THE RIGHT INSIGHT

April 2016

Energy Policy

Author: Ken Malloy

TheRightInsight.org

Energy Policy

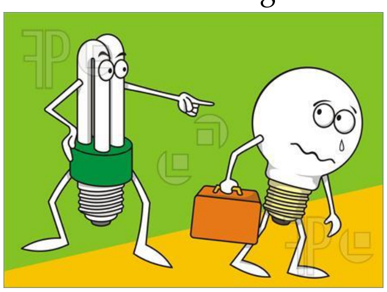
Climate Change

Ethics

State Prosperity Matrix

Introduction

The incandescent lightbulb is now outlawed.[1] This fact is a perfect metaphor for "energy policy." Should it be illegal in the United States to manufacture, sell, buy, and use a traditional incandescent light bulb? Your informed answer to that question will provide deep insight into your views on hundreds of other energy policy questions. (BTW, my answer is no, but I bet you guessed that.)



Energy is the lifeblood of our economy; it touches your life in a hundred ways each day. Yet energy policy--*the set of government rules and regulations that prescribe how energy is produced, delivered, and consumed*--is a complex and even a chaotic subject.

---

[1] This is a good place to make a point. Some pointy headed academics will disagree with even this first sentence. Technically, Congress did not "ban" incandescent bulbs in the Energy Independence and Security Act of 2007. Rather, they set a standard that most, if not all, traditional incandescent bulbs could not achieve and established a schedule for light bulbs of different wattages to meet this standard. So it is fair to say that Congress outlawed incandescent bulbs. But since the accompanying Article is a synthesis of the broad topic of "energy policy" it would needlessly clutter and complicate the text to be "technically" accurate in every instance. The size of the document would need to double and the reader would understand less of the essence of energy policy if I did not make some broad generalizations. Nonetheless, I am sure I will receive some criticism that many of my statements are not "technically correct." I hope that making this point early in the article will allow for a better understanding of the content of the Article.

Energy was an uninteresting subject for the average person prior to the **OPEC Oil Embargo** in 1973. Oil prices had been stable at about $20 a barrel in real terms for nearly a century and electricity prices had declined from about 22 cents per kilowatt to about 13 cents from 1960 to 1973, even as consumption of electricity quadrupled from 1950 to 1973, as more and more homes and appliances used electricity and utilities became better at building large coal and nuclear plants.

But the OPEC Embargo changed everything about energy and energy policy. Four points will illustrate this importance.

- President Jimmy Carter's presidency (1976 to 1980) was dominated by energy issues which he characterized as the "moral equivalent of war."
- A little more than two decades later a California governor was recalled because he botched an electricity crisis in California and Arnold Schwarzenegger was elected Governor.
- There is a widespread perception that the US has gone to war in the Middle East over oil issues.
- The Pope of all people has recently declared war on climate change, most of which is laid at the feet of fossil energy.

Part of the complication in energy policy is that it must be addressed on many fronts; international, national, State, and local governments all have a role in stirring the pot.

Many books and articles are written on very specific aspects of energy policy but most are written for other experts. Surprisingly, few are written that cover the broad landscape of energy policy. Even fewer of these writings take a strong market-oriented perspective; the vast majority take an interventionist approach largely for environmental and oil import reasons. And none that I have found are addressed to the pro-market political activist who has a real job during the day and then tries to save the country in his or her spare time. This discussion is for that heroic citizen, The Forgotten Man.

So what's the bottom line on energy policy?

- First, we make energy policy much more difficult than it has to be. Energy is a commodity just like wheat or cars or hamburgers. Mostly, we rely on competitive markets in each of these other commodity industries to make sure that we have an adequate supply to meet the consumers' needs at reasonable prices. But we treat energy differently. I venture to guess that there are only a few industries more affected by government intervention than energy. Why is that? Does that mean we benefit from that intervention? Is there a better way? The article explores these questions.

- Second, right now energy policy is being driven by climate change. Even if one is sympathetic to some of the claims made about climate change, many stupid actions are being taken in its name that has profoundly negative effects on energy markets.
- Third, oil issues get the most attention but we do not face any *real* danger in oil markets. Oil trades in global markets and while there may be price fluctuations (as I write, oil is about $35 a barrel, having been over $100 in the recent past), we will never face a situation where we run out of oil. Most countries with plentiful oil have built their economies on oil revenue and the recent drop in oil prices has created serious political problems for these countries. They simply can't afford not to produce oil. But problems in oil markets can result in unnecessarily higher prices and thus we need to pay some attention to them in order to promote prosperity.
- Fourth and **most important**, electricity faces *real problems* that could result in catastrophic failure of the system, thus threatening not only prosperity but human life. The major framework for electric policy was set in 1935. That framework worked fine up to the OPEC Embargo. Electricity can compete against oil and natural gas in many applications. Thus adjustments were necessary to the historical framework after the Embargo. But policymakers have only nibbled at the edges of electricity policy and have not fundamentally changed the 1935 framework. Yet little more than additional tinkering is being done to promote an electricity industry for the 21st Century. Many special interests are pushing and pulling on the antiquated framework for personal gain but few are fundamentally committed to a complete rethinking of the role of the electric system of the future, especially given the increasing digitalization of our economy. And as noted above, unsound policies on climate change make electric issues even more difficult.

Energy Policy

I. Perspective on Energy Policy

Prometheus was punished by the gods for bringing fire to humans. This Greek myth demonstrates the longstanding importance of energy to humanity.

Energy is ubiquitous because it directly and indirectly is part of the cost of every product and service and essential to virtually every creature comfort. Similar to food and housing, energy is one of the dominant factors of the cost and quality of living. Energy costs have an effect similar to inflation because they disproportionally burden people of limited means and retirees and others with fixed incomes. Lower cost energy promotes investment in energy intensive industries, especially manufacturing, resulting in job creation, economic growth and improved living standards. Low energy costs induce investment by foreign investors and operating companies in the US. Low energy costs also make the country more competitive in a global economy by reducing manufacturing costs resulting in increased exports and reduced imports. This in turn supports the international trade value of the dollar. Thus, all other things being equal, **energy costs matter**. If energy costs matter, then **energy policy matters**.

Policy debates are legion about many issues: health care, minimum wage, budget deficits, foreign policy, education, immigration, taxes, etc. But energy policy is perhaps unique in that it affects literally every aspect of our lives, every day of our lives, though most often in an unseen manner. Mostly, we think of energy, barely, when we flip the switch and the lights come on or when putting gas in our car.

But think about it more broadly. Every commodity we buy and every service we receive is made possible by energy. Indeed, the advancement of civilization itself is the story of harnessing the power of energy in increasingly efficient and cheaper ways. We mostly think about energy when it's not there, as during blackouts, or when it is expensive. What is remarkable about energy is actually how ubiquitous and essential it is and how little we think about it. We largely take it for granted.

Energy is a physical concept; you can touch it or feel it or measure it. An analysis of national energy policy begins with the *resources* of the nation – oil, natural gas, coal reserves, renewable energy, etc., and the existing energy *infrastructure*: drilling rigs, refineries, pipelines, gas liquefaction plants, transportation, storage and port facilities; coal and gas-fired, nuclear and hydroelectric generating plants; and the electricity wires grid.

These resources and the underlying infrastructure allow us to use energy and we use energy in many different ways: heating, transportation, electricity, industrial processes, manufacturing, etc. Matching the *supply* of many different types of energy to the many different *uses* of energy is a complex undertaking, involving physics, technology, creativity, business, and economics.

Two additional issues make it even more complicated. Energy must be "delivered," i.e., moved from where it is located to where it can be productively used; this implicates some complex issues somewhat unique to wires and pipes. In many instances, energy must be "transformed," i.e., processed in a way that converts raw material to useable commodities; this implicates issues of exploration, mining and drilling, transportation, refining and distribution.

The efficient development of energy resources requires an exceedingly complex array of interactive decisions involving planning – e.g., exploration, production, distribution and building, maintaining and expanding infrastructure. The energy marketplace provides a continuous flow of reliable and relevant, up-to-date information based on a nearly infinite number of transactions generated by planners, engineers, investors, energy companies and consumers. The benefit of this input is informed investment, design and operating decisions that minimize cost and provide ample supplies at competitive prices to energy users.

***Energy Policy* is thus the set of laws, rules, and regulations that shape how we produce, transform, deliver and match energy supplies to energy uses to create value.**

It goes without saying that literally thousands of books have been written on various aspects of energy policy, making it an intimidating topic for most people. The goal of this article is to remove much of the mumbo jumbo and describe the critical issues for the future in a way that is understandable to the non-expert. In doing this, I acknowledge upfront that I will make many statements about energy to simplify a complex subject. As a general rule these statements are correct but as a technical matter there may be exceptions to the general rule. For simplicity, understanding, and brevity, we do not try to explain all the exceptions unless essential to an understanding of the issue.

What then should be the goal of **Energy Policy**? That's actually a very controversial issue.

- Some argue that low energy prices should be the goal, even to the extent of government ownership or price controls.
- Some that we should use less energy.
- Some that we should reduce oil imports.
- Some that we should protect oil supplies in the Middle East for national security reasons.
- Some that we should reduce environmental damage.
- Some that we should use only renewable energy.
- Some that jobs should be the goal.
- Some that fairness should be the goal.
- Some that we should have an "all-of-the-above" strategy.
- Each special interest will argue that we should use more of what will be in their financial interest.

In our view, the proper goal of energy policy is simply stated as the *economically efficient use of energy*. In a more common parlance, that would mean using energy to achieve the best use of society's resources. Achieving this simple goal would actually achieve many of the other goals put forward as the justification for a given energy policy. For example, low energy prices are a problem if they lead to supply shortages. Similarly, we would use less energy if prices were higher but that would result in less prosperity. We will explain in more detail below how reliance on competition achieves many if not all the goals put forward for energy policy.

As noted above, there are many sources of energy and many different needs for energy. How do you sort out which energy should be developed for which uses? Generally, we want the *supply of energy* to be in balance with the *need for energy*. We want different energy types (supply) to be used where it is most valuable and useful (demand). To achieve this, economists generally recommend that we rely on prices and free markets to bring supply and demand into balance. We wholeheartedly adopt this framework.

This means we are not pro-nuke or anti-renewable, pro-oil imports or anti-oil imports, pro-consumption or anti-efficiency. ***We are in favor of setting the ground rules of energy so that consumers' decisions determine the efficient use of energy resources based on efficient prices set predominately by market forces.***

So what is *our* "bias?" Our perspective is actually quite simple. We view energy as a commodity similar to other commodities. Energy follows the principles of economics. Price can and should respond to changes in supply and demand. Accordingly, to the greatest extent possible we should rely on competitive market forces to drive adjustments to changes in supply and demand in order to achieve efficient markets. Efficient markets

- achieve a balance of supply and demand,
- promote development of new supplies,
- encourage consumption and conservation in response to prices,
- ensure the development of innovative technologies to meet new challenges,
- include all relevant costs in the price of energy, including environmental costs,
- drive investments of capital to its highest and best use, and
- promote rapid adjustments to unexpected circumstances.

That's the good news!

What makes energy policy so interesting and challenging is that there are instances in which relying on a free market will NOT result in efficient prices. Two **Market Failures** in particular are implicated in the energy industry: market power and externalities.

Market Power: Ordinarily, competition is good because there are many buyers and many sellers who will all respond quickly to the information they get about market conditions and this exchange will result in prices that balance supply and demand. But what if there is only one seller (monopoly) or buyer (monopsony). In theory, they could charge any price and your only option is to choose to buy at the high price set by the monopolist, do without, or buy an inferior substitute good. It turns out that the most effective way to deliver natural gas and electricity is through pipes and wires companies that often have monopoly power over customers. Accordingly, we take the position that **it is appropriate for government to regulate natural gas pipeline and distribution companies and electric transmission and distribution companies**. The proper way to regulate such companies is very controversial and in recent years there has been much change in how we regulate such companies.

In the gas industry, we have undergone profound changes in how we regulate pipelines and distribution companies in the last three decades. These dramatic changes have universally been praised and recognized as having a positive effect on gas markets, energy markets, the economy, the environment, and national security. Indeed, the dramatic transformation of the natural gas industry by competitive policies is a textbook example of the benefits of relying on markets instead of governmental controls. Accordingly, we will develop a case study of the transformation of oil and natural gas policy from a government focused to a market focused policy, largely in the 1980s.[2] Unfortunately, the electric system is currently in a state of flux as we evolve to new policies. This makes electricity issues very complicated and confusing.

Externalities: Ordinarily, we rely on sellers to include all the costs of producing a product in decisions on how to price the product. But sometimes it is possible for a company to avoid including certain costs and impose those costs on other parties that are not part of the transaction. A good example is air pollution. If a coal plant belches sulfur and nitrogen oxides into the air, air pollution will result that can impose costs on other people who have to breathe the polluted air. Absent government intervention, these costs are not included in the price of the coal that is used to generate electricity. Accordingly, all other things being equal,[3] coal and electricity use will be underpriced and overused compared to other less polluting alternatives or more efficient consumption technologies. Economists use the technical term "externalities" to describe this market failure. Unfortunately, all energy use causes some externality, even renewable energy. In general, we believe **it is appropriate for government to set sound rules that deal with serious externalities of pollution from energy**. There are many different views, however, as to what constitutes "sound" or "good" policy for dealing with environmental externalities. The specifics of this debate will be dealt with in the chapter on the environment and discussions of specific fuels and uses. *To be very clear, advocating for competitive markets does NOT mean we oppose including serious environmental costs in the price of energy, though I expect we will be accused of such an attitude.*

To sum up, competitive markets are fantastic when they work, but sometimes government intervention may need to correct market failures related to market power and externalities, thus improving the operation and efficiency of competitive markets. Unfortunately, many analysts stop there. They find a small market failure and then automatically assume that the government solution they recommend will fix the problem and not cause other problems. To put it in extreme terms, proposing to crack a nut with a sledgehammer is obviously overkill.

---

[2] Cite to the case study's location when available

[3] Ceteris Paribus is Latin for all other things being equal. This is an important concept. It means that looking only at the variable under observation, what will happen if you change that variable and that variable alone. In other words, holding all other variables constant, how does changing only the variable under consideration impact the world? This is important because it allows you to make fairly concrete statements about the impact of certain policies. When such generalizations are made, someone who disagrees with the policy will often point to some examples that seem to contradict the generalization. On close scrutiny, you will often find that their argument depends on another variable changing that renders the outcome different.

In the last 50 years or so, economists have come to better understand that many interventions into markets made with good intentions have side effects or unintended consequences. Additionally, some interventions are made even when there is not a legitimate market failure, possibly out of good intentions but very often out of abuses of political power for private gain or just plain stupidity. Dr. James Buchanan won the Nobel Prize for Economics in 1989 for his work on what is called public choice. Essentially, this relatively new field deals with what might be called **Intervention Failures**. Just as there can be market failures that produce inefficient results, there can also be intervention failures that produce inefficient results. Typically, we use a tool called cost-benefit analysis to help us achieve as much efficiency as possible or to reduce any harms to efficiency as much as possible.

Without a doubt, this is a very complex, difficult tool but for now it is enough to grasp the overall concept that not all government interventions are beneficial and sometimes it is very controversial to determine which ones are good and which are bad. Perhaps an example will help. One of my favorite authors, Bjorn Lomborg, uses the following example to illustrate his position on radical reduction of carbon in response to climate change. Suppose you wanted to save energy and eliminate highway deaths. The solution that achieves the greatest energy saving and lowest deaths is to pass a law that sets a 5 miles per hour speed limit. Even without a sophisticated cost-benefit analysis, you can intuitively see that while the solution might no doubt achieve the goal, the costs of such a policy far exceed the benefits. Thus we are willing to sacrifice some goals (energy saving and deaths) to achieve other goals (reasonable transportation and prosperity). (Thus he concludes that radical reduction of carbon is not sound policy because its costs are likely much greater than its benefits. That is largely our position as well.)

If a market-driven energy sector describes optimal energy policy, existing U.S. policy falls far short because Federal and State governments have subordinated the marketplace to pervasive and often perverse legislative and executive mandates, prohibitions, subsidies, guaranties, taxes and tax benefits that overall result in increased costs (including compliance costs), reduced supply, higher market prices, higher taxes, and unintended consequences. A couple of examples. A government subsidy for renewable wind and solar energy have a meaningless impact on climate change or environmental values in general but substantially increases electric generating costs and resulting rates to consumers as well as making electricity less reliable. Government mandates that automobile miles-per-gallon increase (CAFE Standards) because of a misplaced desire to use less oil have induced auto manufacturers to reduce vehicle weight, which has resulted in an increase in highway fatalities and serious injuries.

Government mandates and prohibitions have pernicious characteristics, in addition to any substantive effect of interfering with or superseding the normal functions of the marketplace. Most regulations are drafted on the premise that "one size fits all" —a necessity because distinctions and flexibility add complication and ambiguity.

A companion characteristic is the intended permanence of a finalized rule or regulation— "etched in stone." The more complex or important the issues, the longer it takes to finalize the regulation, the more interdepartmental coordination it requires, the more drafts that are circulated, and the more input from interested parties and lobbyists, creating the conviction that the final version has unconditionally and comprehensively resolved the issues for the foreseeable future. The possibility of materially changed conditions or of unintended consequences is deemed to be remote if not farfetched. This "etched in stone" attitude is well illustrated by the failure to make major revisions to the original of allocation of jurisdiction between the Federal government and the State governments for the electric system. The penetration of electricity to virtually every home and business in 2015 differs markedly from the situation in 1935 when the jurisdictional pattern was established and electricity was far less ubiquitous and interconnected in a grid that extends over many States. In some countries, States, provinces, departments and cantons have very little authority over the electric system, far different from the US.

In summary, then, our view is that government should rely on competitive markets to set the price of energy services to bring supply and demand into balance and should establish policies to deal with ***serious*** *market power and environmental externality problems. Such legitimate interventions in markets should be cautious and tempered to avoid a myriad of intervention failures.* **If you disagree with this statement, you will disagree with many of the recommendations that we make in this Article.**

In conclusion, this **Energy Policy Article** explains the broad contours of the energy policy landscape. I wish it weren't so but there are three realities that we will have to deal with. First, energy policy is complicated and made more confusing by special interests that needlessly complicate the debate over energy policy. Second, energy policy is currently a mess, possibly because it is so complex and controversial, but in no small way because the last two Presidents strayed far from the central principle of competitive markets. Third, it is vital that we adopt sound energy policies given the essentiality of energy to our standard of living, our environment, and the prosperity of our economy. So we have our work cut out for us!

This Article will be a very basic explanation of current energy policy problems. Additionally, it makes some broad recommendations on oil and electricity. In general, it concludes that while much attention is given to oil in the popular press, there is little chance of a serious crisis in gasoline markets since oil trades in a global market and the producing countries need oil revenue to fund their economies. While we will not face supply shortages in the sense that we have "run out" of oil, we will face price volatility as supply and demand conditions change. The more serious problems are in electricity. In general, it concludes that the current electric system is predicated on an anachronistic framework set in 1935 and is ill prepared for the challenges of the 21st Century.

The **Article** does not purport to be a history or a complete statement of the law, engineering, science, or institutions of energy policy. For a very basic understanding of the science of energy, the California Energy Commission has established a very useful website consisting of 20 short chapters describing the many forms of energy. It is not a policy discussion of what we should do. Rather, it is merely descriptive and reasonably free of bias. For a basic introduction to energy information, the Federal Government's Energy Information Administration has an excellent and very objective overview of energy nuts and bolts.

This **Article** is a foundation for more detailed discussion of energy policy issues. These discussions will come in the form of Commentaries, hopefully on a monthly basis. The Commentaries will focus on a single issue and capture the essence of a problem and a solution to that problem in about 5 to 10 pages. Additionally, this project will also include a weekly blog posting of about 500 words on a "hot" energy topic or a particularly interesting article or book. Unlike much that is available on the internet, the audience for these **Article, Commentaries,** and **Blog Postings** is not the energy expert or academics or even public officials who are responsible for energy policy decisions. Rather, the goal of this effort is to make energy policy accessible to the layperson. Thus it strips away a lot of detail and complexity by getting right to the nub of the issue. It assumes no prior knowledge or experience in energy policy.

One cautionary note about "special interests" is necessary at this point. We begin with an assumption with which many energy experts and special interests will disagree: *free markets should be the core foundation of energy policy and governmental intervention into energy markets should be very limited*. The author and the financial backer of this effort do not have any financial interest in energy policy. The author has been a law professor, a public official in both State and Federal government and has founded and run think tanks dedicated to sound energy policy, currently CRISIS & energy markets!. The financial backer of this effort (the **Berens Foundation**) did not make his millions in energy; neither does he have any significant financial investments in energy. This is very different from most of the commentary you may see on energy policy. Many commentators have a so-called “dog in the fight,” meaning a personal stake in the outcome of a debate. They typically are aligned with an industry segment or other special interest such as an environmental group. That doesn’t mean they are necessarily wrong but it does mean that that you must understand where their self-interest lies before assessing their arguments. If their self-interest aligns with their policy recommendations, you have a right to be suspicious. Again they may not be wrong: it is just that it is hard for you to know if they are being objective. An umpire may have an outstanding reputation and be an ordained minister but if one of the pitchers is their son or daughter we would forgive the coach of the other team if they were worried about objectivity.

II. Setting the Stage for Thinking about Energy Policy

Before we discuss specific energy issues, there are some issues that are overarching and often misunderstood, many rising to the level of myths. Typically, these myths apply broadly to all aspects of energy policy and it is good to keep them in mind as you read more detailed discussions.

Perhaps the most important myth about energy policy relates to finite supplies. We will **NEVER** run out of energy and there is no shortage of energy (one wag puts it that government red tape can be turned into energy so we will never run out of energy). Whenever you see a discussion of energy "shortages" or "running out of energy" it is usually because of governmental actions that impede the efficient pricing of energy. For example, the US had natural gas "shortages" in the mid-1970s. Presidents Ford and Carter and the Congress thought we were running out of natural gas and adopted policies based on that assumption (price ceilings and bans on using natural gas). Actually the shortages were caused by Federal price controls that kept a ceiling on natural gas prices below market levels, made especially pernicious after the OPEC Oil Embargo quadrupled the price of oil, a competing energy source. There were no "shortages" of natural gas in intrastate markets that were not subject to Federal price controls. So producers had no incentive to produce more gas for Federally regulated markets but consumers had incentives to consume more gas at the less-than-market-price regulated ceiling. Voila! **Natural Gas Shortages!** The Reagan Administration dramatically changed natural gas policies to rely more on competitive market forces than government controls. Twenty-five years later, we now find that we have **plenty of natural gas,** measured in hundreds of years, and it has become the centerpiece of our national energy picture.

Often, the term "shortage" is used when energy prices are increasing. But it is actually a discussion of the cost of energy. Energy price changes (both increases and decreases) that are adjustments to supply and demand changes, while sometimes painful, are actually economically efficient and beneficial. Thus increasing prices even in times of emergency is usually efficient and allegations of price gouging are misplaced. Similarly, every time oil prices increase the major oil companies are accused of conspiracy to fix prices. The US government routinely investigates such allegations and NEVER finds any such conspiracy. Oil prices are set in globally competitive markets.

We hear the terms "cheap energy" and "expensive energy." But these are relative terms. Energy prices have been much higher than they are today and they have been lower. While it matters a lot to the economy whether we have "cheap" or "expensive" energy prices, the better view is to have the "right" energy prices, meaning prices that balance supply and demand and let people and businesses adjust accordingly.

Also one needs to be careful about such terminology when comparing energy sources since the actual delivery of energy involves more than just the resource cost of the energy. We did not begin to use crude oil because we ran out of whale oil. Crude oil became cheaper and more flexible as an energy source than whale oil. Some use such terminology when referring to renewable energy, i.e., that it must be cheap since the wind and the sun are free. But that is far from true since there are many other costs associated with using renewable on a large scale basis. [*Commentary 1: In Praise of Global Oil Markets: Will the Idiocy End?* contains a more comprehensive discussion of how supply markets work to ensure adequate supplies of energy.]

The second myth is that there is a **Free Lunch**. Nobel Prize winner Dr. Milton Friedman popularized the notion that there is *no such thing as a free lunch*. Much of the rhetoric around renewables and efficiency tries to suggest that there is a free lunch (something for nothing) but this is misleading. Every energy supply has environmental and cost implications and it is naïve to ignore that reality. Even energy efficiency, i.e., adopting technology to use less energy, has environmental and cost implications. As is often the case, if something is too good to be true, it's probably not. Thus conspiracies about technologies that produce "free energy" are hyperbolic.

The third important concept to understand relates to safety and terrorism. Energy facilities represent a somewhat unique security threat for two reasons. First, any disruption can affect thousands if not millions of people; witness the outage of much of the northeast in 2003. Security in few other industries implicates such large numbers of people. Second, the very nature of energy facilities presents a difficult challenge. Energy facilities often involve equipment spread over very long distances, often in densely populated areas but also often in remote locations. This makes protecting such facilities very challenging. It is actually surprising that there has never been a significant intentional catastrophe[4] involving energy facilities. There is much that we do not know about what is being done to protect energy facilities because it is classified. Nonetheless, despite the lack of a significant intentional catastrophe and that steps to

[4] In April 2013, there was an intentional attack on a power substation that raised alarms as to whether electric facilities were sufficiently protected. As of September 2014, the FBI has not yet determined responsibility for the attack. http://en.wikipedia.org/wiki/Metcalf_sniper_attack

protect energy infrastructure are classified, one should not underestimate the potential implications of possible terrorist attacks on energy facilities.

In addition to terrorism, significant disruptions of service or catastrophic environmental damage can be caused by accidents, negligence, or extreme weather. Exxon Valdez and BP's Deepwater Horizon accidents have caused significant environmental damage. Hurricanes Katrina and Sandy, Chernobyl, and the earthquakes in Japan (Fukushima) caused significant loss of life due to damage to energy facilities. These are cautionary examples of the need for significant attention to safety and security that is attendant to energy facilities.

One of the key issues in securing energy facilities is the cost. How much security is enough and who should pay for it? Should this be a taxpayer burden or an energy customer burden? This makes a difference because it affects the price of energy, which in turn affects the role of energy in our pursuit of a prosperous economy. *Commentary 2: Electricity and Prosperity* explores some of these issues in more depth.

Fourth, we need a word about **energy efficiency**. Much that you read on "energy efficiency" will be confusing because the term can mean two different things that are virtually the opposite of each other. ***Engineers*** use the term energy efficiency to mean that you can get more output for the same input. An example will help. Suppose you have one car that gets 15 miles to a gallon of gas and one that gets 25 miles to a gallon. An engineer would say that the second car is more "efficient," i.e., more miles per gallon. An ***economist*** would have a very different view. The economist would be focused on the total cost of going 15 miles versus 25 miles. An extreme example will help. Suppose a car company invented a car that got 300 miles per gallon but costs $17 million per car. Compare that to another car that got 30 miles per gallon but cost $17 thousand. An engineer would say the first car is more efficient (more miles per gallon) but the economist would say that the second car is likely more efficient. The economist would divide total miles expected to be driven into the total cost of driving those miles and the calculation with the *lowest total cost per mile* would be the "efficient" outcome for the consumer. In general, if market prices accurately balance supply and demand (including sound policies for monopoly and externality market failures), then we do not have to worry about "engineering" or "economic" efficiency. The consumer will decide for themselves the tradeoffs between paying more upfront for a more energy efficient appliance or car and the energy savings at some point in the future. Government cannot possibly make those tradeoffs accurately for each consumer and economic *inefficiency* results when government sets efficiency mandates, which it does all the time.

Fifth, energy policy is made more complex by the startling number of government organizations that have a role in making energy policy. Most obviously, the President and Congress play a role in setting the broad policy that affects energy policy. But there are many more players.

Maybe not so surprisingly to some, the US Environmental Protection Agency probably has more to say on energy policy than any other single organization. But the US Departments of Energy (mostly new technologies and nuclear waste issues) and Interior (energy on Federal lands) also have significant roles. Somewhat more obscure is the Department of State (climate change negotiations and import/export issues) and the Federal Energy Regulatory Commission (natural gas pipelines, hydroelectric, and electric transmission). The Federal government also owns some generating capacity usually associated with large Federal dams such as Hoover and Grand Coulee. The Tennessee Valley Authority or TVA is the most recognizable. But there are other so-called Federal power marketing administrations that also operate in other regions.

There are also hundreds of State and local agencies that have an impact on energy policy. The most significant state agencies are State public utility commissions or PUCs. The general pattern is that state PUCs regulate not only energy (natural gas and electric) but also telecommunications, water, some transportation (usually trucking), and a variety of other economic activities depending on the State.

But every gas or electric utility that falls under the jurisdiction of a PUC recognizes that the PUC has the power of life or death over that utility. Accordingly, utilities spend a lot of time, attention, and money to keep the State PUC happy. The State commissions have a national trade association called the National Association of Regulatory Utility Commissioners or NARUC. Many, if not all States have an executive branch office that deals with energy and the environment issues. The patterns will vary from State to State. The trade association for State energy officials is the National Association of State Energy Officials or NASEO. The trade association for State environmental officials is Environmental Council of the States (ECOS). Additionally, many States have consumer advocates and their trade association is National Association of State Utility Consumer Advocates (NASUCA).

While the predominant model for most consumers in the US is to be served by a privately owned, for-profit, public utility (yes the terminology gets confusing), there are actually many more local governments that serve primarily rural customers called munis and co-ops (short for municipally or cooperatively owned). They are non-profit organizations and serve relatively few customers compared to public utilities. Munis selling electricity are represented by the American Public Power Association and the coops are represented by the National Rural Electric Cooperative Association. Munis selling gas are represented by the American Public Gas Association.

In addition to these trade associations of governmental entities, there are a host of trade associations too numerous to name representing the special interests of virtually all segments of the energy industry.

