

A Whole New Ballgame: Indiana Coal and the New Energy Landscape

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Applied Economics Clinic

**Prepared on behalf of
Citizens Action Coalition of Indiana**

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Executive summary

This Applied Economics Clinic report, prepared on behalf of Citizens Action Coalition of Indiana, responds to several myths that persist regarding claimed benefits of aging coal-fired generators over renewable wind and solar. Table ES-1 below summarizes these myths and corresponding real-world facts. Ultimately, legacy power generation sources like coal are characterized by a lack of flexibility, making them costly and inconvenient to integrate with more modern renewables.

Table ES-1. Common myths about renewable integration

Myth	Reality
1) Supply Must Equal Demand	With new energy storage technologies, supply need no longer meet demand instantaneously.
2) Coal Competes with Wind	All resources compete with all other resources to determine what's included in a cost-effective generation portfolio.
3) Existing Power Plants are Free	Aging coal plants are costly to run, and ratepayers foot the bill.
4) A Megawatt is a Megawatt	The number of megawatts does not determine customer costs.
5) Surplus Wind is Costly	It is common practice to scale back wind as needed, just as it is with any other generation source.
6) Renewables Need Gas to Integrate	Renewables integrate easily and do not need back up gas generation.

The report makes three key points regarding aging resources and their more up-to-date counterparts:

1. **Indiana's electric grid is supplied by a diverse portfolio of resources.** No single resource can reliably supply Indiana's energy needs; the most reliable strategy is to invest in a mix of different, complementary resources. Putting all your eggs in one basket is not a way to ensure reliable electric supply, especially in the midst of a nation-wide shift away from coal-fired generation: 2019 saw the largest annual decline in U.S. coal generation on record, and in April and May, renewable energy provided more power than coal for the first time in U.S. history.
2. **Indiana is years, perhaps decades, away from needing to do anything at all to integrate additional renewable energy.** Today, just 9 percent of Indiana's electric generating capacity is wind and solar. If all of Indiana's coal were to be replaced with wind and solar today, 64 percent of Indiana's supply would be renewable, but only 21 percent of the greater MISO region's supply—far below the 30 to 40 percent threshold that would necessitate additional integration investments.
3. **Over half of Indiana's coal capacity is beyond its economic lifetime, leading to additional capital costs that are passed along to ratepayers to repair, maintain and upkeep these aging plants.** A less expensive option for Indiana's electric customers would be to retire aging coal plants, refinance any remaining capital costs, and build more affordable and more flexible new wind and solar resources.

Introduction

In January 2020, Indiana State Representative Ed Soliday introduced House Bill (HB) 1414, which would delay, and possibly prevent, a public utility from retiring, selling, or transferring any coal-powered electric generating unit in Indiana with a capacity over 80 megawatts (MW). The proposed legislation requires that a public utility may not retire a coal-fired unit in Indiana without: (1) notifying the Indiana Utility Regulatory Commission (IURC) of their intent to retire the unit; (2) the IURC conducting a public hearing to receive information related to the reasonableness of the proposed retirement; and (3) receiving recognition from the IURC that the plant’s retirement or closure is reasonable. HB 1414 would also prevent a public utility from terminating any power purchase agreement (PPA) with a “legacy generation resource” without notifying the IURC at least three years in advance, and—if the IURC approves of the termination—the utility may recover the costs it incurred under the PPA via a fuel adjustment charge on ratepayer bills. This proposed legislation could prevent public utilities from retiring uneconomic power plants without express permission from the IURC and permits public utilities in Indiana to pass more costs through to consumers.

Legacy power generation sources like coal and nuclear are characterized by a lack of flexibility, making them costly and inconvenient to integrate with more modern renewables and recently built gas generators. Nonetheless, several myths persist regarding claimed benefits of coal over renewable wind and solar (see Table 1).

Table 1. Common myths about renewable integration

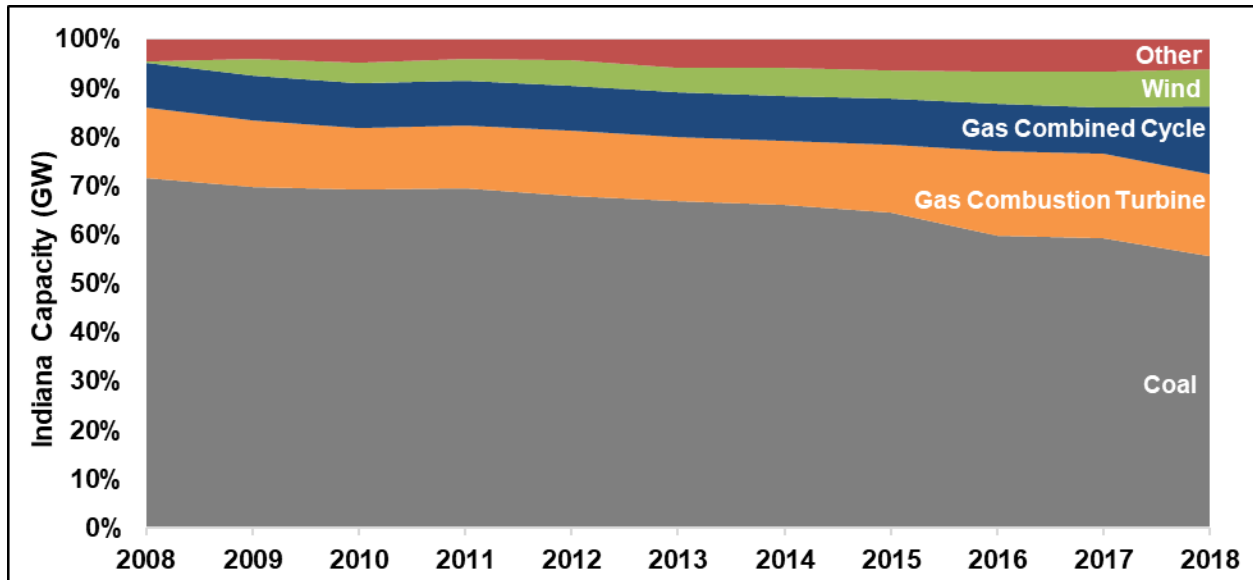
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6) Renewables Need Gas to Integrate	Renewables integrate easily and do not need back up gas generation.

