Market Consequences of Wind Generation Promotion: Towards a Rational Energy Policy

By Raul Bajo-Buenstado and Maria Garcia

INTRODUCTION

Policy makers in many advanced countries have shown an increasing concern about environmental problems associated with fossil fuel use. This fact is reflected in multiple and well-known policies, such as the Renewable Electricity Production Tax Credit (PTC), Renewable Portfolio Standards (RPS), and Feed-in-Tariffs, among many others. In general, the goal of these policies is to promote clean generation technologies by increasing the presence of renewable resources in the capacity mix.

This policy makers' "renewable obsession" is definitely good news for society. The promotion of clean generation resources undoubtedly has a positive effect on welfare via environmental gains. Modern societies need a solid presence of renewable resources as a way to demonstrate commitment to combat climate change as well as to achieve other celebrated environmental goals. The trouble comes when emotional and political motives, rather than a reasonable and well-planned energy and electricity policy, surround the "green policies" debate. If so, we are at risk of ignoring some other market consequences.

Following this concern, we want to point out that even though an increase in renewable resources is desirable from an environmental point of view, market participants' incentives are not innocuous to a renewable resources promotion. In particular, we want to focus on some potential consequences that an increase in wind generation is expected to have on both the generation capacity mix and on market prices.

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See footnotes at end of text.

Due to the aforementioned policies, wind penetration has been rapidly increasing in many countries and regions, and it is still projected to rise in the near future in many of them. For instance, as shown in Figure 1, the installation of both onshore and offshore wind turbines in the European Union experienced a steady increase over the last decade. A similar story holds for the USA, where the penetration of wind has been especially intense in states such as Texas and Iowa, as shown in Figure 2.

Following this rapid increase in the share of wind capacity in the energy mix, some markets experienced notorious changes. Possibility the most salient consequence was the existence of negative prices in MISO and Texas ERCOT[1] that, as expected, have had (and will have) a "displacement effect" on current generation capacity. This displacement effect takes place in the context of an increasing concern about the resource adequacy problem (or "missing money" problem).

This notorious "negative prices" effect originated by the promotion of wind, together with some other consequences discussed below, lead us to raise the question of whether the promotion of wind generation capacity may also jeopardize some of the goals that policy makers set during the privatization wave in the nineties and to additional concerns regarding the resource adequacy problem. If that is the case, we argue that the so-called "green policies" must be articulated with some other policy measures to incentivize a rational, reliable and well-designed electricity market.

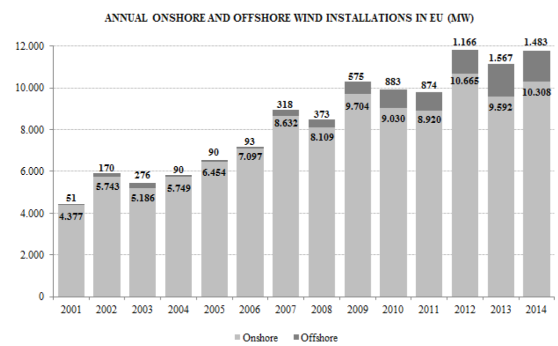


Figure 1
Source: EWEA

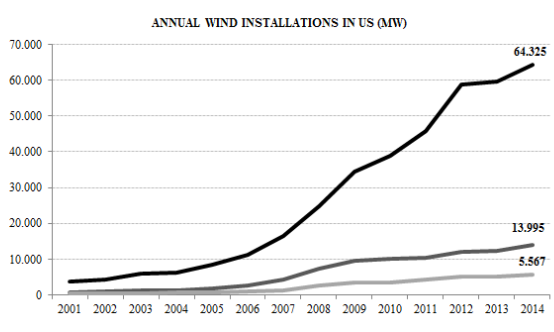
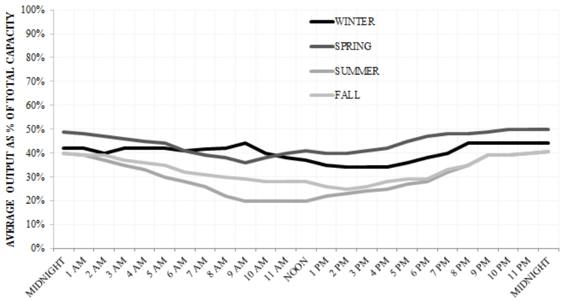


