Envisioning Pennsylvania's Energy Future

Using renewables to achieve a zero-emissions future

Synapse Energy Economics: Pat Knight and Patrick Luckow *December 2016*

How can Pennsylvania lead the way in achieving a zero emissions future powered by renewables?

That's the question that the Delaware Riverkeeper Network asked Synapse and EQ Research in the October 2016 report "Envisioning Pennsylvania's Energy Future." Serious, imminent, and irreversible damages to natural ecosystems, infrastructure, agricultural production, and human health make dramatic reduction of greenhouse gas emissions a key priority for communities around the world. Governor Wolf's recently proposed initiative to boost solar energy is just the first step: by following a pathway to powering all of Pennsylvania's energy needs through wind and solar by 2050, the Commonwealth can be on the vanguard of avoiding catastrophic climate change.

Envisioning renewables in Pennsylvania's future

Delaware Riverkeeper Network asked Synapse Energy Economics and EQ Research to explore one path to zero emissions by 2050. Although an infinite set of such paths exist, Synapse and EQ evaluated a future that would achieve zero emissions using the following four strategies:

- Using expanded energy efficiency programs to reduce consumption of in-state electricity
- Building renewable resources in Pennsylvania to replace existing emitting generation
- Electrifying all end uses, including all cars, trucks, heating of homes and businesses, and electrical processes
- Where cost-effective, purchasing renewable energy from states adjacent to Pennsylvania to meet the remainder of the 100 percent renewable portfolio standard

In this 100 percent wind-and-solar future, Pennsylvania's energy mix sees substantial change. The energy used by

Figure 1. Solar capacity (GW) in Pennsylvania and other regions, 2015 and 2050

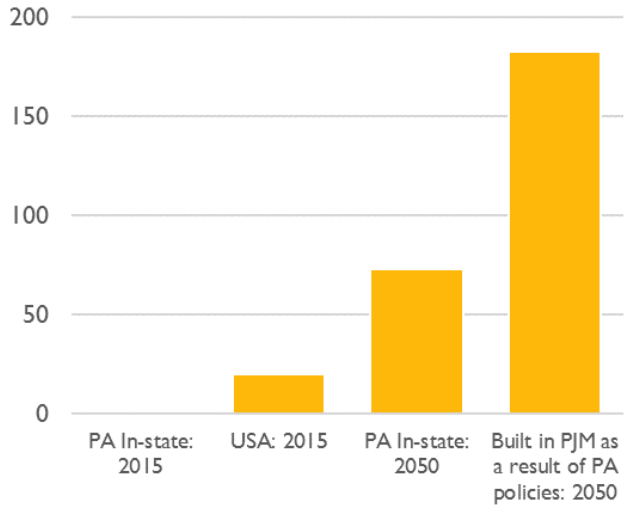
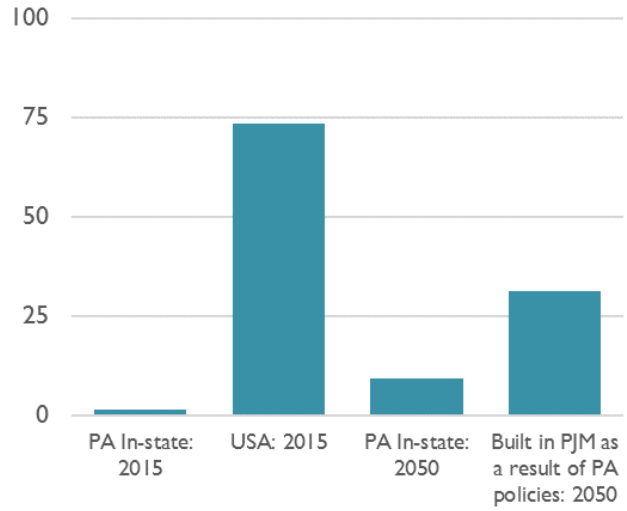


Figure 2. Wind capacity (GW) in Pennsylvania and other regions, 2015 and 2050



Pennsylvania consumers shifts from mainly relying on coal, natural gas, and nuclear energy (95 percent in 2015) to a future wholly dependent on renewables.

By 2050, Pennsylvania builds 9 gigawatts (GW) of wind and 73 GW of solar in-state. This capacity represents a 50-fold increase over the renewable capacity currently installed in Pennsylvania—the in-state solar capacity expansion alone is over three-and-a-half times the 20 GW of solar capacity built nationwide as of 2015. Furthermore, as a direct result of Pennsylvania's expanded RPS policy, an additional 106 GW of wind and solar is built in nearby states.