Given all the cooks in the kitchen, it is not surprising that following energy policy issues is mindboggling.

Sixth, the myth of the "all-of-the-above" strategy should be debunked. Perhaps the best known proponent of an all-of-the-above energy strategy is John McCain when he was running for president in 2008. There is no formal definition of this "strategy." So it can mean different things to different people. In its most innocuous form, it might mean that government should remove any governmentally imposed impediments to fair competition. This is obviously a sound goal but it is probably not the goal of most of those advocating a "all-of-the-above" strategy.

Another interpretation might merely mean that no fuel source should be taken off the table by government fiat each fuel has a role in helping meet our energy needs. Under this interpretation, the market would determine the portfolio mix of energy and if one source was more competitive and dominated the market mix then so be it. Government should not be concerned with this outcome. *I don't believe that those who advocate this strategy adopt this meaning.*

I believe they adopt a more pernicious meaning. I think they typically mean that they want the fuel they support *forced* into the mix of fuels to meet energy needs. John McCain for example wants to make sure that the US develops nuclear energy more aggressively. Coal interests mean they want coal to be used more aggressively. Even renewable interests mean they want ***their*** particular form of renewable used in greater amounts. At the turn of the last century, as cars were becoming more popular, horse buggy manufactures demanded an all-of-the-above transportation strategy. Just kidding! But you get the point.

*So my paraphrase of the pernicious meaning of "all-of-the-above" is to heck with market outcomes use government force to **use more of my special interest's fuel/technology**.*

Often, natural gas is the target of some of this rhetoric. If coal and nuke are off the table, then the US will have to rely on natural gas generation. This development concerns some, as it should. Natural gas markets will be distorted by the artificial lack of availability of coal and nuclear as part of the generation mix. But the answer is not to use political muscle to force a certain percentage of coal and nuclear into the mix. Rather it is to adopt policies that allow competitive markets to drive the mix of generation. Competitive markets are typically fairly good at sending signals as to the right portfolio of risk when there are different options with different risk profiles. So "all-of-the-above" should be banned from the lexicon of energy policy strategies in favor of allowing the market to determine the right portfolio of energy resource use.

Seventh, policy must be "robust." What does that mean? Robust means that it must work under any and all conditions. Many books and articles that I have read about energy policy start by stating an **outcome** that the author believes is desirable. Frankly, most start with the premise that we need to radically alter our energy system because of climate change. But there is a fair sprinkling of books between 2000 and 2010 that started with the premise that we were running out of oil. These "outcome" premised books would then recommend a host of actions that would achieve the outcome they wanted.

I like the example of the oil books between 2001 and 2007. Here are just 18 titles of books actually published during that period.

2001	Hubbert's Peak: The Impending World Oil Shortage
2001	The Carbon War: Global Warming and the End of the Oil Era
2002	Resource Wars: The New Landscape of Global Conflict
2002	Supply Side Aspects of Depletion
2003	The 2030 Spike: Countdown to Global Catastrophe
2003	The Party's Over: Oil, War and the Fate of Industrial Societies

2004	Crossing the Rubicon: The Decline of the American Empire at the End of the Age of Oil
2004	Oil, Jihad and Destiny: Will declining oil production plunge our planet into a depression?
2004	Out of Gas: The End of the Age of Oil
2004	The Coming Oil Crisis
2004	The End of Oil: On the Edge of a Perilous New World
2004	The End of Suburbia: Oil Depletion and the Collapse of the American Dream
2004	Blood and Oil: The Dangers and Consequences of America's Growing Dependency on Imported Petroleum
2005	Beyond Oil: The View from Hubbert's Peak
2005	The Final Energy Crisis
2005	The Long Emergency: Surviving the End of the Oil Age, Climate Change, and Other Converging Catastrophes of the Twenty-first Century
2005	Twilight in the Desert: The Coming Saudi Oil Shock and the World Economy
2007	Freedom from Oil

Today, these books look a little silly; we are virtually swimming in oil. New technologies now allow us to produce oil from formations that even a few years ago were thought impossible. We have broken the back of OPEC and it is likely that oil supplies will be plentiful for centuries.

Today, you can read a raft of books about the urgency of climate change. These books then make recommendations based on the premise of climate change. What if today's climate change alarmism is just as wrong as those oil books were?

The point is that our energy policies (and all other policies for that matter) should work no matter what the future turns out to be. Economists express this concern by urging that we focus on "processes" not "outcomes." Policy should set up a *process* that provides incentives to make adjustments to new facts and technologies. Adopting a certain *outcome* as your goal will look pretty foolish if that outcome turns out to be wrong, as was the case with natural gas in the 1970s.

Robustness is the essential difference between capitalism and socialism/central planning. In capitalism, private investors make bets on different outcomes. Some turn out to be right and they become billionaires before they are 40. Others turn out to be wrong and they lose their investment. But there is a built in flexibility that allows for quick adaptation to new information. In socialism, a government entity makes decisions as to how many cars are needed and in what color. Maybe they will be right. But so far history has not been kind to centrally planned economies. Such economies are slow to adapt to new information. Hence the value of ensuring that policies are robust and will work even as new information of a wide variety comes to light.

Let's apply this insight to the natural gas reforms of the 1980s. At the time, the conventional wisdom was that we were running out of natural gas. The Fuel Use Act passed in 1978 banned the use of natural gas in new industrial boilers and new electric generating plants. Based on my first-hand experience at FERC in the economic policy office that developed the blueprint for the reforms that were implemented between 1985 and 1992, I can attest to the fact that we did not predicate our recommendations on any assumption about how much gas we had or what the price of gas would be. Charles Teclaw was the chief architect of the natural gas reforms. He was a devout adherent to the Austrian School of economics. One of their primary insights was to design policy so that it could adapt to new facts and technologies. Today, I am just as surprised as you, maybe more so, as to how central a role natural gas plays today in our energy picture. The architects of the gas reforms had no idea that that's what would be the result of our efforts.

Let's apply this to climate change. There is a heated (pun intended) debate about climate change. Some would completely redesign the electric system around the assumption of climate change being the "most serious threat to mankind." Outcomes not process. Our reform efforts especially of the electric system should be done to ensure that the system works whether or not it turns out that we have a serious climate change problem. Process not outcomes. Structure reform so that as much as possible private investors driven by incentives (such as a carbon harms charge for example) make bets with investor dollars about how serious climate change will be. If it becomes clear that the problem is being hyped, then those who placed big bets on alarmism will be the losers. Similarly, if it becomes clear that the problem is very serious, then the alarmists who bet money on that outcome will be the winners. In any event, consumers and taxpayers should be insulated as much as possible from being put in the role of investor. Historically, government has a very checkered track record of picking winners and losers.

Eighth, this Article is about energy policy and its reform. I adopt a somewhat purist approach when it comes to energy policy. It's a bit like the old joke of three accountants applying for a job. Each is asked how much 2 plus 2 is. The accountant who answered "How much do you want it to be?" got the job. When it comes to energy policy I believe 2 plus 2 equals 4. My answer does not depend on political feasibility or political correctness. Yes, I am biased if you want to use that word in favor of reliance on market forces and somewhat skeptical of government command-and-control policies. In my mind, that is just good policy. There are millions of examples of competitive markets delivering the goods and millions of examples of government solutions that created more problems. So I defend my bias. But it is important to note that many of the reforms and recommendations that flow from my bias are NOT politically feasible **right now**. The bolded "**right now**" is important because times change and the impossible can become possible. Just one example will illustrate this truth. FERC Chairman Mike Butler is reputed to have lost his job in the Reagan Administration because he had the audacity to recommend wellhead deregulation in the early 1980s. House Energy and Commerce Chairman John Dingell was incensed and demanded Mr. Butler's head on a pike. Butler's replacement, Chairman Ray O'Conner instructed the policy office (where I worked at the time) to devise reforms for the natural gas industry that did NOT include wellhead decontrol, which we did in 1985. Long story short, Dr. Phil Sharp, then the chairman of the House subcommittee on Energy and Power and now the President of Resources for the Future, proposed legislation in 1989 to deregulate natural gas. The legislation passed. Dr. Sharp was a consuming state Democrat and a protégé of Mr. Dingell. What we thought was impossible in 1985 came to pass in 1989. My how times change!

Ninth, and lastly, is the issue of research and development (R&D) and innovation. Let's start with the incentives in the private sector to innovate. Thomas Edison is said to have tested over 6000 filaments for the incandescent bulb before achieving success. There are literally thousands of examples of inventors who made a discovery in their garage or basement that changed the world and made them millionaires, even billionaires. Indeed, the Founding Fathers so respected the "discovery" process that one of Congress's few enumerated powers in the Constitution is the so-called "copyright or patent clause." Article I, Section 8, Clause 8 provides an authority for Congress "To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries." The US thus has a system of patents and copyrights that encourages innovators to develop new products and insights and to benefit thereby.

So why isn't that sufficient for research and development? The Federal Government also provides support to research and development in several ways in addition to patents and copyright. First, there are tax subsidies for various types of R&D. Second, there are direct grants to develop R&D. Third, the government itself does R&D.

Energy R&D is affected by all these different types of support. The main role of the Department of Energy is R&D. There is one fundamental policy principle about R&D. R&D can be categorized into "basic" research and "applied" research. Simply stated, *basic research* is research for the purpose of understanding the world such as scientific inquiry into biology or medicine or the universe. *Applied research* is the application of basic research to solve a problem, like building a more efficient turbine or a better wind machine. Again simply stated, most analysts, even most hardline conservatives, recognize a legitimate role for government in supporting basic research on the grounds that it is not in any company's financial interest to pursue science that will benefit everyone and for which they cannot capture a specific benefit. Fewer analysts support government subsidies and support for applied research. The argument is to let the market use basic research to create innovations for which they can capture the benefit in a patent or a copyright. Some, especially those representing special interests who will benefit from the subsidies, believe that the government should also be involved in applied research where there is arguably some benefit to society.

The tricky part of government supporting applied research is the concept of "crowding out." Crowding out in this context means that government support of applied R&D in certain areas will chill private sector support for R&D not only in that area but potentially in other areas that might compete with the applied area.

Then there is the problem of government picking winners and losers. Government is notoriously incompetent at picking technological winners and all too often wastes taxpayer dollars supporting losers. Recently the US Government spent billions of dollars to support "green" technologies as part of the stimulus package, only to have many of the supported companies go bankrupt. Problematically, many of the dollars flowed to powerful Democratic supporters. (To be fair, Republicans also often embrace crony capitalism when they have the power to do so.)

An example may be helpful to illustrate several lessons about energy R&D. Two energy technologies have had dramatic impacts on energy markets in recent years: natural gas turbines and fracking. Long story short, neither of these revolutionary technologies resulted from support from the Department of Energy. In the case of turbines, the Pentagon in the early 1980s supported development of more efficient turbines so their jets could fly longer distances without refueling. The private sector took advantage of this technology improvement to develop combined cycle natural gas generation. In the case of fracking, even the New York Times recognized that the heroic effort of George Mitchell, a successful Texas independent producer, was responsible for the revolutionary technology of fracking.

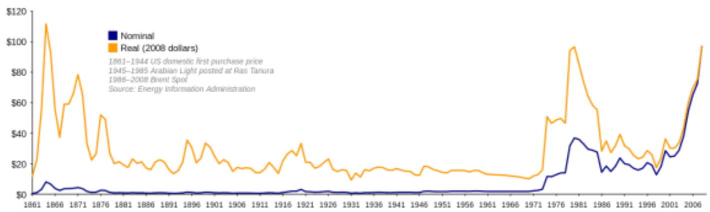
The upshot is that we need to be very careful about government support of R&D. The right R&D can be revolutionary but the wrong support can distort markets, waste taxpayer dollars, and incentivize a feeding frenzy of lobbying to allow more pigs to feed at the trough.

III. A Brief History of Energy Policy

There is one date that is relevant beyond all others in the history of energy policy: October 16 and 17, 1973. On those days, the *Organization of Petroleum Exporting Countries* or ***OPEC*** raised the price of a barrel of oil by 70% and put an oil embargo in place against certain countries, including the United States. Given the impact of this price increase and the flexing of OPEC's muscle, everything we thought we knew about energy had to be reevaluated. To say that chaos reigned in US energy policy since then might only be a tad strong.

Energy Policy before 1973

The key word to describe energy policy prior to October 1973 would be stability. Oil prices were virtually flat in real terms for nearly a century. Electric prices had been declining for decades because of advances in generating technologies and economies of scale. Residential electric prices from 1960 to 1973 fell from 21 cents to about 13 cents per kWh in real terms, despite dramatic increases in consumption. Nuclear energy was going gangbusters with over 100 plants approved in the U.S. during the 1960s and 1970s.



Natural gas was comprehensively regulated by the Federal government since 1938 and a Supreme Court case in 1954 held that the Federal Power Commission had the authority to regulate wellhead prices of natural gas that was eventually shipped in interstate commerce. This kept natural gas prices stable and low until the OPEC Embargo – although price controls caused some severe shortages in States that imported natural gas from producing States.

Relatively cheap and abundant energy fueled the industrial revolution and the engine of American prosperity. US energy policy was generally pro-development and had begun to ameliorate some of the environmental harms that were the consequence of its rapid economic growth. Addressing air and water pollution began to be taken seriously during this period.

Energy Policy Since 1973

To say that the OPEC Embargo was a momentous event in the US is an understatement.

Since energy has many forms that can be substituted for one another in certain uses (industrial boilers can use natural gas or oil; electricity can be used to heat homes competing with oil and natural gas), the dramatic increase in the price of oil overnight had dramatic ripples on other energy resources. President Nixon gave two nationally televised speeches within about a month of the oil embargo. Emergency legislation was put in place within six weeks.

A national quest for "energy independence" entered the political lexicon. Over the next 7 years a myriad of energy policies were enacted, many of which remain with us today:

- oil price ceilings
- oil export prohibitions
- vehicle mileage standards
- strategic petroleum reserve
- subsidies for renewables
- subsidies for energy efficiency
- subsidies for oil substitutes
- natural gas and oil consumption regulations

In 1978, Congress passed the National Energy Act, a conglomeration of 5 statutes comprehensively enacting a wide variety of energy policies, all aimed at the mantra of "energy independence."

As discussed more fully in the **Supply Chapter** and **Commentary 1**, "energy independence" is a silly goal. Oil trades in a global market and countries pay the same price on the global market whether they have indigenous resources (Britain's North Sea reserves) or no such resources (Japan). Oil producing countries have built their economies on the expectation of oil revenues and need a steady revenue stream to support their economies. Indeed, there is even an economic concept known as the Dutch Disease or Holland Effect that posits that an abundance of natural resources can actually have a perverse effect when a country over relies on resource development and ignores manufacturing and agriculture. The recent dramatic drop in oil prices has had a profoundly negative effect on many oil producing economies, many of which are our adversaries in foreign affairs.

To be sure, large producing countries can manipulate how much supply to put on the market and thus influence the price of oil. But energy independence does not protect against such price fluctuations. If a producer in Canada can get $90 a barrel on the global market, why would anyone sell it for $50 to the US or Canada? Thus the goal of *energy independence* is a shiny object to keep our attention on things that don't matter. I suspect that "energy independence" is and was always just a buzz word to motivate the public to embrace whatever the speaker advocated regarding energy or foreign policy.

What does matter, however, is that the US should have sound energy policies that facilitate competition among all of our natural resources. Yet we adopted policies that flew in the face of trying to break the back of OPEC market power:

- limited exploration and production rights on Federal land and offshore areas;
- moratoria prohibiting exploration and production in deep and shallow water areas of the Gulf of Mexico and Alaska;
- multiyear delays in approving pipelines;
- EPA clean water and clean air regulations that restrict drilling and mining;
- the prohibition of exports of oil and multi-year delays in granting export licenses for natural gas;
- continued regulation of natural gas and oil prices.

The Federal obstacles are compounded by the prohibition and restrictions at the State level. Many States made it difficult to build electric transmission though a State that would have permitted "coal by wire." That is, producing electricity by coal say in Ohio but shipping it to New England to displace that region's heavy reliance on oil. But the electric transmission wires would have to go through states such as Pennsylvania that did not need electricity so they blocked the construction of necessary facilities. New York's recent ban on fracking and horizontal drilling in the economically distressed Western counties of the State is another example of how bad policy can frustrate efforts to improve our energy situation.

Federal mandates and prohibitions are often not in accord with the cultural and constitutional American guaranties of personal liberty. Most Americans will accept government regulation on matters that genuinely contribute to the common good, but resent and will resist rules that affect their lives for a trivial or imaginary benefit. A compelling example is the creeping ban of incandescent light bulbs that in one year will produce miniscule energy savings when compared to total energy consumption, the replacements of which cost considerably more.

As you can see in the graph above, the price of oil fluctuated dramatically from 1973 to the present. With each dramatic fluctuation, there was agitation for government to take some action in the name of "energy independence."

President Carter had a very statist approach to dealing with the energy crisis. His "Moral Equivalent of War" speech was about energy. He proposed and was successful in getting Congress to usher in a host of interventionist policies to address the energy crisis in 1978. The explicit goal of the **National Energy Acts** was to reduce reliance on oil and natural gas and increase reliance on coal, nuclear, renewables, and conservation.

Six things happened between 1978 and 1988 (ten years, a blink of the eye in energy timeframes) that undermined the key assumptions made by President Carter.

- First, President Reagan allocated significant amounts to the military. One of the things they needed was a jet engine that could travel further on a given amount of jet fuel to eliminate the need to refuel in order to make longer trips. The research on efficient turbines resulted in the ability to use natural gas much more efficiently to generate electricity (combined cycle). This undercut President Carter's belief that natural gas should not be used for electric generation.
- Second, FERC adopted a radically changed regulatory paradigm for natural gas that relied very heavily on markets, resulting in an aggressive successful search for new supplies. This undercut President Carter's belief that we were running out of natural gas.
- Third, DOE published a study in 1988 that dramatically changed in the perception about the abundance of natural gas. This further undercut President Carter's belief that we were running out of natural gas.
- Fourth, on June 13, 1988, Dr. James Hansen of NASA first testified about the impact of carbon on global warming. This undercut President Carter's belief in using more coal for electric generation.
- Fifth, Three Mile Island meltdown occurred in 1979 and the Chernobyl nuclear accident happened on April 26, 1986. This undercut President Carter's belief in using more nuclear for electric generation.
- Sixth, despite significant efforts in conservation and efficiency, electric demand continued to rise, increasing 36% in the decade from 1978 to 1988. This undercut President Carter's belief that we could use less energy.

So within less than a decade, coal, nuclear and conservation were completely discredited as energy strategies and our assumptions about the role of natural gas in electric generation were turned on its head. This is perhaps the best possible energy example of the concept of "fatal conceit," pioneered by Friedrich Hayek. He believed that central government could never have sufficient prescience about the future to plan economies. Only free markets could transmit nearly instantaneously changes in the supply and demand equation and allow markets to make quick and sound adjustments based on accurate and timely information of new and unexpected developments.

President Reagan had a very different worldview on energy from President Carter. He made some progress toward establishing market reliance in energy the dominant policy of the US. His **first** Executive Order used his authority under the powers granted to the President under existing legislation to deal with energy emergencies to lift price controls from oil. He also made it clear that he wanted to establish competitive policies for natural gas. As previously mentioned, during the seven years between 1985 and 1992, a myriad of governmental actions were made in the natural gas arena that resulted in a dramatic restructuring of the natural gas industry from statist to competitive policies.[5]

President Reagan also shut down the Synthetic Fuels Corporation, believing that government should not subsidize the development of alternative fuels. Rather, he believed that free markets would best ensure development of the most economic supplies.

But many interventionist policies remained and are still with us today.

Congress has also passed several energy bills after the Reagan Administration. Not surprisingly, many of these bills produce major interventions into energy markets.

During the 1990s, there was an effort to apply some of the competitive lessons of the telecommunications and natural gas industries to the electric industry. This has had a mixed success and is discussed more comprehensively in the **Electric Chapters** and **Commentary 2**.

---

[5] Full Disclosure: The author of this Article was one of the architects in establishing the competitive policy on natural gas while an official at FERC and the Department of Energy from 1981 to 1996. As with all self-serving statements, one should be as skeptical of these claims regarding natural gas as one would be about any self-serving statement and independently verify these claims. See MIT Professor Dr. Paul Joskow, Natural Gas: From Shortages to Abundance in the U.S. (2012)

IV. Energy by the Numbers

The statistics of energy can be mind boggling and for the most part are not all that important to understanding energy policy: good policy is good policy and bad policy is bad policy. But it may help to have some broad perspective of the magnitude of energy resources and how we consume energy. What follows are the 10 most important facts about energy.

Fact 1. *Fossil fuels dominate our use of energy.*

The world uses about 12,730 units of energy, about 20% of which is used by the US (2,265). This column compares which energy sources the world and the US use.[6]

	World	US
Oil	**33%**	**37%**
Natural Gas	**24%**	**30%**
Coal	**30%**	**20%**
Nuclear	4%	8%
Hydro	*7%*	*3%*
Renewable	*2%*	*3%*

First, the US uses energy supplies in roughly the same percent as does the world. Second, fossil energy (**bold**) accounts for about 87% of the world's use of energy, the same as in the US. Third, for all its attention, you can see that renewable energy (*italics*) is less than 10% of the energy we use, and some environmentalists object to including hydro in the renewable category.

Fact 2. *Energy use is closely linked to economic activity, not population.*

Both the US and China each use about 20% of the world's energy. The US has about 5% of the globe's population while China has about 20%. This leads some to criticize the US for being piggish because we use a greater percentage of energy compared to our population size. While there is some debate about this, it appears that China and the US each account for about 20% of the global economy (GDP). So the correct comparison for the amount of energy a country will use is its economic activity not its total population.

[6] This is expressed in millions of tonnes of oil equivalent. One of the confusing aspects of energy is that there are many ways to express the same concept, i.e., British Thermal Units (BTU), Joules, calorie, or kWh.

Fact 3. *Fossil fuels dominate in the generation of electricity.*

About 40% of the energy used in the US is used to generate electricity. The following shows which energy sources are used to generate electricity.

Coal	**39%**
Natural Gas	**27%**
Nuclear	19%
Hydro	7%
Wind	4.13%
Biomass (including ethanol)	1.48%
Geothermal	0.41%
Solar	0.23%

Fact 4. *Liquid energy dominates in the transport of people and goods.*

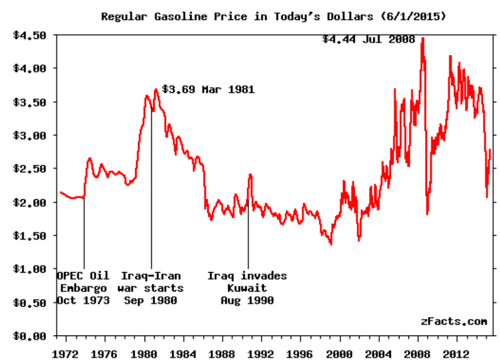
About 28% of energy used in the US is oil for transportation of goods and people. But of that 28%, nearly all the energy consumed in the transportation sector is oil or a derivative product, i.e. gasoline or jet fuel. Some analysts believe that we should diversify the transportation sector by encouraging greater use of natural gas or electric vehicles. This position is largely driven by either environmental concerns or concerns about the security of supply of oil. The environmental question related to air pollution from cars but modern technology has reduced by over 90% the air pollutants from cars. The remaining concern relates to carbon emissions. The issue of carbon emissions is dealt with elsewhere. Regarding security of supply, that has changed dramatically over the last several years and provides a weak rationale for diversity. Inexpensive natural gas supplies might provide a rationale for some increase in the use of natural gas for transportation.

Fact 5: *Energy imports are volatile.*

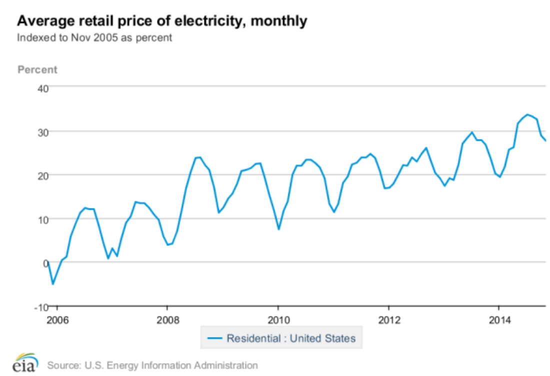
As recently as a few years ago, the US imported 60% of our oil. But more recently we import about 25%, as a result of lower demand and increased US supply. As oil prices have dropped dramatically recently, one could expect that our use of imports of oil will increase since our oil production is more expensive than other regions with cheaper supplies. The **Supply Chapter** and **Commentary 1** discuss the issue of whether we should be concerned about oil imports.

Fact 6: *Energy prices are volatile.*

There are two energy prices with which most of us are familiar: gasoline prices and electric prices. The following two graphs will give you some idea of the volatility of these commodities.



This graph shows gasoline prices from the OPEC Oil Embargo to the present. Two things are noteworthy. First, international events have an impact on oil prices. This is a reflection of the risk of supply disruptions and the risk premium built into the price of oil and therefore gasoline. The second is the dramatic volatility over time. Gasoline prices can fluctuate significantly. The significance of these two points is that it is folly to base policy on an expectation of future oil/gasoline prices. Rather, policy needs to support a robust dynamic that allows rapid adjustment to new developments.



This graph shows monthly electricity prices for residential customers over the last decade. Two observations are noteworthy. First, there is a cyclical pattern to electric pricing. This is a reflection of how we use electricity. We use more electricity in the summer for air conditioning and in the winter for heating (peak periods) and less in the spring and fall (off peak periods). Second, the obvious trend over the last decade is for electric prices to increase. While increasing competition in the electric industry will no doubt result in efficiencies that will have positive impacts on the economics of the industry, it is not necessarily the case that prices will be lower. As discussed in the chapters on the electric system, there are many factors that are at play in the electric system that will have an impact on price.

The significance of these facts is that since oil prices became volatile in 1973 because of the OPEC Oil Embargo energy prices have been and will remain volatile. The key point is that this should affect your strategy in consuming energy. Expect volatility. Don't overinvest in energy efficiency technologies on the assumption that prices will always be high and increasing. Don't ignore the energy efficiency characteristics of your energy consuming purchases on the assumption that energy will always be cheap.

Would life be less complicated without the roller coaster of energy prices? Sure. But that is not the world we live in.

Fact 7. *The US has lots of energy.*

Doomsday analysts are always predicting that we will face shortages of a variety of things necessary for life. They typically extrapolate population growth and known resources and predict a catastrophe at some point in the future. There was even a famous wager between two esteemed scientists on scarcity of resources versus abundance. Abundance won! The key point to understand is that human ingenuity is always underestimated. We always create new technologies and business processes to find, produce, and use energy.

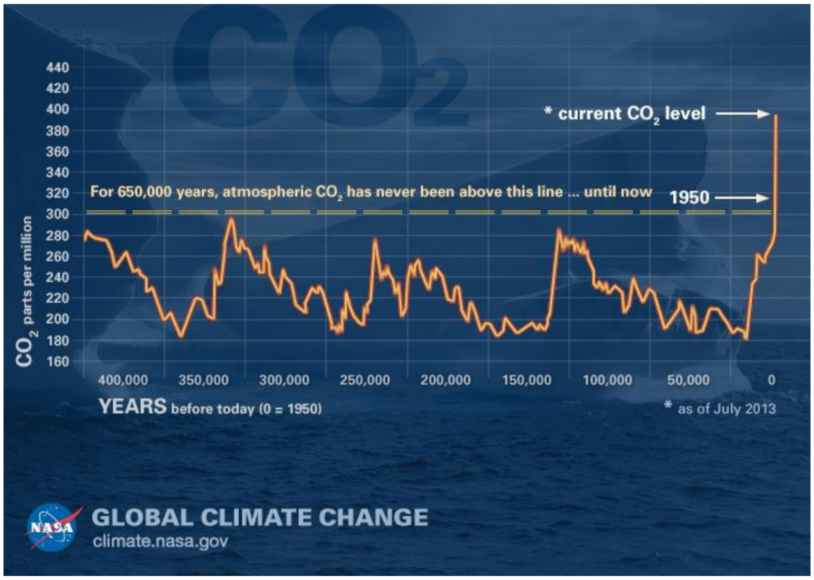
Lately, the big story is hydrologic fracturing (fracking). As a result of that technology, we now realize that we have hundreds of years of oil and natural gas more than we thought just a few years ago. So I could bore you with lots of statistics and charts about abundant energy resources but the bottom line would be the same. We have lots of energy and we will figure out lots of ways to find and use even more energy in the future. The main issue with abundant energy is whether there are government policies that make it difficult or unprofitable to use the energy we know we have. **Commentary 1** on oil markets provides a more in-depth discussion of resource abundance.

Fact 8. *Carbon concentration in the atmosphere has been increasing over the last century.*

You can't discuss energy policy without the issue of climate change rearing its head. So let's deal with it. The first thing to realize is that there are facts, theories, speculations, and outright lies, ironically on both sides in the debate. And it is hard to distinguish among them in all the clatter in the media. Second, I don't have all the answers. No one does. We learn more each year and some of what we learn leads in different directions. **Commentary 3** on the Consensus on Climate Change deals with this issue in more depth.

But let's start with some facts that no one would disagree with.

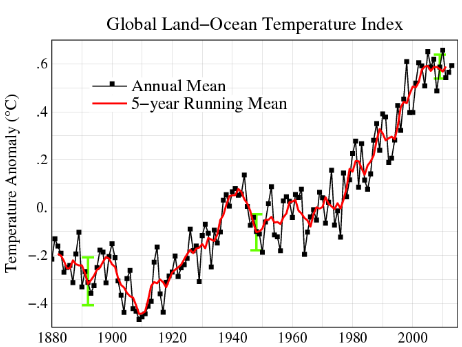
Using fossil fuels for energy has increased dramatically since the industrial revolution. Using fossil fuels releases carbon dioxide into the atmosphere. We can measure that. The amount of carbon in the atmosphere has increased over the last 100 years. NASA put a man on the moon and also produced the following graphic.