House Bill 1414 represents a lifeline for Indiana’s aging coal-fired power plants that will place undue fuel, repair, maintenance and upkeep costs on Indiana ratepayers. This report explains why it would be detrimental to continue to run Indiana’s aging coal plants and more beneficial to move toward renewable wind and solar resources instead.

Overview of Indiana's Electric Supply

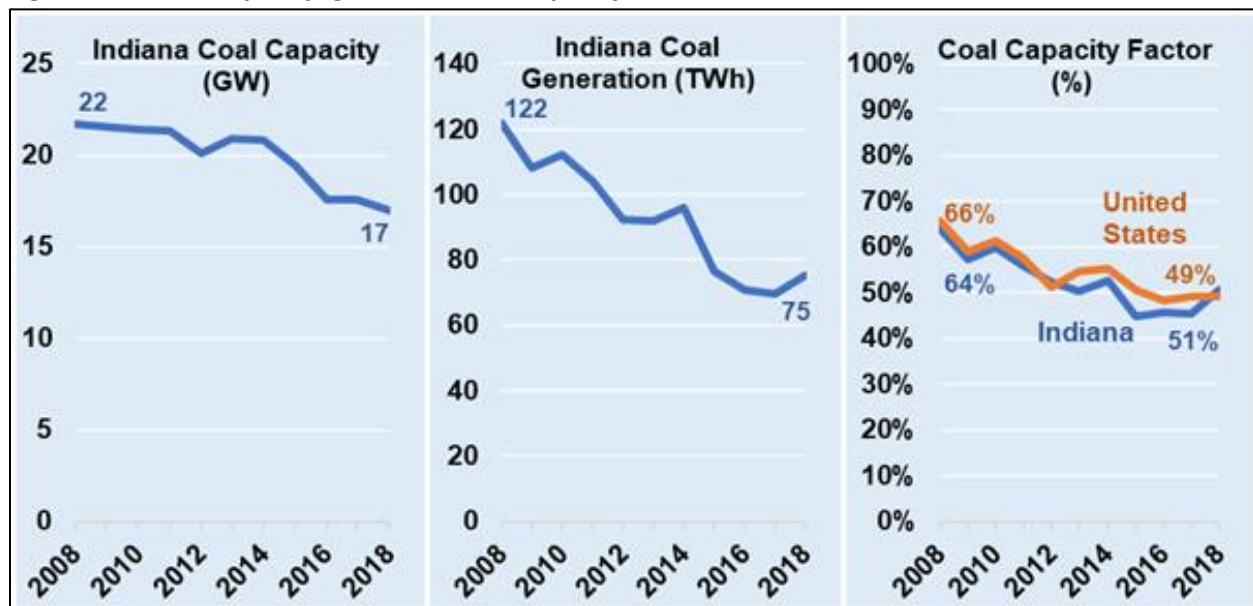
Indiana's coal-fired capacity fell from 72 percent of total state electric capacity in 2008 down to 56 percent in 2018 (see Figure 1). The state's coal-fired generation capacity, generation and capacity factors (share of electric capacity used) have steadily declined over the last ten years (see Figure 2).

Figure 1. Indiana installed electric capacity (gigawatts (GW)), 2008-2018



Source: U.S. EIA. 2008-2018. Form EIA-860 Data - Schedule 3 Generator Data. Available at: <https://www.eia.gov/electricity/data/eia860/>.