One of the defining features of this 100 percent renewables future is a sea-change in the way electricity is provided to Pennsylvania's consumers. Today, 80 percent of all energy consumed in Pennsylvania comes from non-electric sources. In contrast, by 2050, in our 100 percent renewables case, no energy comes from non-electric sources. As a result of this shift to the electric sector, electric sales in Pennsylvania more than triple from 150 GWh in 2015 to 500 GWh in 2050, even after accounting for energy efficiency. Even though Pennsylvania's in-state generation remains relatively constant at about 240 GWh from 2015 to 2050, this tremendous increase in electric sales causes Pennsylvania to become a net importer of electricity by the year 2030.

It is important to remember that this scenario is just one vision of the future: other possibilities could exist where more renewables are constructed in Pennsylvania than in other nearby states, but at a potentially greater cost per MWh.

Renewable integration: A solved problem

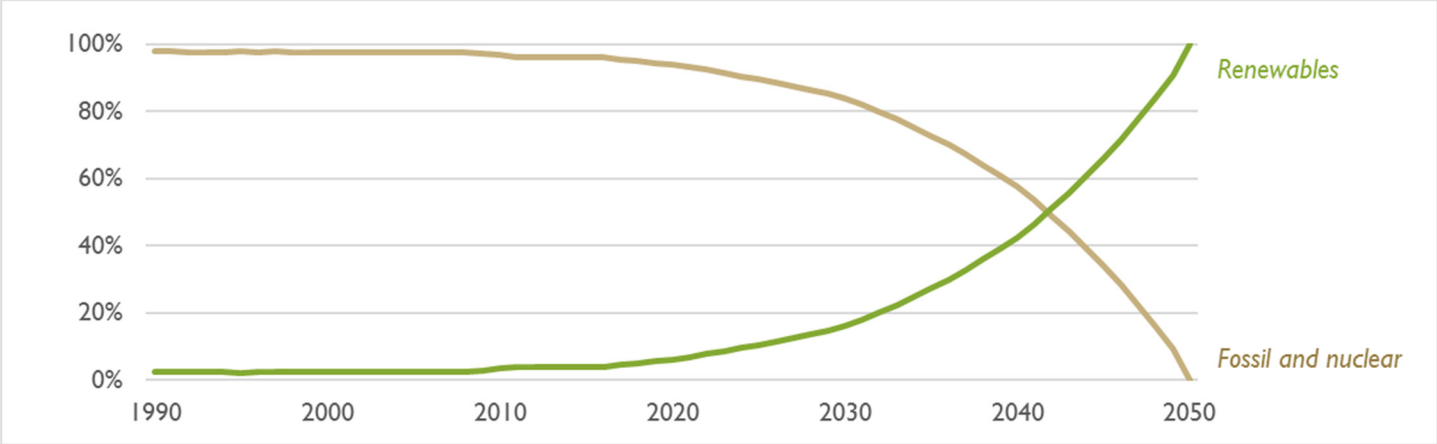
As Pennsylvania moves towards a future wholly dependent on renewables, system operators will face challenges posed by increased levels of variable resources. However, in the near term, they can easily address these challenges with already existing planning and operational tools, all at a low cost.

Variable resources like wind and solar experience rapid swings in generation caused by both expected solar declines at the end of the day and unexpected swings due to forecast errors. Others have put forth that wind or solar energy must be balanced by gas generation at every hour to create a flat, firm power profile, to compensate for the uncertainty in weather forecasts. While entities like the California Independent System Operator (CAISO) has famously discussed the theoretical challenges of ramping conventional generation during evening periods, in practice, CAISO is well prepared for this, and will likely be able to meet these requirements without major modifications to its systems or processes.

System operators are already coming up with solutions to address these challenges, including:

- **Improving regional coordination:** Pennsylvania is already part of the PJM regional transmission organization, one of the largest wholesale electricity markets on the planet. Large, well-connected systems

Figure 3. Resource share of Pennsylvania's energy needs



like PJM are already predisposed to take advantage of geographically diverse resources and loads. In a February 2014 renewable integration study, PJM found it could accommodate 30 percent variable renewable energy, today, with no operational changes or resource additions. In addition, while system operator coordination can help to distribute swings in renewable resources, geographically dispersing the wind and solar resources themselves can also reduce the incidence of rapid power swings, smoothing overall generation over time. Other regions have already successfully found solutions to this issue. System operators in California, Texas, and the Midwest, have regularly and successfully integrated renewable energy in excess of 50 percent of total system generation in certain hours.