The graphic shows the parts per million of carbon dioxide in the atmosphere and it shows how this compares over a long historical period. Looks scary to me!

But the real question is the impact of an increase in the concentration of carbon in the atmosphere. Let's be clear. The graph shows that the atmosphere went from being .000180% carbon to .000380%. That's less than .04% of the atmosphere. Seems like a small amount when compared to the total atmosphere. But does this increase and any future increase bring us to a tipping point where it starts to affect climate? To be continued.

Fact 9. *The earth's temperature has increased by about 1 degree centigrade over the last century but has not increased in the last two decades.*



The graph below shows that there has been an increase of about 1 degree centigrade over the last century. Does anyone list a 1-degree increase in temperature during the 20th Century as one of the most dramatic developments of the century? No because it is gradual and we make adjustments over time. Yet given that Fact 8 showed an increasing concentration of carbon in the atmosphere, some posit that this increase in temperature is caused by the increase in carbon emissions. But if you look closely you can see that 1998 was the highest year and that it has not increased since then. This lengthy "pause" in temperature increase (contrary to all the climate model projections) at the same time that the global carbon emissions have increased by about 33% leads some to question the correlation between temperature and carbon dioxide.

Fact 10. *Very little carbon is emitted by using fossil fuels for energy by both the world and the US in comparison to natural emissions.*

A lot of different things contribute to the "greenhouse effect." Based on the debate you would likely surmise that man-made, also called anthropogenic, emissions account for a lot of the greenhouse effect. But actually man-made contributions account for very little. "Natural" emissions account for nearly all the greenhouse emissions. The graph below breaks it down and it is a very complicated statistical analysis but the bottom line is that man accounts for about a quarter of one percent of greenhouse emissions.

Anthropogenic (man-made) Contribution to the "Greenhouse Effect," expressed as % of Total (water vapor INCLUDED)

Based on concentrations (ppb) adjusted for heat retention characteristics	% of Greenhouse Effect	% Natural	% Man-made
Water vapor	95.000%	94.999%	**0.001%**
Carbon Dioxide (CO_2)	3.618%	3.502%	**0.117%**
Methane (CH_4)	0.360%	0.294%	**0.066%**
Nitrous Oxide (N_2O)	0.950%	0.903%	**0.047%**
Misc. gases (CFC's, etc.)	0.072%	0.025%	**0.047%**
Total	100.00%	**99.72**	**0.28%**

There is very little debate about this fact. But there is a huge debate about the significance of these man-made emissions.

V. Environmental Protection

Let's wrap our head around the three E's: economics, environment, and energy or what I like to call ecoviergy.

Economics: competitive markets are great at many things and usually work well. As briefly discussed in **Chapter 1**, however, sometimes markets fail. Policy is the application of sound economics, including market failures, to real world problems.

Environment: markets sometimes fail when environmental costs are not included in the market price a good, technically called an "externality." Effective policy adopts tools to include costs of serious environmental harms into the price of a good, called "internalization." But *ineffective* government intervention can also cause problems in markets. The trick is finding the serious externalities and capturing the greatest benefit for the least cost using the right tools.

Energy: environmental externalities exist in nearly all energy markets. Adopting policy in energy markets that requires effective internalization makes energy policy very complex. But it is undeniable that environmental policy and energy policy are inextricable.

Ecoviergy is analysis that integrates the principles of ***eco***nomics, en***vir***onment, and en***ergy***. I coined this term to emphasize that need for such integration. Many commentators engage in silo thinking that emphasizes one aspect of this complex integration and thus reach distorted recommendations on energy policy.

This chapter deals with some of the big picture environmental issues. More detailed discussions of the environmental issues are covered in the discussion of specific energy issues.

Books are written on environmental issues in the energy sector, but the key environmental issues relate to the following issues:

- Air and water pollution
- Land use issues required for infrastructure development, damage caused by production of fossil fuels, and storage of nuclear waste
- Climate change and carbon dioxide

First, let's acknowledge that the US has made major progress on serious issues of energy and the environment. Nearly every such discussion trots out the fact that the Cuyahoga River caught fire due to water pollution a number of times starting in 1869. Additionally, air pollution was a real problem in the 1960s and 1970s and remains a problem today, though less so, in parts of the US. Much of the cause of this air and water pollution can be traced to energy production and consumption. Major actions were taken in the 1970s and today by **all accounts** there is much less water and air pollution than 4 decades ago. Some might quibble with the tools used to achieve this accomplishment but you cannot quibble with the results. There are additionally innumerable other examples of environmental protection that have been enacted that move the energy industry toward cleaner policies, even if it is sometimes done in an unnecessarily costly manner.

Second, let's acknowledge that all uses of energy have some impact on the environment. By definition, all actions to require the internalization of costs in the price of energy will increase the price of energy. And market distortions can result by increasing energy prices higher than they need to be to achieve an effective level of environmental compliance. Especially tricky is the fact that different energy sources compete with each other and ineffective environmental policies can create energy market distortions.

Third, our goal cannot be to eliminate all pollution. As desirable a goal as that seems to be, we simply could not live our lives without some pollution. This is where the concept of "opportunity cost," also called "tradeoffs," becomes important. If I have $10, I cannot go to a movie for $5 and a lunch for $7. The opportunity cost of going to the movies is that I cannot buy a $7 lunch. In the environmental context, if I want a very clean environment, then the cost will be accordingly high and I will use less energy and there will be fewer jobs and less money for other goods and services. So balancing the different goals we have can be a difficult process. The best tool for understanding these tradeoffs is called cost-benefit analysis. Long story short, the benefits of any environmental policy should be higher than the costs. Given that these policies are largely made in a political process, it is not surprising that much of our energy policy relating to the environment leaves much to be desired.

Air and Water Pollution

Emissions into the air and water can cause serious health risks. Given that air and water pollution do not recognize State borders, few would disagree that it is appropriate for the Federal Government to take action to ameliorate the impact of air and water pollution. But what is the "right" action to take?

There are several basic approaches to dealing with pollution.

Technology Standards: the government determines the "best" technology and mandates its use and/or prohibits certain technologies. A good example of this relates to pollution from cars. Air pollution from cars used to be a much more serious problem. This has been significantly ameliorated by Federal requirements that cars meet certain technological standards that have been increased over time. The Federal government requires that cars meet a miles-per-gallon (mpg) standard, catalytic converters, and unleaded gasoline as pollution prevention policies (though mpg has also been advocated to reduce oil imports). Many economists do not support "technology" standards because they freeze innovation (also called premature lock-in) around other alternatives to achieve the same ends that might be more cost effective. For example, a sound argument could be made that catalytic converters are now counterproductive. Modern computer technology (including fuel injection) significantly diminishes the inefficiency of the fuel mix ratio justifying catalytic converters in the mid-1970s. The best argument for technology standards is that pollution reduction is less uncertain than other options and it at least incentivizes technology innovation around the mandated technology (called technology forcing). But economists generally agree that imposing technology standards are usually more costly than other alternatives.

Harms Charges: the government sets a price on the unit of pollution and charges this price to the polluter, who then includes the price in its output. The incentive is for the polluter to either become more efficient or to find a less polluting alternative to the polluting fuel in order to reduce costs and make more sales. This promotes greater efficiency but is less certain in achieving the goal of pollution reduction, i.e., it may be worth it to the manufacturer to pay the harms charge and use more energy thus increasing pollution. Additionally, some mistakenly believe it is simply morally wrong to sell "rights to pollute."

Trading Programs: government determines the approximate amount of pollution it is willing to tolerate and sells/gives away permits to pollute up to that level. Such permits can be bought and sold in an open market. The price of the permit is then included in the cost of doing business. This provides incentives to use the most efficient technology (which often cannot be known years in advance since entrepreneurs will innovate once the permit price is established) or to find less polluting alternatives. Trading for sulfur oxides and nitrogen oxides was pioneered in the early 1990s with amendments to the Clean Air Act. That program has been generally been regarded as successful. This seems similar to a "harms charge." But in a harms charge approach there is no certain limit in emissions but certainty of the price of pollution. In a trading program, there is certainty to the limits to emissions, but volatility and gaming in the price of pollution. Pick your poison.

Economists typically oppose technology standards and favor harms charge or trading approaches, with a slight tilt to harms charges as being easier to implement and less bureaucratic.

Land Use and Infrastructure Development

NIMBY stands for "not in my back yard." BANANA stands for "build absolutely nothing anywhere near anything." And NOPE stands for "not on planet earth." All three express the common sense attitude that no one wants a nuclear power plant in their neighborhood.

Perhaps more than any other industry, however, the energy industry faces challenges over the need to build infrastructure. And there is no doubt that some balancing is necessary. One need only look at the Keystone Pipeline debate to see how politicized these decisions can become.

The list of issues would be quite long of all the types of land use and infrastructure issues posed by energy facilities, but the following are illustrative:

- Oil and Natural Gas Pipeline Siting (typically in rural settings)
- Electric Transmission Siting (typically in rural settings)
- Gas and Electric Distribution Siting (typically in urban and suburban settings)
- Liquefied Natural Gas Facilities
- Wind Farms
- Solar Farms
- Nuclear and Coal Power Plants
- Hydro Facilities
- Oil and Gas Drilling
- Coal Mining
- Uranium Mining
- Waste Caused by Nuclear Generation
- Waste caused by Coal Ash

The American Society of Civil Engineers in a 2013 report gave the US a D+ for policies related to the development of energy infrastructure.

An excellent case study of the problems of infrastructure development involves electricity in New England. The New England States have made four things perfectly clear:

1. their hostility toward nuclear and coal plants in their region;
2. their hostility toward natural gas and electric delivery infrastructure (pipelines and transmission lines);
3. their preference for increased investment in efficiency and renewable energy; and
4. their view that natural gas use for electric generation should be a short bridge from fossil/nuclear to efficiency/renewables.

Well, the chickens have come home to roost. The last three winters have magnified the flaws in this strategy. During the coldest weather, natural gas pipeline capacity and storage were used for natural gas home heating, since they had paid for such firm capacity. Thus there was insufficient pipeline capacity during these cold days to use natural gas for electric generation, which relies on cheap prices for using pipeline capacity when not being otherwise used by firm customers. Even having taken extreme measures to use environmentally undesirable generation alternatives (diesel oil), electric prices on the spot market at times soared from about 18 cents a kWh to over 100 cents. Businesses closed down for days, weeks, or months to avoid these prices, in line with the market's reaction to scarcity. Well, New England is panicked.

Given the regions unique energy issues, the Governors created a committee to deal with electricity issues in 2006. That committee (New England States Committee on Electricity or NESCOE) has been tasked to divine a strategy for getting more natural gas to the region. But environmentalists oppose new fossil fuel capacity and electric generators refuse to take the risk of paying for firm pipeline capacity to be built when it will be used for only those days when it is very cold. At some point, it is at least possible that all hell will break loose. The policy problem has little to do with natural gas pipeline policy. It has everything to do with New England's uncompromising attitude on climate change. Nothing, let me repeat that, nothing that New England is doing on climate change will amount to a spit in the ocean in terms of global temperature in 2100. In the meantime, it is risking lives and treasure in a mindless pursuit.

Climate Change and Carbon Dioxide

Climate change concerns are founded on the belief that CO2 emissions from the combustion of carbon-based products such as oil, natural gas and coal will cause global atmospheric warming that will slowly but inexorably increase worldwide temperatures that will melt the polar ice caps and glaciers, resulting in rising ocean levels that will inundate islands and coastal areas. Global warming is also believed to increase the frequency and intensity of summer and winter storms worldwide, as well as droughts and a myriad of other bad things.

To prevent this disaster, advocates argue that carbon-based energy should be gradually replaced by renewable energy such as wind, solar, and tidal, supplemented by ethanol and biomass, hydrogen fuel cells, and eventually nuclear fusion. Strangely, nuclear electric generation is not popular even though it does not create CO2. High dams are opposed because of earthquake risk and because the reservoirs created alter the natural environment and affect the ecosystem.

Perhaps the most controversial issue is whether using fossil fuels for electric generation causes global warming. Obviously, agreeing on a harms charge for carbon will depend greatly on one's view of global warming and whether a harms charge/carbon tax or cap and trade system would be an effective policy for dealing with the possibility of global warming. But, in principle, these two approaches are typically viewed as an effective way to deal with serious environmental issues relating to generation.

While a very complex issue, it is premature to develop regulations that radically curtail carbon emissions. What should a thoughtful person think about climate change?

There are extremists and ideologues on both sides of the debate and it is easy to become confused by listening to these extremes. The "alarmists" are renowned for making predictions of calamity that never quite seem to happen and to attribute every weather event to "climate change," the latest being the uptick in the summer of 2015 of shark attacks on the east coast. There are thousands of reports and blog entries that catalog the shoddy analysis of many of the alarmists. There is also ample evidence that many activists use "climate change" hyperbole as a critique against Western Civilization and capitalism, a not-so-hidden agenda.

All too frequently, however, some of those of a conservative persuasion try to deny that there is extremism on the side that opposes climate change. There are "extremists" on the skeptical side of the debate. To believe that one KNOWS that global warming is a hoax is to deny the work of very respected skeptical scientists that agree that relatively more carbon concentration can have a "greenhouse" effect (Dr. Roy Spencer, University of Alabama, Dr. Judith Curry, Georgia Tech, Dr. Richard Lindzen, MIT, Dr. Willie Soon, Harvard, and Dr. William Happer, Princeton to name a few). Even the most authoritative skeptical publication states at page 4 that "Atmospheric carbon dioxide (CO2) is a mild greenhouse gas that exerts a diminishing warming effect as its concentration increases." This is settled science but in and of itself it is a meaningless fact. We know the sun has a warming effect yet we don't try to prevent the sun from shining.[7] The issue of the *degree of impact* that carbon concentration has is highly debated. But in their haste to characterize environmental alarmism as a plot against capitalism (which for many it is, see Naomi Klein's book "***This Changes Everything: Capitalism vs. The Climate***"), skeptics sometimes feel compelled to deny some legitimately settled scientific issues.

> *At a fundamental level, climate skeptics who play down the effects and risks associated with global warming are just like climate advocates who hype them. Each side has an agenda and the loudest, high-profile voices of the two sides often use selective evidence and freighted polemics to advance their respective agendas. If reasoned heads continue to call out the disruptive antics of both sides, perhaps that will widen the space for a more nuanced and constructive dialogue.*

Climate Extremists Shrink the Space for Reasoned Debate.

[7] Indeed, there is now concern that even the Sun may "go quiet" and usher in an era of cooling.

Three points about extremism and climate change. First, alarmists receive inestimably more funding than skeptics from the Federal Government and other funding sources. Thus they seem to have more voice and credibility. Second, possibly relating to the first, there is far more "extremism" in my judgment on the alarmist side than on the skeptical side of the debate. The main piece of evidence for this is that alarmists refuse to debate skeptics and seek to shut down debate with statements like "the debate is over" and "97% of scientists agree" and skeptics/deniers should be prosecuted or worse put to death. There is even a campaign to prevent skeptics/deniers from getting their views published in the press and in academia. There is no commensurate movement from extremists denying climate change. Indeed, the alarmists' opposition to debate seems positively anti-scientific. The essence of the scientific method is skepticism.

> Being a good scientist requires patience, perseverance, imagination, curiosity, and skepticism; the essence of science is to doubt without adequate proof. Science also requires knowing how to make and interpret observations (which presupposes a broad point of view), how to ask the right questions, how to theorize without getting lost in the details, and knowing when to do experiments and apply statistical tests.

Rothchild, An Eclectic Overview of the Practice of Science. Third, the belligerent extremists believing in global warming far outnumber the skeptical extremists.

Yet it would be unwise for the sake of science or policy to assume that "truth" lies somewhere in the middle. That is just lazy thinking. Both sides can be right about some things and both sides can be wrong about some things. It seems important to try to, as objectively as possible, state the best analysis of what we know and don't know about climate change, while leaving political agendas out of it.

One must be careful about some of the rhetoric regarding climate change. It is often claimed, even by President Obama, that "97%" of scientists believe in climate change. Since such a strong "consensus" exists, so the argument goes, the "debate is over." While there is a strong consensus on some issues relating to climate change, the totality of the factors affecting atmospheric temperature climate change is very complex and it is completely incorrect that there is a "consensus" on ***all important issues*** relating to climate change. **Commentary 3: The Consensus on Climate Change: Facts and Myths** considers these issues in more depth.

There are two macro umbrellas under which most questions fit and that it is useful to keep them separate in trying to understand the debate. The first is **SCIENCE.** What do scientists say about climate change? Where do they agree and where do they disagree? From a solid base of understanding the certainty/uncertainty of scientific facts, we then have the second umbrella of questions: **POLICY.** What should the government do? This does not preclude *individuals* from doing whatever they want to do in pursuit of their own views. If you are a change enthusiast and you want to be a vegan and ride a bike, then have at it. If you are a change skeptic and want to buy an SUV and eat meat, then have at it. This **Article** is solely concerned with what government should force all of us to do in pursuit of a coherent position on climate change.

The "uncertainty" question is at the heart of the debate. We all make decisions in the face of uncertain information. Should I lose 5 pounds to avoid a heart attack? Should I buy life insurance? Should I marry this person? The wisdom of each of these actions will depend on uncertain events that will occur in the future, sometimes very far into the future. Should that uncertainty paralyze us to inaction? The more certain a given outcome the more confident we will be in our decision. The more uncertain the probability of harm the less confident we will be.

Balanced against the uncertainty of outcome is the cost of avoiding that outcome. It may make sense to take action if there are low costs to avoid an uncertain outcome with potentially large harm (life insurance). It may also make sense to take action if there are high costs to fairly certain harm (health insurance). The tough call is what to do if there are high costs and an uncertain harm. Unfortunately, that may be the case with carbon emissions and climate change. The following is a brief overview of the key issues relating to uncertainty.

Science Questions

Has the earth been both colder and warmer than it is today?
Yes.

Has the earth's climate warmed in the 20th century?
There is some uncertainty about this because of temperature reading technology (we may just be better at measuring temperature than we were 100 years ago) but on balance it seems that the better view is that the earth has warmed by about 1 degree Celsius between 1950 and 2000. There is even a debate about the accuracy of this temperature increase because of the placement of ground based thermometers, i.e.,

topography changes over time such as the urban heat island effect. Satellite technology is now used to measure global temperatures and is generally conceded to be more accurate.

Has the earth warmed, stalled, or cooled since 2000?
The earth has not warmed since 2000. The warming appears to have leveled or "paused." It is very uncertain whether the earth has cooled or merely maintained a level temperature.

Are manmade carbon emissions causing an increase in the earth's temperature?
There is strong scientific theory that increased carbon emissions in the atmosphere will result in some increase in temperature.

There is however strong debate about how much a given amount of carbon emissions will increase warming. There is also a strong understanding that we do not know how clouds, ocean vapors, cosmic rays and aerosols will impact this warming.

Thus there is significant debate as to the impact of carbon emissions over the next century.
The numerous climate models that have been used to predict a dramatic increase in global temperature in 2100 **did not predict the leveling of temperature over the last 18 years**.

How much carbon dioxide does man emit compared to natural carbon emissions?
Three things emit carbon into the atmosphere: ocean, manmade fossil fuel burning, and natural processes. Manmade fossil fuel burning is responsible for a very small, almost infinitesimal, amount of carbon emissions.

Some believe however that even this small amount is a tipping point that will trigger higher temperatures. But there is significant disagreement on this point.

What is the likely impact on the earth of possible temperature increases?
Basically there are two types of impacts: good ones and bad ones. The bad impacts get the most press. Increased temperature could result in: floods, productive land becoming unproductive, droughts, etc. Good impacts do not get much press. Increased temperature might result in a net increase in productive land (Siberia can grow wheat), less deaths from cold (on balance more people die from cold than heat), etc.

Given that temperature changes will take place over long time periods humans will react to changes and thus adapt to new geologic and climactic realities. Thus, it is debatable as to whether the impact of temperature increases will be on net positive or negative.

What actions would eliminate, ameliorate, or reverse such temperature increases?
This is perhaps the greatest uncertainty. The go-to solution of alarmed advocates is to eliminate man's reliance on fossil fuels. But this has a significant impact on the cost of energy and concomitantly the economy and our standard of living and the standards of living for developing countries. And there is significant debate as to how effective this solution will be in ameliorating global warming. Some argue that it will merely slow down how fast atmospheric carbon impacts temperature.

Geoengineering (high tech futuristic actions that may reduce carbon such as a microbe that absorbs carbon) is another approach but would require significant research.

Science is not very helpful on the costs and benefits of different approaches given significant uncertainties.

Policy Questions for US Policymakers

In light of significant uncertainty of science, should the US do anything regarding climate change?
Yes. Climate change as a theoretical possibility could have potentially catastrophic impacts on man's existence on earth. Similarly, it is a theoretical possibility that a geomagnetic disturbance from the sun could fry all our electric and telecommunications devices. There is certainly some justification for developing a better understanding of the science and the remedies to deal with climate change if it becomes a more certain and well understood threat. But as with all things, perspective and prioritization are necessary and difficult.

The US should adopt a policy of "no-regrets." If there are two actions that each would have an equally good outcome and similar costs but one results in less carbon emissions, then the lower carbon option should be taken. But carbon reduction should not be an end in itself given the range of uncertainty and impacts on economic growth.

Should the US continue to study climate science?
Absolutely but the funding should be less politicized than it is now. It is undeniable that alarmists have been successful in distorting funding in favor of the alarmist position.

Can anything the US does alone make a difference in climate change?
No. It is simply ridiculous to think that a State (California), a region (Northeast Regional Greenhouse Gas Initiative), or a country (USA) can take sufficient actions to make any difference in the future of the earth's temperature.

US carbon emissions have been virtually flat in the last two decades but the developing countries have dramatically increased their emissions of carbon.

Despite the small difference dramatic US reductions in carbon will make, some believe that if the US does not show leadership on this issue there will never be the global will to do anything.
Some are now worried that mandating lower emissions of carbon will lead to continued impoverishment of developing countries and lower standards of living in developed countries.
Some are concerned that the costs of reducing carbon far exceed the likely impacts on climate but as a practical matter will only slow the pace of warming.

Should the US promote adaptation to climate change?
The US should consider very low cost options that would increase resilience and adaptation to various climate scenarios.

The most effective policy allowing for adaptation in the event of a significant threat is a prosperous economy. This should be a high priority for many reasons but it would especially help increase our ability to adapt to potential threats created by increased temperature.

The above-discussed environmental issues swirl around nearly all discussions of energy policy. The confluence of energy, environmental, and economic policies—ecoviergy, if you will—is one reason that energy policy is so complex and controversial. Be that as it may, it is vital to base actions on a coherent and honest understanding of these impacts.

VI. Supply Resources

The world has virtually unlimited supplies of energy. The world does not have unlimited supplies of *cheap energy*. Some energy is abundant and cheap to use. Other energy is limited and expensive. Whale oil was once the boon of the US energy industry but as whale oil became more expensive we discovered oil. The trick in using the supplies of energy that we have is allowing the price of different forms of energy to signal where, when, and how we should use different energy resources. This chapter is an overview of the main issues related to energy supply. Additionally, **Commentary 1** discusses in more depth some aspects of these issues.

A. Oil, Petroleum, Gasoline, Ethanol, Storage, and Delivery Issues

The title of this section alone gives you some sense of both the importance of oil/petroleum to energy policy but also the complexity. Believe it or not, however, electricity is even more complex and in terms of energy policy more important.

The internal combustion engine was revolutionary. Characterized as the third most important invention of all time, it liberated humanity from geographic limitations, environmental and health discomfort (horse poop in cities), and allowed machines to do the heavy work. But it was made possible and ubiquitous by the commercial production of crude oil.

About 30% of all the energy consumed in the United States is in the transportation sector—cars, trucks, jets, railroads, pipes and wires. By far, most of the energy used in this sector is crude oil/petroleum derived products, about 90%. So this section of the **Article** will predominately be about oil/petroleum and how it is produced, refined, transported and used in the US economy. This section discusses policy issues relating to transportation fuels, primarily oil. This section covers issues up to the fuel pump. Issues beyond the pump, i.e. consumption taxation, CAFE Standards, and environmental impacts of vehicles, are covered in other sections. As with other sections of the **Article**, we do not discuss history, law, physics/engineering, and technologies of transportation fuels, except as directly relevant to an issue. Extensive hyperlinks, many to Wikipedia, the US Energy Information Administration, and the US Environmental Protection Agency, are included for further depth. Additionally, this **Article** is a broad overview of the topic and deeper discussions of specific issues will be included in future Commentaries.

There is one important concept that must be firmly understood about oil policy: ***scarcity*** versus ***abundance***.

The history of oil and natural gas from 1973 (OPEC oil embargo) to about 2010 was based on an assumption of limited domestic supply and dependence on imports. **All that changed around 2010**. The emergence of new drilling technology ***dramatically*** changed the US oil and natural gas supply picture. Transportation fuels policy must now be based on the assumption of abundant supply and the possibility of the US becoming a net exporter of energy.

Perhaps, the most dramatic evidence of this new reality is that fact that as I write gasoline prices have dipped below $2 at the pump. The history of oil prices suggests that there is a correlation between instability in the Middle East and oil prices: the more instability the higher the price. In January 2015, instability in the Middle East was at an all-time high: Israel at war, ISIS beheadings, Syrian civil war, economic embargo on Iran, Iraq insurgency, low oil prices creating serious political instability for countries that rely heavily on oil production revenues (Russia, Venezuela, and several Middle East and African countries), etc. Yet oil prices, while still higher as a result, have not responded with dramatic increases as it has in the past.

Why? The answer is that the US is producing and can continue to produce large enough quantities of oil and natural gas in a reliable, stable manner that the risk of politically induced shortages is not perceived by markets as a serious possibility. The less the world has to depend on Middle East oil, and its concomitant concern with supply disruptions, the lower oil prices will be. Indeed, long term oil prices will probably stabilize at about $50 a barrel or lower as advanced drilling technology becomes ubiquitous and/or as the Middle East achieves political stability. Indeed, at current prices (2016), there is a strong likelihood that some US supplies will become uneconomic to produce and we will see an increase in cheaper oil imports. Such will be the yin and the yang of oil price volatility over the next several decades.

The significance of this observation is profound. **All oil policies enacted before 2010 were premised on a shortage/import mentality and for the most part are now WRONG and must be reconsidered!** In place of these policies, the US must adopt policies based on market prices driven by an **assumption of**

abundant/domestic supplies and volatile prices. This change in assumption has a dramatic impact on oil policy.

Official policy of every Administration since Richard Nixon has been American "energy independence"—no net import of crude oil or oil products. In no year since 1972 has this objective been achieved. A more realistic policy would be North American energy independence, if energy independence is ever the right goal. Petroleum and natural gas production by Canada and Mexico does not pose political or security risks similar to Middle Eastern, African and South American production. But even this view is flawed. As long as there is a global market for oil, the price at any given moment will reflect supply and demand conditions globally. Even if the US produced all its oil, the price would still fluctuate with global prices.

So how much oil do we have? In some sense, this is the wrong question. As long as price sends clear signals regarding scarcity vs. abundance, the market will signal when we should transition from one supply source to another.

But it is understandable that some are concerned with how much oil is in the ground. An understanding of this requires a foray into some technical distinctions regarding an energy resource that is buried deep in the earth. Here, the distinction between reserves and resources is important. In essence, reserves are oil that we are highly certain is in the ground and capable of being produced commercially. Typically, this means that wells have been drilled and testing has been done to increase the probability that the estimates of the amount of oil are highly reliable. Even this category breaks down further into proved and unproved, with unproved being further broken down into probable and possible, going from the most certain to less certain. "Resources", on the other hand, are even less certain. We know there is oil but we are taking a guess as to how much is there and how much it will cost to produce. Typically banks will only lend money on "reserves."

Another concept needs to be understood to better appreciate the abundance of our oil resources. Initially, when a well is drilled it will be under sufficient pressure that a certain amount of oil will be recovered (primary recovery). But eventually enough of the well has been drained that additional efforts must be made to continue to produce oil from the well (secondary recovery), which usually involves injecting something down the well to create additional pressure to bring up additional oil. But even these techniques will peter out and still leave lots of oil in the ground. Additional and more sophisticated techniques (tertiary recovery or enhanced oil recovery) have developed that allow yet more of the oil in the reservoir to be produced. These tertiary recovery techniques are revolutionary. The US Department of Energy estimates that tertiary recovery can result in up to 60% greater production from some wells. Combined with fracking, advances in tertiary recovery have dramatically increased estimates of how much oil can be produced in the United States.

Needless to say, we have abundant supplies of oil. One think tank estimates that we have "enough oil to fuel every passenger car in the United States for 430 years… enough natural gas to provide the United States with electricity for 575 years at current natural gas generation levels… [and] provide enough electricity for approximately 500 years at coal's current level of consumption for electricity generation."

Below is a list of the overarching factual conclusions that should be adopted in discussing oil policy.

