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About the Author

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Executive Summary

Over the years, there have been significant changes in the fuel mix used to generate electricity in the United States. Generally, this mix has become less carbon-intensive, relying less on coal and more on natural gas and renewable sources. Nevertheless, concerns over the environment and a desire to promote the emergence of "clean energy" industries have led a number of people to advocate policy measures to induce, if not compel, power suppliers in the United States to alter their fuel mix away from fossil fuels and towards non-carbon sources. For example, many states have established Renewable Portfolio Standards (RPSs), which compel power suppliers to utilize minimum percentages of renewable fuels that usually rise over time. At the federal level, President Obama has proposed a 'clean energy standard' and Senator Jeff Bingaman (D-New Mexico), Chairman of the Senate Energy Committee, recently introduced a RPS bill that would compel power suppliers everywhere in the country to meet that standard.

In this paper, we examine what actually has been happening over time with respect to the power producing fuel mix in the United States. The purpose is to see whether such mix already is being shaped by market forces that are driving it towards lower carbon content. If so, question arises whether there is any need for policy measures such as RPSs or subsidies for non-carbon sources. Further, as mandates or subsidies have substantial costs, question arises whether these costs are justified.

Our findings are that:

- The U.S. power generation fuel mix has been falling in carbon intensity for the past 50 years.
- This trend towards a less carbon intensive fuel mix has accelerated in recent years as the price of natural gas has fallen relative to that of coal.
- Federal projections of the power production fuel mix into the future suggest the trend will continue for many years.
- Though virtually all forms of energy are subsidized by the government to some degree, renewable sources have received very large subsidies per unit of output in recent years, likely affecting power generation choices at the margin.
- Subsidies and mandates impose substantial costs on taxpayers and on ratepayers. They also induce rent-seeking behavior by suppliers which impose deadweight costs on society and which breed cynicism about the U.S. system of government and its relation to economic activity. Given continuing market trends, no expansion of such mandates or subsidies is justified. Indeed, with the exception of basic research, a relaxation of mandates and a reduction in energy subsidies if not their complete disappearance would be the more desirable course of action.

Introduction

One of the most important questions concerning energy and environmental policy in the United States is what fuel mix should be used to generate power. On the one hand, low-cost fuels provide power relatively inexpensively to consumers, which helps stimulate economic growth and maintain economic well-being. On the other, low-cost fuels include coal, which is carbon-intensive, and oil and natural gas, which are less so but not as pollutant-free as, say, wind or solar power.

This question of power generation fuel mix has stimulated a good deal of interest among policy makers. At the federal level, President Obama has proposed a Clean Energy Standard that purportedly would double the production of power from renewable sources, nuclear, natural gas and coal with carbon capture.[1] The proposed standard was incorporated into a bill introduced by Senator Jeff Bingaman, the Clean Energy Standard Act of 2012, which would impose a RPS on power generators at the federal level (S. 2146). Already, 29 states plus the District of Columbia impose this type of constraint upon local power generators.

In addition, federal and state officials have granted a number of subsidies to renewable fuels and to nuclear power to stimulate their production and use in power generation. The President's Fiscal Year 2013 (FY13) budget included $5 billion in direct subsidies for the manufacture of clean energy sources, extension of tax credits for renewable sources such as wind, and continuation of programs featuring payments in lieu of tax credits.[2] Debate over the level of subsidies and how long to extend them is ongoing.

In this paper, we first take a close look at what has actually been happening with respect to the power generation fuel mix in the United States. We look at this question over the longer term (60 years), an intermediate term (over the past 15 years) and the short term (17 months). We also look at worldwide changes over the past few years. The results of this examination are intended to inform debate about whether new constraints should be imposed on U.S. power producers at this time.

We then examine some of the drivers for the fuel mix changes that have taken place. This discussion focuses on relative fuel prices, changes in technology and the role of subsidies.

We briefly discuss some implications of imposing new constraints on power producers, and of continuing, if not increasing, subsidies to various fuels. Among other things, we discuss implications for consumers, taxpayers, and the U.S. political system of imposing the constraints and granting the subsidies. Finally, we offer conclusions and recommendations.

Background

One of the more contentious issues in the U.S. today is how best to deal with environmental challenges such as climate change. At one level, there is scientific debate whether the climate is changing as a result of anthropogenic activity, and if so, to what extent. At another, there is policy debate over what to do. Because power generation accounts for roughly 40% of U.S. greenhouse gas (GHG) emissions, much of this policy debate has centered on that sector, and in particular on the fuel mix used for generation.

As above mentioned, many states have imposed RPS constraints on their local utilities. These constraints set schedules for producing some minimum level of power from renewable sources such as wind, geothermal and solar. In some cases, hydroelectric power is included in the mix, in others not. Montana for example, though a coal-producing state, has set an RPS which includes certain hydropower sources plus several other forms of renewable energy under a schedule which requires that 5% of a supplier's electricity be generated by renewable sources in 2005, 10% by 2010, and 15% by 2015 and thereafter. Ohio provides a second example. That state requires that 25% of power generation come from alternative energy sources by 2025, but includes energy efficiency measures, 3rd generation nuclear power and clean coal (CO_2-free) among eligible sources.

Senator Bingaman's Clean Energy Standard Act of 2012 would amend the Public Utility Regulatory Policies Act of 1978 to require utilities to obtain a certain percentage of the power they supply from what are defined as "clean" energy sources. A wide variety of sources is included, including natural gas, and the following schedule is proposed:[3]

Table 1. Ever-Increasing Calendar Year Minimum Annual Percentages of Clean Fuel Alternative Sources of Power are Specified in S.2146

2015	24%
2020	39%
2025	54%
2030	69%
2035	84%

Essentially, S. 2146 is aimed at removing coal and oil from the power generation mix unless GHGs associated with those sources are captured and stored so as not to enter the atmosphere.

