Is a Rational U.S. Electric Power Policy Possible?

By Daniel C Mussatti

Daniel Mussatti is a Power Economist with the Nuclear Regulatory Commission. He may be reached at daniel@mussatticonsulting.com

See footnotes at end of text.

This January we began a new approach to an energy policy for the United States. Past rhetoric of “drill, baby, drill” and “all of the above” have again moved to the front of the fray, and the President has already signed two Executive Orders that expedite the environmental permitting for the Keystone XL and Dakota Access pipelines. But while these old sayings have a certain degree of appeal at the fifty-thousand-foot level of detail, upon closer inspection, they are like junk food: bland calories, devoid of usefulness. What we need, instead, is a mantra that is more precise—a targeted policy that is a bit less inclusive than the entire energy needs of the U.S.

Tackling the whole energy policy of the United States is a daunting task. A total energy policy involves not only the electricity sector, but (among others) those of transportation, heating and air conditioning, and process engineering as well—all of which have very different characteristics and requirements. You may be able to take the fossil fuels out of electricity, but you cannot do so for the transportation sector—when was the last time you saw a wind powered Boeing 777? Given these differences, a carbon-free energy policy seems highly problematic. In the words of former U.S. Senator George Allen (VA), “there is no single silver bullet [to meeting energy needs] . . . we need silver buckshot.”[1] So how do we proceed? In some ways, it is not very different form the riddle “how do you eat an elephant?” One bite at a time. This paper takes a first bite by examining the opportunities available for a national electricity policy by examining the economics of power generation without consideration of any necessary changes to the grid infrastructure. With apologies for the simplifications that have been used to make the points of this article succinctly, for anyone who so desires, all the data used are readily verifiable from the Energy Information Administration at www.eia.gov.

When establishing an energy policy for the United States, the first question one should ask is “How much energy do we need?” followed closely by “How much do we have?” According to the Energy Department, we need is “a lot;” somewhere in the neighborhood of 11.17 billion kWh per day in 2015. Of that amount, coal contributed 34 percent (3.8 billion kWh), natural gas about 33 percent (3.68 billion kWh), nuclear contributed 20 percent (2.23 billion kWh), and hydro and non-hydro renewables contributed about 13 percent (1.45 billion kWh). This power was supplied by a 2015 U.S. generating fleet of about 1,069,332.2 MWe. That inventory included: 284,501.7 MWe of coal fired generation, 438,723.5 MWe from natural gas, 98,729 MWe from nuclear fuels, and 182,020.6 from renewables; with the difference being made up from petroleum byproducts and other small contributors. Figures 1 and 2 display the differences between these two sets of data.

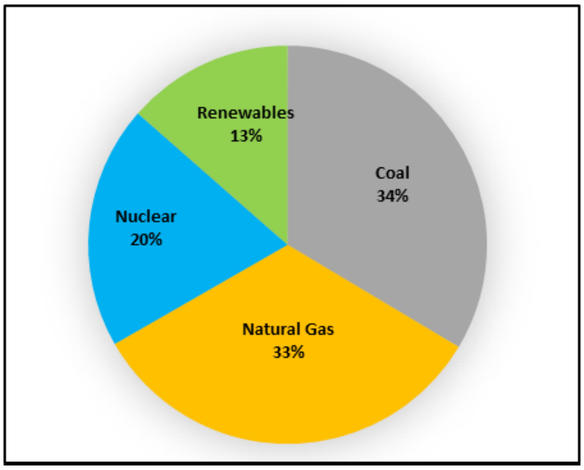

Figure 1: 2015 Average Daily Electricity Generation by Fuel

Source: U.S. Energy Information Administration, February 2016 Electric Power Monthly, Table ES1.A. Total Electrical Power Industry Summary Statistics, 2015 and 2014.