Figure 2
Source; EIW

WIND PENETRATION AND THE EFFECT ON THE GENERATION MIX

Most countries and regions rely on more than one fuel/source to generate electricity. Thus, the generation capacity mix is usually divided into two main types of generators, namely, base load generators and peak load generators. The first group typically includes nuclear and coal-fired generation, while the second group typically includes natural gas (combine cycle and gas turbine) and oil-fired generation. How does the introduction of an



Note: These profiles are based on ERCOT data for 1996-2012.

Figure 3. Source: Electric Reliability Council of Texas

intermittent resource (wind) affect the base load and the peak load generators?

To properly answer this question, let us take into account the following considerations. First, according to some recent empirical evidence from the Texas ERCOT market (see Figure 3), wind usually blows at night, precisely when the demand for electricity is low. In the absence of wind generation, base load generators (coal and nuclear plants) would typically have enough capacity to satisfy night demand. However, during windy nights, wind turbines will be online, taking market share from base load generators. If wind penetration is high enough, and considering that the marginal cost of wind generation is nearly zero, during windy nights market clearing prices will be close to zero, making production non-profitable for coal-burning power plants and nuclear plants.

Second, in some countries wind production receives a subsidy per kWh generated. For instance, in the U.S. the so-called Production Tax Credit (PCT), which is imposed at the federal level, currently grants $0.023/kWh to wind producers. This implies that wind generators are willing to bid even below zero, since the subsidy will guarantee that production is profitable for them as long as they are plugging power into the system. If so, power generation will be even less worthy for coal-fired plants and nuclear plants, since these power plants will incur negative profit.

Third, peaking generators, such as gas-fired turbines, have low shut down costs and are able to come online in 30 minutes. Therefore, when a peak in demand is anticipated, these plants are likely to be ready to generate power. This is not true for coal and nuclear plants (base load). For these types of plants, shut down and ramp up costs are high, that is, it is not cheap, nor easy nor quick, to turn them on. As a consequence, these plants face the tradeoff of staying online 24/7, as is the case for nuclear plants, at the risk of not covering variable costs if the wind is blowing (and even getting negative prices in the presence of subsidies), or shutting down whenever the wind is blowing, which makes these plants incur cooling down and ramp up costs.

Therefore, and according to Peter Hartley[2], due to both the intermittent nature of wind and the fact that wind generation satisfies base load demand (night demand), an increase in wind generation is likely to discourage investment in base load generation (coal and nuclear capacity) and encourage investment in natural gas capacity. This effect is further enhanced by (current) low natural gas and oil prices.

WIND PENETRATION AND THE EFFECT ON PRICES

The promotion of wind generation is also likely to have an effect on the electricity market price. The key question is whether this impact is positive or negative for consumers. Again, we shall consider the following issues to properly address this question.

The marginal cost of wind generation is zero (or near to zero). This implies that whenever the wind is blowing, electricity prices will be low, and even negative as it was the case in Texas ERCOT and MISO, due to the presence of subsidies and coal plants' shut down costs (see footnote 1). But, what happens if the wind is not blowing?

If our previous argument is correct, nuclear and coal-burning power plants are likely to be displaced over time in favor of peaking plants (natural gas generation and oil-fired generation) as wind generation penetrates the market. As a consequence, if the wind is not blowing, the "market clearing fuels" are likely to be natural gas and oil, which are more expensive than coal and uranium (nuclear production). In other words, the electricity market price will be subject to high jumps, whose size is the difference between the marginal cost of wind generation (zero) and the marginal cost of natural gas. Moreover, these jumps will move according to the pattern of wind, which is unpredictable.