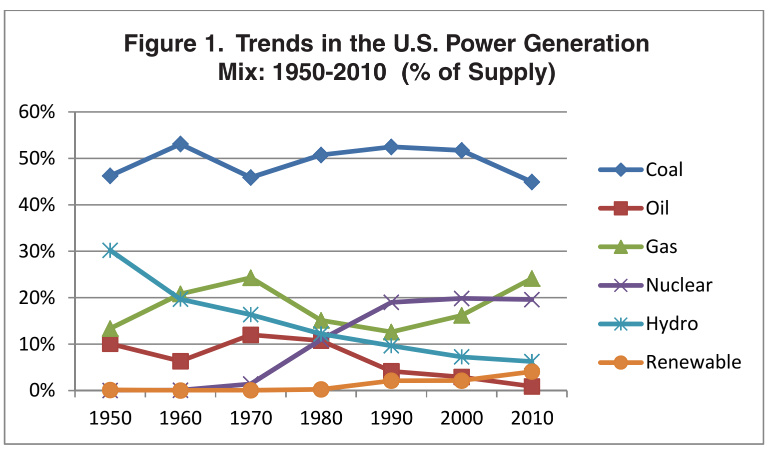
Another approach taken to encourage changes in the nation's power mix has been to strongly subsidize non-fossil fuel sources of energy, including nuclear power, geothermal, wind and solar. Nuclear power, for example, receives subsidies in the form of insurance guarantees, loan guarantees, tax credits and ongoing government-sponsored research and development. The American Recovery and Reinvestment Act (ARRA) included almost $400 million in spending on geothermal energy, over and above typical annual federal spending on this energy source of a little under $50 million. Wind and solar energy receive around $15 billion annually in the form of tax credits, loan guarantees, R&D and other activity, and because these sources are a small part of the energy mix the $15 billion generates very large per unit subsidies, as much as $776 per megawatt hour for solar energy in 2010.[4] Per unit subsidies are directly relevant to power generation choice since decisions regarding what to invest in are made at the margin, where the unit costs of alternatives are directly compared.

These and other energy subsidies, including fossil fuel subsidies, have caused a good deal of controversy and legislative activity over the years. They often are advocated as means to create jobs and generate income.[5] We resume discussion of this method of encouraging change in the power mix later in this paper.

Trends in the U.S. Power Generation Mix

Long Term Trends

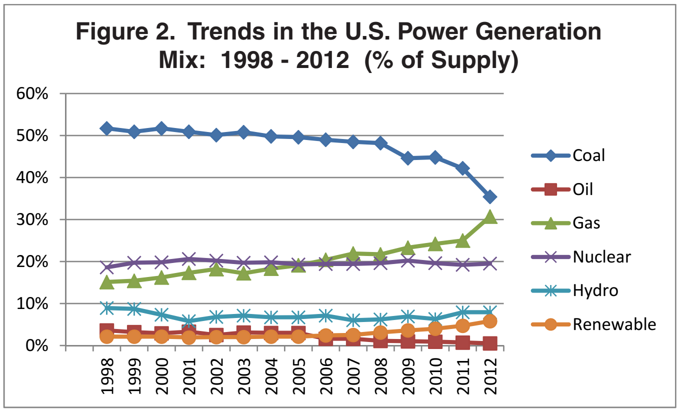
We first examine how the U.S. power generation fuel mix has changed since 1950. Figure 1, based on data from the Energy Information Administration (EIA) shows the percentage of power produced over that period from each of 6 sources: coal, oil, natural gas, nuclear, hydropower, and other renewable sources. The figure shows that coal has more or less held its own, natural gas rose for a time, then fell, and then rose again in the 20 years since 1990. Oil and hydro show steady declines in their generation share, nuclear rose and then leveled off, and renewable sources other than hydro have increased somewhat in recent decades.



Source: EIA, Annual Energy Review 2010.

Intermediate Term Trends

We next examine more recent trends by looking at a similar chart covering the past 15 years, from 1998 through the first few months of 2012. This is shown in Figure 2.

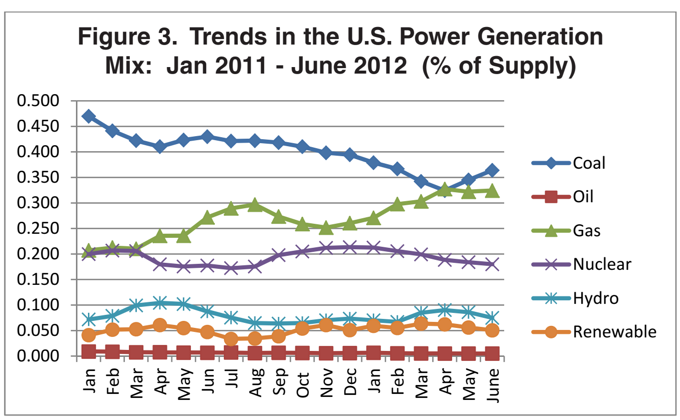


Source: EIA, Monthly Energy Review

Looking only at the past 15 years provides a somewhat different picture. Coal clearly has been losing share, while natural gas and renewable sources other than hydro have been gaining share. Hydro and nuclear more or less have held their own while oil has dropped from a low level to an even lower one. The substitution of natural gas for coal occurred steadily over the period, and appears to have accelerated within the past few years.

Short Term Trends

Lastly, we look at the mix of generation sources over just the past 18 months, through June 2012 (the latest available data from EIA at the time of this writing). This is shown in Figure 3.