Figure 2. Indiana capacity, generation and capacity factors, 2008-2018

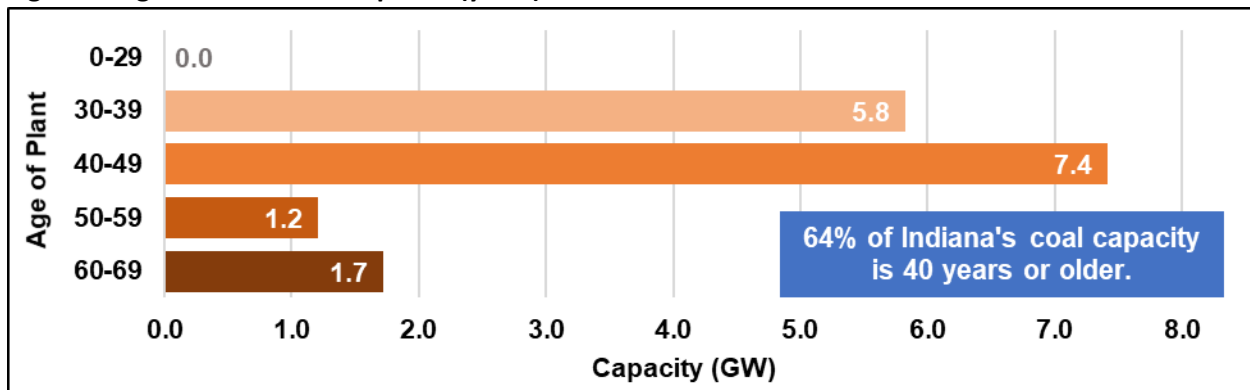


Sources: 1) U.S. EIA. 2008-2018. Form EIA-860 Data - Schedule 3 Generator Data. Available at: <https://www.eia.gov/electricity/data/eia860/>. 2) U.S. EIA. 2008-2018. Form EIA 923 detailed data with previous form data: Electricity. Available at: <https://www.eia.gov/electricity/data/eia923/>.

Indiana is not alone in its shift away from coal-fired generation: 2019 saw the largest annual decline in U.S. coal generation on record.¹ According to the economic consultants at the Rhodium Group, nearly a quarter of the current national coal fleet (37 GW) is set to retire by 2025.² Globally, investment in renewable wind and solar is outpacing investment in fossil fuels.³

Sixty-four percent of Indiana’s 2018 coal capacity is already past its economic lifetime (older than 40 years, see Figure 3). Thirty of Indiana’s 43 coal-fired units are operating beyond their expected useful economic lifetime of 40 years (see Figure 4 below).⁴ Only three of those 30 legacy units have announced planned retirement dates:⁵ University of Notre Dame Units 5, 6 and 7.

Figure 3. Age of Indiana’s coal plants (years)



Source: U.S. EIA. 2018. Form EIA-860 Data - Schedule 3 Generator Data. Available at: <https://www.eia.gov/electricity/data/eia860/>.

Indiana’s electric utilities are finding coal generation increasing uneconomic and are ready and willing to leave it behind and move on to more modern—and less costly—generation resources.

¹ Houser, T. Pitt, H. 2020. “Preliminary US Emissions Estimates for 2019”. *Rhodium Group*. Available at: <https://rhg.com/research/preliminary-us-emissions-2019/>.

² Ibid.

³ Brunetti, B. and Fan, L. March 25, 2019. “Tracking global power capacity: Renewables growth outpaces fossil fuels”. *S&P Global Platts Insight*. Available at: <https://blogs.platts.com/2019/03/25/global-renewables-growth-outpaces-fossil-fuels/>.

⁴ In addition to the sources listed below Figure 4, the following sources were used to determine the retirement dates of Indiana’s coal units: 1) Ziegner, DE., Veleta, DE. 2019. Cause No. 45052. Indiana Utility Regulatory Commission. Available at: https://www.in.gov/iurc/files/45052_ord_20190424102046480.pdf; 2) Williams, M. 2019. "IPL to retire two units at Petersburg Super Polluter coal plant". Sierra Club. Available at: <https://www.sierraclub.org/press-releases/2019/12/ipl-retire-two-units-petersburg-super-polluter-coal-plant>; 3) University of Notre Dame. 2019. "Notre Dame ceases to burn coal, a year ahead of schedule". Available at: <https://www.nd.edu/stories/notre-dame-ceases-to-burn-coal/>; and 4) Tribune Star. 2020. "Hoosier Energy announces planned closing of Merom Generating Station". Available at: https://www.tribstar.com/news/hoosier-energy-announces-planned-closing-of-merom-generating-station/article_c8d2a9ba-3c5a-11ea-9e68-df99cae7e824.html.

⁵ Five units operating within their useful lifetime have also announced retirement dates. See Figure 4.



NIPSCO:

President Violet Sistovaris: “It's a decades-long transition to a more balanced portfolio. We're going from coal-fired generation to lower-cost cleaner energy sources that will result in \$4 billion in cost savings. It's a more balanced, more diverse and more affordable way to reliably provide electricity. It's not politically driven or environmentally driven. It's lower cost... Retiring all of our coal plants as quickly as possible was the least-cost option. Running the coal plants to the end of life was the most expensive. They have aged and gotten more expensive to maintain and operate as anyone who runs an industrial facility can appreciate.”⁶

Joe Hamrock, President and CEO of NiSource Inc. (NIPSCO's parent company): “[W]e'll continue to see renewables and other technology become more cost competitive...[T]he market is changing in a fundamental and permanent way.”⁷

IPL:

President/CEO Vince Parisi: “Said in written comments that the utility used economics, flexibility, grid reliability and other factors to support ‘our decision to invest in a more balanced energy mix, which minimizes risk to our customers and takes into account a rapidly-changing energy landscape.’”⁸

Vectren:

President/CEO Carl Chapman: “The unfolding of Vectren's Smart Energy Future plan illustrates how our company is transforming the way it produces and delivers power to become a next generation energy company...This decade-long generation portfolio transition will meet growing demand to provide cleaner energy for our region while maintaining the reliability our customers deserve and have come to expect.”⁹

Duke:

CEO Lynn Good: “We will need a diverse set of resources including nuclear, natural gas renewables, battery storage, energy efficiency, and the electrification of transportation...We will also need coal for some time even as we increasingly rely on other fuel sources.”¹⁰

⁶ Pete, J.S. November 21, 2019. NIPSCO estimates shift from coal will save \$4 billion. *NWI Times*. https://www.nwitimes.com/business/local/nipsco-estimates-shift-from-coal-will-save-billion/article_7713f085-6a0b-50b0-914b-4aba16481f60.html.