Overarching Factual Conclusions

- The United States was blessed with an abundance of cheap oil. That cheap oil fueled much of the prosperity of the 20th Century. We have consumed that cheap oil and we now have an abundance of oil that is relatively more expensive to produce.
- Other countries can produce oil cheaper than the US and there is plenty of supply available.
- As the US consumed its cheap oil, it has relied on oil imports to meet some of its growing consumption demands.
- Many analysts, both liberal and conservative, have been concerned that the levels of oil imports are a problem and many current policies were based on the assumption that we had to reduce oil imports and oil consumption. Relying on the doctrine of comparative advantage, some conservatives have rejected the need to reduce imports in favor of relying on global competitive markets for oil.
- With modern extraction technology (fracking, 3D seismic, and horizontal drilling), the US is now able to access more of its oil resources at cheaper prices than was the case even a few years ago. Accordingly, in the last several years we have produced more oil domestically and we have lowered our need for imports. The US became the largest producer of oil in the summer of 2014, bypassing Saudi Arabia.
- The US and the world have plenty of oil; supply availability is not a serious concern. Discussions of "peak oil" (after which production declines) have been discredited. U.S. peak oil production was officially thought to have been reached in 1970, but is going to be superseded by current production gains caused by fracking and horizontal drilling technology, thereby moving it forward by at least 42 years. The worldwide situation is similar. Based on International Energy Agency data, in 1980 worldwide proven oil reserves were 680 billion barrels. Between 1980 and 2011, proven reserves had increased to 1.6 trillion barrels, notwithstanding that during that period 800 billion barrels of oil were consumed. Relying on estimates of resource availability is largely a fool's errand.

- While supply availability is not an issue, price is an important issue. Because it is largely fungible (a barrel of oil produced anywhere in the world is the same), oil prices are set in a global competitive market. Because these prices respond to supply/demand, political instability and weather events, oil prices are volatile.
- Crude oil production in the past several years has increased dramatically on State and private land but has dropped on Federal lands. There is a large amount of oil reserves on Federal lands both onshore and offshore.
- The cost of producing a barrel of oil varies widely over the globe. It can be as cheap as $10 in Saudi Arabia and as much as $50 to produce hard-to-reach oil. Indeed, there is oil available that may never be produced because it would be too expensive compared to the global price of oil or oil substitutes.
- We have constrained refinery capacity—not enough refineries—and it is politically difficult to build more refineries.
- Oil is dirty and there must be some environmental rules that ensure that there is no unreasonable harm to the environment.
- One key issue is how oil is transported. Different modes of transportation of oil have different environmental risks.
- The vast number of vehicles currently run on products refined from crude oil—gasoline, jet fuel, and diesel. But vehicles can also run on electricity, natural gas, hydrogen, methanol, and ethanol.
- The US government mandates that ethanol be mixed with gasoline in order to lower our reliance on crude oil.
- While air pollution caused by vehicles was a serious problem in the past, new cars achieve over a 90% reduction in air pollution over older vehicles. Thus, air pollution has been significantly reduced since the 1970s.
- Oil is a fossil fuel and thus emits carbon when combusted, more than natural gas but less than coal.

Overarching Policy Conclusions

- Oil import levels are not a significant concern. The global competitive market sets the price and we will import oil based on its price compared to the cost of producing oil domestically.
- Some analysts argue that by importing oil we are funding the terrorists. Indeed, former CIA Director James Woolsey has publically stated "Before you get out to [pay for] your gas, turn the rearview mirror just a couple of inches and look into your own eyes and then ask the question: 'I wonder who's paying for those little boys to be taught to be suicide bombers?'" **This is complete hyperbole.** There is a global market for oil and if we don't buy it someone else will. All that matters is the price. If we were to completely eliminate oil imports, the terrorists would still find buyers for their oil.
- Fracking has environmental consequences if done improperly but all reliable studies, including the US Environmental Protection Agency, establish that it can be done in an environmentally responsible manner.
- The Keystone Pipeline should receive the necessary permits to be built.
- The private sector should be permitted to build more refineries, with appropriate environmental safeguards.
- The Government should not seek to influence the fuel for vehicles. The role of the government is to set the harms charge for each possible fuel source and let the market decide how many alternative fuel vehicles will be most efficient.

- Ethanol mandates and other energy subsidies should be eliminated.
- The US Government's Strategic Petroleum Reserve should be sold to the private sector.
- See **Generation Chapter** for conclusions on carbon emissions and climate change.

Oil Imports

Over the last 50 years, a lot of concerns were raised about the fact that, though the US was once the dominant oil producer, an increasing amount of the oil came from imports, much of it from the politically unstable Middle East. More recently, those concerns have diminished as the US has adapted to new technologies (see fracking below) that allow a much greater amount of US, Canadian and Mexican supplies to be developed.

Despite the recent dramatic shift in the availability of US/North America produced oil, many current policies linger based on very different assumptions about oil availability. Most dramatically, it all starts in 1973 when the Organization of Petroleum Exporting Countries (OPEC) announced an oil embargo against the US. In the next year oil prices quadrupled and created an energy crisis for the remainder of the decade. (President Carter's "Moral Equivalent of War" speech was about energy.)

Since that embargo, every US President has declared that reducing or eliminating oil imports was a high priority in their administration, often coined "energy independence." But none succeeded despite the adoption of severe market distorting policies. In 1972, the year before the embargo, the US imported 28%. By 1977, it rose to 46%. Then it rose to 55% in 2001, after hovering in the 30 to 40% during the decade of the 80s and 90s. And now it has declined to about 28% in 2014. Ironically, for all the anti-Middle East rhetoric, most of that 28% is imported from Canada and Mexico.

There is one useful historical lesson to be learned from the experiences related to the OPEC oil embargo. In response to inflation concerns, President Nixon imposed price controls on the US economy, including gasoline. This led to long lines at the gas pump and rationing of gasoline, especially after the increase in global oil prices after the OPEC embargo. In order to ameliorate these lines, the Federal government instituted a program under which only odd number license plates could buy gasoline on certain days and even numbers on other days. The best that can be said for this practice was that it may have restrained gasoline prices to some extent. But it created chaos in gasoline markets and caused consumers to spend hours on lines in order to get gasoline. If one were to monetize the hours spent looking for gasoline stations with gas supplies and waiting on lines as part of the pump price of the gas it is very doubtful that there were any serious net savings. The lesson learned is that price caps and rationing are usually a very poor substitute for allowing markets to send clear price signals about the scarcity of a given commodity and send the appropriate signals to consumers to conserve and producers to produce, no matter how painful or politically unpopular that may be.

Refining

Crude oil itself is not a usable commodity. Crude oil must be refined into a wide variety of usable products. Not all crude oil is exactly the same from a chemical point of view. There are heavy crudes, light crudes, sweet crudes and sour crudes. And various types of crude oil will be converted into relatively more or less different refined products: gasoline, jet fuel, diesel fuel, propane and many other variations, including some that are used to make goods such as plastics and polyester. Thus refining is a critically important process to making crude oil useful.

There are a wide variety of chemical processes that are conducted in refineries and thus they are not usually esthetically pleasing. Additionally, there are serious environmental effects of refining operations.

One of the key policy issues is that it has been very difficult to build new refineries in the US. No new refinery has been built since 1976 and more than a hundred have closed since that time. The lack of refinery capacity results in retail prices that are higher than they might otherwise be.

Air Quality Issues and Blends of Gasoline

As noted above, vehicles have historically been responsible for emissions that caused serious air quality/pollution issues. But there has been dramatic progress and success on reducing the pollution emitted by newer model cars. One of the issues that impacts vehicular air emissions is the type of gasoline that is used. For example, regions in California, especially Los Angeles, still have significant air quality issues during the summer months. Thus California has mandated a blend of fuels that lowers pollution during these periods but results in higher prices for gasoline.

Development on Public Lands

The United States Government owns vast quantities of land, especially in the west and Alaska. Not surprisingly, politics is often involved in policies relating to accessing the oil, gas, and coal deposits on Federal Lands.

ANWR represents a textbook example of this. ANWR, the Arctic National Wildlife Reserve, has been a political punching bag for three decades. ANWR is a huge Federally owned land mass on the north slope of Alaska. The majority of Alaskans support oil development of ANWR. Conservationists/Environmentalists oppose such development. To develop some idea of the absurdity of the debate, imagine ANWR as a football field. How much of that football field would be "destroyed" by development of the oil reserves in ANWR? Lay a dime on the football field and it would be twice the size on a percentage basis of the area of proposed development.

Development of Federal lands only arises because of the huge amount of land owned by the Federal government. (The US Government owns 81% of Nevada.) Needless to say, the general policy should be to allow development of the energy resources on these lands in an environmentally responsible manner. That doesn't mean we should allow oil wells in the Grand Canyon but it does mean that environmental extremism should not prevent rational development. Given that politics is in the DNA of Federal Governmental decision-making, a mechanism should be developed that allows States to decide the development policies of land within their borders, either through sale of massive swaths to the private sector, gifting the land to the States, or control by the State over development decisions.

Fracking

Currently, the most controversial issue regarding oil and natural gas is the issue of hydraulic fracturing or "fracking." The development of this technology allows oil to be produced in quantities and geologic formations that were historically thought to be impossible. Essentially, various chemicals are deposited in a deep hole and put under intense pressure. This pressure "breaks" up the rock-like shale formations and allows oil and gas to become available for production. Part of this technology advance is also the ability to drill at horizontal angles to more efficiently drain a reservoir of oil or gas. While no one questions the ability of fracking to make many more years of oil available, some have raised environmental concerns about whether the chemicals used in fracking will spoil the water supply and whether fracking will cause earthquakes. New York for example has banned the use of fracking because of these concerns.

The US Environmental Protection Agency (EPA) has undertaken a study of fracking and issued a draft assessment in 2015. The preliminary results and statements of the top official indicate that there is "only an upside to hydraulic fracturing" and "shows hydraulic fracturing activities have not led to widespread, systemic impacts to drinking water resources." Despite the fact that the Obama Administration has been very responsive to environmental concerns, e.g., Keystone Pipelines and War on Coal, environmentalists nonetheless continue to attack fracking on environmental grounds.

The Fracking issue is important for another reason. It illustrates the folly of government directed research and development (R&D). The Department of Energy (DOE) has spent literally billions on R&D since its founding in 1978. Billions have gone to nuclear, renewables, efficiency, and coal research. Fracking has NEVER been a priority of DOE's research agenda and very little has been spent by DOE on fracking research. A similar case could be made regarding natural gas combined cycle turbines. These turbines are today the backbone of the electric generation industry. Yet DOE research support played literally no role in perfecting this technology for electric generation. These two technologies alone—fracking (including horizontal drilling) and combined cycle turbines—are the two most important energy technological breakthroughs in the last three decades. And DOE had virtually no role in their development. The lesson is a cautionary one. Government is not particularly good at picking winners and losers regarding innovative commercial technologies.[8] Additionally, government funding of R&D can have what is called a "crowding out" effect. The private sector will be reluctant to do research that competes with government for fear that they will not realize the full compensation for their innovation and invention.

Oil Transportation

Oil typically must be transported from the wellhead to the refinery and then to end use markets. Because it is a stable liquid a variety of transportation modes are available: ships, pipeline, train, and truck. (In contrast, natural gas as a practical matter can only be economically transported by pipeline.[9])

Maybe you are old enough to remember the Exxon Valdez accident, causing hundreds of thousands of barrels of crude oil to spill into the Prince William Sound in Alaska. More recently, a train loaded with crude derailed in the middle of a city in Quebec, Canada, killing nearly 50 people. Wikipedia has an entry of oil pipeline accidents in the 21st century alone that goes on for nearly a dozen pages. We all probably

[8] A particularly insightful book about the government's consistent failure in picking winners and losers is Uncle Sam Can't Count: A History of Failed Government Investments, from Beaver Pelts to Green Energy. See especially chapter 8 on energy.
[9] Natural gas can be liquefied or compressed for transportation but it is very expensive and does not account for a significant percentage of natural gas transport.

remember an instance where a tanker truck overturned on the highway and created chaos until the oil product could be cleaned up.

Needless to say, transporting oil in its many modes involves risk; risk to human life and risks to the environment. One of the interesting policy issues is whether considerations other than risk affect the mode of transport. A good example of this is the Keystone Pipeline planned to bring oil from Canada to the Gulf of Mexico. Environmentalists have made Keystone a centerpiece of their strategy to stop infrastructure construction that adds to carbon emissions. Problematically, no one really doubts that Canada will find a market for its oil. The question, then, is what is the best, most environmentally benign way to transport the oil? Railroad and truck transport are riskier than pipeline transport. Thus, especially since all environmental reviews of the Keystone Pipeline have shown that it will not have a significant environmental impact, environmental opposition will likely result in more economic and environmental risk for the transportation of oil from Canada. This being the case it is obvious that it is only political reasons that are preventing approval of the Keystone Pipeline Project. Were it not for the fact that it crosses an international border, no such federal review would be required and it would have been built years ago.

Strategic Petroleum Reserve

A significant amount of the world's oil is produced in politically unstable countries such as the Middle East countries, Africa and Venezuela. Believing that oil supplies could be used as a weapon in international politics and could be cut off, the Federal government decided that it should establish reserves of oil that could be used in emergencies, called *Strategic Petroleum Reserves* or SPR. Again, the market rationale for the government using tax dollars to hoard oil and to release it when the government deemed it an emergency (often heavily influenced by political considerations) has always been weak. Businesses are much better at hedging than the government. Additionally, it is naïve to assume that oil producing countries will create physical shortages of oil. The fact is that Russia, Saudi Arabia, and Venezuela all depend on oil revenues to sustain their economies. In some sense, they need us more than we need them, given the newfound abundance of US supplies. Accordingly, the US should be encouraged to sell the supplies of the SPR and eliminate the SPR. If some private sector interest buys the caverns that house the SPR and wants to hedge the price of oil, that should be of no concern to the government.

Ethanol

Cars can run on a variety of fuels in addition to gasoline, one of which is alcohol in the form of ethanol. In order to use less oil and because it was originally perceived as being more environmentally benign, Congress mandated that ethanol be added to gasoline. Ethanol is a biofuel which means it can be made from a variety of vegetation. Brazil makes ethanol out of sugarcane. The US primarily makes ethanol out of corn. In an effort to reduce oil imports, various policies were enacted to encourage the production of ethanol.

Ethanol is currently subsidized in two ways. First, Federal law requires that gasoline sold in the US contain at least 10% ethanol. The Obama Administration has indicated that it favors increasing the percentage to 15%. Second, Federal law sets targets for the annual production of ethanol. But EPA acknowledged in 2013 due to some unanticipated market developments that it would be cutting the mandate for ethanol production from about 18 billion gallons to about 15 billion for 2014. (In addition to the implicit subsidy embedded in these mandates, there used to be a production subsidy but that was allowed to expire in 2011.)

The rationale for mandating ethanol was weak to begin with but has completely evaporated in the last several years. Environmentalists have lost much of their enthusiasm for ethanol as we better understand its true environmental impact. Additionally, the rationale for ethanol as a substitute for imported oil has always been weak but has become increasingly so in the current situation where it has become abundantly clear that the US and the world have large reserves of crude oil. Lastly, there is a vigorous debate about whether it takes more energy to produce a gallon of ethanol than the energy in that gallon, called the ethanol fuel energy balance.

The ethanol mandate is irrational given that the energy cost of mechanically planting, cultivating, fertilizing and weeding corn, transporting it to ethanol distilling plants; distilling it; and transporting it to oil refineries limits the energy benefit gained from using it as a gasoline additive. What is clear is that this balance is lower for ethanol produced from corn as it is in the US than from other types of biomass such as sugarcane or biodiesel. This shortfall is aggravated by the trees cut down to provide land for new cornfields that no longer absorb CO_2.

Perhaps more problematically, the dramatic increase in the use of corn for making ethanol has had a dramatic impact on food prices. Thus, ethanol subsidies hurt the poor in two ways. It increases both fuel and food costs, with no concomitant benefit to energy policy or environmental policy. Tragically, because corn is grown in states that have strong predispositions to elect Republicans, many Republicans support these subsidies and mandates. This represents an excellent example of the triumph of special interests over both the general and national interests.

In any event, given the newfound abundance of oil, all such mandates relating to ethanol should be eliminated.

Natural Gas and Electric Vehicles

Predicated on the belief that oil consumption should be reduced, the US has embarked on policies to encourage the development of vehicles that run on electricity, either in whole or in part, or natural gas. Given that modern petroleum technology has eviscerated the assumption of dwindling supplies and increased reliance on oil imports, it is no longer sound for the US government to predicate policy on fuel consumption for vehicles. All subsidies, mandates, and policies distorting markets in favor of electric or natural gas vehicles should be eliminated.

Production Subsidies

In general, oil producers should not be subsidized for producing oil. The market will send a price signal and producers can respond to that signal. No governmental subsidy is needed. The same should be true for all energy resources. Establish processes to ensure accurate price signals, including internalizing externalities, and let different technologies respond to price signals.

Subsidies are insidious. When government favors one technology with a subsidy it distorts the market, not only in terms of supply and demand but also in terms of research and development incentives for future sources. Perhaps, most perniciously, it creates opportunities or other technologies to argue that they should also be allowed to sidle at the trough of government slop. With each success, energy markets become more distorted. Millions are spent on lobbying and lawyers rather than on innovation and resource development.

While it is easy to say "no subsidies," there is a massive debate over what is a "subsidy." A tax deduction for property taxes available to all industries is not likely a subsidy to a particular energy source. (It may be a subsidy to States with high real estate taxes though.) But few would argue that a property tax deduction is a subsidy to the oil industry, as long as it is available to all other industries on an equal basis.

Some tax policies are not as easy to determine if they are or are not subsidies. For example, oil companies receive a special tax treatment for oil in the ground called an oil depletion allowance. Some argue this is a subsidy to oil producers.

In part because of these difficulties, Congress requested that the Energy Information Administration (EIA) do a study of energy subsidies. The results show that of about $37 billion in energy subsidies, about $3 billion went to the "Natural Gas and Petroleum Liquids" sector, or a little less than 10%. By contrast, renewables received about $14 billion, or about 37%. **Appendix A** is an abstract from the EIA study on energy subsidies.

In general, an effort should be made to minimize ALL energy subsidies in favor of reliance on market prices to drive choices between different technologies.

Oil and Natural Gas Exports

The US banned or heavily regulated most exports of oil to other countries over the last four decades. Given the change in supply made possible by modern oil production technology, it is obvious that these rules should be reconsidered and eliminated. Thankfully, Congress threw sound energy policy a bone by recently eliminating the ban on oil exports.

The government still imposes impediments on natural gas exports. Given the abundance of natural gas, it would seem an easy question as to whether we should freely allow the market to dictate whether natural gas should be exported. Some still oppose relaxation of impediments to natural gas exports, either on environmental grounds or self-interested grounds fearing an increase in natural gas prices.

State Policies on Oil

Similar to the Federal situation, most States have licensed a limited portion of their land, and many States have not leased any offshore areas. Although Southern California has active offshore wells, it currently is not granting any offshore leases. Similarly, there are prohibitions of exploration and drilling along the Atlantic Coast and the eastern Gulf (Florida).

It would be too detailed to list the myriad State policies that impede the development of oil and natural gas supplies. Suffice it say that as with Federal policies predicated on a shortage mentality, similar State policies need to be reconsidered in light of the dramatic new factual predicate of abundance.

B. Natural Gas: Supply and Delivery

The discussion of current natural gas issues can be short and sweet. This is not because natural gas policy lacks a very long complicated history of market manipulation and distortion. It does have such a history, but thankfully it is HISTORY.

While President Reagan is not usually acknowledged for his energy policy, the fact is that time has dramatically vindicated his views. His first executive order was entitled "Decontrol of crude oil and refined petroleum products." He similarly made it clear that he wanted to take the necessary steps to deregulate natural gas.

Pursuant to the ultimate goal of wellhead deregulation, in the decade of the 1980s and early 1990s, the Federal government took a series of actions that radically altered natural gas policy. In a nutshell, the policy of greater reliance on market forces replaced the historic policy of reliance on government command-and-control. While controversial at the time, it is no longer seriously debated that this change in policy was extraordinarily beneficial to the nation's economy, environment, electricity system, and energy security. There are lessons here for the electric system to be discussed later.

Yet because of the complicated road (literally hundreds of executive, judicial, regulatory, and legislative actions) that was necessary between 1981 and 1992 and because it took several years for natural gas markets to respond to these new reforms, President Reagan is given little credit for the salubrious situation in which the Nation finds itself today. His last speech says it all:

> My friends, we did it. We weren't just marking time, we made a difference. We made the city stronger - we made the city freer - and we left her in good hands. All in all, not bad. Not bad at all.

There are, however, three energy policy issues that affect natural gas supply but they are linked to similar issues for other energy sources and are largely discussed elsewhere in a larger context, with no need to be repeated here. First, there is the fracking and Federal lands issues, which are discussed above in the oil section. Second, there is the issue of carbon dioxide emissions, which is discussed in the environmental chapter. Third, there is a subordinate issue of whether the US should allow natural gas to be exported via liquefied natural gas. This issue has largely been resolved and permits to build facilities and export gas have been granted, but this issue tends to reemerge as part of an environmental issue or a misplaced concern about the keeping domestic supplies of natural gas for domestic uses.

There are three issues of some importance to natural gas infrastructure. First, much of the natural gas infrastructure in the US is aged and in need of repair and replacement. Because this infrastructure is regulated either by States (local delivery) or the Federal government (interstate delivery), costs must be approved by regulators. The issues in a regulated industry rate case are both technically and politically complicated and boring to boot. Be that as it may, it is clear that regulators must take appropriate actions to allow the aging infrastructure to be modernized and consumers will have to pay for this modernization. There are issues related to incentives created by different rate structures but this document is not the place for such a technical discussion. Suffice it to say that the need by utilities to invest in modernization of infrastructure is legitimate, but one should continue to be skeptical of self-interested claims by utilities.

The second serious issue relates to natural gas supplies to New England. This issue has already been covered more thoroughly in the Environmental Chapter.

The third relates to some changes in retail natural gas markets that flow from Federal reforms. This relates to giving customers who use natural gas the right to choose their own supplier, also called customer choice. The issues of natural gas customer choice are similar to the issues raised in giving electricity customers the right to choose their own supplier. Accordingly, we will discuss customer choice in more detail in the discussion of retail electricity.

C. Coal: supply and flow

Coal is an exquisite study in tradeoffs: plentiful and cheap but dirty and unhealthy. There are three things to keep in mind about coal: environment, environment, and environment. While there are no doubt other issues, coal is currently fighting for its life and losing against the Obama Administration. This is especially ironic given that the US has been called the Saudi Arabia of coal. More disturbing, if the US does not use cost-effective coal for electric generation, it can be exported to developing countries like China and India, thus defeating any illusory benefit to reductions in CO_2.

Undeniably, environmentalists have virtually banned new coal plants and want to shut down existing ones. For coal, everything hinges on what the US does regarding carbon emissions.

Coal still has significant market share in the electric generation market. In 2013, over 90% of coal use was for electric generation. Coal accounted for about 40% of electricity generation. It is ironic that as the US ratchets down coal, developing economies are ratcheting up.

In order to think coherently about coal's environmental issues one must distinguish between direct health effects of using coal and indirect climate effects. Coal is perhaps one of the most regulated commodities exceeded perhaps only by pharmaceuticals. Enormous progress has been made over the last 4 decades with making coal and coal mining cleaner and safer; there will always be debate about the regulation of the direct impacts of mining and using coal. Safety, health, and land use environmental regulation have a role in the production of coal. While there are debates to be had over the nature of this regulation, it is not primarily these issues that threaten coal use today.

Coal's real problem today is the issue of carbon dioxide. Coal emits more carbon dioxide than any other fossil fuel. Thus it is the primary target of those concerned about climate change. This document has discussed the science and policy of climate change in **Chapter V**. But a word needs to be said about current initiatives by EPA.

Coal accounts for about 40% of electric generation, the most of any fuel. The Obama Administration was unsuccessful in getting climate change legislation through Congress even when Democrats had a majority in the House of Representatives and a filibuster-proof majority in the Senate (2009-2010). Yet the EPA has declared a so-called war on coal. It has finalized

a standard for building new coal plants and one for existing coal plants., the so-called **Clean Power Plan** (a topic on which a **Commentary** will be developed later this year). Both these rules will make it very difficult and very expensive to use coal in electric generation. Thus it is widely anticipated that many fewer coal plants will be built and many existing plants will have to close. As noted in the **Environmental Chapter**, even if the US were to somehow magically achieve a zero manmade carbon emission level, it would have a negligible impact by even the most aggressive models on climate change. Additionally, now natural gas is the only likely fuel to fill the gap left by the decline in coal and it no doubt will result in increases in natural gas prices from what they otherwise would be, not only for generation but for all uses of natural gas. Thus enormous costs will be imposed on electric generation which will inevitably result in higher electricity prices and some decline in jobs and prosperity in the US economy (**Commentary 2** covers some issues related to Prosperity and Electricity.)

D. Renewable Energy

Big picture: it is useful to think of two broad resource categories of energy: fossil and renewable. Fossil energy is oil, coal, and natural gas and is made from the decay of past vegetation and animals.[10] Renewable energy is hydro, solar, and wind and is energy that we can never run out of; it is by definition "renewable," and it is abundant. And it can be less environmentally harmful than fossil resources. By definition, we have a limited amount of fossil resources, though we have a lot of it, many hundreds of years in fact. But we have an *unlimited* amount of renewable resources. It is intuitively attractive to think that it would be a good idea to use renewable rather than fossil resources since we will never run out of it and it is "green." But what would be the fun in that!

The major issues relating to the choice between renewable and fossil relate to cost and predictability.[11] Simply stated, do we want reasonably priced energy delivered when we need it or do we want expensive energy that is unreliable? On both those criteria, fossil resources are usually superior to renewable resources. There are instances, however, where renewable resources can be more economic than fossil resources. The key consideration usually has to do with the unique geographical location of the resource. While renewable generally wins on the perception of environmental friendliness, even this does not help

[10] There is some debate on this. Some believe in abiogenesis, i.e., that petroleum and natural gas might also have nonorganic origins.

[11] For an exceptionally insightful view of renewables, see Bryce, Power Hungry: The Myths of "Green" Energy and the Real Fuels of the Future (2010).

renewables very much. And it is wishful thinking to believe that fossil energy will be replaced by renewables any time soon. Renewable energy has a place in the energy mix but it is likely to very limited. In any event, the rightful place of renewables in the energy market should be determined by policies that rely on market forces, not government mandates and subsidies.

Hydro

The granddaddy of renewable energy is hydro. Watermills put to productive effort have been around since third century BC. Today, dams can be placed on rivers to produce electricity through turbines called hydroelectricity. About 3% of our electricity comes from hydro. The problem with hydro is that by definition you can only use it where there is a river that has enough current to turn turbines to produce electricity, or by storing water behind a dam. So while hydro is renewable in the sense that it is powered by the natural flow of rivers replenished with rain, it is not unlimited or reliable. Much of our hydro potential has already been exploited. Additionally, environmentalists generally do not favor hydro because of its impact on fish and aesthetics. Indeed, environmentalists advocate that hydro not be included in the definition of renewable because of its potentially harmful environmental consequences.

Wind

Wind is plentiful in certain geographic regions. But the wind does not necessarily blow all the time. The term used to describe this limitation is that wind is "intermittent." What do we do if the wind stops blowing when consumers need energy? Wind needs either "storage" or "backup." It is generally conceded that there is no cost effective means of storing electricity. Of course, we have batteries that can "store" electricity but not on a scale that is economic. Backup is generally natural gas plants that can be turned on when more energy is needed than is provided by wind. Another approach to dealing with intermittency is called demand response. This essentially means paying customers, usually industrial customers, to turn off machines during the rare occasions that backup isn't sufficient to handle the ebb and flow of wind and solar.

Much of the wind generation that exists has been made possible by heavy subsidies in the form of government mandates, grants, tax credits, and preferential sales to utilities. Additionally, there is a significant issue of how to get the electricity generated by wind to market. Often wind is only feasible in rural geographic areas far from where the electricity is needed in urban centers. Thus for wind to be used it is often necessary to build long transmission lines to deliver electricity far distances. The question is who should pay for the transmission facilities. Requiring wind producers to pay would dramatically increase the price of wind but requiring the costs to be spread to all customers gives wind and advantage over other generators. Lastly, the issue of wind machines killing birds and creating noise has become increasingly contentious.

One wind issue receiving some attention is off-shore wind, wind built long distances from shore in the ocean. Currently there is no operating off-shore wind project in the US but several have been proposed. Europe has had off-shore wind projects up and running for several years. Current proposals suggest that such wind is very expensive when compared to conventional generation. Moreover, the reliability of such projects on a large scale has recently been questioned.

Heavily subsidized wind farms are popular with some policymakers, but are anathema to landowners and residents because of the low frequency noise the windmills generate as well as their intrusive profile. The seminal examples are the Cape Code, Nantucket and Martha's Vineyard beach property owners in the vicinity of a proposed huge offshore wind farm successfully opposing off-shore wind.

In 1918, the United States entered into a treaty with Canada protecting migratory birds. Wind farms annually kill tens of thousands of such birds, including eagles, geese, ducks and other migratory species in apparent violation of the US' treaty obligations which are ignored in vivid contrast to Federally determined prosecution of someone who has accidentally killed a single migratory bird.

Solar

Actually, it is misnomer to suggest that solar energy is renewable. The sun is scheduled to end life on earth in about 3 billion years. But let's just worry about the next century. The sun has been THE preeminent source of energy forever. The question is how to harness it to provide reasonably priced energy that is reliable. In case you hadn't noticed the sun doesn't always shine. It is best to discuss solar in two different categories: big solar and little solar.

Big solar is typically hundreds if not thousands of solar cells in a remote location. While capable of producing significant quantities of electricity, similar to wind it suffers from intermittency and must have some form of backup for when electricity is needed and the sun is not shining. Also similar to wind is the issue of transmission lines needed to get the electricity to where it is needed. Battles over who should pay the costs of this transmission are complex and contentious. Additionally, there are a variety of subsidies that incentivize solar energy that distort electricity markets, e.g., Renewable Portfolio Standards discussed in the **Generation Chapter**.