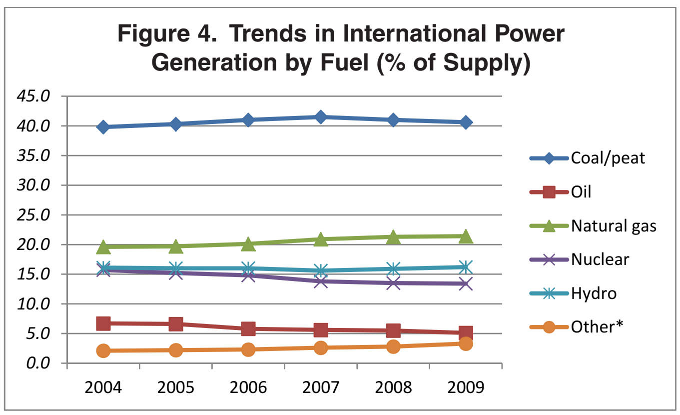


Source: EIA Monthly Energy Review

If anything, the trend towards substitution of gas for coal is accentuated in this figure. Oil, nuclear and hydro vary a little from month to month and renewable sources other than hydro increase some, but the change in generation mix over this period clearly is dominated by the gas for coal substitution.

Worldwide Trends

The trends shown for the U.S. above are consistent with predictions made by Ausubel for the world at large.[6] Ausubel cites a chart compiled by Victor that shows that the global carbon intensity of primary energy use steadily declined between 1850 and 2000.[7] Primary energy use is a broader category than fuel for power generation, for which there is comparatively little data. However, the International Energy Agency (IEA) has published annual estimates of the worldwide power general fuel mix between 2004 and 2009, and these are summarized in Figure 4.



* Other includes geothermal, biofuels, wind, solar, waste, and captured heat.
Source: IEA Key World Energy Statistics, various years.

The chart shows that coal, natural gas and renewable sources other than hydro have slightly gained market share over the 5-year period while nuclear and oil lost market share. One driving force in international power markets has been rapid economic growth in such countries as China, India and Brazil, which in turn has driven increased power consumption, much of it from fossil fuels. China, for example, is the world's largest coal consumer, and its consumption alone rose from 1066 million metric tons of oil equivalent in 2004 to 1580 million metric tons in 2009, a gain of over 48%.[8] On balance, the carbon intensity of the world's power generation fuel mix has not much changed over this 5-year period, but the period is too short to draw firm conclusions in any direction.

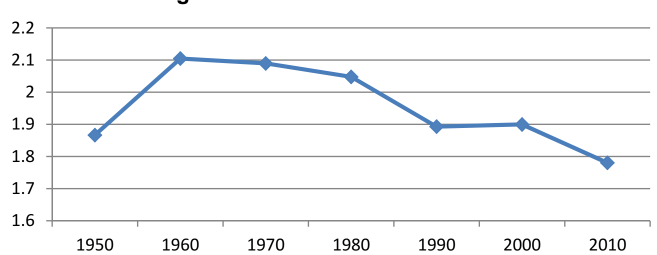
Carbon Intensity of U.S. Power Production

As previously mentioned, there is ongoing concern in the U.S. and elsewhere over anthropogenic causes of climate change, including the possible contribution of U.S. power production to such change. For that reason, we next calculate how the carbon intensity of U.S. power production has changed through time. To do so, we calculate a simple index of carbon intensity as follows: Coal is given a value of 3, oil a value of 2.5, natural gas a value of 1.7, and all other sources a value of 0, as these numbers are roughly consistent with EIA estimates of relative quantities of CO_2 produced per BTU of bituminous coal, residual fuel oil and natural gas.[9] We then multiply the relative proportion of each fuel in a given year by these numbers to obtain the value of the index in that year (non-fossil fuel sources are multiplied by zero and do not enter the index). The numbers do not incorporate life cycle considerations such as the building of plants, non-fuel inputs to those plants, and plant disposition and residues. Still, they give a first order indication of how the carbon intensity of U.S. power generation has changed with time.

Long-Term Carbon Intensity

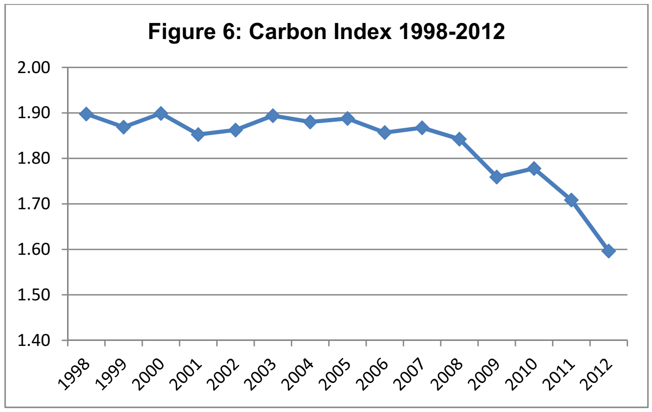
Figure 5 provides data on long term changes in the carbon intensity of U.S. power generation. The vertical axis shows the level of the index. According to the figure, carbon intensity rose significantly between 1950 and 1960 as more coal and natural gas were used, but has fallen fairly steadily ever since. By this measure, the 2010 figure is the lowest over the entire period, and the reduction in intensity between 2000 and 2010 among the most rapid over any 10-year period shown.

Figure 5: Carbon index 1950-2010



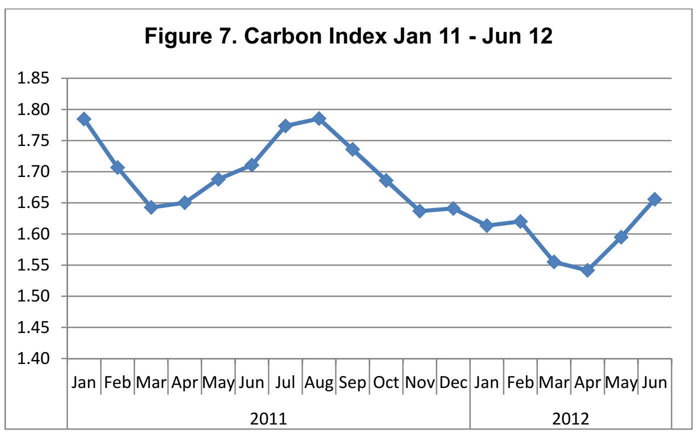
Medium-Term Carbon Intensity

In Figure 6, changes in the carbon intensity of the U.S. power generation mix are shown over the period 1998 through the first several months of 2012. These numbers show a slow decline in intensity between 1998 and 2008, followed by a much steeper decline over the past 4 years, through 2012. Overall, as measured by this index, the carbon intensity of the U.S. power mix declined by almost 16% over the period.