- **Implementing focused transmission investments:** Moderate, focused investments can allow electric systems to incorporate significant quantiles of new renewable energy. The same February 2014 study by PJM found that $8 billion in system upgrades could facilitate the addition of 100 GW of wind energy, with no major operating issues and minimal curtailment (GEII, 2014). In one single year this scenario lowered costs from the "reference case" by $16 billion. A similar study by Synapse in PJM also found significant cost savings even with levels of renewables in excess of 20 percent (Fagan et al., 2013).
- **Investing in demand response and smart grid:** New tools can actively reduce load at specific times, and can help reduce the level of fossil ramping required during times of tightly constrained periods. Since 2011, PJM has made a concerted effort to increase the flexibility of the demand response products procured in its energy markets.
- **Reducing dependence on old, inflexible units:** Aging, conventional electric generating units are constrained by minimum loads and limited response rates. Newer, flexible resources can respond to variable resource changes more rapidly. These attributes are not exclusive to natural gas plants: storage, imports, demand response, and other flexible generation can also assist with ramping needs and are not dependent on natural gas power plants.

Even towards the end of our study period, the entire PJM region reaches a maximum level of 44 percent of generation coming from renewables—on par with the level of generation currently balanced by other large regional system operators today.

Natural gas: A bridge to zero emissions or a costly detour?

Despite the progress that is being made on integrating renewables into our current aging, inflexible electric system, some continue to argue that natural gas is needed as a "bridge" fuel to bridge the gap from a coal-dominated electric system to an electric system powered entirely by renewable energy. This assertion hinges on a number of myths and misconceptions which, when addressed, make clear that natural gas is not an adequate bridge in many cases, and in other cases is simply not needed at all. Instead, conservation, efficiency, and investing in more renewables is a more cost-effective and sustainable path forward.

First, recent historical experience by other states indicates that a bridge fuel is not needed at all. Preliminary data through August 2016 shows that over the past 12 months, renewable generation exceeded 20 percent of total in-state generation in 11 states in at least one month. Like Pennsylvania, all of these states are not electricity islands. Instead, they depend on regional cooperation to ensure electric system reliability and renewable integration. With this regional coordination, these states are able to consistently integrate very high levels of renewable generation while still maintaining electric system reliability. At the same time, many other states, including Pennsylvania, have a long way to go before they reach the installed renewable capacity of these leading states; in our study, Pennsylvania does not reach 20 percent renewables in-state until 2036. Even if Pennsylvania were to have unique issues hindering high

levels of renewables integration, there are 20 years to prepare for this. While generation from existing natural gas facilities may be used in the short-term to balance generation from renewables, in the longer-term, this role is projected to be largely handled by demand response and storage resources.

Second, renewables are the logical resource to replace coal from a cost perspective. Our 100 percent renewable scenario uses detailed information on expected costs from Lawrence Berkeley National Laboratory, embedded in the NREL ReEDS model. Cost trends from this research indicate that by 2030 the average resource costs in Pennsylvania will be $60 per MWh for wind and $105 per MWh for utility-scale solar compared to $50 per MWh for coal or $75 per MWh for natural gas combined-cycle units. Meanwhile, energy efficiency, widely available in large quantities even today, is estimated to be even cheaper at $40 per MWh, almost half the cost of procuring power from natural gas in 2015.

Third, even if renewables were not ready to take on the burden of providing a high share of the grid's electricity, natural gas cannot be expected to defer high levels of greenhouse gas emissions, even when compared to coal. On average, natural gas generators in Pennsylvania have CO_2 emissions rates 42 percent that of coal generators. At the same time, natural gas (composed primarily of methane or CH_4) itself is a harmful greenhouse gas, containing about 25 times as much global warming potential per pound as CO_2 over a 100-year timeframe, and 86 times as much over a 20-year timeline. As a result, methane leaked during the production and transportation of natural gas may significantly worsen the climate implications of using this fuel.

Because of this, the production, processing, and transportation of natural gas has been very controversial. Despite recent EPA regulations aimed at reducing emissions of methane, it is estimated that between 2.1 and 3.3 percent of natural gas is lost to the atmosphere during the distribution stage alone (McKain et al., 2015). If these leaks are left unchecked, just taking into account natural gas lost to transmission to power generators could cause the emissions rate of natural gas generators to increase to an emissions rate of 530 kg per MWh, or 55 percent that of coal generators. Research is showing that even larger quantities of methane could be lost during extraction and processing. Data on the quantity of leaked methane per MWh generated continues to be collected, and the ultimate climate impacts of this wasted fuel could ultimately be much worse.

Far from being an effective bridge to clean energy future, expanding the use of natural gas will only make it increasingly difficult to meet long-term CO_2 reduction goals.

Sources

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