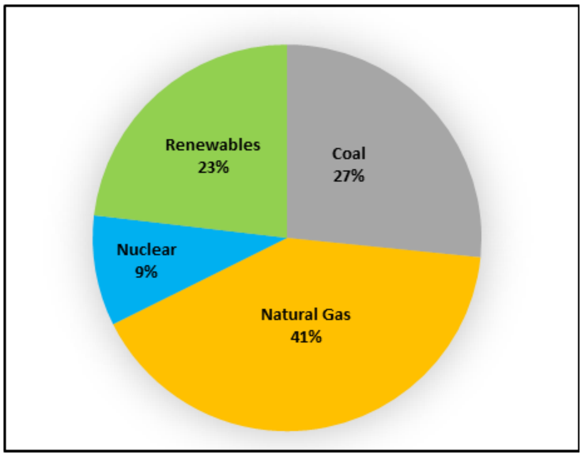

Figure 2: December 2015 US Electricity Generating Fleet by Fuel

Source: U.S. Energy Information Administration, February 2016 Electric Power Monthly, Table 6.1. Electric Generating Summer Capacity Changes (MW), November 2015 to December 2015

The data are from the same source, for the same year, and, most likely, from the same team of analysts, so what causes the differences between what we consume (left side) and where it comes from (right side)?

On the surface, the data do not fit the prevailing political narrative. For the past decade, federal policy has revolved around restricting carbon-based and nuclear energy in favor of the carbon free generating alternatives of wind and solar power. By now nuclear and natural gas should be contributing less power (in terms of their inventory share) than the data show—and coal should be almost a thing of the past. But coal and nuclear generation actually provide more than their inventory share. Coal provides about a third of the electricity produced in the U.S. while it represents only slightly more than a fourth of the nation's generating capacity, an "overachievement" of about 26 percent. More significantly, the US nuclear fleet constitutes slightly less than one tenth of the country's generating capacity, but produces about two-tenths of its power, a 116 percent overachievement. Natural gas provides less than one might expect, given all the planned new generation that has sprung up because of the recent discoveries of cheap gas. Gas generates about twenty percent less than its inventory share, with 41 percent of the country's capacity but only a third of its actual power.

On the other side of the prevailing narrative are the renewables, which one would expect to be a flourishing industry that is steadily eroding the market shares of all other energy sources. However, the optimistic announcements of unprecedented growth in the green energy industry should be tempered by the rule of small numbers, that data based upon small populations can often generate extreme observations. From the hyperbole, one would expect to see vast tracts of land across the country where environmentalists can point with pride to their fully (or near fully) carbon free generation; but as of 2015, that was not the case. All renewables (including hydro, biomass, and other fringe energy sources) amounted to about a quarter of the national generating fleet but provide less than one-seventh of its power—an underrepresentation of about 45 percent.

Why is it that coal and nuclear power plants provide more than their share of the electricity generated in 2015? Economics. The thesis of this paper is that despite the efforts to force a change in our energy production pattern through green policies and regulations, the current electricity market continues to follow basic economic principles. The differences reveal that after a decade of manipulation of the electricity marketplace to elicit specific culturally appropriate energy results, the long-established queueing process for electricity generation still works. Sort of.

Before deregulation, the queueing of generating units to support electricity demand was straight forward. As demand increased, the utility added the next available unit in the queue, starting with the least cost generator and sequentially adding units (ranked from the cheapest to most expensive cost of production). This ensured the utility always produced the needed amount of electricity at the lowest possible cost. (The dual of that is that the company maximized its profits.) Coincidentally, the cheapest generators were also those that produced the greatest amount of electricity. Coal was not crowned King because it was pretty. Coal is cheap, abundant, and can be processed into a useable form at a reasonably low cost. And more importantly, it has one of the highest energy contents per volume, which allowed for the construction of large generating units. Cheap to operate and capable of generating large quantities of electricity on a continuous basis, coal and nuclear power plants proved to always be first-run alternatives, with natural gas and other fuel types relegated to perform on a less continuous basis, depending on their cost of production and their ability to ramp up quickly to meet spikes in demand.

This regulated market process was feasible because the utility was not playing free market economics, they were playing Monopoly: Utility A could not offer their electricity to someone in service area B, and vice versa for Utility B. And the market was also playing Monopsony, since users could not reach out to generators outside their service area. Their only source of electricity was their friendly neighborhood public utility. The key here is the word "public." Electricity markets are considered "natural monopolies" because the infrastructure necessary for their function acts as a barrier to entry for competitors. No one would install hundreds of miles of transmission lines on the chance they can find a market, and no utility would willingly allow a competitor access to the transmission lines that they installed and maintained. So (with recognized exceptions ignored here for simplification), the standard operating procedure for the regulated electricity market was one company for one service area. And because monopolies tended to abuse their market power, there was a high probability for extraordinary abuse, so regulatory oversight groups—utility commissions—were established to provide oversight and price control.