Short-Term Carbon Intensity

Finally, we examine changes in the carbon intensity of the U.S. power generation fuel mix over the past 18 months, between January 2011 and June 2012. These changes are shown in Figure 7. Generally, the carbon intensity declines over the period, though it rises in the late spring and summer of 2011 before resuming its longer term trend, and rises again in May and June of 2012. Presumably the late spring and summer increase is related to the increased use of fossil-fuel plants to meet demand during those months.



Driving Forces

What accounts for the changes in fuel mix choices and in the carbon intensity of this mix over the period studied? Between 1998 and 2012 in particular, we see that natural gas has largely substituted for coal, while oil has lost share and non-hydro renewable sources have gained. We here examine some major forces that likely drove much of this change: relative prices of the various fossil fuels, technological change, regulation and relative government subsidies.

Relative Prices

In Table 2, we show relative prices of oil, natural gas and coal over the period 1998-2012. All figures are annual average prices except for those in 2012, where the numbers are averages over the first 4 months.

Table 2. How Fossil Fuel Prices Changed Between 1998 and 2012

	Oil (¢ per gallon of residual fuel)	Natural Gas to utilities ($ per MCF)	Coal to utilities ($ per short ton)
1998	28.0	2.40	25.64
1999	35.4	2.62	24.72
2000	56.6	4.38	24.28
2001	47.6	4.61	24.68
2002	53.0	3.68	24.74
2003	66.1	5.57	25.82
2004	68.1	6.11	27.30
2005	97.1	8.47	31.22
2006	113.6	7.11	34.26
2007	135.0	7.31	35.29
2008	186.6	9.26	40.69
2009	134.2	4.93	43.33
2010	169.7	5.27	44.27
2011	233.6	4.87	46.80
2012*	265.2	3.28	47.00

*Average of first four months.

Several things are apparent from the table. The price of oil rose steadily throughout the period and by 2012 had reached a nominal value almost 10 times that in 1998. Little wonder that oil lost market share in power generation over the period.[10]

The price of natural gas is seen to generally rise between 1998 and 2008 but to have fallen dramatically since then. The latter is due to improvements in natural gas extraction technology that have made immense quantities of this resource economic to extract. The improvements are a combination of reservoir fracturing techniques and horizontal drilling, which increases access to pockets of gas within a fractured reservoir. These techniques have enabled producers to extract gas resources which previously had been left in the ground, mainly in shale rock formations. The result has been record additions to U.S. natural gas reserves, 28.8 trillion cubic feet (TCF) in 2009 and 33.8 TCF in 2010. Because of additions of this magnitude, total U.S. gas reserves have risen from 192 TCF in 2000 to 318 TCF in 2010 despite production of about 20 TCF annually between 2000 and 2007, with increases since then reaching 23 TCF in 2010.

Rising natural gas production and reserves led to a situation where, by the early months of 2012, the average nominal price of natural gas to utilities had fallen by almost two-thirds relative to its 2008 level and had risen by only 37% since 1998, whereas the price of coal had risen by over 83% since that year. This fall in the relative price of gas relative to the price of coal is a major reason why gas has been substituted so extensively in U.S. power production.

What of the relative prices of wind and solar energy? Estimation of their cost is complicated by their intermittency, the subsidies they receive and the conditions under which they operate (i.e., whether in "good" or not so good areas for wind or solar power generation). Nevertheless, according to one source, the cost of wind power fell from around 25 cents per kWh in the early 1980s to under 10 cents per kWh by the late 1990s.[11] A variety of wind-advocacy sources indicate this cost has reached around 8 cents per kWh today, though a DOE estimate shown in Table 3 below suggests a levelized cost of 9.7 cents per kWh in 2017.

Solar power also has come down in cost, but that cost remains well above those of other power generation technologies. For example, a recent DOE national laboratory report indicates that the behind-the-meter average cost of installed photovoltaic power dropped from $11/watt in 1998 to $6.20/watt in 2010 and had fallen further in the early months of 2011.[12] To be competitive, however, that cost would have to drop considerably further, to approximately $1/watt.[13] These costs are at a household level, however. DOE levelized cost projections for solar shown in Table 3 below are for utility level projects.

Power Plant Technology and Regulation

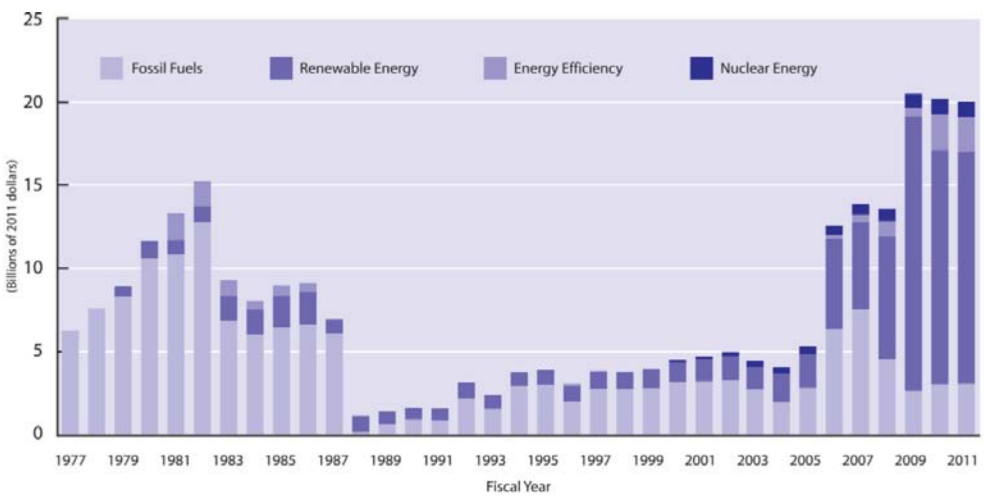
There are several other drivers of recent substitutions of natural gas and renewable sources for coal. One is that gas-fired plants can be economically constructed at smaller sizes than coal plants, reducing capital risk. This smaller size also enables faster construction once permits have been obtained, on the order of 6 to 12 months for a single cycle plant and 18 to 30 months for a combined cycle plant (in a combined cycle plant the heat from combustion is captured and utilized as an input to the production of power rather than dissipated). An optimally sized coal plant normally takes about 3 to 4 years to construct, once permits to build it are in hand.