Little solar is usually "rooftop solar" or some other use of solar near the point of consumption. Rooftop solar raises a host of questions that relate to how the distribution company should price and treat rooftop solar. These issues are covered more fully in the **Generation** and **Wires Chapters.**

An issue with both solar and wind is the question of the land use consequences of building to a scale that would be meaningful in substituting for even half of fossil fuel generation. It would take coverage of large land masses to generate such electricity.

Other Renewable Energies

In addition to the big three—hydro, wind, and solar—there are an additional long list of renewable energy sources—geothermal, tides, wood, biomass, ethanol—but these do not figure prominently in the future of energy on a percentage basis and so little discussion is needed. Wikipedia has an excellent overview of these technologies.

E. Nuclear Energy

The US currently has about 100 nuclear power reactors and the world has about 450, with another 75 or so under construction. Nuclear energy has always been controversial.

The first thing that should be stated is that there are different types of nuclear reactors. We are most familiar with reactors that use uranium. But it is also possible to generate electricity with fusion and thorium reactors. The decision to use uranium was largely driven by research funding related to using uranium/plutonium for making bombs. Thorium as a fuel for nuclear reactors actually offers many advantages over uranium since it "is more abundant in nature than uranium, is not fissile on its own (which means reactions can be stopped when necessary), produces waste products that are less radioactive, and generates more energy per ton." (The Thing About Thorium: Why The Better Nuclear Fuel May Not Get a Chance, Forbes, 2012)

The second thing is that nuclear has been very subsidized. It was sold to the American public in the 1950s as eventually making electricity "too cheap to meter." It hasn't quite turned out that way. Indeed, one of the subsidies is called the Price Anderson Act. This act protected electric utilities who built nuclear plants by limiting their liability to $12.6 billion in the event of an accident. The taxpayer is responsible for any damages over that amount. (The Fukushima nuclear meltdown in Japan is estimated to have about $500 billion in economic loss.) The act is in force until 2025. No other energy source or any other industry in the US to my knowledge has similar protection. Congress and the utility industry believed it was necessary to limit the nuclear industry's liability in order to accept the risk of building a nuclear plant. That should have been a tipoff right there that nuclear would be problematic from a market perspective.

The third thing is waste disposal. All utilities with nuclear facilities were required to pay into a fund that would be used to create a disposal strategy for nuclear waste. (The Nuclear Waste Fund fees were suspended in 2014.) Pending such a strategy, utilities have been storing the waste on-site. There is a huge controversy over the disposal strategy. A site at Yucca Mountain (the name's not a joke) in Nevada was selected and developed as a permanent disposal site. After billions spent and having jumped through innumerable regulatory hoops, Senator Harry Reid, the senior senator from Nevada and Senate Majority Leader, put a stop to final approval. Thus nuclear waste continues to be stored on-site of nuclear power plants. With his announced retirement, interest in Yucca Mountain may be revived.

Nuclear generation has the advantage in that it does not emit CO2. Some environmentalists who are concerned about climate change thus support nuclear. But there is also strong opposition to nuclear in the environmental community.

Without question the main issue with nuclear energy is safety from meltdowns. There have been three major accidents (Three Mile Island (1979), Chernobyl (1986), and Fukushima (2011)) involving nuclear plants. Not surprisingly, the Nuclear Regulatory Commission has adopted very strict safety requirements for building nuclear plants.

No plants have been given permits to build nuclear plants since the late 1970s. Recently, there has been a strong push to build new plants in the US. The **Energy Policy Act of 2005** was a bonanza for the nuclear industry as seen in the summary of provisions below:

- "it extends the Price-Anderson Nuclear Industries Indemnity Act through 2025;
- it authorizes cost-overrun support of up to $2 billion total for up to six new nuclear power plants;
- it authorizes production tax credit of up to $125 million total a year, estimated at 1.8 US¢/kWh during the first eight years of operation for the first 6.000 MW of capacity,[10] consistent with renewables;
- it authorizes loan guarantees of up to 80% of project cost to be repaid within 30 years or 90% of the project's life [1];
- it authorizes $2.95 billion for R&D and the building of an advanced hydrogen cogeneration reactor at Idaho National Laboratory;
- it authorizes 'standby support' for new reactor delays that offset the financial impact of delays beyond the industry's control for the first six reactors, including 100% coverage of the first two plants with up to $500 million each and 50% of the cost of delays for plants three through six with up to $350 million each…"

Given the outrageous subsidies granted for new nuclear power plants, it should not be surprising that several companies have applied for permits for new nuclear plants in the US.

Conclusion

The world and the US have an abundance of supply options to meet its energy needs. Unfortunately, there is a lot of bad policy clutter that distorts energy resource markets. This clutter largely derives from special interests seeking to gain a competitive advantage for their energy resource against other energy resources, always couched in ways that seem as if they are in the national interest. As an advantage is given to one resource, it merely incentivizes supporters of other resources to make largely analytically questionable, indeed silly, claims for mandates and subsidies that distort supply markets.

VII. Electricity Generation Policy

We use electricity every day in hundreds of ways. But usually all we know is that you flip the switch and the lights come on. The regulatory, legal, economic, business and administrative processes of sending a watt of electricity to your light switch are complex, changing rapidly, and in need of dramatic reform.

At a basic level, the electric system is fairly simple. In some sense it is just like any other consumer good. Farmers grow wheat. Wheat is transported to the baker. The baker makes bread. The baker sells to the consumer. Electricity is made (generated). It is transported by wires to the electric company. The electric company sells it to you.

But there are three characteristics in the electric system that make public policy a bit, maybe a lot, more complicated for electricity than for most other industries.

First, unlike most industries that are fully capable of operating under a competitive framework, some elements of the electric industry can operate under competitive conditions (generation and retail) and some require a monopoly model (wires) to operate efficiently. This dichotomy makes public policy much more important to the health of the electric industry than most other industries.

Second, most industries are not vertically integrated. For example, it would be rare for a farmer to grow wheat, own trucks to bring the wheat to his bakery, bake bread and own a bakery to sell the bread. Typically, each of these functions would be carried out by a different company that specialized in that function, e.g. trucks and trains can carry other commodities besides wheat. The electric industry however has historically been vertically integrated. One company did it all. The "electric utility" built, owned, generated, transmitted, and sold electricity directly to customers. This was however an accident of history, not a conscious decision as to how to best organize the electric system. As times and technology have changed, the underlying assumptions about vertical integration have changed. Reassessing the right organizational construct for the electric industry is thus more complicated.

Third, very few industries have as many environmental implications as the electric industry.

Thus the combination of monopoly, historic industry structure, and environment mean that the public policy issues are very troublesome to sort out, making it very difficult for non-experts to understand the key issues facing the industry.

For about a *century*, the US followed a framework where *private companies* (confusingly called "*public utilities*") owned and operated all the facilities (generation, long distance transmission of electricity, short distance distribution to the end user, billing, metering etc.) needed to provide electric services. Because these public utilities were given a territorial monopoly by the State, each State set the rules under which the utility could operate. The State, usually through a public utility commission, sets the price the utility could charge, authorized it to build new facilities, and imposed an obligation that required the utility to serve all customers in the utilities monopoly area, called a franchise. (The Federal government had a very limited role in electric power, to be discussed later.)

Today, all of this is in a state of flux. Nearly every State is experimenting with different ideas of how electric power should be generated, delivered, and consumed. Some are motivated by the failures of the historical model, others by environmental concerns, others by the need for modernization of the electric grid, and others by an ideological commitment to competition. Needless to say, with so many moving parts this makes understanding electric policy a challenge.

This **Article** explains the policy issues behind the major components of the electric services industry:

- Generation (producing electricity, its economic, and environmental consequences);
- Wholesale Markets (the recent development of competitive institutions for selling electricity in large quantities);
- Transmission (delivering electricity over long distances);
- System Operations (the process of ensuring that supply and demand are balanced on a second-by-second basis);
- Distribution (the traditional function of a utility constructing lines to deliver electricity to a home or business);
- Consumption (using electricity and the efficiency issues associated with its use); and
- Retail Services (dealing with the customer for selling, metering, billing and various ancillary services related to end use of electricity).

This **Chapter** covers issues related to "generation," the production and sale of an electron. **Chapter VIII** covers the delivery of electrons to the consumer through wires. **Chapter IX** covers issues related to consumption. As is the general approach of this Article, the purpose is not to explain the physics, law, or history of electricity but to introduce the important policy issues that the industry is currently facing. Many hyperlinks are cited, many to **Wikipedia**, to provide fuller explanations.

Electric Generation relates to the various technologies that can be used to produce a unit of electricity (watt[12]) that will eventually be delivered to allow some light or appliance or motor to be used. The big picture policy issues in electric generation that the public cares about are:

- Will we have enough generation to keep the lights on at all times?
- How much will it cost?
- How much harm will it cause the environment?

Underneath these three issue areas is a vast array of policy issues that can be very complicated. This part of the Article will describe the issues and many of these issues will be the subject of more in-depth Commentaries in the future.

The interesting thing about generation is how many different ways there are to make the same thing: a watt of electricity. You can produce electricity from coal, natural gas, uranium, steam, garbage, biomass, dams, tides, wind, solar, hot steam from the earth (geothermal), and it exists in nature as lightening (heck even a human can produce electricity on a bike hooked up to a small turbine). All of these energy sources are capable of being converted to produce a watt of electricity that will turn on your lights when you flip a switch.

So how do we decide which fuel to use for generation? We first have to understand the characteristics of each of the fuels and then decide which one best fits the need we have for producing electricity at a given time and place. For example, a combined cycle natural gas generator can be turned on and off nearly instantly; whereas a coal or nuclear plant cannot be turned on and off at will (it takes hours, if not days, to turn them off and to restart them depending on technology). Wind turbines only produce electricity when the wind blows and solar when the sun shines. Yet consumers' demand for electricity can change in a second. The weather is unseasonably hot so the air conditioner is turned on. The electric system has to instantly accommodate that request for additional electricity.

[12] A thousand watts is a kilowatt (kWh). A thousand kWh is a megawatt (MW). A thousand megawatts is a gigawatt (GW). And a thousand gigawatts is a terawatt (TW). For perspective, the average home uses about 10,000 kWh hours a year, which is 10 MW hours. A nuclear power plant can produce about 1 GW of electricity an hour or 24,000 MW hours a day. The US consumes about 4000 TW hours a year.

All this would be a simple matter if we had to produce the same amount of electricity all the time. But consumption of electricity is far greater on the hottest day of the year when everyone wants air conditioning and is very low at 3 am on a fall or spring day when it is 70 degrees outside. Because there is virtually no effective electric storage capability, generation thus needs to ramp up and down according to how much is needed by consumers literally every second of the day every day of the year. Thus a portfolio of types of generation is needed to meet these consumption patterns.

Another characteristic that varies widely with different generation technologies is cost. Some types of generators are very expensive to build but then very cheap to run. For example, a wind farm has a lot of upfront costs but is very cheap to run because the wind is free. A natural gas plant is relatively cheap to build but the fuel costs—natural gas—are very volatile and can make electricity generated from natural gas either the cheapest source when looking at total costs or a very expensive option.

A third important characteristic is the environmental consequences of different types of generation. One key point is that ALL generation options have some environmental impact. Coal and nuclear both have significant environmental impacts but in very different ways. Coal is a dirty fuel. Burned in an uncontrolled manner, it emits a lot of pollution into the air and water, and leaves toxic ash waste. Nuclear emits no air pollution but the disposal of the fuel after it has been used up is very dangerous for a very long time. And as we have seen recently with the Fukushima plants in Japan, accidents can be catastrophic. Wind kills birds, makes noise, and has land use implications. Hydro can kill fish and disturb natural habitats. So part of the balance in the choice of generation is that it must have some sensitivity to its environmental impact.

A complicating factor relating to the environmental impacts of generation is public opinion and intentional distortions by advocates for different generation technologies. Some environmentalists believe we can transition to a fully renewable based electricity system. Some homeowners do not want a large generating plant in their backyard. Others want the jobs that come with a certain fuel. Needless to say, decisions relating to generation can be controversial.

In addition to the traditional types of environmental issues that we have been struggling with for decades, there is the more current question of carbon dioxide emissions. This is a very complex and controversial issue and especially affects the type of generation we decide to build in the future. Coal is now responsible for about 40% of the electricity we generate. Coal emits the most carbon dioxide of any generation type. Natural gas emits the least carbon dioxide of the fossil fuels and is responsible for about 30% of our electricity. Nuclear emits no carbon dioxide and is responsible for about 20% of our electricity. Some environmentalists want to adopt policies that would eliminate the use of fossil fuel for electric generation, but they also oppose nuclear power. Some environmentalists oppose carbon fuels but support nuclear. Some environmentalists are concerned about climate change but recognize that it would be very damaging to our economy to ban the use of fossil fuels for electric generation. Complicating this issue is that it has become very partisan and personal. Thus it is often difficult to have an intelligent discussion about carbon emissions. The environmental chapter discussed the issue of climate change in more detail. Also **Commentary 3** discusses the issue of the "consensus" on climate change and climate change issues in more detail.

So how do different generation technologies stack up against one another? Table A below gives a snapshot of the key characteristics of different generation sources and how they differ on several important dimensions.

- Column 1 is the fuel type in alphabetical order.
- Column 2 is the percentage of the current generation from that fuel source. The take away from this column is that coal, natural gas, and nuclear make up almost 90% of the fuel for generation. There are many other technologies for generating electricity but they do not currently make a significant contribution to total generation.
- Column 3 characterizes how "dependable" a given fuel is. This means how flexible is the resource in meeting instantaneous needs for electricity. Some are intermittent, meaning that they only work when the sun shines or the wind blows. Some are "must run" meaning you cannot turn them off and on at will. Some are very flexible meaning you can turn them on or off virtually at will.
- Column 4 characterizes how long it takes to build generating plants that will use different fuels. This is important because some generation technologies take a decade or more to build and then last 50 years or more. Some can be built much more quickly. This is significant because it implicates the challenge of planning a system to meet consumers' needs both in the near term and long term.
- Column 5 characterizes the different fuels by environment and safety challenges.
- Column 6 characterizes technologies by carbon emissions.

Table A: Differing Characteristics of Electric Generation Sources

1. Fuel Source	2. Current % (2013)	3. Dependability	4. Timing to Build	5. Environmental and Safety	6. Carbon Emission
Biofuel	-	Very Flexible	Medium		Low
Biomass	<1	Very Flexible	Medium		Low
CHP	12	Very Flexible	Medium		Depends
Coal	39	Must Run	Long	High air pollutants and safety concerns	High
Geothermal	<1	Intermittent	Medium		None
Hydro	7	Intermittent	Long		None
Hydrogen	-	Very Flexible	N/A		None
Natural Gas	27	Very Flexible	Short	Low carbon dioxide	Low
Nuclear	19	Must Run	Very long	Disposal of waste; radiation accidents	None
Oil	<1	Flexible	Short	Medium air pollutants and medium carbon dioxide	Medium
Pumped Storage	minus	Very Flexible			None
Solar (large)	<1	Intermittent	Medium	Land use	None
Solar (small)	<1	Intermittent	Short	Making and disposing of panels	None
Thorium	-	Must Run	N/A		
Tides	-	Intermittent	N/A		None
Wave	-	Intermittent	N/A		None
Wind	4	Intermittent	Medium	Birds; land use; noise	None

Table B was developed by the Energy Information Administration and helps understand the cost implications of different technologies. While a bit complex, the key point is that some technologies are cheap to build but expensive to operate (natural gas) and others expensive to build but cheap to operate (solar or hydro). This is important for planning purposes.

- Column 1 is the fuel source.
- Column 2 is capacity factor and is the approximate percentage of time that that capacity will be available for use. For example, nuclear can run nearly constantly and only needs to be shut down for maintenance periodically, so it has a high capacity factor. Solar only runs when the sun shines and has a low capacity factor. This is important for planning purposes since electricity must be reliable, meaning available whenever consumers demand it.
- Column 3 is the upfront cost. You can see that gas is cheap to build and wind and solar expensive.
- Column 4 is the cost of operating the plant. Natural gas is easy/cheap to operate but nuclear is expensive.
- Column 5 is fuel costs to operate. Natural gas is expensive and renewables are cheap, indeed free.
- Column 6 is the cost of delivering electricity over transmission lines.
- Column 7 is the total cost when all costs are added together, called LCOE or levelized cost of electricity.
- Column 8 is the amount of subsidy that government gives to a particular technology.
- Column 9 is the final cost after the subsidy is included.

Table B. Estimated Levelized Cost of New Generation Resources, 2019

		U.S. Average LCOE (2012 $/MWh) for Plants Entering Service in						
1. Plant Type	2. Capacity Factor	3. Capital Cost	4. Fixed O&M	5. Variable O&M (including fuel)	6. Transmission	7. Total System LCOE	8. Subsidy	9. Total LCOE including Subsidy
Dispatchable Technologies								
Conventional Coal	85	60.0	4.2	30.3	1.2	95.6		
Integrated Coal-Gasification Combined Cycle (IGCC)	85	76.1	6.9	31.7	1.2	115.9		
IGCC with CCS	85	97.8	9.8	38.6	1.2	147.4		
Natural Gas-fired								
Conventional combined	87	14.3	1.7	49.1	1.2	66.3		
Advanced Combined Cycle	87	15.7	2.0	45.5	1.2	64.4		
Advanced CC with CCS	87	30.3	4.2	55.6	1.2	91.3		
Conventional Combustion Turbine	30	40.2	2.8	82.0	3.4	128.4		
Advanced Combustion	30	27.3	2.7	70.3	3.4	103.8		
Advanced Nuclear	90	71.4	11.8	11.8	1.1	96.1	-10.0	86.1
Geothermal	92	34.2	12.2	0.0	1.4	47.9	-3.4	44.5
Biomass	83	47.4	14.5	39.5	1.2	102.6		
Non-Dispatchable Technologies								
Wind	35	64.1	13.0	0.0	3.2	80.3		
Wind – Offshore	37	175.4	22.8	0.0	5.8	204.1		
Solar PV[2]	25	114.5	11.4	0.0	4.1	130.0	-11.5	118.6
Solar Thermal	20	195.0	42.1	0.0	6.0	243.1	-19.5	223.6
Hydroelectric	53	72.0	4.1	6.4	2.0	84.5		

The main point to be derived from Tables A and B is the challenge of planning for generation. There are a lot of factors that affect the decision of what to build, when to build it, and how much it will cost. Without a doubt, this is a difficult process and has broad implications for society as a whole. As we will see below, one of the main questions is whether government or markets is best at such complex planning.

What are the Policy Problems in Electric Generation?

Understanding that there are many different potential paths to generating electricity, one can easily see that there are a wide variety of policy issues presented by the need to provide reliable, affordable, and environmentally sensitive electricity. These policy issues are compounded by the fact that electric utilities provided electricity using the same market/regulatory framework for about a century, but now that framework (or model) is in a state of flux. The one certainty is that the future of electricity policy is very uncertain. So this is a good time to develop a deeper understanding of the many issues that will need to be resolved over the next several decades.

Who decides what type of generation should be built?

There are three basic approaches as to who should decide what generation to build.

The first is that the government owns and builds the generation. Then the government will decide what and when to build. The US Government currently owns quite a bit of generation in the Tennessee Valley Authority and the Bonneville Power Administration as well as high dams such as Hoover at Lake Mead and Glen Canyon at Lake Powell, and the Grand Coulee on the Columbia River. Additionally, some local governments own generation. There are a variety of problems with this model of generation. The main ones being that such decisions are influenced by politics, inefficiency, and the use of government owned utilities as patronage jobs. This is the model used in many countries but increasingly they are moving to a private ownership model.

The second is that the government has to approve a private corporation's proposal to build a generating plant. Since the cost of the new plant will usually be guaranteed to be included in the utility's rates, typically a utility must seek the permission of a State public utility commission. Because the goal of the commission is keep electric prices affordable, the commission will determine if there is sufficient need for new generation (and its additional costs) and will have a strong role in the type of generation that is proposed by the utility. Additionally, the Federal government must approve proposals to build nuclear power plants (Nuclear Regulatory Commission) and hydroelectric dams (Federal Energy Regulatory Commission). This was the dominant model for nearly the first century of electric generation and it is still probably the main approach used by States.

The third is that a private entity, either a business or an individual, decides to build based on whether they think they can make a profit by selling the generator's electricity in a competitive market. For example, some companies will build generation that they can sell directly to the utility. Some companies build generation that they plan to sell to other companies in the wholesale market. Some companies build generation on the site where they have major needs for electricity (called self-generation), e.g., a college campus or an industrial facility. Some individuals put solar panels on their rooftop or have a small generator to provide electricity to a house. Since the costs of the plant will usually only be recovered in a competitive market, the government does not decide whether it is economically wise to build the plant. (In some instances, such as rooftop solar, government rules require that the utility buy any excess power at a price set by the government.) In this model, the investors bear the risk of mistakes, not the ratepayers. While the government will set rules relating to zoning, safety, environment, and siting (as it does with any large industrial facility), the decision of what to build, when to build it, and what to charge is up to the private entity as influenced by the competitive market. Over the last 20 years there has been a movement in the direction of letting private parties follow this model but it is by no means yet the dominant model.

In a perfect world, we would treat generation just like fast food restaurants. We don't usually give government the power to decide whether a restaurant should serve chicken or beef. Government sets certain rules in advance, such as zoning laws, that would apply to any type of fast food restaurant and then we allow the market to determine what kind of restaurant to build. If the investors make a mistake and lose money that is their risk. If they invest wisely and make profits that is their gain.

Generation is a little more complicated because different types of generation are better suited to different geographic areas. The wind blows differently in different parts of the country. Coal is more accessible in some areas. Sometimes you need to build generation where there are plants that need to be retired or where population is increasing their consumption of electricity.

But the principle is still the same. We should allow competitive markets to decide who builds, where they build, and whether they make a profit or a loss. Government should set sound rules, including environmental policies, for building new generation and then let the market decide these issues. While we are moving in that direction over the last two decades, we are still a long way from this ideal market-based model.

Who should own generation?

Up until the 1970s, most generation was owned by electric utilities (there may have been some companies that self-generated) and the US government owned a significant amount of generation. In the last 35 years much has changed with regard to who can own electric generation and it is very likely that much will change in the near future regarding who owns generation.

The original conception of electric utilities was that they would own the entire infrastructure that was necessary to deliver electricity to homes and businesses. That meant the utility would build generation, run the generator, build the wires from the generator to the home or business, deliver the electricity, measure the use, and bill the customer. This was premised on the assumption that by giving the utility a vertically integrated monopoly it could produce electricity more cheaply under the guidance of state regulation. That premise has been significantly eroded and there is a growing school of thought that generation should not be owned by utilities and the price should be determined in competitive markets.

With regard to generation owned by the Federal Government, there is no sound economic reason for that to continue. The Federal Government should be required to sell off its generation facilities. Many countries around the world have privatized their electric generation over the last two decades. Some special interests (beneficiaries of cheap electricity at the taxpayers' expense) will no doubt caterwaul at such a recommendation.

Who should set the price for electricity?

Currently, public utility commissions set most of the prices that can be charged to retail customers, especially households. Some industrial customers can buy in competitive wholesale markets at prices set by the market and in some rare instances households can buy from competing marketers, e.g. Texas.

As part of a strong plan for reforming the electric services industry from top to bottom, it would be sound policy to increasingly allow competition to set the price of electricity, especially as technology makes advances in metering and control technology.

Should there be any entry restrictions?

Assuming that a number of other reforms are undertaken relating to the electric grid, there should not be any limitations on who can sell or generate electricity, assuming that normal consumer protection laws are followed.

Should there be subsidies?

Currently, there is a complex array of subsidies for energy which would include a number of subsidies for different generation sources. For example, in order to encourage the development of nuclear power, Congress has limited the liability of the owner of a nuclear power plant in the event of an accident. Without this provision, it might be the case that no insurance company would cover nuclear accidents. Congress has also established subsidies for renewable energy. Congress also authorizes the Department of Energy to conduct research and development that supports different technologies. Congress requested that the Energy Information Administration (EIA), a Federal governmental agency, conduct a study in 2011 (updated in 2015) of the types and magnitudes of the subsidies provided to the energy industry, including the electric industry. Not surprisingly, in a very objective analysis, EIA found a complex array of subsidies. **Appendix A** is a summary of the EIA's findings on energy subsidies.

In general, government should not provide subsidies that incentivize different fuels for generation. Subsidies distort the market and set up a competition among those with powerful lobbies to encourage governments to enact rules that will give one type of generation an advantage over another. The goal should be a level playing field in which the market determines what generation is built, not influenced by government subsidies.

To be clear, however, imposing an environmental harms charge on a generator because of the pollution that their generation source may cause is ***not*** a subsidy to other fuels, as long as appropriate harms charges are applied to all generation sources based on their actual impacts on the environment.

Should there be mandates?

Currently, most States have adopted mandates for renewable energy called "renewable portfolio standards" or RPS. A typical RPS would require that the mix of generation in a given State must include some governmentally mandated percentage, something like 25% renewables by 2025. Renewable energy has some desirable characteristics that may make it competitive in certain geographic areas. And admittedly the current playing field is not level. But as noted in the previous discussion, all fuel sources should have to compete in an effectively designed competitive market. Our goal should be to create the right market environment in which such competition can take place and then let renewables compete for its efficient market share.

Mandates such as RPSs are not sound policy. A well-functioning market where competition directs the mix of technologies should be the goal of sound generation policy.

Are there security concerns?

Electricity is the lifeblood of our lives and our economy. Because of the necessity of spreading facilities over large land areas, electricity is also very vulnerable to a variety of threats like computer hackers, terrorists, and weather related disturbances. It is fair to say that the electric system was not designed in the best way to address these vulnerabilities. There is currently a strong push to address security concerns in the electric industry. Companies are usually incentivized to avoid actions that will harm their relationships with their customers. Thus a well-functioning electricity industry would be better able to deal with security concerns. Currently, there are many problems in the electric industry and it would be surprising if the needed amount of money is being spent on security. Given the role of government in the electric industry it is likely that some companies spend too much on security and others too little.

What level of government is best suited to handle questions related to generation?

Answering this question requires some discussion of assumptions. Currently, State public utility commissions or State legislatures have the most significant impact on what generation gets built. The Federal Government has some impact through its implementation of safety (nuclear) and environmental rules (war on coal). It is also fair to say that powerful interest groups, specifically environmentalists and advocates of different types of generation, have a significant role in deciding what generation gets built. Reliance on market forces to guide generation decisions is the exception not the rule.

Originally, the generation and use of electricity was done on a very local basis. Wikipedia describes the first use.

> Pearl Street Station was the first central power plant in the United States. It was located at 255-257 Pearl Street in Manhattan on a site measuring 50 by 100 feet (15 by 30 m) … just south of Fulton Street. It began with one direct current generator, and it started generating electricity on September 4, 1882, serving an initial load of 400 lamps at 85 customers. By 1884, Pearl Street Station was serving 508 customers with 10,164 lamps.

Thus it made sense initially for cities and eventually States to regulate the entirety of the electric industry in their locality. But over the next century electricity has become ubiquitous throughout the US and has grown to be a much more integrated national network industry. Additionally, society increasingly depends much more on electricity for its comfort, well-being, and prosperity. But the allocation of regulatory jurisdiction did not change much and today States still possess most of the authority over electricity. This is a big problem.

Thus, like the blind men in the Indian parable, today literally hundreds of regulatory authorities hold a piece of the elephant, but no one yet fully sets policy consistent with the full interstate commerce reality of the essentiality of electric services to our lives ("Though each was partly in the right, and all were in the wrong!" The Blind Men and the Elephant, John Godfrey Saxe (1816-1887)).

Our increasingly digital economy, the age of our grid infrastructure, the environmental implications of generation, and the very real threats of security to the grid unquestionably require that policy be reevaluated to permit the necessary adjustments to modernity.

Article I, Section 8, Clause 3 of the US Constitution states that the Congress has the power "To regulate Commerce with foreign Nations, **and among the several States**, and with the Indian Tribes" (emphasis added). This is commonly referred to as the Commerce Clause and has been interpreted to mean that if an activity has an impact on interstate commerce then the Congress can step in and decide the policy in that area. Often, this would prevent the States from acting in that area, called preemption. But Congress has not completely preempted States from regulating generation specifically or electricity generally. Currently, there is shared jurisdiction between the Federal, State, and local governments over issues related to generation.

This shared jurisdiction has resulted in a patchwork of policies in generation that is not effective. This shared jurisdiction model has existed in other areas such as regulation of airlines, trucks, natural gas, telecommunications, and railroads. But shared jurisdiction proved very difficult in these other network or connective industries and eventually the Federal government preempted State jurisdiction and established a "competitive" policy for these industries. Scholars generally regard that these competitive reforms of network industries have been successful. Thus, by analogy and logic, it may be necessary for the Federal government to preempt much of State authority over electric services in order to allow for the development of a coherent, market-based industry structure. This issue will be discussed further in the other sections relating to electricity.

How should we deal with the environmental issues raised by generation?

Currently, there is a patchwork of rules relating to the environmental issues surrounding generation. Rules exist at the Federal, State, and local levels of government that relate to environmental issues. These rules can be complex, burdensome, sometimes conflicting, ineffective, and expensive.

What should be done? First, let's make the heroic assumption that all generation has to compete in a competitive market and take whatever price is set by the market. As you can see in **Table A** above, we have a lot of options for generation and they have a lot of different safety and environmental implications. If the government sets no rules regarding the environment, then the generation owner will have an incentive to pick the lowest cost generation and let the rest of us deal with the problem of pollution. Economists call this type of market failure an externality.

