – Small Modular Reactors

One way forward for nuclear power is to pursue small modular reactors (SMRs). SMRs offer a variety of benefits over conventional large reactors, which may go a long way to addressing the chronic problems facing the industry. Enhanced flexibility, cost advantages and safety features offer up SMRs as a viable path forward

Inertial Confinement Fusion at the National Ignition Facility

Inertial Confinement Fusion is one of the two main approaches to fusion energy. The National Ignition Facility (NIF), a leading Inertial Confinement Fusion laboratory part of the Lawrence Livermore National Laboratory, uses the world's most powerful lasers to compress a fuel pellet. With heat and pressure, the lasers force the atoms in the fuel pellet to fuse together, releasing enormous amounts of energy.

Endnotes

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7. Potential Gas Committee, Press Release: "POTENTIAL GAS COMMITTEE REPORTS SIGNIFICANT INCREASE IN MAGNITUDE OF U.S. NATURAL GAS RESOURCE BASE" April 9, 2013 http://potentialgas.org/press-release

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Governor Christine Todd Whitman

Christine Todd Whitman is the President of the Whitman Strategy Group, a consulting firm that specializes in energy and environmental issues.

The American Security Project (ASP) is a nonpartisan organization created to educate the American public and the world about the changing nature of national security in the 21st Century.

Gone are the days when a nation's security could be measured by bombers and battleships. Security in this new era requires harnessing all of America's strengths: the force of our diplomacy; the might of our military; the vigor and competitiveness of our economy; and the power of our ideals.

We believe that America must lead in the pursuit of our common goals and shared security. We must confront international challenges with our partners and with all the tools at our disposal and address emerging problems before they become security crises. And to do this we must forge a bipartisan consensus here at home.

ASP brings together prominent American business leaders, former members of Congress, retired military flag officers, and prominent former government officials. ASP conducts research on a broad range of issues and engages and empowers the American public by taking its findings directly to them via events, traditional & new media, meetings, and publications.

We live in a time when the threats to our security are as complex and diverse as terrorism, nuclear proliferation, climate change, energy challenges, and our economic wellbeing. Partisan bickering and age old solutions simply won't solve our problems. America – and the world - needs an honest dialogue about security that is as robust as it is realistic.

ASP exists to promote that dialogue, to forge that consensus, and to spur constructive action so that America meets the challenges to its security while seizing the opportunities that abound.

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