Yet another factor is the increasingly stringent environmental regulation that coal plants are facing. On April 13, 2012, EPA proposed New Source Performance Standards under Section 111 of the Clean Air Act that would limit all new fossil fuel plants to 1,000 lbs of carbon dioxide per megawatt-hour. Under this limitation, new coal-fired power plants essentially would be required to invest in carbon capture and storage or some other method of carbon disposal. Though the proposed rule is not yet final, it signals EPA's intent to limit the construction of coal fired plants or, at minimum, to add substantially to their cost.

Subsidies

Energy subsidies have existed for decades and apply to virtually all forms of production. The amounts of subsidy for fossil fuels have decreased in recent years, but still reduce their costs to consumers relative to a subsidy-free environment. At the same time, subsidies for renewable fuels other than hydropower have grown very substantially. Until now the costs of these fuels have rendered them uneconomic except in unique circumstances; they likely could not have entered the power generation fuel mix beyond minimal amounts without such subsidies. Figure 8 below, taken from a Congressional Budget Office report, displays energy tax preferences for a range of fuels between 1977 and 2010. The figure shows that tax preferences given fossil fuels have been falling relative to their levels of the 1970s and 1980s while those for renewable fuels jumped significantly around 2006 and have accounted for the bulk of such preferences since 2008.

Figure 8. Energy-Related Tax Preferences, by Type of Fuel or Technology[14]



Source: Congressional Budget Office based on data from Molly F. Sherlock, *Energy Tax Policy: Historical Perspectives on and Current Status of Energy Tax Expenditures*, CRS Report for Congress R41227 (Congressional Research Service, May 2, 2011), p. 26; Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2011–2015*, JCS-1-12 (January 17, 2012), pp. 33–35; and Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2013: Appendix* (February 2012), p. 1068.

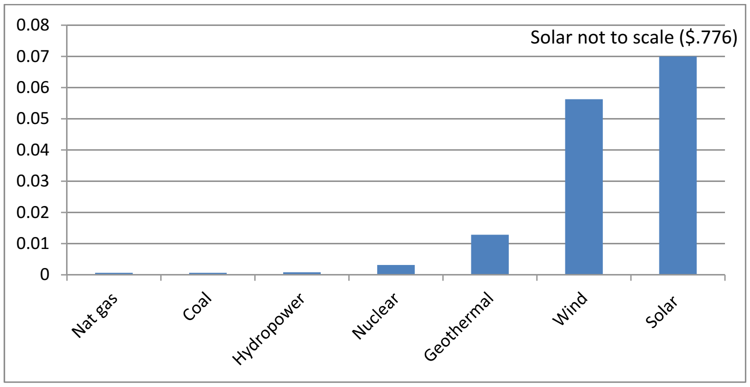
Notes: The estimates do not account for any potential interactions among preferences and do not include tax provisions estimated to cost less than $50 million.

Estimates do not reflect the amount of revenues that would be raised if those provisions of the tax code were eliminated and taxpayers adjusted their activities in response to those changes.

The figure does not include tax preferences that could not be allocated to a particular fuel or technology.

For subsidies to influence the power generation fuel mix, they must affect behavior at the margin of power production, i.e., they must lower the cost per unit of production in such a way as to cause a power supplier to choose the subsidized form of energy over another. Figure 9, taken from a recent AEI paper,[15] provides data on the per unit of output impact of energy subsidies.

Figure 9. Federal Electric Subsidies per Unit of Fuel Production
(2010 cents per kilowatt hour)



According to the figure, wind and solar received substantial subsidies per unit of production in 2010, much higher than those for conventional fuels such as coal and gas or for nuclear, all of which were well under a penny per kWh. In that year, wind subsidies were 5.6 cents per kWh and solar subsidies 77.6 cents per kWh. Subsidies at these levels very likely are a chief reason why renewable sources have increased their share of the U.S. power-generation mix as they have.

Projections

Where is the U.S. power generation market fuel mix headed? The answer revolves around two separate factors—economics and policy. We here focus mainly on economic factors, but acknowledge that policy may play as much a role, if not a bigger one, in deciding that question.

Future Relative Prices of Fuels

As shown in Table 2, the relative price of natural gas has declined dramatically in recent years, as new supplies enabled by technological developments in gas extraction have come to the market. For the time being, these relatively low prices are likely to continue, but there has been recent movement away from gas drilling and towards oil drilling and this trend may result in some alteration in the relative prices of those two fuels.

Advocates for renewable sources argue that further engineering improvements plus greater production economies of scale will continue to reduce their costs. In addition, both wind and solar can provide power at times when demand is high, reducing the need for expensive peaking plants. However, their generation sites often are not located near where power is demanded. Further, because they supply power intermittently, there remain challenges of backing them with conventional power sources and otherwise integrating them into the grid. Advances in energy storage technology and in power management and possible interconnection of local or regional grids to incorporate more sources may help to overcome these challenges, but the costs of raw materials for producing solar energy and the costs of siting windmills, transmitting their power to where it is demanded, and integrating their variable output into the grid remain formidable issues.