An externality is a cost of production imposed on third parties that is not reflected in the price of the good. Economists and most conservatives typically support a role for government in dealing with externalities.[13] Let's first agree that there is no such thing as "no pollution." Given our Western lifestyles and our 21st Century economy, zero pollution is just not possible. Economists generally agree that having government pick the best technology is not a good solution. Government doesn't have sufficient information or incentives to make the right decisions and politics will play a role in the choices they make. Economists generally agree that forcing some of the costs of the pollution into the price of the electricity is a better approach.[14]

There are two ways to do this in generation. The first is to set up a trading system and sell the "right to pollute" up to a certain level. This is the approach taken by the Clean Air Act for sulfur oxides and

[13] Some libertarians can conceive of establishing property rights in such a way that it would not even be necessary for government to establish rules for pollution. In essence, we would sell the right to pollute in return for a payment to use our property. This gets a bit abstract when it comes to air, water, and climate change.

[14] Unfortunately, other approaches are more popular politically but economists generally agree that they actually are less effective and efficient. For example, one way to deal with carbon might be to require all coal plants to develop "carbon capture and storage." This essentially requires the generator to pump the carbon into a hole and "capture" the carbon so it isn't emitted into the atmosphere. This technique is typically characterized as "command and control" regulation and typically promotes less economically efficient outcomes.

nitrous oxide. This has worked pretty well and air pollution from these pollutants has been significantly reduced in the last three decades, and at a cheaper cost than originally expected (how rare is that for the government to overestimate the cost of something?).

The other approach is to determine a "harms charge" that is paid to the government for each unit of pollution and allow the generator to include it in the price of electricity. So for example, if we were concerned about carbon dioxide we might establish a carbon harms charge. Coal would pay more than oil which would pay more than natural gas. Nuclear and renewables would not have to include the carbon tax in the price (though they might have to include some other types of harms charges, e.g., for nuclear waste disposal). Once all the harms charges were set then generators could decide on the most economic form of generation to build given the expected market price for electricity at different points in time.

There are complex issues involved in setting up a trading system or a harms charge. Some of these complexities will be discussed in future Commentaries.

General Assessment of the State of Generation

The discussion above demonstrates that the issues surrounding generation are complex and changing rapidly. Currently, one would have to be critical about some of the key policy aspects of generation.

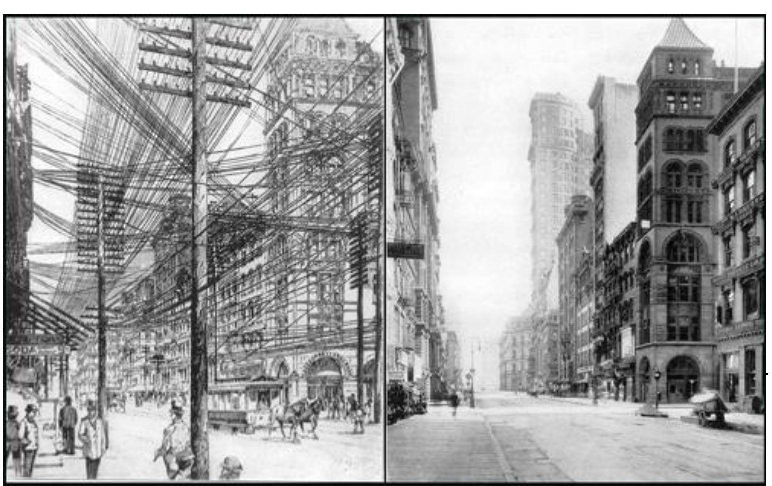
It is very difficult to build nuclear and coal plants in this politicized environment. Low natural gas prices, new environmental regulations and age will force a significant number of coal and nuclear plants to shut down over the next decade. While there are widespread assumptions that various renewable subsidies and mandates will be able to fill the gap, this is unrealistic and would be excessively expensive and unreliable. Countries in Europe have tried this approach and have cut back significantly because of the high cost and resultant price increases. (Germany's electric prices are 300% higher than the US average and Ontario, Canada is in the midst of a kerfuffle over its green energy policy.) Natural gas generation will most likely fill the gap in the need for generation. This is a sound short term strategy. Natural gas generation is relatively cheap to build, very flexible in ramping up and down, relatively clean, and natural gas is plentiful. The one down side of natural gas is that its price can be volatile. Even though supplies are plentiful, natural gas prices will respond to demand (and to oil prices) and could rise, indeed, rise significantly, as they did in the early 2000s.

Complicating this generation picture is the fact that the entire electric industry is in a state of flux regarding public policy. We still have one foot in the old "utility" framework that existed for a century and another foot in the "competitive" framework that has begun to emerge in the last two decades. This is not a healthy situation. Political uncertainty makes it very difficult to formulate business plans. Given that many electric utility investments are for equipment that can last up to 40 years, investors may be reluctant to make long-term investments in this politicized environment. This will lead to greater reliance on older equipment and this will result in reduced efficiency and lower quality of service.

Consumers can be expected to react to increasing electricity prices and there will likely be some relaxation of the barriers to building cheaper generation. Thus more reasonable regulations may be enacted in the future that will allow nuclear and coal generation to assume a larger role in the generation mix. But both coal and nuclear need long lead times for building and are very expensive to build (but possibly less than gas to operate). Similarly, because of the lead time and expense, investors may be reluctant to invest until the "rules of the game" become more certain. As will be seen in other sections relating to electric services, changing the "rules of the game" will be both necessary but difficult in order to have a coherent industry over the next two or three decades.

VIII. Electric Wires and Delivery

Generally, in order for electricity to be useful it must be delivered through wires between generation and the point of consumption. Broadly, Federal and State policy divides "wires policy" into "transmission" and "distribution." For our purposes, it is enough to think in terms of big wires that deliver electricity over very long distances (transmission) and little wires that deliver electricity into the business or residence (distribution). There are a variety of distinctions between transmission and distribution but for our purposes big/little and Federal/State are good enough approximation.



One key point dominates policy for the delivery of electricity. Even very conservative pro-market economists largely agree that electric wires present an example of a natural monopoly market failure requiring some degree of governmental intervention (though there is a minority that argues that regulation even under these circumstances is unnecessary since market innovation and technology will likely result in more efficient alternatives than regulation.) The explanation of a natural monopoly involves some technical economic criteria but for our purposes it is enough that it is more efficient for electric delivery to be a monopoly. How many duplicative distribution wires do you want running down your street?

The primary implication for policy of transmission vs. distribution is that the Federal government regulates transmission and the States regulate distribution. So each will be discussed separately.

But first this might be a good point to discuss one of the current overarching issues relating to wires, both transmission and distribution. Depending on your age, you are no doubt either more or less familiar with the fact that digital technology has literally transformed the world as we know it. I recently had a discussion with my 30-year-old son and explained how we made copies when I was in grade school. We used a mimeograph. When I described the technology, he was incredulous and looked at me as if I was part of the Stone Age. Some electric utilities are still using a mimeograph, only kidding! But it is not an overstatement to say that the technological revolution in digital technology has only been slowly absorbed by utilities. Perhaps only government has been slower to take advantage of technology than are utilities. (Witness the debacle of the Obamacare website.)

The new wave of demand for speedier progress in absorbing new technologies into the wires part of the electric system is called "Smart Grid." At the same time that utilities face increased challenges with climate change, aging infrastructure, changes in industry structure, increased costs to customers, and security threats to the grid, they must also cope with deciding the nature and pace of incorporating new technologies into their systems.

Purely private sector companies can try new ideas and fail. Some of you may remember the transition from radio, 8 track tapes, cassette tapes, CDs, IPod, streaming, and now cell phones that do everything. A lot of companies innovated and then crashed and burned. Even Apple, perhaps the most innovative company ever, almost crashed and burned at one point.

Electric utilities are monopolies. If a single utility crashes and burns there is no other utility that can just pick up the slack. They cannot be allowed to crash and burn. People's lives depend on highly reliable electric service. The entire economy depends on electricity. Read One Second After for a chilling account of what the world would be like if the electric grid suddenly cratered. We may be frustrated with utilities on occasion for being risk averse but they deserve more sympathy than we normally give them, given that mistakes can have catastrophic consequences.

Many special interests (renewables, independent generators, energy efficiency contractors, industrial customers, technology vendors, etc.) have a financial stake in the utilities decisions to adopt new technologies and are putting pressure on regulators to force utilities to change faster. But these technologies can be expensive and what happens if mistakes are made in embracing a technology that doesn't work as expected or is obsolete in 3 years. Utilities cannot go out of business and must pass costs on to consumers to stay in business. Sure they can and have been punished by regulators for mistakes but that only makes them more risk averse.

Yet surely we want utilities to take advantage of some of these smart grid technologies. But it would surely help if utilities knew with some certainty what the future structure of the electric system will be. On this issue, only the Federal government can lead as it did in other network/connective industry reforms. Alas, neither the Bush nor the Obama Administrations has provided the leadership for a national strategy on the electric system. Indeed, both made decisions that have made matters worse. Nor have any of the current flock of candidates for President in 2016 announced the need for the development of a national strategy for the electric system. (Full disclosure: the author of this article was the energy and environment advisor to Dr. Ben Carson's Campaign and I was barely able to get a sentence or two about the electric system in the vision he finally issued on energy and the environment.) Maybe with all the other problems that Washington must face it is too much too hope for. But I fear that it will take a crisis to get their attention. At the level of detail in this **Article**, all one can do is to be aware of the problem. Future Commentaries will deal with issues relating to electric industry structure and smart grid.

Related to the technology question of the resiliency of the grid is the question of the reliability of the grid. Historically, utilities were members of regional reliability councils, that were part of a national organization called the North American Electric Reliability Council (also known as NERC), formed in 1968, no doubt in response to the great Northeast blackout of 1965. These reliability councils had no authority to order utilities to improve their systems' reliability. But as a practical matter, issues raised by the reliability council were taken very seriously by utilities. In 2005, Congress passed legislation that gave

FERC the authority to mandate the development of a reliability organization that had some teeth. This was no doubt inspired by both the blackout of 2003 and the debacle in California. The old NERC morphed into the new NERC, under the authority of FERC.

The new mission as stated by NERC is:

> The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority whose mission is to assure the reliability of the bulk power system in North America. NERC develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the bulk power system through system awareness; and educates, trains, and certifies industry personnel. NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico. NERC is the electric reliability organization for North America, subject to oversight by the Federal Energy Regulatory Commission and governmental authorities in Canada. NERC's jurisdiction includes users, owners, and operators of the bulk power system, which serves more than 334 million people.

One more overarching issue needs to be discussed before discussing issues specific to distribution and transmission. And that is the issue how regulated assets are priced. Normally, in a competitive market, prices fluctuate with supply and demand. But with all parts of the electric system that are regulated, the utility has a monopoly and there is no competitive market in which the pricing system can do its magic. Prices for regulated assets are set by regulators and utilities can only charge those prices. Indeed, it is probably wrong to even call them "prices" and they are usually called "rates." Books have been written on the process of setting regulated prices. So it would be impossible to provide much detail in this summary.

But a brief explanation will highlight the problems with regulated ratemaking. The following would largely be true for regulated generation, transmission, and distribution and for all public utility commissions. (Indeed, much of it would be true historically for telecommunications, natural gas, and water.) In essence, the regulated company presents all its anticipated future costs to the regulator in a rate case. There are elaborate debates about many aspects of these costs, especially the profit margin, called the rate of return. But the utility is only allowed to recover its "prudent" costs. Out of this process comes a decision on what costs can be recovered. Then there is the process of allocating these costs to different services and customer classes. You can imagine the debates. Once costs are allocated the amount of anticipated service is determined. Simplistically stated, you divide costs into units consumed and you get an average rate per kWh. The utility is then allowed to charge that rate to customers so long as it is deemed "just and reasonable." You can see there is a lot of room for fudge.

This ratemaking process has many flaws and it has been under attack for many years. To summarize the debate:

1. The incentives for the utility to keep costs low by being hyper efficient are minimal. If they are hyper efficient their rates will just be lowered in the next rate case.
2. There is an incentive for gold plating on those costs that are subject to a rate of return (the rate base) as this is where the profit comes from.
3. Average cost pricing sends bad price signals to consumers since costs actually vary quite a bit over the day and by season. This means sometimes the average cost is too low and too much consumption takes place and sometimes it is too high and creates disincentives for otherwise efficient consumption.
4. There is an incentive to invest in generation rather than promote more energy efficient technologies to the consumer.
5. Incentives to innovate are blunted since the they may not be deemed "prudent" and costs have on occasion been disallowed, especially related to nuclear energy.

And this is just the tip of the iceberg.

In response to these criticisms, economists have supported a more flexible system called performance based regulation or PBR. PBR allows rates to rise with inflation but a "productivity" factor lowers rates over time. In essence, more efficient operations are assumed to take place and the utility will benefit from such efficient operations but customers will share in these efficiencies with somewhat lower rates. Great Britain has been a pioneer in this type of alternative.

In conclusion, there is one overarching reality about wires. Like generation, policy relating to wires is in a state of flux. Thus, the issues are complex and frankly chaotic right now. There is much pushing and pulling on the electric system writ large and it is difficult to predict where the industry will be in the next decade, much less 50 years from now. The best we can hope for in this type of overview **Article** is to understand the drivers of change, the key issues, and some of the initial attempts to answer these difficult questions.

Electric Distribution

Nearly every house or facility in the US has a wire running from the structure to either a pole or underground that connects to the electric grid. This wire is the conduit for delivering electricity to the structure. That wire is owned and operated by a company many of us know only as the "Electric Company." There are indeed thousands of such companies in the US and they are known in the industry as "local distribution companies" or LDCs and many are privately owned but regulated by the State, though many are owned and operated by municipalities or cooperatives.

LDCs are a unique type of corporate entity. They are all monopolies and heavily regulated by a State or municipality. Thus the rules that apply to them are very different from any other company with which you might be familiar, except maybe the natural gas company. (While cable and telephones were once similar to gas and electric companies, technology has rendered them sufficiently different so that they no longer fit this model.) What makes LDCs interesting is that they are in the midst of the most tumultuous transformation in their century old history.

There are two basic models of LDC in the US today, with some variations between these basic models—the traditional monopoly model and the newly emerging competitive model. (Some of the following will be repetitive of earlier discussions in generation. But if one is not reading this **Article** from beginning to end it would be confusing not to discuss certain issues again.)

The traditional monopoly model of an electric utility was that a single company would own and operate all the facilities and provide all the services needed to allow you to flip a switch and turn on the lights. They would build, own, and operate generation, wires to transport electricity over long distances (transmission), wires directly into the home or business (distribution), and the meters. They would then bill you for your use and collect the proceeds.

A century ago this made sense since all these facilities would be located very near the population that was using electricity. Because of its local nature, the city or town first started to regulate the electric company but eventually all States regulated the electric companies operating in their territory.

Given that the state was granting a monopoly to the utility, the regulation was comprehensive. Literally, the electric company had to get permission from the State agency, often called a public utility commission, to do nearly everything that they needed to do to carry out their business. The utility was usually required to install wires to hook up any customer in its monopoly franchise territory and had to stand ready to provide as much electricity as was demanded. This requirement is known as the "obligation to serve."

The commission also required the utility to seek permission to build new generation and transmission facilities. In return, the utility was more or less guaranteed a profit, generally modest, on its investment. Utilities owned all the generation and the only sales of electricity, other than to retail customers, were to other utilities. These sales to other utilities were regulated by the Federal government but it was generally fairly light-handed since the States provided most of the protection against utilities making serious mistakes.

The one exception to this rule was called self-generation. Sometimes large industrial customers or concentrated customers like universities would install their own generation equipment for their own use. More recently, some homeowners have installed solar panels or installed generators that make electricity from natural gas, propane, or gasoline. But self-generation was always a very small percentage of the total amount of generation, and still is, though that is changing.

This model of electric distribution started to change in 1978, with a small crack in the door. The Federal government, as part of comprehensive legislation on energy, created a requirement that utilities had to buy power from certain non-utility companies that developed certain types of electric generation (essentially small power producers or electricity generated from waste heat).[15] This was the first action that began to break up the electric utilities' monopoly power over generation. In 1992, Congress created additional requirements that utilities buy electric power from certain third parties. This created an even larger exception to the utilities monopoly over generation.

Several events were important to the next set of actions that changed electric utilities. In the late 1970s and early 80s, Congress deregulated airlines, trucks, and railroads. In 1982, a Federal district court broke up

[15] The 1978 act was part of the National Energy Act and was called PURPA or the Public Utility Regulatory Policies Act. "One provision of PURPA is the requirement for increased use of energy cogeneration. The law forced electric utilities to buy power from other more efficient producers, such as cogeneration plants, if that cost was less than the utility's own "avoided cost" rate to the consumer; the avoided cost rate was the additional costs that the electric utility would incur if it generated the required power itself, or if available, could purchase its demand requirements from another source."

the AT&T monopoly over the telephone industry. Between 1985 and 1992, the Federal Energy Regulatory Commission (FERC) issued a number of orders that injected competition and market forces into the natural gas industry, with Congress eventually deregulating natural gas in 1989. Additionally, in 1989 the Berlin Wall fell, marking a dramatic end to the historic battle between markets and central planning, with markets being the victor. All these events had positive impacts on the economy and were perceived as successful market reforms. The lone remaining monopolist was the electric utility.

In the 1980s, FERC had successfully given a degree of choice of supplier to the natural gas pipelines' historic customers (mainly local gas distribution companies and large industrial companies). This was mirrored in the telephone industry when customers were allowed to choose their own long distance carrier (and with the advent of cell phones their own local carrier). Thus the mantra in electric became "customer choice." Customer choice required that State commissions either encourage or mandate that utilities allow either all or certain customers to buy electricity from someone other than the utility. To be clear, there was no Federal requirement for customer choice. Each State had to decide who, if anyone, would have the choice to buy electricity from someone other than the utility. To facilitate this new competitive environment, some States even required utilities to sell their generation (divest) to the private market and prohibited utilities from owning generation.

As utilities opened up their systems to customer choice a bevy of marketers started to sell electricity to customers who could now choose a supplier other than the electric utility. It is important to note that this new approach did not mean anyone could build new wires into the home or business. All electricity would still be delivered through the electric utility's wires. But the utility would be required to allow third parties to use the wires for a price to deliver non-utility electricity to the customer (think of it as freight on a railroad car).

But a funny thing happened on the way to the forum, about 20 States adopted some form of customer choice and the rest didn't. As it stands today, both models of electric distribution exist. Some States still have the traditional model, mostly States in the southeast US. Some have opened up their systems to customer choice, mostly States in the northeast.

At the same time that many analysts were reconsidering the underlying policy relating to LDCs, a technology revolution was taking place. It was becoming increasingly clear that computer and digital technology as well as certain generation technologies were challenging the assumption about the efficacy of giving the LDC a comprehensive monopoly over the distribution wires.

Perhaps the best way to illustrate these burgeoning tensions is to focus on what the State of New York is considering in rethinking the role of the LDC.

Under the extraordinary leadership of the Chairman, Audrey Zibelman, the NY Public Service Commission began a proceeding in 2014 called "**Reforming the Energy Vision**." This proceeding is the most comprehensive reconsideration of the role that LDCs should have in the 21st Century and is being followed with much anticipation.

As described by the Commission:

> The energy industry is in transition. Technological innovation and increasing competitiveness of renewable energy resources, combined with aging infrastructure, extreme weather events, and system security and resiliency needs, are all leading to significant changes in how electric energy is produced, managed and consumed. New York State must lead the way to ensure these trends benefit the State's citizens, whose lives are so directly affected by how electric energy is manufactured, distributed, and managed.
>
> To meet this challenge, the Commission commenced its Reforming the Energy Vision (REV) initiative to reform New York State's energy industry and regulatory practices. This initiative will lead to regulatory changes that promote more efficient use of energy, deeper penetration of renewable energy resources such as wind and solar, wider deployment of "distributed" energy resources, such as micro grids, on-site power supplies, and storage. It will also promote greater use of advanced energy management products to enhance demand elasticity and efficiencies. These changes, in turn, will empower customers by allowing them more choice in how they manage and consume electric energy.
>
> The Commission has identified six core policy outcomes relating to customer knowledge, market animation, system-wide efficiency, fuels and resource diversity, system reliability and resiliency, and carbon reduction. A Staff Report and Proposal sets forth a vision for how to accomplish the

> Commission's objectives. The proposal describes how customer-side resources can become a primary tool in the planning and operation of the utility system, which will improve system efficiency and enable the deployment of cleaner and more resilient technologies. The Report further explains how reforms in the utility ratemaking process will be necessary, to provide the correct incentives for utilities and markets to develop a cleaner and more efficient electric system.

This proceeding has already begun a spirited conversation about the future and promises to be indicative of conversations that will be undertaken in many States over the next decade. A future Commentary will discuss the New York REV proceeding in greater depth. Some of the issues raised in the NY REV proceeding are discussed at the end of this chapter since they implicate some questions about transmission as well.

Electric Transmission

In order to get to the distribution company, electricity will usually have to travel at high voltage levels over relatively long distances. The traditional pattern for building large power plants (called central station base load plants) was obviously not to build them in the middle of densely populated areas. Thus large wires from the distant power plant to the distribution grid were necessary. This function is called electric transmission. Not surprisingly, transmission is also in a state of flux because of the changes being made to the historic models of electric regulation.

Again at the risk of some repetition, historically, a single company called an electric utility owned the entire electric service operations in a service territory. As noted above, this meant that a State commission typically approved plans to build new transmission lines and determined the transmission costs that would be included in the customer's charges.

"Transmission" actually involves four very different functions that are sometimes glossed over but need to be separately appreciated, especially as we transition from the traditional model to the newer model. The first is ownership. The second is decisions to build new facilities. The third is actual movement of electrons along the wire. The last is the very important and delicate task of system operations, or keeping all the pieces working together so that changes in supply and demand are met on an instantaneous basis. Think of this last function a little like an air traffic controller.

One important point about electric transmission needs to be made. Permission to build new electric transmission is handled on a State by State basis. By contrast, permits to build new natural gas pipelines, unlike electric transmission wires, are handled at the Federal level by FERC. Thus a single State cannot prevent a pipeline from being built across State lines (though States and other stakeholders can participate in the FERC proceeding to decide the issue of new pipeline construction.) State control makes building new electric transmission facilities more difficult. Pursuing their self-interest, some States have blocked the construction of electric transmission facilities because it would merely go through the State without sufficiently benefiting the State's citizens. This has been recognized as an anachronism in the original Federal Power Act amendments in 1935. Thus far, Congress has tinkered around the edges of reform but has not fully reconciled the difference between natural gas pipelines and electric transmission construction policy.

Transmission became much more complicated once public policies in some States were changed so that the generation monopoly would be eliminated and that some customers would be able to choose their own electricity supplier. Under the traditional system, the utility's closed system would determine which electrons would be generated, which customers needed electricity, and which generation and transmission facilities would accordingly be used.

Under the new system the need for and use of transmission would depend on which customers bought electricity from which generators. The problem is that some customers might want to buy electricity from a generator that would have to use the transmission facilities of several utilities. In order for beneficial competitive transactions to occur there had to be a way of coordinating the transmission facilities of utilities. Think of transmission as the interstate highway system. Now think of how difficult it would be if you had to negotiate a contract with each town that the highway went through in order to make a trip. (In theory, we "pay" for using the roads of different cities or towns by paying a tax on gasoline that is supposed to be allocated for road construction and maintenance. Thus we can use the roads without the need to pay for each road we travel on separately.)

There are several ways to deal with this problem and it is actually not as rare a problem as you might think. It turns out that transmission facilities are a lot like other "network" or "logistical" or "connective" industries. For example, we have highways, natural gas pipelines, airports, navigable rivers, telecommunications, cable, and many others. In fact, courts have drawn analogies from these types of industries for movie theatres and Microsoft Windows Operating System. For example, many different producers of movies want to show their movies in movie theaters. Movie theatres are the "connective" industry, connecting film with theatregoers. Suppose the major Hollywood movie producers (MGM, Warner Brothers, Sony, and Paramount) bought up all the movie theaters and then only would show movies produced by that company. Independent filmmakers and consumers would suffer from a lack of competition. So the Supreme Court in 1948, upheld a decision to prohibit the major movie producers from owning movie theatres. This meant that more movies (think generators) were able to get access to the market and consumers had more choices of movies (think suppliers of electricity). Similarly, Microsoft entered into a consent decree to stop using its dominant market share in Windows Operating System (think transmission) to prevent competitors from gaining easy use of Windows for their products (think marketers using transmission to gain access to customers). More recently, Europe has initiated a proceeding against Google on much the same theory. Google is accused of using their near monopoly in its search engine to benefit Google-affiliated products, which in practice discriminates against non-Google-affiliated competitors.

You might think that since there are so many different types of network/connective industries the transition in using transmission from the historical to a more competitive model would be straightforward. Alas that is not the case.

There are actually three different models of transmission regulation that are in use today: the traditional model, the Regional Transmission Organization (RTO) model, and the Texas model.

The traditional model is fairly easy to describe. The utility owns all electric facilities (generation, transmission, and distribution) and sells electricity to customers in its service territory and is comprehensively regulated by the State. It owns and operates the transmission system as part of its vertically integrated business. No muss, no fuss.

The RTO model is much more complex. This is where the issue of which level of government has authority becomes important. Under the traditional model, a Federal agency (the Federal Energy Regulatory Commission or FERC) had authority or "jurisdiction" over "sales for resale." Sales for resale historically were few and far between and were largely any electricity sold by a third party to an electric utility. The electric utility would then sell it to its customers (a sale for resale). Historically, this was not a very important authority since it was usually one utility selling excess power to another utility when mutually agreeable.

Things changed dramatically in 1992 after the enactment of legislation. The legislation shifted Federal policy to encourage "wholesale" competition.[16] That meant that it was now easier for independent generators to build generation and sell it into a competitive wholesale or sale for resale market. While generator's now had the right to sell into the wholesale market, they still had to arrange for transportation of the electrons from the generating facility to the point of consumption, be it a utility or an end user. Given the historical reality that hundreds of utilities owned pieces of transmission capacity, this was very difficult and inefficient. (Because the historical reality was different for natural gas pipelines, it was relatively easy for a producer to sell natural gas to a distant customer but arrange transportation between the production area in Texas or Louisiana to Boston or Chicago through a single pipeline.)

In order to address this problem, FERC used this new authority to create a new type of organization called RTOs, though sometimes also called ISOs or Independent System Operator. For our purposes, RTOs and ISOs are synonymous.

An RTO is usually a nonprofit organization that organizes the wholesale electric market. Think of it like the New York Stock Exchange. It is created to allow electrons to be bought, sold, and delivered over wires. In order for wholesale competition to succeed, someone had to coordinate when wires owned by different companies would be used. So FERC gave the RTO the authority to run the transmission wires operation. There are three important points. First, the utilities still owned the wires but "control" of the wires was given over to the RTO. Second, the RTO did not have control over the wires directly into the home or business; the local utility still operated that set of wires. Third, the RTO did not build new or additional transmission wires, which were still the responsibility of utilities.

[16] While the terminology of "wholesale" sales is used in electric, this can be confusing to those who assume the common meaning of wholesale. The dictionary definition of wholesale is "the selling of goods in large quantities to be retailed by others." Technically if a large industrial customer or even a large commercial customer like a Walmart or McDonalds buys from a generator or marketer, it would be a "retail" sale since it is not bought for the purpose of being "retailed to others." In the electric industry, however, the term "retail" is reserved to sales by the utility to residential and commercial customers. The term "wholesale" in the electric industry is anyone who buys in bulk and has it delivered by the utility. Again here the distinction between big and small makes more sense. The "wholesale" electric market is for big purchases of electricity and the "retail" market is for smaller purchase.

RTOs are organized into geographic regions. Today, there are six RTOs regulated by FERC.

And then there is Texas. Because Texas is not connected to the national grid, Texas operates its own RTO regulated by the Texas Public Utility Commission known as ERCOT. While there are some important differences between FERC's RTOs and Texas' RTO, those differences are not relevant here.

In addition to the three models discussed above, there are potentially a myriad of other models that might be used to organize the electric industry.

In some other countries (and in the US to some degree for the natural gas industry), electric transmission is mandated to be a single company that operates all the transmission in the region and creates a competitive wholesale market. In this model the transmission company is not allowed to own generation or distribution companies. Under this approach, the transmission company is the umpire and should be objective in operating its transmission system, with the goal of creating and operating a competitive wholesale market. Allowing the transmission company to own generation would set up a situation where the transmission company had a conflict of interest. They might give preferences to their own generation and disadvantage a competitor's generation.

Another model is for the government to own and operate the electric transmission function, as in New Zealand and China. Think of this as akin to the US interstate highway model. And there are other possible ways to organize transmission and wholesale markets which are slight variations on these different models.

Electric Transmission will be the topic of a future commentary, but the key points about electric transmission are as follows:

- Some States, mainly in the southeast, still operate under the traditional monopoly model.
- Some States are part of RTOs.
- RTOs have permitted reasonably robust competition in wholesale electric markets.
- RTOs have been very bureaucratic and expensive to operate.
- Making investments in new transmission is easier in the traditional model than in the RTO model, where there is disagreement among stakeholders on how to price new capacity.

Blurring the Lines between Generation, Wires and Jurisdiction

More recently, the lines between wholesale/retail markets, transmission/distribution functions, and generation/distribution/transmission functions have begun to blur even more. Both policy and technological changes make it possible to build certain types of generation closer to the customer, called distributed generation.

For example, if a homeowner puts solar panels on the roof, it can generate some of the electricity needed for personal consumption. But since solar is intermittent, there will be some occasions when more electricity is generated by the solar panels than is consumed and sometimes less. So the homeowner will have to continue to rely on the electricity to be supplied to the home when power is needed.

When a homeowner's rooftop solar generates *more* electricity than the homeowner needs at the moment, things really get interesting and controversial. If battery technology existed so that the excess electricity could be saved and used when the homeowner needs more than is generated by the rooftop solar there would be no problem. It would just be a form of self-generation, similar in concept to an industrial customer or a college building its own generation on-site. But as of yet there is no cost effective battery technology for storing electricity.