⁷ Blunt, K. 2019. “Utilities Speed Up Closure of Coal-Fired Power Plants”. *The Wall Street Journal*. Available at: <https://www.wsj.com/articles/utilities-speed-up-closure-of-coal-fired-power-plants-11547035201>.

⁸ The Associated Press. December 30, 2019. IPL to retire 2 of 4 Petersburg coal-fired units. *The Dubois County Herald*. Available at: <https://duboiscountyherald.com/b/indiana-utility-to-retire-2-of-4-remaining-coal-fired-units>.

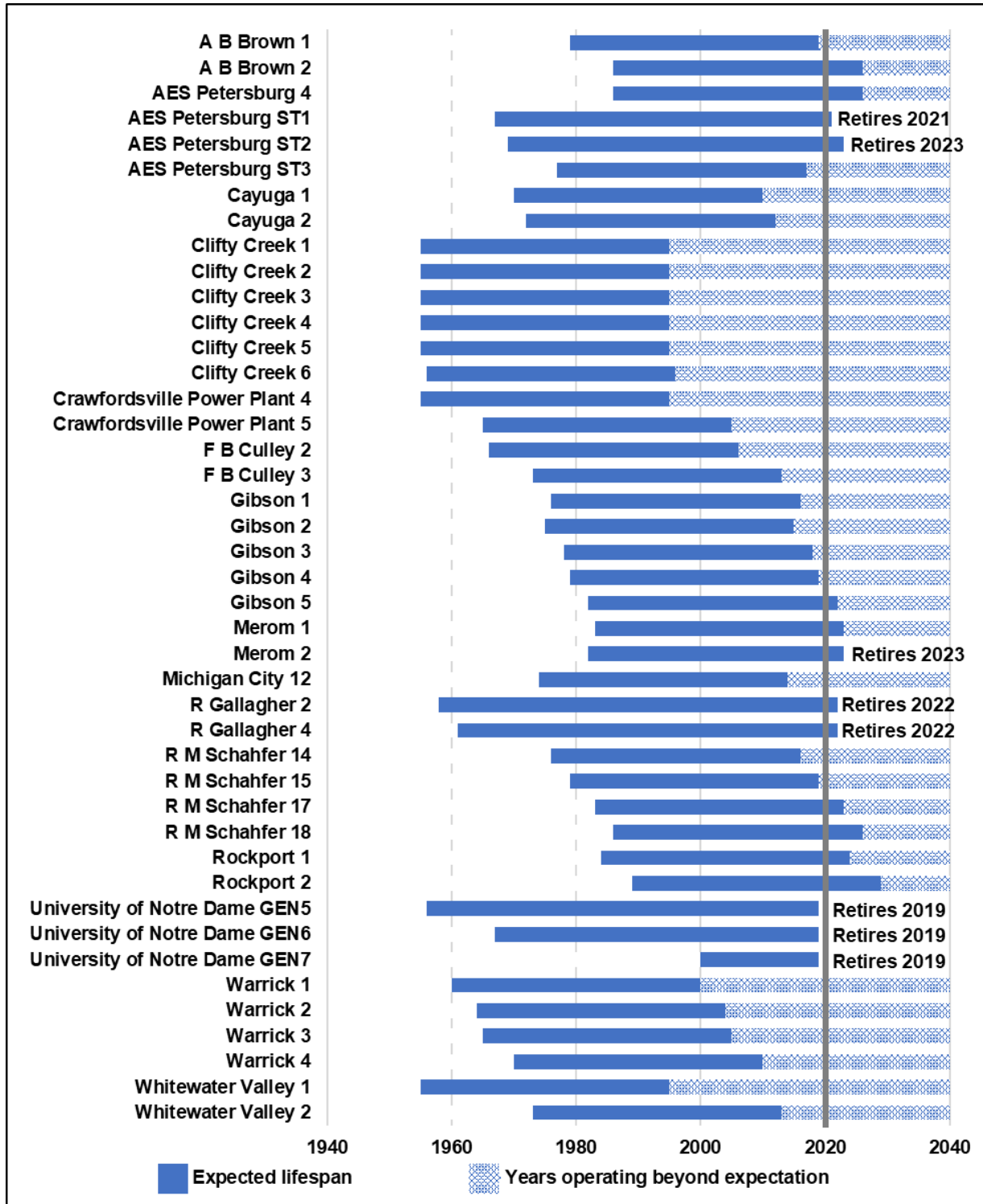
⁹ Power Engineering. February 28, 2018. Vectren to Build Gas, Shutter Coal. Available at: <https://www.power-eng.com/2018/02/28/vectren-to-build-gas-shutter-coal/>.

¹⁰ WUSF Staff. September 19, 2019. Duke Energy To Focus On Renewable Energy, Close Coal-Powered Plants. *WJCT Public Media*. Available at: <https://news.wjct.org/post/duke-energy-focus-renewable-energy-close-coal-powered-plants>.



Depending on rapidly aging coal-fired power plants to supply nearly three-quarters of Indiana's total electric generation makes the state's power sector needlessly expensive and rigid in the face of fundamental and permanent changes in the electric market. Allowing coal plants to retire at the end of their useful lifetimes and/or in response to market forces will facilitate a shift towards more affordable and more flexible generating resources.