In recent years, the U.S. Department of Energy has been projecting the Levelized Cost of Energy of producing power from various sources. These levelized costs include capital costs and all variable costs, including fuel and maintenance, with an assumed rate of plant utilization. The levelized cost is the cost that must be covered by a brand new plant entering service as of the time stipulated. DOE's latest projection is for levelized costs 5 years in the future, in 2017. The Department makes a 3% addition to the cost of capital for coal plants on grounds that they will have to deal with carbon emissions. According to the DOE analysis, such a 3% capital cost is roughly equivalent to a carbon tax of $15 per metric ton. DOE also excludes all subsidies from its projected levelized cost numbers. Table 3 below shows DOE's projected levelized cost per megawatt of power from several sources, expressed in $2010.

Table 3. DOE-Projections of Levelized Costs of Power in 2017

Power Source	Levelized Cost ($/Megawatt)
Conventional Coal	99.6
Advanced coal – with carbon sequestration and storage	140.7
Natural gas – advanced combined cycle	65.5
Natural gas – with carbon sequestration and storage	92.8
Advanced nuclear	112.7
Geothermal	99.6
Hydro	89.9
Wind (onshore)	96.8
Solar PV (utility scale)	156.9

From this table, natural gas clearly is projected to remain the least-cost form of power production over the next 5 years. Most of the rest of the sources are roughly comparable in levelized costs, with the exception of coal with carbon sequestration and utility scale solar PV. However, subsidies given various of these fuels, not counted by DOE, will play an important role in power generation choice. We saw from Figure 9 that in 2010 these were very large for wind and solar, less so for geothermal and nuclear. Not all of these subsidies go to utilities or others who build power plants (some, for example, are aimed at homeowners), but the implications are clear: more solar PV and more wind likely will be added than their relative costs would imply, while relatively little coal-fired power will be added if such plants are required to bear the costs of carbon capture and storage.

Future Technological Change

Just as technological improvements in natural gas extraction have brought down the relative cost of that fuel source, so might future changes in technology improve the prospects for other sources. For example, investment in power from geothermal energy presently is limited to areas where conventional geothermal resources are located, specifically copious quantities of underground heat, porous rock and water. However, advanced geothermal technology could extend the locations where power from this source can be obtained.[16]

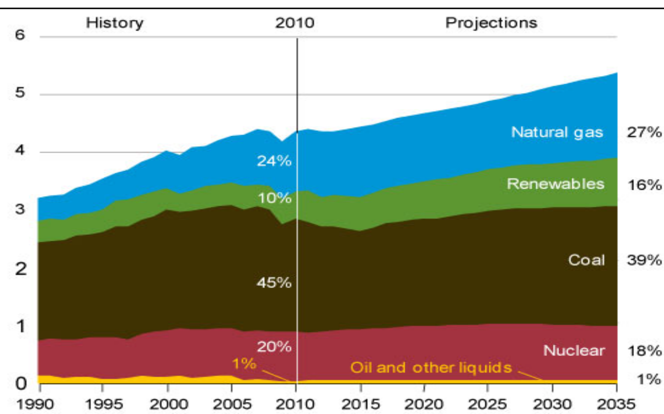
Advances in technologies for the production of solar, wind, ocean thermal, space solar and other forms of renewable energy plausibly will occur. Just as plausibly, though, technological advance will continue in the extraction, processing and distribution of more conventional fuels.

Projection of technological change is inherently very difficult. Suffice it to say that DOE's levelized cost of energy projections likely will be off the mark because of improved technologies, but it is hard to say which of the technologies analyzed will most benefit, or whether some technology not even considered may enter the picture.

Projected U.S. Power Generation Fuel Mix

Though it is difficult to project the U.S. power generation mix with any certainty, the U.S. Department of Energy does offer such projections in its Annual Energy Outlook. Figure 10 below shows the latest such projection. The figure indicates that, compared to 2010, the relative shares of natural gas and renewable sources will increase while those of coal and nuclear will decline. Because hydropower is not increasing either in share or absolutely, all of the projected increase in the share of renewable energy is from non-hydro sources.

Figure 10. Projections of Electricity Generated by Fuel: 2010 – 2035 (trillion kWh per year)



Interestingly, the relative share of coal is shown to decline steadily through 2015, but then to begin rising again. Since under EPA's recently proposed new source performance standards, new coal plants will not be able to be built without carbon capture and storage, and since existing coal plants are coming under increasingly stringent environmental regulation, the presumption appears to be either that the cost of carbon capture and storage will fall dramatically, or that some form of tradable carbon permit scheme will evolve via which a new coal-fired power plant could purchase sufficient annual permits to offset its CO_2 emissions.[17] In either case, the implication is that coal-fired power plants will become far less carbon intensive, perhaps meriting a value of zero in the carbon intensity index presented above.

What would this mean for the carbon intensity of U.S. power production? If we assume that by 2035 fully half of all U.S. coal-fired power generation no longer emits CO_2, then the carbon intensity of power production in that year would be 3*.195 + 2.5*.01+1.7*.27 = 1.07. Given that it stood at 1.78 as recently as 2010, such a reduction would equate to 40% reduction in a period of 25 years.

Present Policy

U.S. policy clearly is to encourage the production of non-fossil fuel sources of power through mandates or subsidies of one sort or another. The drivers are a desire for environmental improvement and the notion of an emerging "clean energy" economy, in which thousands of new jobs and associated incomes are generated. The subsidies are particularly large for wind and for solar power, but are substantial for nuclear power as well. In addition, many states have chosen to mandate that their utilities include a certain percentage of non-fossil fuel sources in their fuel mix, generally with targets that rise through time.