So what happens to the excess electricity? Many States **require** utilities to buy the excess electricity from the homeowner and use it to serve the utility's customers. Traditionally that would have made the sale from the homeowner to the utility a sale for resale and the homeowner would have been subject to FERC regulation as a wholesale generator, a ridiculous unintended consequence. But recent laws have greatly simplified the process. Utilities are required to buy the excess electricity and engage in a type of payment called "net metering." If at the end of the month the homeowner has used less electricity than was generated, the utility will pay the homeowner for the difference. The price is not a negotiated price but is rather mandated by regulators.

These net metering prices are very controversial. Some States set them at a level that is actually higher than the utility could buy on the competitive wholesale market or than it would cost to generate electricity from its own generation. Thus prices for electricity are higher. One neighbor is subsidizing her next door neighbor. But some believe that since rooftop solar is a renewable technology that this subsidization is appropriate. Thus the controversy.

The issue of creating a right to install rooftop solar has even caught the attention of the Tea Party movement. Utilities preventing homeowners from installing rooftop solar is seen as a restriction on liberty by a government created monopolist.

Up until recently, there was too little rooftop solar to create reliability, system management problems, or serious price increases. But as solar prices are subsidized and as technology prices dropped rooftop solar is becoming a bigger issue.

Rooftop solar is the most common form of distributed generation. Other forms of distributed generation are fuel cells, small wind and small hydro. State rules determine what will qualify as distributed generation.

There are two important issues broadly raised by distributed generation. First, the distribution grid and the current pattern of generation were not built with the expectation of distributed generation, i.e., the two-way flow of electricity in and out of the home. If the complaint of utilities was merely "but we never did it that way" there would be little reason for sympathy.

But utilities' complaints are more legitimate and serious than that. Take Hawaii as an example. Rooftop solar is reaching rather high levels of penetration. But here is where intermittency is a problem. If all the sudden clouds form and block the sun, a large part the electricity that the utility was counting on is no longer available. But 30 minutes later, the sun comes out and there is a lot of rooftop solar available. The grid was not designed to handle the radical voltage spikes and valleys that can occur in this situation. Thus, a small amount of rooftop solar is manageable but as the amount of rooftop solar increases the grid management problems become more difficult.

Second, as the penetration of rooftop solar increases, the utility must have more backup generation available to meet the demands for electricity when the sun don't shine. Utilities can be caught in a Catch 22. They lose revenue to rooftop solar and they must allow more of their generation facilities to be idled when the sun shines. Not surprisingly, the utility wants to be compensated for these costs, especially since it is the result of mandates that they buy the excess electricity from rooftop solar. This increases the price of electricity and causes some customers to complain about such prices.

Yet another disruptive technology is the concept of the microgrid. Especially as digital technologies are much more sensitive to even a one second interruption in electricity, demands for highly reliable supplies of electricity are increasing. Some of this increased demand can be filled with self-generation or backup power, but this can be expensive. Another idea is for a group of customers to get together and interconnect their systems by wires and then install generation for this cluster of consumers. A university campus, an industrial or technology park, or a shopping center are examples where such a "microgrid" might have some application. But this starts to look like a mini-utility and the question is will they be regulated like a utility and can such an electrical system exist consistent with the notion of the utility's monopoly franchise over wires. One of the benefits of a microgrid is that it can island itself off from the larger grid in times of emergency outages. The concept of the microgrid is yet another issue creating a state of flux for the electric system.

In conclusion, the issue of electric wires from a policy standpoint is complex and in a state of flux. But electricity is too important to the economy and quality of life to make serious mistakes. Thus there is a push and pull between those who want change quickly and those who worry that mistakes may be made by moving too quickly. Additionally, the Federal government has not been very aggressive in recognizing that the circumstances on which present policy have been predicated have dramatically changed. There is no Federal policy to rationalize these dramatic changes. Thus change seems very chaotic at the moment.

Normally, one could rely on national think tanks (largely located in DC) to take up issues that could have such a dramatic impact on prosperity, security, and health and welfare. But for some reason, the national think tanks (e.g., Heritage Foundation, Brookings Institute, American Enterprise Institute etc.) have not dealt comprehensively with electric industry organizational structure. Rather they have nibbled at electric issues only where they intersect other issues such as national security, environment, or economic policy. Hence, it is probably the case that these issues will continue to muddle along over the next decade.

Discussions with industry experts from all political and ideological persuasions indicates that there is fairly broad recognition of the dysfunctional state of electric policy but no consensus on what should be done. Unfortunately, these types of difficult issues (e.g., national debt, immigration, health care, education, national security etc.) are often allowed to fester until there is a bona fide crisis. That, I suspect, is what will happen in electricity. While not hoping for a catastrophe, it is likely that sufficient attention will not be paid to these issues until there is some significant failure in the electric system.

IX. Consumption and Efficiency

Using energy is vital to every part of our lives and we use a lot of it. Indeed, the ability to find ways to increase our use of energy is the story of the rise of civilization itself. Man once relied on his own muscle power to find the meat that would sustain him. Man's daily activities were dictated by the sun. Eventually, animal power became important. Today, everything is made easier by the availability of reasonably priced energy and the technologies that use that energy.

While using energy may seem like an unalloyed benefit to mankind, there are some who see using energy as problematic if not downright evil. Some simply believe in a conservation ethic. Some genuinely fear that with the exponential growth in population we will run out of energy. Others deem the energy needed to sustain the earth's population as harmful to the earth. And others object on moral grounds to what they perceive as the wasteful use of the earth's resources (affluenza). Indeed, there is even a political movement that promotes degrowth, the rejection of increasing standards of living through technology.

So there is a vigorous debate about "using energy." Actually, you are probably familiar with some of these issues since they directly affect you as a consumer. Traditional incandescent lightbulbs are now illegal for you to purchase. You may have noticed that your shower head does not have the same force that it used to (low flow shower heads to conserve water and the energy to heat water). You may be aware that the government mandates that the cars you buy have to get more miles on a gallon of gas (Corporate Average Fuel Economy or CAFE Standards). If you have bought a major appliance lately you might have noticed the Energy Star rating, an indication of the efficiency of the appliance. And there are many "efficiency" impacts of which you are not even aware.

So what's the debate all about?

As we discussed in the Introduction, the term "energy efficiency" is a bit confusing. An engineer thinks of energy efficiency as getting more energy output for the same amount of input, i.e., more miles per gallon, more heat per unit of natural gas, more light for less electricity. Notice that in each of these examples the engineer does not look at cost. If you are not careful you will assume that if you get more for less, then it must be cheaper. An economist thinks almost exclusively about cost. To an economist, energy efficiency considers the technology that results in the *lowest total cost* of achieving a certain end. We all have different ways that we use energy. I may put 35,000 miles a year on my car but you may only drive 5,000 miles. And this could significantly affect the total cost of a given activity. In the Introduction we used the example of a car that could get 30 miles to the gallon or 300 miles to the gallon. The engineer would conclude that the second car is more "energy efficient." The economist would not be able to tell solely based on knowing the miles per gallon. The economist needs to know how much the different cars cost and how many miles are expected to be driven over the life of the car. The economist can then calculate which would be the most *cost-effective* for a given consumer.

Since consumers may use the car very differently, the answer of which is most "efficient" will depend on consumer behavior. It is this insight that not all consumers behave the same that makes it ***impossible*** for government to effectively mandate efficiency. By definition, mandating energy efficiency means some consumers will pay more for their total cost of energy. By the same token some *may* pay less, but that is not a given since it is highly dependent on the cost of the technology that is necessary to meet the standards.

Let's first start with the most important concept regarding efficiency: price. Ronald Reagan famously said: "if you want more of something, subsidize it; if you want less of it, tax it." This is just a clever restatement of the law of supply and demand. If the price of something goes up, we will use less of it. If the price of something goes down, we will use more of it. Similarly, if the supply of something goes up, price will go down. If the demand for something goes up, the price will go up. This is perhaps the most important point in economics. **Price signals are crucial to how consumers make decisions**.

Though all you see is $3.99 for a pound of beef, that price signal carries with it a ton of information about what it took to get that pound of beef to the grocery store; literally hundreds of people made decisions based on the knowledge of market conditions to price that pound of beef. Indeed, one clever analyst wrote an ode to the pencil explaining the "genealogy" of the pencil, concluding that no single person possesses the knowledge to make a pencil from beginning to end and hundreds have been involved in getting that pencil in your hand, yet it costs a nickel. Friedrich Hayek made much the same point about the dispersed nature of knowledge in society, leading him to conclude that it was impossible for a central government to have all the knowledge it needed to make efficient decisions.

If gasoline prices decrease, so will the price of beef. If inflation is high, a pound of beef will cost more. If corn is expensive, it will increase the price of a pound of beef. If weather conditions are adverse to cows, it will decrease the supply of beef. And so on.

So important is this fact that Friedrich Hayek, a Nobel Laureate in Economics, once observed

> I am convinced that if it were the result of deliberate human design, and if the people guided by the price changes understood that their decisions have significance far beyond their immediate aim, this mechanism would have been acclaimed as one of the greatest triumphs of the human mind.

Much of the mischief in energy efficiency policy derives from a profound misunderstanding of how price drives consumer behavior. Energy is no different from other commodities. If gasoline prices are high, we will drive less and search for substitutes either of fuel (bicycle power) or technology (natural gas vehicle or more miles per gallon). If electricity prices are low, we will turn up the air conditioner.

Generally, in a free market, prices balance supply and demand. We regard that as a good thing and do not believe that government needs to get involved in telling us we are using too much cotton or too little broccoli. The general belief is that it is up to the consumer, responding to price signals, to decide how much of a particular good they want to buy, and for producers to respond accordingly.

Unfortunately, many believe that energy does not fit this basic approach, and to some extent they have a point. Again as we noted in the Introduction, if the price of a good is distorted by a market failure or an environmental externality then it might be appropriate for government to intervene and influence the price.

But this is critical. The goal must be government action to promote efficient prices and then let the consumer decide. The goal should not be to use mandates to control consumer behavior. Indeed, to take it one step further, if there are efficient prices, then there is no moral consequence to a consumer's decisions. Even further, if there are efficient prices then it is immoral for the government to mandate different outcomes from the market outcome based on consumer sovereignty.

You should consume as much or as little energy as you want as long as you are willing to pay market prices. If prevailing market prices are distorted by monopoly or externality, then policies should adopt mechanisms to improve the price signal. It should **never** be appropriate to tell a consumer that they should not consume energy if that is their desire and are willing to pay for it. Similarly, if prices are efficient, then it is completely improper for government to mandate more "efficient" technologies. Most of the mischief done in this arena actually represents the lack of political will to adopt policies that promote efficient pricing.

Case Study of Natural Gas Distortions

Today, natural gas pricing and competitive markets are good examples of sound energy policy. So we start our discussion of the problems of consumption and efficiency with natural gas, because it wasn't always so, a good before and after example. The history of natural gas policy in the US is one of the ugliest periods of bad energy policy. An understanding of the before and after provides valuable context for understanding the problems of price that exist in other energy resources.

The first problem began in 1954. For a complicated set of reasons not really important here, the Supreme Court told the Federal Power Commission that they had to set price ceilings on natural gas that was sold in interstate commerce. Needless to say, economists strongly believe that price controls are rarely a good idea. As noted above, price plays a critical role in balancing supply and demand. Consequently, a huge bureaucratic structure was put into place to set the price of natural gas for each producer, of which there were thousands. The FPC muddled through but things went from bad to worse after the OPEC Oil Embargo in 1973. OPEC dramatically increased the price of oil overnight.

Think about it. The Federal government kept the price of gas below its market value and OPEC increased oil above its market value. If you had a choice to use either oil or natural gas as some consumers and businesses did, what would you do? Sure enough there was a surge in demand for natural gas. But natural gas prices could not respond because of Federal price ceilings and we had shortages of natural gas in the 1970s in various parts of the country. Importantly, there was no shortage of natural gas in intrastate markets (markets where gas was consumed in the same State in which it was produced, e.g., Texas, Louisiana) because the market set the price in these markets).

During the Ford and Carter Administrations there was a widespread perception that we were running out of natural gas. In response, a number of policies were enacted that either reduced or prohibited the use of natural gas. All these policies have mercifully been eliminated but their legacy should provide a valuable lesson of just how badly the government can screw up a market with bad pricing policy.

In 1978, Congress passed a law to reform the chaos that had resulted from price ceilings, but ironically added more chaos. In sum, it established over 20 different categories of natural gas and gave each a price ceiling. In fairness, it did deregulate a small amount of gas. Interestingly, it began to regulate the price of intrastate gas to prevent the situation where producers refused to sell gas into the interstate market to avoid price controls. When I joined the Reagan Administration in 1981, I was assigned to write rules for this complicated scheme of natural gas price ceilings. But President Reagan had made it clear that his ultimate goal was to deregulate the price of all natural gas and let markets set the price of natural gas. Eventually, after years of regulatory reforms, Congress agreed and lifted price controls in 1989.

On the theory that we were running out of natural gas, Congress passed a law in 1978 (the Powerplant and Industrial Fuel Use Act) that prohibited the use of natural gas for new electric generation plants and new industrial boilers. That's right it was **illegal** to use natural gas for electric generation. Congress repealed this policy in 1987. By contrast, today, now that we have fixed the policies on natural gas in the 1980s, about 90% of new generation uses natural gas. Think about just how wrong Congress was in correctly predicting the future.

As part of the 1978 laws relating to natural gas, Congress made it more expensive for some industrial businesses to use natural gas. Under a policy called "incremental pricing" natural gas that was deregulated was allocated to industrial customers, both to disincentivize the use of natural gas and to shield residential customers from higher prices. This was a very complicated, bureaucratic program that was quickly recognized two years later by the General Accounting Office as an unsound policy.

During this period of government induced shortages, many States enacted bans on using natural gas in newly built houses, called moratoria, leading to increased use of electric for heating, an arguably less effective type of heating. Additionally, certain uses of natural gas were prohibited. For example, some States made it illegal to heat swimming pools with natural gas.

Thankfully, this chaotic and counterproductive period of atrocious policy on natural gas is behind us. During the 1980s and early 90s, government policy undid nearly all the constraining regulations on natural gas and allowed competitive markets to drive production and consumption decisions. Today, we consume the highest annual volume of natural gas in US history and it is estimated that we have literally hundreds of years of natural gas resources.

One would hope that DC's policymakers would have learned valuable lessons from this contrast between government control of natural gas production and consumption and relying on competitive markets. Alas, there is little evidence that they got the memo. What follows are examples of current policies that affect price and consumption decisions.

An Example of Unintended Consequences

Government has been trying to curb energy consumption for over 4 decades. Yet we consistently find that we continue to use more energy (though our use on a per capita basis has slightly declined). The explanation for this is called the "rebound effect."

There are two dimensions to this rebound effect. First, if an appliance is more efficient (air conditioner) and thus cheaper to use, we may use more of it (turn on the air conditioner earlier in the season or decrease the temperature setting to increase your comfort). Thus paradoxically more efficient appliances and cars may either increase total energy consumption or at least not result in as much energy savings as originally hypothesized.

The second dimension is that saving money from energy efficiency puts more money in your pocket. Not surprisingly, you may spend that money on something that increases your use of energy (install a pool in your backyard or take an additional trip). Thus, again, the hoped for total savings in energy consumption do not achieve the original goals of the advocates for mandated efficiency standards.

The rebound effect is a good example of unintended consequences and Hayek's dictum about the challenges to government intervention. Given the benefits that we know that derive from relying on efficient competition and the sometimes hideous effects of government intervention in markets, one would hope that this would result in a more humble attitude when it comes to such interventions. There seems to be little evidence that such lessons have been learned.

Electricity

As we have seen in the **Electricity Chapters**, because of monopoly problems the government normally must approve the price a utility charges. The approach adopted by nearly all commissions was to set the price of electricity on a cents per kilowatt basis that would be charged on all kilowatts that the consumer used. (Believe me, there is a lot of complicated rigmarole behind the process used by commissions to determine this cents per kWh charge. Wiki has a simplified explanation if you are curious.)

The problem with this price, let's say it's 10¢, is that it represents an average of a lot of different costs. Sometimes it costs the utility only 2¢ to generate electricity (midnight on a spring day) but at other times it might cost 50¢ or in extreme circumstances a dollar. So consumers use air conditioning on the hottest day of the year (peak period), as if they valued it at 10¢ but it actually takes 50¢ or more of society's resources to produce that unit of electricity. Analysts have long complained that average cost pricing results in the inefficient use of society's resources. Just think about it, would you use less air conditioning or buy a more efficient air conditioner if the price were 5 times higher during the peak period. It might affect how big a house you buy or how much insulation to use or when to do your wash or cooking. So prices have consequences. The regime of "average cost pricing" of electricity leads to overinvestment in generation to meet an artificial peak and underinvestment in more efficient consumption technologies.

To their credit, Congress long ago in 1978 highlighted this problem,[17] but merely required States to study the issue of the distortions of average cost pricing. Unfortunately, States made few dramatic changes in their pricing policies and even today, more than 35 years later, distorted pricing is the rule rather than the exception in the vast majority of states.

In addition to the problem of government set prices, there is the environmental externality problem. In the **Electric Generation Chapter**, we concluded that a cost should be included in the price of a good, in this case a kilowatt of electricity, that roughly reflects the cost to others affected by the pollution caused by

[17] Indeed, Samuel Insull the father of the electric utility industry recognized the distortions of average cost pricing at the outset of the electric utility industry nearly a century ago. A fascinating biography on Insull can be found in the first five chapters of Dr. Robert Bradley's brilliant book, Edison to Enron: Energy Markets and Political Strategies.

producing that good. We called it an environmental harms charge, though some call it a tax.[18] We also discussed that there are many different generation technologies that have very different environmental consequences. So electricity pricing should also reflect some of the costs associated with the relevant environmental harms.

This is a legitimate problem. Analysts all over the political spectrum would agree that traditional electric prices send bad signals on when and how to consume electricity. The fun begins when you try to fix the problem. There are four basic approaches to dealing with bad electricity pricing.

First, believing that the rates for electric service are to low and thus more electricity is used than is "necessary," the Federal government has mandated the use of more efficient appliances. Today's more efficient refrigerator uses about 400kWh a year compared to about 1200kWh in 1980. That's a staggering energy savings. But remember our definition of energy efficiency. The total cost of "refrigeration" is the price of the refrigerator plus the cost of electricity (which varies widely by State) over the life of the refrigerator. Thus it is quite possible that the more expensive efficient refrigerator may not result in the cheapest "refrigeration" even though it is cheaper to run. (Interestingly, when studies were done on the savings in energy from new, more efficient refrigerators, they were lower than expected. Researchers found that some people put the old refrigerator in the basement or garage as backup. Similarly, when people brought more efficient air conditioners they sometimes adjusted them to a cooler temperature, thus little energy savings, albeit greater comfort. This is referred to as the Snackwell Effect (or rebound effect) after the low calorie cookie. Dieters just ate more cookies and not necessarily less calories.

Additionally, the Federal government has outlawed the traditional incandescent bulb. There are literally hundreds of Federal and State rules that mandate various forms of electric efficiency. Notice that these efficiency standards have nothing to do with price. Whether you are in New England with the highest national prices for electricity or the Southeast with the lowest, the national standards are the same. Additionally, comfort needs differ by geography. New England may not need as efficient air conditioners and the South may not need as efficient heating. The key to mandated standards is that they cannot possibly account for differences in consumer behavior, consumer need, or differences in prices.

---

[18] Does anyone call a postage stamp a tax? No. It is the cost for a given service provided by government. A tax is a charge by government to raise revenue. Since a fee on electricity for the use of the environment is a fee to use a good, it is more appropriate to think of this a harms charge, not a tax. Calling it a tax is often used to raise political objections rather than to cogently discuss environmental policy. This is not to say that a carbon tax is yet the appropriate policy for carbon emissions. But that has to do with the uncertainty associated with the harm of carbon emissions, not the efficacy of a carbon tax if the harm were more certain.

Second, policies required that the utility develop programs that encourage people to use less electricity. So for example, the utility would provide insulation at a reduced price or provide more efficient light bulbs. The key thing to remember is that there is no such thing as a free lunch. If the commission mandates that the utility install electricity saving devices, it will raise rates to other customers in two ways. The cost of the efficiency program will be included in the utility's rates. Additionally, the utility will make less money because it is now selling less electricity. Since it is compensated for all its wires and generation, it will have to spread its fixed costs over less units of electricity and that may mean higher rates for all customers. To be fair, some customers may pay lower bills because the price per kWh may be higher but the amount of electricity they use may be lower, thus a lower bill.

Third, some commissions try to set prices that reflect the differences in price by season and time of day. For example, they may have a summer price and a winter price. The price in the period when less electricity is used (off-peak) is lower than the price during high use times (peak). But these are guesses, educated though they may be. The major limitation is metering. When meters were installed they only measured the total units of electricity that were used. The meters did not have the ability to tell you *when* the electricity was used. They could not differentiate whether you used a kWh during a peak time of day or week (we use less at midnight than at noon and less on Saturday than on Monday) or an off peak time. So setting what is called "real time pricing" was impossible. But meters and digital technologies are becoming increasingly sophisticated and cheaper and it is only a matter of time before all homes and business have better meters.

Fourth, let markets set the right price. What a radical idea! Over the last two decades, a handful of States have radically altered their electric systems to allow customers to buy from marketers rather than only being able to buy from the utility. Part and parcel of that reform is also allowing third parties to build generation facilities. Think of it like a railroad. Generators can put goods on a train and pay the train for delivery services. The utility would be required to allow marketers and generators to use their wires to deliver electricity. Having specialized in these policies for three decades, I will be the first to admit that these reforms are very complicated and some people question whether it is worth the effort.

Do consumers really want to shop around for electricity? Maybe. Look at how many cell phone ads are on TV. The savings from competing cell phone carriers is likely comparable to savings from competitive electricity. But that's a question for another day. Today, only Texas for electricity and Georgia for natural gas have 100% of customers buying from competitive marketers.

In any event, allowing the market to set the electricity price solves only part of our problem. We still have to deal with the environmental externality and monopoly on wires part of the problem. The externality problem can be dealt with by putting a harms charge on the generator based on its environmental characteristics. This charge is then passed on to the consumer and the market will sort out which technology is more cost-effective. The monopoly wires problem is still a difficult problem but is discussed in the electric wires chapter.

As mentioned many times in this **Article**, there are many aspects of the electric system that are in a state of flux. Thus many new ideas are being considered in light of different perceived problems in the system. We have already discussed the problem of average cost pricing and peak and off peak pricing. Theoretically, a competitive wholesale market should reflect more accurate prices that balance supply and demand. But many perceive that even these prices do not send sufficient price signals to incentivize efficient technologies at the peak period. Especially in New England, even with astronomical price increases, there is a perception that more than price signals need to be relied on to allow supply and demand to balance.

Enter a concept known as "Demand Response or DR." When wholesale electric consumption increases dramatically, it can result in very severe price spikes for short periods. Some believe that there are opportunities for some customers to reduce their consumption during these periods, resulting in lower price spikes. Programs are being designed to allow consumers *to be paid* to reduce demand during these periods. Similarly, there are some consumers that have long term contracts at fixed prices. DR also includes creating incentives for these customers to forgo some of the electricity they have under contract and permit it to be sold in the wholesale market, again reducing the price spike at the peak.

An example of DR may be helpful. Some utilities provide an incentive to a homeowner who allows the utility to turn off their air conditioning for a 15-minute period every hour during severe peak periods. As long as this is voluntary you may not think this is such a bad idea. But once the mechanism is in place to enable the utility to control various appliances in your home, who says it will remain voluntary. Look at some of the ways that California is coping with its drought situation and rationing water.

Again we come back to one of the main points in this Article. Price sends the best signals for balancing supply and demand. If price is not allowed to do its job than supply and demand can get out of whack and guess what. Government will declare a crisis and more aggressively intervene into the market, second guessing the consumers' decisions. Every such government intervention has some winners and some losers. It is not surprising that the winners applaud the intervention, leaving the losers dissatisfied. Once the camel's nose is under the tent, don't be surprised when segments of the populace start to demand more interventions where they will be the winner and some else the loser.

Cars

As I write this (April 2016), the big story is that gasoline prices have fallen dramatically over the last year or so and are falling below $2 in some parts of the country. Within the last several years they have hovered around $4. That's quite a fluctuation. The price of petroleum products has a direct effect on how many miles we will drive and how often we will fly. All other things being equal, more people will go to Disneyland in 2016 than 2014 because it is cheaper to travel.

In 1973, OPEC made a momentous decision to use oil as a political weapon. Energy policy has never been the same since that event. There was a belief that since much of our oil was imported from OPEC countries, the US had to reduce it consumption of oil. So profound was this belief, that President Nixon imposed price controls and other emergency measures on gasoline as part of his wage and price controls policy to reduce inflation. These price controls caused long lines at the gas pump even before the OPEC Embargo and were exacerbated after the Embargo. President Carter gave a dramatic speech about energy in 1977 in which he called the energy crisis the "moral equivalent of war."

Much of our energy policy on oil and petroleum products is the result of this psychic scar on our nation. Over the last several decades, our policies on oil and related petroleum products have been based on a shortage mentality and a fear of oil imports. As is the case with most policies put in place in a time of crisis, it is rare to revisit the policy after the crisis has passed. So today, though our oil situation is dramatically different and though OPEC is a shadow of its former self, we nonetheless struggle with counterproductive policies left over from these past times.

Congress first required that car manufacturers meet a minimum miles-per-gallon or mpg target for their fleet in 1975. The term for this is *Corporate Average Fuel Economy* or CAFE. Consumption mandates are principally imposed on consumers because business interests push back against them, e.g., CAFE rules apply differently to medium and heavy trucks or off-the-road equipment. These rules require, subject to severe penalties, each manufacturer's model year fleet to meet average increasing mpg, which the manufacturers have gamed by pricing models to encourage or discourage their sale.

The Federal government has increased these standards over the years and not surprisingly cars now get much higher mpg than they used to. But there are problems with CAFE standards. It makes cars more expensive. Manufacturers use lighter materials to increase gas mileage, thus resulting in more deaths from accidents. It is a basic affront to consumer choice. Now that gas is cheaper, what would be the rationale for keeping CAFE standards?

Indeed, President Obama's Administration has dramatically increased CAFE standards over the next decade from about 35 mpg to about 55 mpg. Even liberal think tanks like Resources for the Future raise issues with such policies. Libertarian think tanks such as CATO are apoplectic about raising CAFE standards. With oil prices dropping significantly in the last year, there is even less justification for such coercive measures.

Cars need roads in order to be useful. Since it has largely been impractical to charge people on a per mileage basis for the cost of roads and highways, we have used a tax on gasoline as a rough surrogate. (But states are challenging this assumption and experimenting with mileage based taxes.) The gasoline tax to some extent can also be thought of as a harms charge for the environmental harms associated with the use of gasoline. At a theoretical level, both of these rationales are legitimate. Be that as it may, there is little doubt that these taxes affect the consumption of gasoline and promote more efficient use of gasoline. But one would be hard pressed to argue that the State and Federal taxes on gasoline precisely approximate these costs.

Conclusions and Recommendations Relating to Price and Consumption

Prices set in competitive markets produce truly astounding adjustments to changes in supply and demand. These prices give consumers valuable information about the changing value of different energy resources. Policymakers should be VERY hesitant to play games with energy prices. If energy prices are reasonably responsive to competitive conditions, the pattern of consumption by consumers will likely be rational (even if that rationality irritates some utopians' vision of how consumers *should* act). Thus policymakers should be very reluctant to coerce consumer consumption decisions.

There are some instances where prices will not adequately reflect competitive conditions, primarily where a company has market power or where there are environmental externalities. We have tried lots of different approaches to dealing with market power and externalities. Some have been disastrous and others have been highly effective. The key is to pay careful attention to the tools of economics and the lessons of past energy policies.

X. Summary, Recommendations, and Conclusions

If you have read this long overview of energy policy from beginning to end, then I salute you. But where does this leave us.

Early in the Article, we discussed the standard for sound energy policy: *whether a given policy allowed price and competition to drive private decisions on supply and consumption*.

No doubt you may be disturbed by the long list of issues where US energy policy falls far short of this standard. There are literally hundreds of issues that would need to be addressed to bring energy policy in line with this standard. Some of the issues are inadequately addressed *market failures* involving monopoly or externality problems. But the vast majority of the problems are created by *intervention failures*, actions taken at various levels of government that distort the efficient outcomes of energy markets.

One is tempted at this point to develop a long laundry list of issues and recommendations that would move energy policy towards perfection. But that is unlikely to be a meaningful action plan for change. Rather, there must be some attempt to prioritize energy policy issues based on which are most important to the long term prosperity of the US and which are just demands for ideological purity—not that there's anything wrong with that.

For example, government mandated mpg (CAFE) has been part of the fabric of energy policy for more than three decades. It is undeniable that this has caused distortions in oil consumption and cost many consumers both their lives and their dollars. We are now on a forced march towards higher CAFE standards. "54.5 miles per gallon (mpg) by 2025, and they piggyback on the 2009 mandate for a CAFE average of 35.5 mpg by 2016, up from 27.3 mpg in 2011." One could broadly adopt one of two strategies for dealing with the inefficiency of CAFE: advocate for complete elimination (which is analytically justified but politically difficult) or argue for the elimination of any increases in the future (which is analytically "impure" but politically more achievable).

Rather than just make a laundry list of imperfections in energy markets that would no doubt please some partisans and some think tanks in Washington, DC, it will likely be more helpful and possibly more effective to prioritize recommendations based on some notion of the depth of the seriousness in affecting future prosperity and quality of life. This would give us a limited but potentially achievable set of actions that would significantly improve energy markets. It would result in a list that basically tries to prevent any further damage to energy markets caused by certain policies. First, do no harm, a Hippocratic Oath for energy policy, if you will. Then we should pay attention to energy policy issues that are the creating the most harm or will create the most harm in the future.