Figure 4. Age and planned retirement dates of Indiana’s coal plants



Sources: 1) U.S. EIA. 2008-2018. Form EIA-860 Data - Schedule 3 Generator Data. Available at: <https://www.eia.gov/electricity/data/eia860/>. 2) Lazard. 2019. Lazard's levelized cost of energy analysis. Version 13.0. p.18. Available at: <https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-13-0-vf.pdf>.



Myth #1: Supply Must Equal Demand

Reality: With new energy storage technologies, supply need no longer meet demand instantaneously.

To avoid power outages, electric system operators must supply enough electricity to meet customer demand in every minute of every day—however, that does not mean that energy generation needs to meet demand instantaneously. It is common practice for utilities to employ storage technologies and demand response measures to meet demand in a more flexible and more affordable way. Storage technologies—like large capacitors, pumped hydro, batteries and flywheels—allow grid operators to store energy when it is cheap to generate and/or demand is low, and then dispatch stored energy to match supply to demand in real time, without requiring additional generators to ramp up.¹¹ Demand response programs provide incentives to electric customers to use less energy at times of peak in order to reduce peak demand.¹²

Using storage technologies and demand response to reduce or shift peak demand as needed is less expensive than building new power plants (or keeping existing, costly plants operational) to provide energy for just a few hours each year at times of highest customer demand. In Indiana, for example, peak demand occurs in the late afternoon during summer hottest days, when households are using a lot of energy to stay cool and comfortable (see Figure 5 and Figure 6).

Plants that are built to serve peak—known as peakers—are notoriously expensive. Research by Advanced Energy Economy found that 10 percent of the U.S. electric system is used to meet demand in just 1 percent of the total hours in a year.¹³ A report by Strategen Consulting found that New York City ratepayers spend over \$268 million per year to keep plants running that are only turned on a few hours of the year.¹⁴ Reducing the need for costly peakers can have a significant impact on ratepayer bills. Ultimately, flexible, economic electric systems combine base load resources with intermittent resources plus storage.

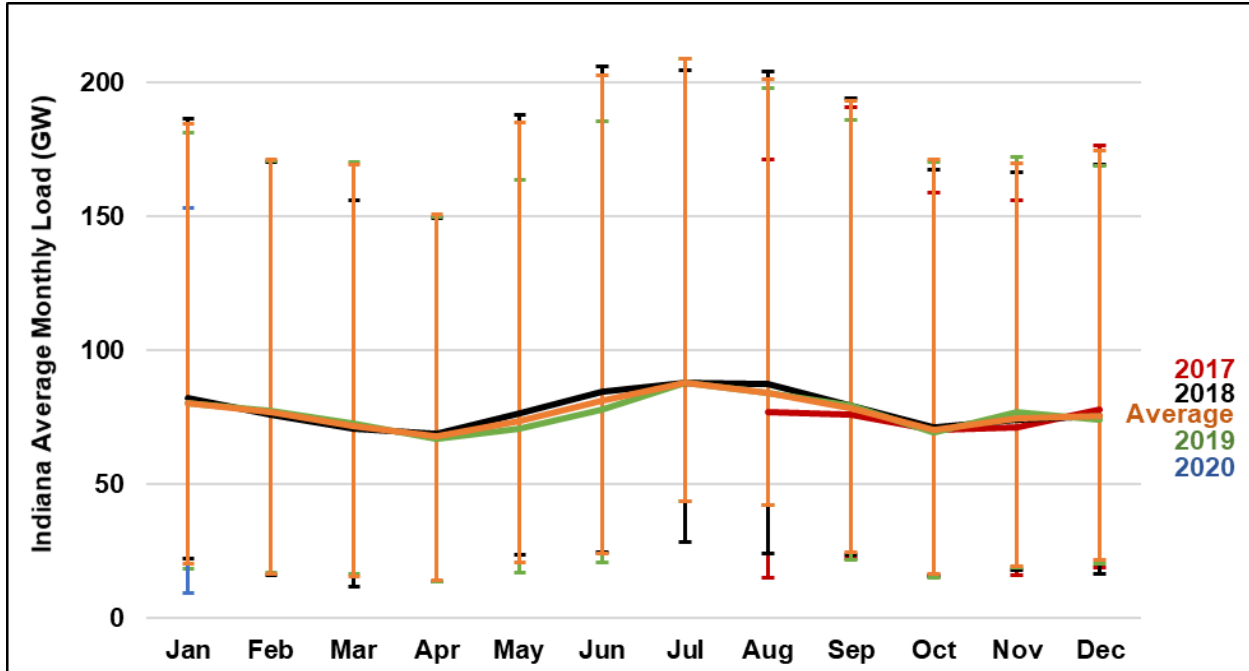
¹¹ U.S. EIA. 2012. “Electricity storage can smooth out moment-to-moment variations in electricity demand”. Available at: <https://www.eia.gov/todayinenergy/detail.php?id=6370>.

¹² Association of Edison Illuminating Companies (AEIC). 2009. *Demand Response Measurement & Verification*. p.5. Available at: https://www.smartgrid.gov/files/demand_response.pdf.

¹³ Feldman, B. Tanner, M. Rose, C. 2015. *Peak demand reduction strategy*. Advanced Energy Economy. Prepared by Navigant Consulting. Available at: <https://info.aee.net/peak-demand-reduction-report>.