The Obama Administration has made it clear that it will not encourage the use of coal in new power plants unless that can be done with minimal emissions of CO_2 into the atmosphere. In this, it is implementing a 2007 decision by the U.S. Supreme Court that greenhouse gas emissions are a pollutant under the Clean Air Act and that EPA therefore has a responsibility to regulate them.[18]

Federal and state policy on the use of natural gas in power production has been mixed. The Administration has chosen to restrict oil and gas drilling to a select set of onshore and offshore areas and has slowed the issuing of offshore permits since the BP Macombo oil well spill. It is studying the practice of hydraulic fracturing by natural gas drillers, but has not sought to impede it. Some states have issued regulations under which this type of fracturing can be done while others, such as New York, have effectively banned the practice. On balance, federal and state policies have not much encouraged natural gas activity, but with some exceptions have not sought to prevent it either.

Costs of Subsidies and Mandates

Subsidies and fuel mandates have clear-cut costs for taxpayers and consumers, and divert resources from the production of consumable goods and services to rent seeking, which has no social product. Subsidies, for example, have direct costs in terms of the monies raised either through taxation or through borrowing. According to DOE, subsidies to all forms of energy were $37 billion in 2010, an increase of 108% over their level in 2007. In view of the historically very large budget deficits presently being incurred by the United States,[19] one may question whether this $37 billion is money well spent.

Mandates impose costs on utility rate payers because they require suppliers to offer a power mix that is higher in cost than what they otherwise would choose. Further, because such mandates usually contain schedules under which renewable sources must be included, they also may require premature retirement of conventional power generation assets that otherwise would not occur. Unless costs of these assets have been fully depreciated, such premature retirements are likely to result in higher prices to ratepayers.[20]

The imposition of renewable portfolio standards provides hidden subsidies to producers of the sources that are mandated, subsidies that take the form of payments they otherwise would not receive. Ratepayers ultimately pay for these subsidies through higher electricity rates than they otherwise would face.

A recent economic analysis of the Kansas RPS by the Kansas Policy Institute illustrates the point.[21] According to this analysis, the Kansas RPS, enacted in 2009, will raise the cost of electricity in that state over what otherwise would have occurred by 45% by 2020 and will cost Kansas consumers an estimated $644 million through that year.[22]

The notion that legislators can efficiently set targets and schedules for production of power from renewable energy sources seems unlikely on its face. Even experts in the field have little idea when currently non-economic forms of power will become competitive, and can only offer guesstimates. Legislators are even less likely to understand the economic future of these technologies and instead are more likely to react to political forces which are largely unconcerned with costs.

Recent experience with renewable fuel mandates helps to illustrate the point. In 2005 and then again in 2007, the U.S. Congress mandated that the nation's annual fuel supply must include ever-increasing quantities of ethanol, produced first from corn and later from both corn and advanced cellulosic biofuel technologies.[23] Costs and manufacturing difficulties associated with the cellulosic technologies have made it impossible to supply the mandated quantities, and EPA has greatly reduced the annual requirements as a result.

One way of thinking about the costs of subsidies or mandates is in terms of what otherwise could have been produced with the monies. If the government subsidizes an activity, then whether the funding method is immediate taxation or borrowing and deferred taxation, monies are diverted from other purposes. If instead the government mandates an activity, private parties must divert resources to implementation. In either case, the foregone products from activities that the resources otherwise would have paid for are a direct cost of the policy.

Mandates and subsidies impose costs as well through the political process because they induce companies to spend large sums lobbying for their continuation and expansion, and to protect them from cuts. These expenditures are rarely calculated, but in concept could, through competitive lobbying, equal the entire amounts of rents being earned. There seems little doubt that some of America's most talented individuals are drawn into lobbying for (or against) these subsidies, an activity in which they compete with one another endlessly. The cost can be measured in the dollars paid these individuals, but also can be thought of as the alternative goods and services they could have supplied the economy had they not been so engaged.

A further cost of government-granted energy subsidies and mandates is that they confront taxpayers with the appearance that 'insiders' with access to politicians are benefiting at their expense. When companies benefitting from the subsidies are revealed to be managed by important campaign contributors, that impression is only reinforced.[24]

This cost takes at least two forms. For one, citizens lose confidence in the political process. The appearance is that the Federal government is being managed for the benefit of a small number of individuals and companies, not for the public at large. And for another, citizens lose confidence in the U.S. market system. The guiding principle of economic activity appears to be political connection, not what products companies offer consumers in an openly competitive environment. It is difficult to measure this kind of cost, but ultimately citizen perceptions of malfunctioning U.S. political and economic systems are likely to reduce incentives to participate in either and to divert talent and capital elsewhere, to other countries.

Fallacy of Subsidizing the Creation of a Clean Energy Economy

The notion that government subsidization of certain energy technologies will result in substantial economic benefits is fallacious on several counts. First, though government-led job creation may be politically desirable, the quality of such jobs and offsetting job losses must be counted in the mix. Jobs created as a consequence of federal largesse or mandate by definition do not meet a market test and hence their economic value is suspect. Further, if the government subsidizes some technologies at the expense of others, jobs and incomes will be lost in the competing non-favored industries. In contrast to the jobs created by government subsidization or mandate, these jobs would have met a market test. Also, as pointed out earlier, monies used by the government to fund favored technologies must come from somewhere, resulting in lost output and jobs from where it is extracted. And finally, government-led job creation provides ample opportunity for political favoritism and corruption, implying that resources are diverted to uses not highly valued in markets and imposing costs on the American political process and citizen regard for government.