If I were writing for an economics academic journal, then this overlay of "political feasibility" would be improper. But for purposes of encouraging a national dialogue on energy policy it seems helpful to argue over important issues rather than trivial issues. Our advocacy resources are limited and we want the biggest bang for the buck.

A word needs to be said about the elephant in the room, climate change. The following recommendations assume that it is unsound policy to mandate radical reductions in carbon emissions. **Commentary 3** on the consensus on climate change discusses this issue in more depth. But if you believe, as apparently President Obama does, that climate change is more dangerous than terrorism then you will disagree with many of the following recommendations.

There is no question that the US should develop a coherent policy on climate change taking into account the science and all the other challenges that the US must deal with. As Bjorn Lomborg has identified many investments other than carbon reduction that would do more good for humanity, and resources are limited. Perhaps to belabor the point, the Copenhagen Consensus, led by Lomborg, agreed in 2014 that the following were the top 5 most cost-effective actions to take to benefit humanity:

1. Bundled micronutrient interventions to fight hunger and improve education
2. Expanding the Subsidy for Malaria Combination Treatment
3. Expanded Childhood Immunization Coverage
4. Deworming of Schoolchildren, to improve educational and health outcomes
5. Expanding Tuberculosis Treatment.

Indeed, the public, both in the US and internationally, rank action on climate very low when they prioritize the challenges that the world faces, despite the hysterics from much of the media, special interests, and academics.

So the following recommendations regarding energy policy *do not* adopt an extreme view that major reductions in carbon emissions are necessary. If one made the opposite assumption even then the proper framework for achieving such cuts requires that a price be put on a ton of carbon emissions and that that price be imposed globally. Once a price for carbon was included as an externality in energy prices globally, then consumers would then make their decisions on energy supply and consumption in a more rational and economically efficient manner. We do not think we have reached the point in which a carbon tax can be justified on the basis of climate change alone.

A carbon tax might be justified for other reasons. The US currently has a serious national debt problem and even the most optimistic proposal in Congress for balancing the budget would not do so for a decade. Additionally, taxes on income and investments can have a dampening effect on economic growth, which has been anemic of late. Many economists thus favor taxes on consumption instead of on income. Lastly, the current policies being enacted by many Federal, State, and local governments are a patchwork of incoherent, feel-good flotsam and jetsam. It is inconceivable that any serious analyst would argue that the sum total of all these chaotic policies is efficient reduction of carbon emissions. Thus, many policies exist on climate change that cause significant distortions in energy markets. If one adopted a carbon tax to pay down debt, lower income taxes, increase prosperity, and eliminate all other climate change programs, then a carbon tax might make some sense. I am not holding my breath!

Now let's turn to recommendations in order of importance by topic.

General

- Eliminate all energy subsidies, mandates, and tax incentives to energy supply and consumption technologies.
- Reject old, outdated assumptions about energy markets and make policy based on the new realities in energy markets.
- Recognize that much of our energy infrastructure, like all other infrastructure, is aging and in need of modernization. Private companies have incentives to modernize when faced with competitive pressures. Governments or comprehensively regulated private companies have a hard time prioritizing all the demands on government and have a tendency to force infrastructure to be used beyond its sell-by date. Additionally, special interests make it very difficult to build large infrastructure projects in their backyards.

Electricity

Without question, the US's greatest vulnerability is in the current structure, organization, and allocation of jurisdiction of the electric system. There are so many problems in this area that it would be impossible to tackle them individually or all at once. Rather, what is needed is the development of a comprehensive strategy that makes changes in rational stages.

Currently, there is no such strategy, no one is developing such a strategy to our knowledge, and there seems to be little prospect of beginning the development of such a strategy. Thus the **primary recommendation** is to begin the process of developing a consensus around the *existence of serious threat* to the electric system in the US if we continue down the path we are on. **Commentary 2** begins to develop a comprehensive analysis of the existence of such a threat to prosperity and human welfare. That **Commentary** also begins to make recommendations on specific issues related to electric system.

In the absence of such a strategy, the following recommendations make sense on an issue specific basis:

- Repeal all renewable portfolio standards.
- Repeal EPA's Clean Power Plan.
- Reform the construction of electric transmission lines so that the policies are similar to natural gas pipelines (remove States' power to block needed transmission lines).
- Approve the Yucca Mountain nuclear waste disposal facility.
- Repeal the Price Anderson Act that puts the taxpayer on the hook for damages from a nuclear accident.
- Eliminate subsidies for alternative fueled cars.
- Halt all proceedings at the State or Federal level that assume the existence of the current organization structure of the electric system pending a national strategy.

Oil and Natural Gas

- Deregulate natural gas exports.
- Eliminate bans on fracking.
- Open up Federal lands to more exploration for oil and natural gas.
- Eliminate subsidies and mandates for ethanol.
- Allow new refineries to be built.
- Sell the oil in the Strategic Petroleum Reserve.

Transportation

- Stop new mandates for increasing CAFE Standards.

- Eliminate subsidies and mandates for alternative-fueled vehicles.

Efficiency and Consumption

- Stop mandating any new efficiency requirements pending an overhaul of the electric system

National Security

- Ensure that energy facilities are fully protected from terrorist, systemic failure, and geomagnetic harm.

Conclusions

Sound energy policy will have profound economic benefits. For example, increased domestic oil and natural gas production driven by energy markets will produce major economic benefits:

- lower production cost
- increased supply
- lower prices to consumers
- increased employment
- increased economic growth
- increased exports of LNG and manufactured products
- higher international trade value of the dollar
- increased standard of living
- avoiding harmful stealth inflation caused by increased energy costs.

Stephen Moore, Chief Economist of the Heritage Foundation, testified on February 2, 2016 as follows:

> Although this report is not yet public, I will mention one here because the findings are so astonishing. We estimate that the value of oil and gas under federal lands that can be recovered with existing technologies like horizontal drilling and Fracking is at today's prices roughly $50 trillion. This is arguably the greatest treasure chest in world history. Not only would we massively stimulate the economy by drilling on non-environmentally sensitive federal lands, while ensuring at least a half-decade of energy independence, but of special note to this committee, we estimate that over the next 20 years the government would raise $3 trillion in revenues for Uncle Sam - at zero cost to taxpayers! Someone please show me any other plausible plan that raises $3 trillion over the next decade without wrecking the economy.

Sound energy policy will also have foreign policy benefits. For example, countries that are heavily reliant on oil revenues will be hurt by a global oil market with more oil and lower prices. This would include some countries that are less than friendly to the US such as Russia, Venezuela, and some Middle East countries. Additionally, the US will have enhanced trade relationships with countries in Europe and the Far East, which might import significant quantities of LNG, coal, and perhaps petroleum products from the United States.

Finally, beware of special interests. If some interest has an economic or ideological interest in a specific recommendation, assume they have a conflict of interest and view their recommendations with suspicion. The special interest advocate may not be wrong but if they are financially benefitting from their recommendation they should at least be challenged. This applies not only to corporate interests but also to social interests such as environment and low income advocates.

Appendix A: Energy Subsidies

The following material is a lightly edited version of material from an **Energy Information Administration** study updated in March 2015 entitled "Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2013"

Executive Summary

This report responds to a September 2014 request to the U.S. Energy Information Administration (EIA) from U.S. Representative Fred Upton, Chairman of the House Committee on Energy and Commerce, and U.S. Representative Ed Whitfield, Chairman of its Subcommittee on Energy and Power, for an update reflecting Fiscal Year (FY) 2013 data of two earlier EIA reports on direct federal financial interventions and subsidies in energy markets covering FY 2007 and FY 2010.

As in the prior EIA reports on this subject, the scope of the present report is limited to direct federal financial interventions and subsidies that are provided by the federal government, provide a financial benefit with an identifiable federal budget impact, and are specifically targeted at energy markets. As requested, the report focuses on subsidies to electricity production and also includes subsidies to federal electric utilities in the form of financial support.

Given its scope, the report does not encompass all subsidies beneficial to energy sector activities (see text entitled "Not All Subsidies Impacting the Energy Sector Are Included in this Report"), which should be kept in mind when comparing this report to other studies that may use narrower or more expansive inclusion criteria. Consistent with EIA's role and mission, this study focuses on developing data rather than drawing conclusions or discussing policy issues related to subsidies, and in that regard differs from some other reports that address energy subsidies (see text entitled "A Wide Variety of Definitions, Methods and Estimates Occur in Other Energy Subsidy Studies").

Subsidy categories

Energy subsidies and interventions discussed in this report are divided into five separate program categories:

Direct expenditures to producers or consumers. These are federal programs that provide direct cash outlays which provide a financial benefit to producers or consumers of energy.[1]

Tax expenditures. These are largely provisions found in the Internal Revenue Code (IRC, or Tax Code)—Title 26 of the United States Code—that reduce the tax liability of firms or individuals who take specified actions that affect energy production, distribution, transmission, consumption, or conservation.

Research and development. The federal government has an extensive program of funding energy research and development (R&D) activities aimed at a variety of goals, such as increasing U.S. energy supplies or improving the efficiency of various energy consumption, production, transformation, and end-use technologies. R&D programs generally do not directly affect current energy consumption, production, and prices, but if successful, they could affect future consumption, production, and prices.

Catalog of Federal Domestic Assistance

This report uses the General Services Administration's (GSA) *Catalog of Federal Domestic Assistance* to identify energy-related programs. Energy-related programs exist in many federal agencies but are heavily concentrated at the U.S. Department of Energy (DOE).

EIA identified over 70 federal domestic assistance programs, many of which have multiple subprograms, as part of direct or research and development expenditures displayed in this report. However, some agencies administer one large, single program – e.g., the U.S. Department of Health and Human Services (HHS) administers the Low-Income Home Energy Assistance Program (LIHEAP) and the U.S. Department of the Treasury (Treasury) administers the Section 1603 grant program.

DOE operates the most programs and the greatest number of fossil, efficiency and renewable energy incentive programs. The U.S. Department of Agriculture (USDA) also operates several programs. A few programs can also be found among the Departments of the Interior (DOI), Labor (DOL), and Housing and Urban Development (HUD).

Federal electricity programs supporting federal and rural utilities. Through federal utilities, including the Tennessee Valley Authority (TVA), Bonneville Power Administration (BPA), and three smaller Power Marketing Administrations (PMAs), the federal government brings to market large amounts of electricity, stipulating that "preference in the sale of such power and energy shall be given to public bodies and cooperatives."[2] The federal government also supports portions of the electricity industry through loans and loan guarantees made by the U.S. Department of Agriculture's Rural Utilities Service (RUS) at interest rates generally below those available to investor-owned utilities (IOUs). This report measures support provided by RUS and federal electricity programs by comparing an average annual interest expense for their long-term debt to a range of cost of capital for IOUs that they might otherwise have incurred in the absence of federal support. Costs are based upon the savings realized from borrowing at preferential rates compared to market rates. Rather than choosing a single benchmark interest rate to estimate the cost of these programs, a range of borrowing costs starting with the 30-year Treasury rate through the Baa IOU interest rate were used.[3] To facilitate exposition, the Executive Summary presents only midpoint value estimates for these programs.

Loans and loan guarantees. The federal government provides financial support for certain energy technologies either by guaranteeing the repayment of loans obtained in the private debt market or by lending money directly to energy market participants. DOE is authorized to provide financial support for innovative clean energy technologies that are typically unable to obtain conventional private financing due to their high technology risks. In addition, eligible technologies must avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases.[4] The authority to enter into loan guarantees under Section 1705 (added by the American Recovery and Reinvestment Act of 2009, referred to as ARRA in this report) of Title XVII of the Energy Policy Act of 2005—a temporary program for the rapid deployment of renewable energy and electric power transmission projects administered by DOE—expired, pursuant to statute, on September 30, 2011. Further, as noted in Section 5 of this report, no loans were made in FY 2013; hence, discussion in this report is limited. Additional information on this topic is available in EIA's prior subsidy report.

For this report, EIA relies upon many of the data sources and budget documents[5] used in EIA's prior subsidy reports to measure the cost of programs to the federal budget. One significant enhancement is the use of a comprehensive public database summarizing all federal budget obligations that is available through USASpending.gov. For federal agencies other than DOE and Treasury, spending for FY 2010 and FY 2013 is reported based on the obligations reported on that website. Under steady-state conditions, where outlays follow obligations in a regular pattern and there are no sharp discontinuities in the former or the latter, obligation and outlay measures closely correspond. However, with enactment of ARRA, which provided energy funding that dwarfed DOE's previous energy program budgets and also required the rapid obligation of funds that would fund outlays over several years, EIA faced a decision whether to tally spending based on obligations or outlays. Given the multi-year outlays from a 20-year high in budget authority created under ARRA, and the fact that the tax expenditures and grants that constitute the other major spending programs considered in this study are reported in the year where the grant or credit is claimed, EIA determined that that the purposes of the report would be best served by reporting DOE programs based on outlays, using information obtained from DOE's Office of the Chief Financial Officer. Like DOE, Treasury's program is reported based on outlays.

[Note by Author: Be advised that this EIA report only covers Federal expenditures, not State and local mandates and subsidies.]

Key findings

The total value of direct federal financial interventions and subsidies in energy markets decreased nearly 25% between FYs 2010 and 2013, declining from $38.0 billion to $29.3 billion (see Table ES1 **and** Table ES2**).**

Conservation and end-use subsidies (excluding LIHEAP) experienced a substantial decline in both absolute and percentage terms between FY 2010 and FY 2013, declining from $10.2 billion to $4.8 billion (see Table ES1). The decrease in subsidies and support for these programs was led by declines in direct expenditures and tax expenditures (see Table ES2). Of the $5.4-billion decline in support of conservation and end use between FY 2010 and FY 2013, the tax credit for energy efficiency improvements to existing homes (26 U.S.C. 25C) accounted for $2.8 billion, with direct expenditures supporting conservation subsidies decreasing $2.3 billion and having the second-largest impact on the overall decline. This '25C' tax credit funded investments in energy-efficient windows, furnaces, boilers, boiler fans, and building envelope components.

Table ES1. Value of energy subsidies by major use, FY 2010 and FY 2013 (million 2013 dollars)

Subsidy and Support Category	FY 2010	FY 2013
Electricity-Related	**11,694**	**16,112**
Fuels and Technologies Used for Electricity Production	10,862	14,928
Transmission and Distribution	833	1,184
Fuels Used Outside the Electricity Sector	**10,710**	**5,206**
Conservation, End Uses, and Low-Income Home Energy Assistance Program (LIHEAP)	**15,574**	**7,940**
Conservation	7,069	1,964
End Uses and Other Technologies	3,127	2,860
LIHEAP	5,378	3,116
Total	**37,979**	**29,258**

Footnotes omitted.

Subsidies for fuels used outside the electricity sector also experienced a substantial decline in both absolute and percentage terms between FY 2010 and FY 2013, driven mainly by the elimination of the Alcohol Fuel Exemption, also referred to as the Volumetric Ethanol Excise Tax Credit (VEETC). In FY 2010, blends of ethanol and gasoline were eligible for a credit of 45 cents per gallon of ethanol used to produce the blend, resulting in a tax expenditure of nearly $6 billion. This program, however, expired at the end of 2011.

Electricity-related subsidies, primarily directed towards fuels and technologies used for electricity production, increased in both absolute and percentage terms between FY 2010 and FY 2013, reflecting increases in both direct expenditures and tax subsidies. Outlays from Treasury's Energy Investment Grant program (i.e., ARRA's Section 1603 grant program for renewable energy) increased from $4.5 billion in FY 2010 to $8.2 billion in FY 2013, while electricity-related tax expenditures for renewables doubled from $1.9 billion to $3.8 billion.

Between FY 2010 and FY 2013, the share of tax expenditure in total financial interventions and subsidies declined while the share of direct expenditures grew, driven mainly by the elimination of the alcohol fuel exemption on the one hand and significant increases in outlays for ARRA Section 1603 grants for electricity-related renewables on the other. Tax expenditures accounted for 42% ($12.4 billion) of the total value of direct federal financial interventions and subsidies in energy markets in FY 2013, down from 46% ($17.3 billion) in FY 2010, as the share of direct expenditures increased from 39% ($14.8 billion) in FY 2010 to 44% ($12.9 billion) in FY 2013.

The changing mix of direct expenditures between FY 2010 and FY 2013 was primarily driven by ARRA's Section 1603 grant program. Between FY 2010 and FY 2013, the renewable share of direct expenditures increased from 37% to 65%, while the end-use technologies share dropped from 41% to 27%. Total direct expenditures decreased 13% from $14.8 billion to $12.9 billion.

No new DOE loan guarantees were issued in FY 2013. The subsidy cost of the loans issued in FY 2010 totaled $1.7 billion, but this cost is assessed at the time the loan is issued, so there was no subsidy cost for FY 2013. However, there were still outstanding debts in FY 2013 for loans issued in prior years (see Table 25). While lending authority for the Section 1705 loan program had expired by 2013, budget authority remains for future lending on the Section 1703 loan program.

Table ES2. Quantified energy-specific subsidies and support by type, FY 2010 and FY 2013 (million 2013 dollars)							
Beneficiary	**Direct Expenditures**	**Tax Expenditures**	**Research & Development**	**DOE Loan Guarantee Program**	**Federal & RUS Electricity**	**Total**	**ARRA Related**
2013							
Coal	74	769	202	-	30	1,075	129
Refined coal	-	10	-	-	-	10	-
Natural Gas and Petroleum Liquids	62	2,250	34	-	-	2,346	4
Nuclear	37	1,109	406	-	109	1,660	29
Renewables	**8,363**	**5,453**	**1,051**	**-**	**176**	**15,043**	**8,603**
Biomass	332	46	251	-	-	629	369
Geothermal	312	31	2	-	-	345	312
Hydropower	197	17	10	-	171	395	216
Solar	2,969	2,076	284	-	-	5,328	3,137
Wind	4,274	1,614	49	-	-	5,936	4,334
Other	209	-	380	-	5	594	229
Subtotal Renewables Electric	**8,291**	**3,783**	**977**	**-**	**176**	**13,227**	**8,597**
Biofuels	72	1,670	74	-	-	1,816	6
Electricity - Smart Grid and	**8**	**211**	**831**	**-**	**134**	**1,184**	**780**

Table ES2. Quantified energy-specific subsidies and support by type, FY 2010 and FY 2013 (million 2013 dollars)							
Beneficiary	**Direct Expenditures**	**Tax Expenditures**	**Research & Development**	**DOE Loan Guarantee Program**	**Federal & RUS Electricity**	**Total**	**ARRA Related**
Transmission							
Conservation	**833**	**630**	**501**	**-**	**-**	**1,964**	**1,574**
End Use	**3,513**	**1,997**	**466**	**-**	**-**	**5,976**	**2,046**
LIHEAP	3,116	-	-	-	-	3,116	-
Other	397	1,997	466	-	-	2,860	2,046
Total	**12,891**	**12,428**	**3,491**	**-**	**449**	**29,258**	**13,166**
2010							
Coal	46	485	307	-	100	937	74
Refined coal	-	179	-	-	-	179	-
Natural Gas and Petroleum Liquids	80	2,752	9	-	77	2,918	0
Nuclear	66	957	446	279	144	1,893	33
Renewables	**5,491**	**8,539**	**1,140**	**284**	**189**	**15,642**	**5,530**
Biomass	178	551	301	-	-	1,030	246
Geothermal	65	1	2	13	-	81	64
Hydropower	60	18	11	-	181	270	79

Table ES2. Quantified energy-specific subsidies and support by type, FY 2010 and FY 2013 (million 2013 dollars)							
Beneficiary	**Direct Expenditures**	**Tax Expenditures**	**Research & Development**	**DOE Loan Guarantee Program**	**Federal & RUS Electricity**	**Total**	**ARRA Related**
Solar	461	126	320	182	-	1,090	628
Wind	4,063	1,241	58	90	1	5,453	4,105
Other	317	-	368	-	7	691	342
Subtotal Renewables Electric	**5,143**	**1,938**	**1,061**	**284**	**189**	**8,614**	**5,465**
Biofuels	348	6,601	79	-	-	7,028	65
Electricity - Smart Grid and Transmission	**4**	**61**	**534**	**21**	**213**	**833**	**486**
Conservation	**3,091**	**3,364**	**610**	**4**	**-**	**7,069**	**6,375**
End Use	**6,001**	**1,011**	**427**	**1,066**	**-**	**8,505**	**1,126**
LIHEAP	5,378	-	-	-	-	5,378	-
Other	623	1,011	427	1,066	-	3,127	1,126
Total	**14,779**	**17,348**	**3,473**	**1,656**	**723**	**37,979**	**13,624**

The decline in energy-specific subsidies and support between FY 2010 and FY 2013 does not closely correspond to changes in energy consumption and production over the same time period. Overall energy consumption was roughly 97 quadrillion British thermal units (Btu) in both FY 2010 and FY 2013. Domestic energy production, however, rose 10% from 73.7 quadrillion Btu in FY 2010 to 81.1 quadrillion Btu in FY 2013 (see Table ES3). Oil and natural gas production increased 8 quadrillion Btu, with renewables used for both electricity generation and transport increasing 1 quadrillion Btu. The overall amount of federal subsidies and support provided by federal programs within the scope of this report has declined even as total energy production has increased. However, whether at the aggregate level or for individual fuels or technologies, the amount of subsidy per unit of energy produced or consumed does not necessarily provide insight into the current amount of energy production, consumption, or conservation that is or has been supported or influenced. For many programs, there is a disconnect between when the money is spent and when the impacts are felt. For example, many subsidies support capital investments, which may produce little energy in their first year of service (possibly the year a subsidy is claimed), but then produce energy for many years. Also, R&D expenditures are not reflected in the nation's energy mix unless and until they lead to innovations that penetrate the market, which is a process that could take many years.

Table ES3. Energy subsidies and support, selected indicators, 2010 and 2013

Indicators	FY2010	FY2013
Total Energy Subsidies and Support (million 2013 dollars)	37,979	29,258
U.S. Energy Consumption (trillion British thermal units)	97,296	96,584
U. S. Energy Production (trillion British thermal units)	73,659	81,149
U.S. Coal Production (trillion British thermal units)	21,657	20,209
U.S. Natural Gas (dry and liquids) Production (trillion British thermal units)	24,105	28,353
U.S. Crude Oil Production (trillion British thermal units)	11,530	15,342
U.S. Nuclear Production (trillion British thermal units)	8,318	8,117
U.S. Hydroelectric Production (trillion British thermal units)	2,588	2,579
U.S. Biomass Production (trillion British thermal units)	4,272	4,495
U.S. Wind Production (trillion British thermal units)	863	1,549
U.S. Solar Production (trillion British thermal units)	119	286
U.S. Geothermal Production (trillion British thermal units)	207	220

Findings regarding electricity-related subsidies and support

Electricity-related subsidies increased 38% between FY 2010 and FY 2013, from $11.7 billion to $16.1 billion (see Table ES1). This increase was largely the result of a $4.2 billion increase, from $1.1 billion in FY 2010 to $5.3 billion in FY 2013, in support of solar energy, reflecting a large increase in the installation rate of solar facilities utilizing the ARRA Section 1603 grant payments or the 30% Investment Tax Credit (see Table ES2 and Figure ES1). Total subsidies to wind energy also increased between FY 2010 and FY 2013, rising from $5.5 billion to $5.9 billion.

Wind energy received the largest share of direct federal subsidies and support in FY 2013, accounting for 37% of total electricity-related subsidies (see Table ES4**)**. Nearly three-fourths of FY 2013 wind energy subsidies were direct expenditures and largely resulted from the ARRA Section 1603 grant program.

Support for Smart Grid and electricity transmission represented the largest portion of electricity-related R&D subsidies. Nearly 39% of FY 2013 R&D expenditures were devoted to researching the electricity grid's capability to accommodate larger shares of electricity from intermittent sources (e.g., solar, wind, and other renewable energy sources) and offer other potential benefits to producers and consumers of electricity. In FY 2013, electricity-related R&D support was $2.1 billion, or 13% of the electricity-related total value of direct federal financial interventions and subsidies.

Electricity-related renewables received a large share of direct federal subsidies and support in FY 2013 compared with their share of total electricity generation. Renewables (excluding biofuels) received 72% of all electricity-related subsidies and support in FY 2013 (see Table ES3 and Table ES4), yet accounted for 13% of total generation in calendar year 2013.[8] More than three-quarters of the subsidies going to renewables were direct expenditures or tax expenditures targeting upfront capital investments for projects expected to produce energy for at least 20 years.

Interest rate support for federal electricity programs did not increase from FY 2010 to FY 2013. While these programs expanded long-term debt by financing more new generation and transmission projects, the increased debt was offset by lower effective interest rates and more favorable spreads between 30-year Treasury bonds and the cost of debt for IOUs in FY 2013 compared to FY 2010.

Table ES4. Fiscal year 2013 electricity production subsidies and support (million 2013 dollars, unless otherwise specified)

Beneficiary	Direct Expenditures	Tax Expenditures	Research & Development	DOE Loan Guarantee Program	Federal and RUS Electricity[a]	Total	Share of Total Subsidies and Support
Coal	61	642	167	-	30	901	6%
Natural Gas and Petroleum Liquids	18	662	10	-	-	690	4%
Nuclear	37	1,109	406	-	109	1,660	10%
Renewables	**7,408**	**3,373**	**722**	**-**	**176**	**11,678**	**72%**
Biomass	62	9	47	-	-	118	1%
Geothermal	221	22	2	-	-	245	2%
Hydropower	194	17	10	-	171	392	2%
Solar	2,448	1,712	234	-	-	4,393	27%
Wind	4,274	1,614	49	-	-	5,936	37%
Other	209	-	380	-	5	594	4%
Subtotal Renewables Electric	**7,408**	**3,373**	**722**	**-**	**176**	**11,678**	**72%**
Biofuels	-	-	-	-	-	-	-

Table ES4. Fiscal year 2013 electricity production subsidies and support (million 2013 dollars, unless otherwise specified)

Beneficiary	Direct Expenditures	Tax Expenditures	Research & Development	DOE Loan Guarantee Program	Federal and RUS Electricity[a]	Total	Share of Total Subsidies and Support
Electricity - Smart Grid and Transmission	**8**	**211**	**831**	**-**	**134**	**1,184**	**7%**
Total	**7,532**	**5,996**	**2,136**	**-**	**449**	**16,112**	**100**

Findings Regarding Subsidies and Support for Fuels Used Outside of the Electricity Sector

Renewable fuels received 65% of the value of direct federal financial interventions and subsidies in energy markets for fuels not used to produce electricity (see Table ES6**). Subsidies and support for fuels used outside the electricity sector were $5.2 billion in FY 2013, which accounted for 18% of total subsidies and support. Of that amount, the support for biofuels was** $1.8 billion in FY 2013, driven mainly by tax expenditures, including the estimated tax expenditure of $1.6 billion for the biodiesel producer tax credit. As noted earlier, subsidies and support for biofuels have declined substantially since FY 2010, when the tax credits for ethanol-blended fuels that have since expired were available.

Total subsidies for natural gas and petroleum liquids declined 20% from $2.7 billion in FY 2010 to $2.2 billion in FY 2013 (see Table ES2). Support for natural gas and petroleum liquids is primarily based on tax provisions of the IRC. Tax expenditures related to the excess of percentage over cost depletion for wells declined from $1 billion to $530 million between FY 2010 and FY 2013. However, expensing of exploration and development costs rose from $422 million to $550 million over the same period, likely reflecting increased domestic drilling activities.

Table ES5. Measures of electricity production and growth

Beneficiary	2000 Net Generation (billion kilowatt-hours)	2013 Net Generation (billion kilowatt-hours)	Share of 2000 Generation (percent)	Share of 2013 Generation (percent)	Annual Growth from 2000 to 2013 (percent)
Coal	1,966	1,586	51.7	39.0	-1.6
Natural Gas and Petroleum Liquids	712	1,141	18.7	28.0	3.7
Nuclear	754	789	19.8	19.4	0.4
Other	13	20	0.3	0.5	3.3
Renewables	**356**	**532**	**9.4**	**13.1**	**3.1**
Biomass	61	60	1.6	1.5	-0.1
Geothermal	14	17	0.4	0.4	1.2
Hydropower	276	269	7.2	6.6	-0.2
Solar (utility)	-	9	-	0.2	-
Solar (distributed)	-	10	-	0.2	-
Wind	6	168	0.1	4.1	29.9
Biofuels	-	-	-	-	-
Total	**3,802**	**4,068**	**100**	**100**	**0.5**

Table ES6. Subsidies and support to fuels used outside of the electric power sector

Beneficiary	2000 Fuel Production Excluding that used for Electricity Generation (quadrillion Btu)	2013 Fuel Production Excluding that used for Electricity Generation (quadrillion Btu)	FY 2013 Subsidy and Support (million 2013 dollars)	Share of 2013 Non-Electricity-Related Fuel Production (percent)	Share of 2013 Non-Electricity-Related Subsidies (percent)
Coal	2.52	3.50	185	8.0	3.5
Natural Gas and Petroleum Liquids	28.20	35.75	1,657	81.7	31.8
Nuclear	-	-	-	-	-
Renewables	**2.71**	**4.49**	**3,365**	**10.3**	**64.6**
Biomass and Biofuels	2.55	4.15	2,328	9.5	44.7
Geothermal	0.02	0.06	100	0.1	1.9
Hydropower	0.04	0.03	3	0.1	0.1
Solar	0.06	0.22	935	0.5	18.0
Wind	-	-	-	-	-
Other	0.04	0.03	-	0.1	-
Total	**33.43**	**43.74**	**5,206**	**100.0**	**100.0**