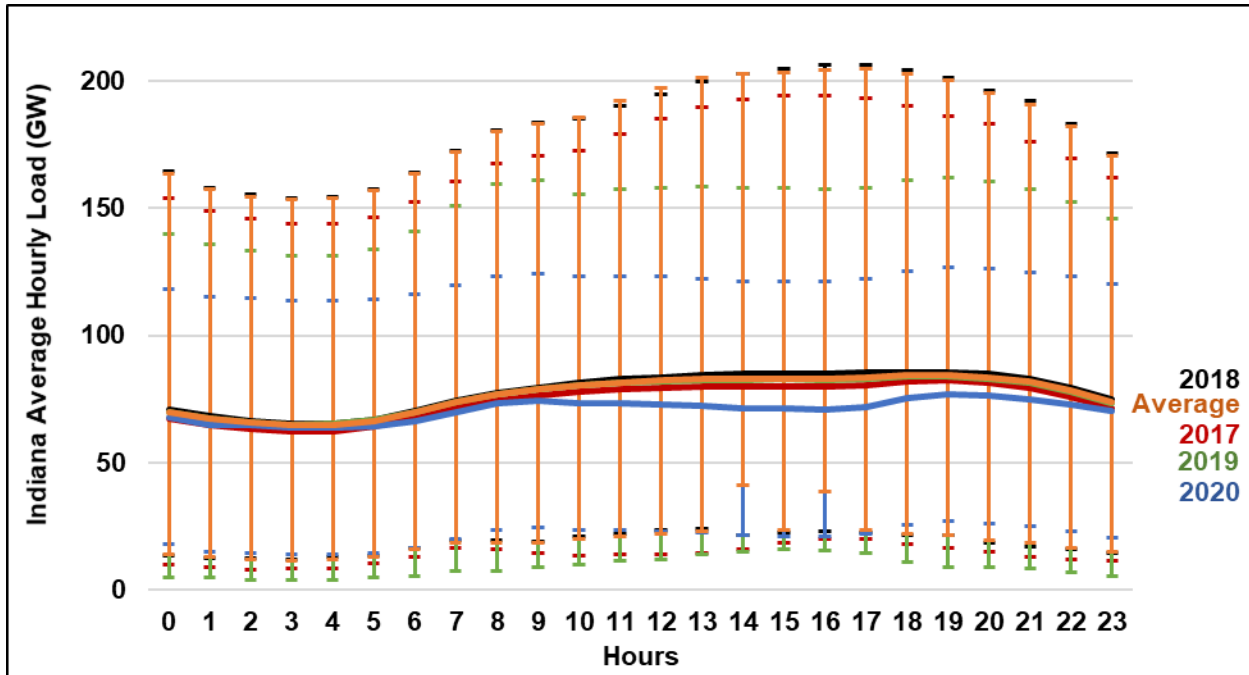
¹⁴ Strategen Consulting. September 20, 2017. “New York City’s Aging Power Plants: Risks, Replacement Options and the Role of Energy Storage.” Available at: <https://static1.squarespace.com/static/571a88e12fe1312111f1f6e6/t/59c3d46ae9bdfdf16412f8b7e/1506006147665/Strategen+-+NYC+Power+Plants+and+Energy+Storage+9.20.2017.pdf>.

Figure 5. Indiana monthly peak load (GW) averaged across all days in the month, 2017-2020



Source: LCG Consulting. 2020. "Energy Online: MISO (Midwest Independent Transmission System Operator) Forecasted, Cleared & Actual Load". Available at: <http://www.energyonline.com/Data/GenericData.aspx?DataId=17>.

Figure 6. Indiana hourly peak load (GW) averaged across all days in the year, 2017-2020



Source: LCG Consulting. 2020. "Energy Online: MISO (Midwest Independent Transmission System Operator) Forecasted, Cleared & Actual Load". Available at: <http://www.energyonline.com/Data/GenericData.aspx?DataId=17>.

Myth #2: Coal Competes with Wind

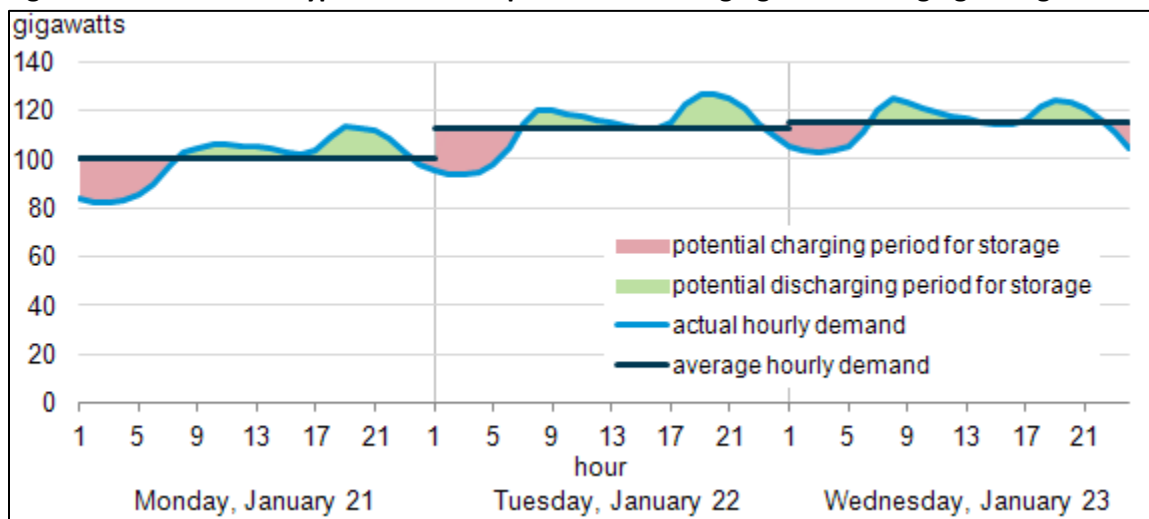
Reality: All resources compete work together to provide a cost-effective generation portfolio.