We are told today's electricity marketplace is a vastly different sort of creature. Clearly, that is somewhat true, with some markets displaying all the characteristics of the old regulated utility system and others operating a wide open "enter at your own risk" approach to entry (and everything in between). Deregulation has even more complexity. Independent System Operators and Regional Transmission Organizations purchase power from a competing group of dedicated power companies, independent generators, companies that discovered their waste heat could be converted to electricity, and entrepreneurial minded citizens with a roof full of solar panels. And, just to cloud up the waters, the demand for electricity is more complex than just the needs of the people. There are power purchase agreements, reliability reserves, interties opportunities for import and export, and transmission constraints to consider. Given all of this complexity, all available power is offered hourly (or, in the case of Texas' ERCOT region, quarter-hourly) to the ISO or RTO, which must then choose who gets to contribute to the hourly demand and who does not.

Regulators and policy makers would argue that this added complexity has rendered the old way of thinking obsolete. As Jon Wellinghoff, the chairman of the Federal Energy Regulatory Commission said on April 22, 2009, "I think baseload capacity is going to become an anachronism. . . Baseload capacity really used to only mean in an economic dispatch, which you dispatch first, what would be the cheapest thing to do. . . You can't ramp up and ramp down a nuclear plant. And if you have instead the ability to ramp up and ramp down loads in ways that can shape the entire system, then the old concept of baseload becomes an anachronism." [2] Wellinghoff was a bit ahead of his time in that the smart grid is not yet here; but from what he said at the time, it is apparent our leadership would like us to believe that the establishment of a national energy policy for electricity must be as highly complicated as the heterogeneous set of markets that it seeks to wrangle. That is not the case. In many important ways, the new deregulated electricity market is pretty much the same as its regulated predecessor, and that is what simplifies our identification of a reasonable electricity policy.

For illustration purposes, consider a stylized representation of how a modern ISO works. The ISO or RTO starts with an estimate of what the demand will be for the next hour of delivery, then examines its list of electricity suppliers who have agreed they would be ready, willing, and able to provide electricity for that hour. This list is pre-sorted (in dollars per kilowatt hour) from the cheapest to the highest bid, and the ISO starts at the top, sequentially adding more suppliers to the roster of that hour's suppliers until the total expected demand has been reached. For the selected suppliers, all of them enter the market simultaneously at the beginning of the hour. (It is this point that some power experts use to base their proclamation of the death of baseload power.)

All suppliers with bids greater than that of the highest supplier selected have bid too high and unless something unexpected happens during the hour, must wait until demand increases enough for them to sell in the market at their bid price, or they can revise their price for greater competitiveness in the future (this is the economics part). Revising prices downward makes sense in that a lower price gives you a better chance at participating in the market, but there is a down side. At some point, even if the supplier were to sell every watt of the energy it produces, if it cannot cover its costs, it will not stay in business. So, what is the lowest possible price that the seller can bid and still survive? In the short run, the supplier must cover its variable costs—those costs that are directly related to the actual production of electricity. Capital cost payments, general overhead, and other such sunk costs are irrelevant to the survival of the supplier in the short run, so in the end it is in the supplier's best interest to bid the variable price of its production and ensure its best chance at being able to make it another day.

Figure 3 displays a simplified electricity marketplace with an hourly demand for electricity of Q* MWh. In the bid process, the ISO would rank order all the (variable cost) bids for that hour, resulting in the step-wise electricity supply curve starting with hydro on the left and ending in the high cost land of cogeneration, diesel, and very old (inefficient) power plants. Each horizontal step indicates a different generator, which allows us to display differences within each fuel type. For instance, there are two coal-fired generators available, each about the same capacity, but one with slightly lower variable costs. For natural gas, there are four different variable costs. In this example the ISO would choose, in order, the hydro unit, the nuclear unit, both coal units, and enough of the lowest cost natural gas units so that the total capacity to be distributed to the grid for that hour was equal to Q*. This establishes the market price for that hour as P*.