Policy Implications

Information contained in earlier figures and tables suggests that over both the long term and the short term, the U.S. power generation fuel mix has been trending towards lower carbon content, and that this trend recently has accelerated. Further, DOE projects that the trend likely will continue, while EPA efforts to constrain CO_2 emissions from new power plants will reinforce it. In view of this, it is questionable whether policy to subsidize or mandate such reduction through, say, renewable portfolio standards or very large subsidies to renewable sources are necessary or wise. If anything, a relaxation of the mandates and reduction in the subsidies would make more sense. Indeed, with the exception of basic scientific research that is unlikely to be undertaken by market participants, it is hard to see much value in the many energy subsidies currently granted, so that movement towards subsidy-free energy markets appears desirable.

Conclusions

The U.S. power generation fuel mix has been evolving for decades towards one that is less carbon intensive, and this evolution has only quickened over the past 15 years and even more over the past year and a half. In part this was induced by changes in the relative prices of fuels spurred by improvements in technology, and in part by policy measures, among them very large per unit of energy subsidies for renewable sources. This pattern of fuel substitution raises question whether mandatory measures such as renewable portfolio standards are either necessary or advisable. It also raises question whether subsidies, which amount to tens of billions of dollars annually among all forms of energy, need to persist.

RPS requirements will impose higher costs of supplying electricity on providers, and therefore higher prices to consumers. They also impose schedules which may require premature retirement of still productive assets, resulting in yet additional costs.

Energy subsidies are a component of the federal budget and contribute a share to the deficits that the U.S. currently is incurring. Some energy-related subsidy in the form of basic scientific research probably can be justified, since private parties cannot easily capture the benefits of the knowledge produced. However, massive grants, loans or loan guarantees to specific energy technologies and companies have little or no economic justification and should be greatly reduced. Though there may be political reward from granting such subsidies, an adverse result is that citizens come to view federal support as the goal of their activity rather than the provision of real goods and services. It also leads to cynicism regarding both the American political and economic systems, cynicism that has real though subtle costs.

The principal implication of our analysis is that little justification presently exists for pursuing RPS standards, whether at the state or federal level. Markets already are responding to price signals in such a way as to yield a less carbon intensive power mix, and projections indicate this is likely to continue. Another implication is that yet greater subsidies for non-fossil sources of energy cannot be justified, and if anything, should be reduced as a means to curb deficit spending. In other words, markets are moving in the direction desired and there is little or no justification for further policy action.

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1. “The Blueprint for a Secure Energy Future: Progress Report,” The White House, March 2012.
2. “Blueprint” cited in Note 1, p. 10.
3. S.2146 proposes a schedule of annual minimums. Only 5 year increments are shown in Table 1.
4. Steven F. Hayward, “Energy Fact of the Week: Solar Subsidies Are Off the Charts,” American Enterprise Institute (AEI), September 28, 2011.
5. The White House Blueprint for a Secure Energy Future states, for example, that DOE clean energy project loan programs will stimulate more than 60,000 new American jobs.
6. See for example, Jesse H. Ausubel, “Decarbonization: The Next 100 Years,” 50th Anniversary Symposium of the Geology Foundation, Austin, TX, 25 April 2003.
7. N.M. Victor, “Program for the Human Environment,” The Rockefeller University, 2003.
8. Data from *BP Statistical Review of World Energy*, June 2012, p.33.
9. See http://www.eia.gov/tools/faqs/faq.cfm?id=74&t=11.
10. As we showed in Figure 1, oil has lost market share at least since 1970. In part this was due to increasing demand for transportation fuels plus improvements to refinery technology that enabled refiners to convert residual fuel, a low-value product sold mainly to power generators, into gasoline and diesel, relatively high value products.
11. Robert L. Bradley, Jr. “Renewable Energy: Not Cheap, Not Green,” Cato Institute, August 1997.
12. “Tracking the Sun IV: An Historical Summary of the Installed Cost of Photovoltaics from 1998 to 2010,” Lawrence Berkeley National Laboratory, September 2011.
13. This assumes a year-round average of 3 hours per day of power generation at a cost saving of 10 cents per kWh. Even then, it would take over 9 years to return the initial cost.
14. Source: Congressional Budget Office, “Federal Financial Support for the Development and Production of Fuels and Energy Technologies,” March 6, 2012.

15. Source: see note 4. The numbers in Figure 9 are converted from dollars per MWh in the original.

16. Advanced geothermal refers to technologies that would enable these resources to be tapped where there are lower heat gradients or less porous rock, and also to techniques to make use of the underground heat even in the absence of a readily available natural source of fluid. As mentioned earlier, under ARRA several hundreds of millions of dollars were allocated to geothermal energy R&D.

17. Under EPA's direct regulatory approach, such a scheme does not seem feasible. Thus, it would have to take the form of a national program such as a cap and trade scheme under which the utilities would have the option of purchasing carbon offsets. Another option would be to replace EPA's New Source Performance Standard with a tax on carbon and then allow power generators to choose whatever fuel mix they prefer.

18. Massachusetts v. EPA, 127 Supreme Court 1438.

19. The Office of Management and Budget recently estimated that the Fiscal Year 2012 budget deficit will be about $1.2 trillion.

20. Even if they have been fully depreciated, their replacement by higher cost sources will impose costs on ratepayers. The point is that utilities forced to retire plants with remaining book value likely will be allowed to recapture that value through higher rates.

21. David G. Tuerck, Paul Bachman and Michael Head, "The Economic Impact of the Kansas Renewable Portfolio Standard," The Kansas Policy Institute, July 2012.

22. These results are for the "average" case analyzed by the Institute. In its "low" case the cost to consumers is $192 million, whereas in the "high" case it is $1.042 billion.

23. The Energy Policy Act of 2005 first established ethanol mandates and the Energy Independence and Security Act of 2007 (EISA) much expanded them. The EPA administers regulations under EISA.

24. This is one reason why the bankruptcy of Solyndra after DOE had granted it a $535 million loan guarantee, of which $527 million had been disbursed, was of major political importance. News reports indicated that one of Solyndra's top executives, a financial backer of the Administration, had frequent access to the White House.

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