When energy planners and grid operators decide which resources to pursue or dispatch, they consider the entire portfolio of supply-side (generation) and demand-side (energy efficiency, demand response, storage, and distributed generation such as rooftop solar) resources. Coal does not compete on a one-to-one basis with alternative energy sources; all resources are options for planners working to design a cost-effective capacity and generation portfolio. This mix of resources is increasingly diverse—a feature of a new energy landscape where demand-side resources compete with and complement supply-side resources, renewables often out-compete legacy coal plants, and behind-the-meter (distributed) generation reduces the need for larger utility-scale power plants.

Even when resource planners choose to build a new wind farm rather than a new gas plant, for example, that does not mean that wind has “replaced” gas because in every hour of every day, a mix of resources are being called upon to meet demand. Sometimes that will include gas, sometimes wind, and sometimes both—the entire portfolio of resources works together as one to serve customer needs.

New coal is not cost competitive to build (see Myth #3 below). As aging coal plants retire, a portfolio of resources will fill the gap left behind; these resources will include renewable wind and solar, flexible resources like gas combined cycle plants or hydro, and energy storage technologies, like batteries. While the whole portfolio of resources works as one to meet demand, Indiana’s energy portfolio does not operate as an island—it is extensively connected to the larger MISO grid, where system operators work to balance supply and demand across the entire region. Indiana’s peak does not necessarily coincide with peak elsewhere in the MISO region, meaning that surplus renewable generation can either be stored for later use (see Figure 7 below for an illustration based on PJM) or exported to meet demand elsewhere. When Indiana is short on energy, it can be imported from elsewhere.

Figure 7. Illustration of hypothetical PJM potential for charging and discharging storage



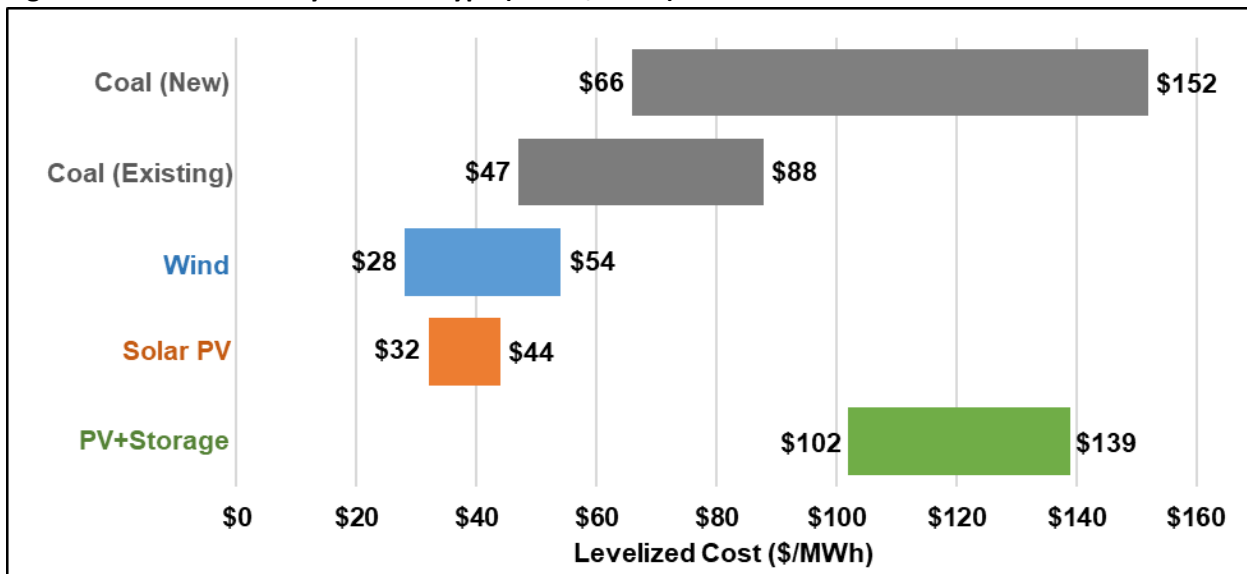
Source: Reproduced from U.S. EIA. September 26, 2013. Variability in electricity demand highlights potential roles for electricity storage. Available at: <https://www.eia.gov/todayinenergy/detail.php?id=13131>.

Myth #3: Existing Power Plants are Free

Reality: Aging coal plants are costly to run, and ratepayers foot the bill.

Existing power plants are costly: an assumption that plant expenses are limited to fuel, staff and minor repairs is simply incorrect. AEC performed a detailed calculation of the total cost per megawatt-hour (MWh) of electricity supplied (called a “levelized cost”) of existing coal plants, including ongoing capital, operations and maintenance costs (see Appendix for details about our methodology and data sources). Figure 8 displays these results in comparison to the levelized cost of new generation resources. We found existing coal plants have a levelized cost ranging from \$47 to \$88 per MWh in 2019 dollars. For comparison, new wind costs between \$28 and \$54 per MWh.