Hence, a greater presence of wind turbines will leave electricity prices subject to two sources of variation. First, subject to jumps created by wind patterns. Second, subject to the fluctuations of oil and natural gas prices in the global energy markets. Moreover, as Riesz, Gilmore and MacGill[3] point out in a forthcoming article, in a high renewable market the proportion of revenue earned during extreme pricing events would need to increase significantly in order to maintain reliability. Hence, according to them, a significantly high market price cap will be also required. An increase in the price cap will add further variability in market clearing prices, since power prices will skyrocket during scarcity events. Considering these facts, we expect that a promotion of wind turbines will produce a significant increase in the volatility of electricity market clearing prices. Whether or not this is a desirable feature is a question that we leave to readers.

Finally, in regions in which wind is likely to blow mostly at night (e.g., Texas), some other generation resources will be necessary to back up production during the day, when the wind is less likely to blow. If so, and considering the displacement effect of wind capacity on base load generation, natural gas and oil power plants will play a prominent role during peaking demand hours. This will not only increase price variability for consumers, but it may also lead to an increase in average consumer prices, especially in markets with relatively high price caps (as is the Texas ERCOT case).

INSIGHTS FROM RECENT TEXAS ERCOT MARKET'S PATTERNS

The Texas ERCOT market provides some relevant insights on how the promotion of renewable resources (with a focus on wind) is likely to affect the power sector. The Texas ERCOT market has traditionally relied on two main sources of electricity generation, namely coal and natural gas. However, as shown Figure 1, the penetration of wind capacity has been increasing significantly over the last decade in Texas. Favorable wind conditions in some regions within the state (such as West Texas) and generation subsidies are two key elements that explain this pattern.

Following this high wind penetration, and in the presence of the PTC, the Texas ERCOT market has experienced some notorious changes. First, as discussed by Huntowski, Patterson, and Schnitzer (see footnote 1), the frequency of negative hourly prices in the ERCOT West zone increased from about 1% in 2007 to over 9% in 2011. Second, as a consequence, wind capacity has discouraged investment in coal-burning power plants. This effect will be exacerbated as a result of the implementation of the recently released Clean Power Plan act, which further pushes the reduction of coal-burning power plants. In fact, recent ERCOT projections[4] show that the only fossil fuel burning capacity additions will be based on gas turbine and combined cycle plants.

With the expansion of the South Texas nuclear generation station cancelled in 2011 and the expansion of the Comanche Peak nuclear power plant suspended since 2013, and with no promising future to restart these projects due to low gas prices, the Fukushima accident alert, and regulatory hurdles, it seems that Texas ERCOT tends towards a generation mix based on renewable resources and natural gas. Unsurprisingly, ERCOT reckons that these changes could increase electricity prices by up to 16% in 15 years (see footnote 4).

THE "IRRATIONAL" ENERGY POLICY IN SCOTLAND

According to our previous analysis, in the context of heavily subsidized wind generation, base load capacity is likely to be displaced. The market will have an incentive to invest in peaking plants, such as natural gas turbines and oil-fired plants, as a way to back up the increase in intermittent generators.

Even though the market tendency is to displace coal and nuclear plants, representatives of the Scottish Nationalist Party (SNP) at Westminster are willing to exacerbate this effect. In fact, according to a recent article by Simon Johnson[5], SNP ministers are using their control of the planning system to promote the construction of additional wind farms while blocking the construction of a new generation of nuclear. These political interventions are taking place at the same time that the closure of coal-fired plants, such as Longannet, and nuclear plants, such as Hunterston and Torness, are planned for the next year.

SNP members understand that investing in green generation is good for Scottish citizens. However the remaining question is, how do policy makers plan to back up production if it happens that there is no wind? It seems that SNP members are avoiding this question. In fact, as Gary Pender states in the aforementioned article, the lack of replacement of the coal-fired and nuclear generators will eventually lead to Scotland to transition from a being a net exporter to being a net importer of electricity. Paradoxically, electricity imports from neighboring regions may come from even dirtier technologies, and at a higher price.