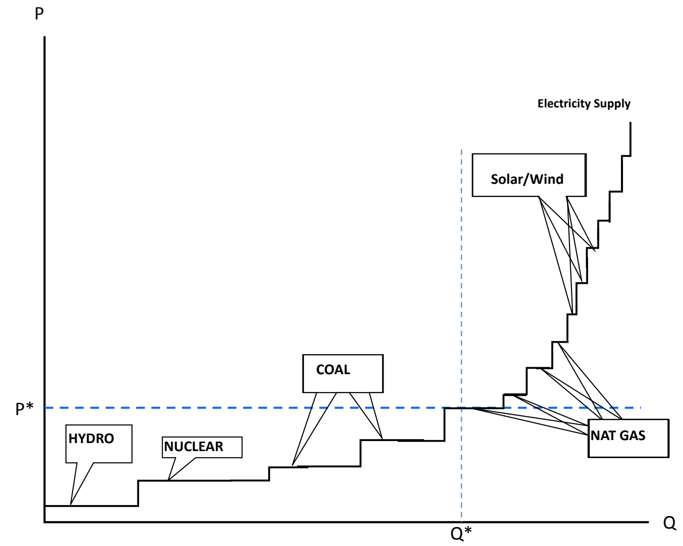

Figure 3: A Stylized Electricity Pricing Model

This is no different than the old-time monopoly utility would have done in choosing its generation mix. There is no illusion of diversification of generation—any other combination of generators that could produce Q* would necessarily carry a higher market price. There is no altruistic effort to push green energy over carbon-based generation, either, for the same reasons. The most altruistic combination of generators that can be assembled is the one that costs the least to the public, which is what the old-time utility and the present-day ISO both choose (because it is the one that minimizes their own costs / maximizes their own profits).

In recent years, the electricity market has seen impossible extremes in pricing—order of magnitude increases in cost per kWh and negative pricing. Both extremes coexisting in the same market are indicative of market interventions that have introduced unexpected consequences while offering frustratingly little progress toward the altruistic goal. Recent subsidization of wind farms has produced a boom market in the production and installation of the giant turbines, doubling wind's generation share between 2010 and the present, but still only 4.7 percent of 2015's total generation. Similarly, utility-scale solar (photovoltaic) capacity contributed about one-tenth of one percent of total U.S. generating capacity while constituting three and five percent of the total U.S. capacity additions in 2011 and 2012, respectively. This matches the incongruities found between Figures 1 and 2. The conclusion appears compelling: that no matter how much effort is put into changing the course of the U.S. generating fleet, the forces of free market influences still dominate the electricity industry.

So, what is the optimal electricity policy for the U.S.? The one that minimizes the cost of electricity to all consumers. Subsidization of unproven and unsupportable energy sources such as the recent push for wind and solar as baseload power are at best inefficient—and at worst, wasteful of resources better used to achieve other ends. Clearly, there is a role for nudging industry in the environmentally right direction. But if a clean green generating machine were economically feasible, why hasn't some new-age Thomas Edison developed it? And if industry were to believe that such an item was on the technological horizon, why hasn't such a device been sought? Technology forcing legislation was used in the late sixties to make more fuel-efficient cars. It was originally thought to be impossible and unaffordable, yet as the deadlines drew nearer, car manufacturers designed the first catalytic converters. The same can be done today, but not by subsidizing the installation of technologies that are not quite able to support themselves, but instead, by the surgical stimulation of well designed, peer reviewed research into new inventions. Development will take care of itself as innovations arise.

Today there are cheap and readily available energy sources to power the U.S. economic growth until these new technologies prove themselves full scale. However, while nuclear generation is almost entirely devoid of carbon dioxide and criteria pollutants, nuclear power plants are expensive and time consuming to build. Modern clean coal technologies have the proven ability to provide low pollution levels, but megawatt for megawatt, these new designs are growing uncomfortably close to the costs of a nuclear plant. As a stop gap between the realities of now and the promises of the future, America needs those baseload units, and a clever government should be able to figure out how to mitigate the cost of construction to bring those coal and nuclear generators on line. Perhaps through tax incentives, low-interest loans, and expedited permitting processes.

Economic terms seem quaint on the surface, but there is something subtly elegant in the philosophy of laissez-faire—the concept of minimal intervention in favor of the power of self-interest. If we need some iconic image to represent viable U.S. electricity policy—a modern day Rosie the Riveter that could capture the essence of this new philosophy in a manner that is unmistakable, then perhaps that icon should be a suited bureaucrat, briefcase in hand, with his leg firmly attached to a really big anchor.

Footnotes

[1]Text of Former Virginia Governor and United States Senator George Allen's speech "McCain, Obama, and America's Security" October 29, 2008 at Bowker Auditorium, University of Massachusetts.

[2] (New York Times, 4/22/2009, Noelle Straub and Peter Behr, "Energy Regulatory Chief Says New Coal, Nuclear Plants May Be Unnecessary")

IAEE International Association for Energy Economics
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