CONCLUSIONS: AN ENERGY POLICY THAT MAKES SENSE

Current environmental challenges are pushing policy makers towards the adoption of policy measures that promote investment in renewable resources such as wind turbines. Undoubtedly, these policy measures are important in modern societies, in order to guarantee minimum environmental standards to future generations. However, this goal cannot compromise current and/or near future energy security and grid reliability. In other words, thoughtlessly "green legislation" that does not consider market consequences, and that does not envision a smooth fuel transition, should not be implemented by any means.

The real challenge for policy makers is not only to promote renewable resources, but also to guarantee a smooth transition from a fossil-fuel based generation mix to a less-carbon-dependent, reliable and sustainable grid. For that purpose, in our opinion, a rational energy policy should consider simultaneously the following points.

- Maintain well-articulated incentives that promote investment in renewable resources, while preserving market competition.
- Increase the thermal efficiency of existing coal plants, which could potentially result in significant reductions of CO_2 emissions. In addition, policy makers should also incentivize the investment in "top-notch" coal plant technologies, such as Carbon Capture and Storage (CCS). According to a recent report by the IEA[6], fitting CCS to a power plant requires additional capital investment for the CO_2 capture and compression equipment, the transport infrastructure as well as the equipment associated with storage. We argue that the right policy and funding mechanisms are needed to help CCS to turn profitable projects such as the Petro Nova porject in Southwest Houston[7].
- Incentivize the investment in safer, out-of-risk nuclear plants. According to Goldstein and Pinker[8], given the current state of the art, without nuclear power "the numbers needed to solve the climate crisis [...] do not add up". Nuclear generation is a carbon-free option, but given the (justified) social alarm created by the Fukushima accident further efforts are necessary to guarantee 100% safe nuclear generation in current and projected plants.
- A well-planned capacity market that sets the revenue adequacy requirement considering not only overall system needs and system existing capacity, but that also considers the negative correlation between intermittent production and market demand. If necessary, the regulator should make a distinction between off-peak and peak demand (net of wind), setting different resource adequacy standards for different periods.
- Study the implementation of "capacity portfolio standars" that take into account not the least-cost generation units but also the least-pollutant generation units. Such "capacity portfolio standars" should be set taking into account also the climatological patterns and the evolution of the renewable resources state of the art. If necessary, the regulator should increase the percentage of "thermal-generation" reserve margin in such a way there is enough thermal generation capacity to satisfy peak load in the worst expected "no-wind period" scenario.

Footnotes

[1] Huntowski, F., A. Patterson, and M. Schnitzer. "Negative Electricity Prices and the Production Tax Credit." The NorthBridge Group, September 10 (2012).

[2] Hartley, P. R. (2014). "Wind Power in the United States: Prospects and Consequences," RISE Working Paper 14-028, Department of Economics, Rice University.

[3] Riesz, J., J. Gilmore and I. MacGill (forthcoming). "Assessing the viability of Energy-Only Markets with 100% Renewables", Economics of Energy & Environmental Policy.

[4] ERCOT (2015), "Analysis of the Impacts of the Clean Power. Final Rule Update". Austin (TX).

[5] Johnson, S. "Engineers urge SNP to drop 'irrational' energy." The Telegraph [London, UK], October 29, 2015.

[6] IEA (2014), "Emissions Reduction through Upgrade of Coal-Fired Power Plants. Learning from Chinese Experience". Partner Country Series, Paris (France).

[7] http://www.nrg.com/sustainability/strategy/enhance-generation/carbon-capture/wa-parish-ccs-project/

[8] Goldstein, J.S. and S. Pinker. "Inconvenient Truths for the Environmental Movement." The Boston Globe [Boston, MA], November 23, 2015.