Figure 8. Levelized cost by resource type (2019\$/MWh)



Sources: 1) Lazard. 2019. *Lazard's levelized cost of energy analysis. Version 13.0. p. 2.* Available at: <https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf>. 2) Lazard. 2019. *Lazard's levelized cost of storage analysis. Version 5.0. p. 4.* Available at: <https://www.lazard.com/media/451087/lazards-levelized-cost-of-storage-version-50-vf.pdf>.

Even after their original capital costs are fully depreciated (our assumption here), legacy coal plants still face capital costs for major upgrades and maintenance, increased operational costs due to their use as peakers rather than constant base load (called “cycling”), and the capital and operating costs associated with environmental mandates related to sulfur dioxide, nitrogen oxides, mercury and particulate air pollution.



Myth #4: A Megawatt is a Megawatt

Reality: The number of megawatts does not determine customer costs.

Renewable wind and solar energy require more capacity in megawatts (MW) than a coal-fired power plant to generate the same level of output in MWh. This is largely due to coal’s higher expected capacity factor as compared to renewable wind and solar. This difference in the number of MW needed to supply customer demand is included in every electric sector calculation as a matter of course, and it does not, by itself, result in higher customer costs. Renewable resources, for example, have no fuel costs, which brings their overall costs down substantially.

Table 2 and Figure 9 provide an illustration of how different amounts of MWs provide the same number of MWh at different costs, based on levelized costs of new coal, wind and solar¹⁵ and a levelized cost of existing coal developed by AEC (see Appendix for details). In our example in Table 2, generating 44,700 MWh using existing coal is the most expensive choice, costing \$2.1 to \$3.9 million. In comparison, the same amount of generation costs \$1.3 to \$2.4 million using wind and \$1.4 to \$2.0 million using solar.

Table 2. Total cost calculations by resource type (2019\$/MWh)

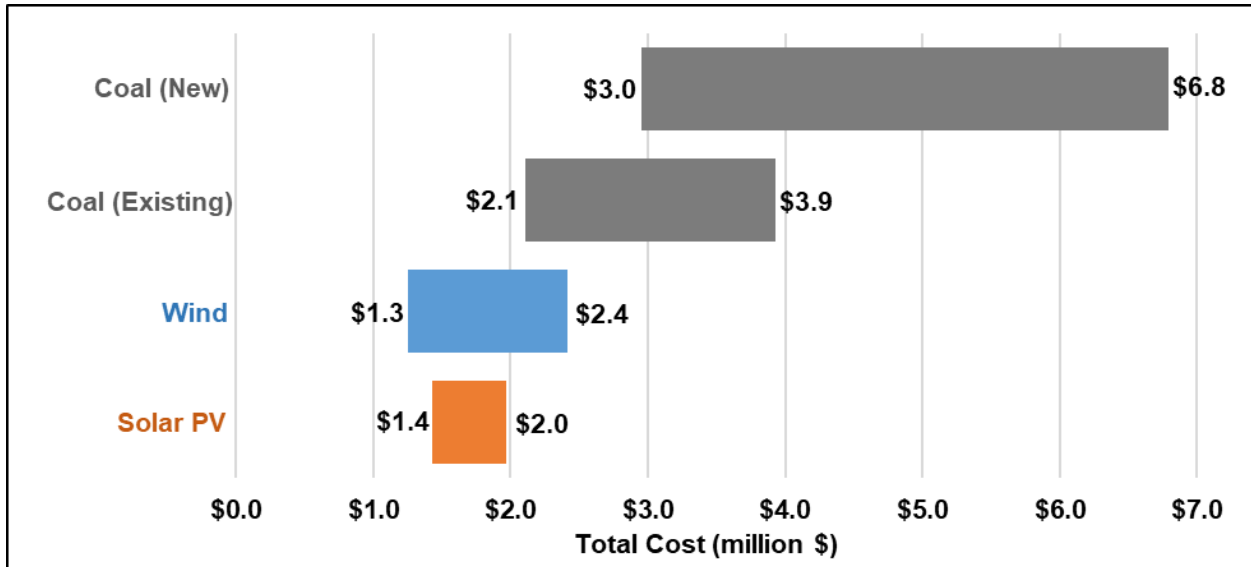
	<i>A</i> Capacity (MW)	<i>B</i> Capacity Factor (%)	<i>C</i> Generation (MWh) <i>A * B * 8760 = C</i>	<i>D</i> LCOE (\$/MWh)	<i>E</i> Total Cost (million \$) <i>C * D = E</i>
Coal (New)	10.0	51%	44,700	\$66 - \$152	\$3.0 - \$6.8
Coal (Existing)	10.0	51%	44,700	\$47 - \$88	\$2.1 - \$3.9
Wind	11.0	47%	44,700	\$28 - \$54	\$1.3 - \$2.4
Solar PV	18.6	28%	44,700	\$32 - \$44	\$1.4 - \$2.0

Source: AEC calculation, see Appendix.

¹⁵ Lazard. November 2019. Lazard’s Levelized Cost of Energy Analysis—Version 13.0. Available at: <https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf>.



Figure 9. Total cost by resource type (2019\$/MWh)



Source: AEC calculation, see Appendix.

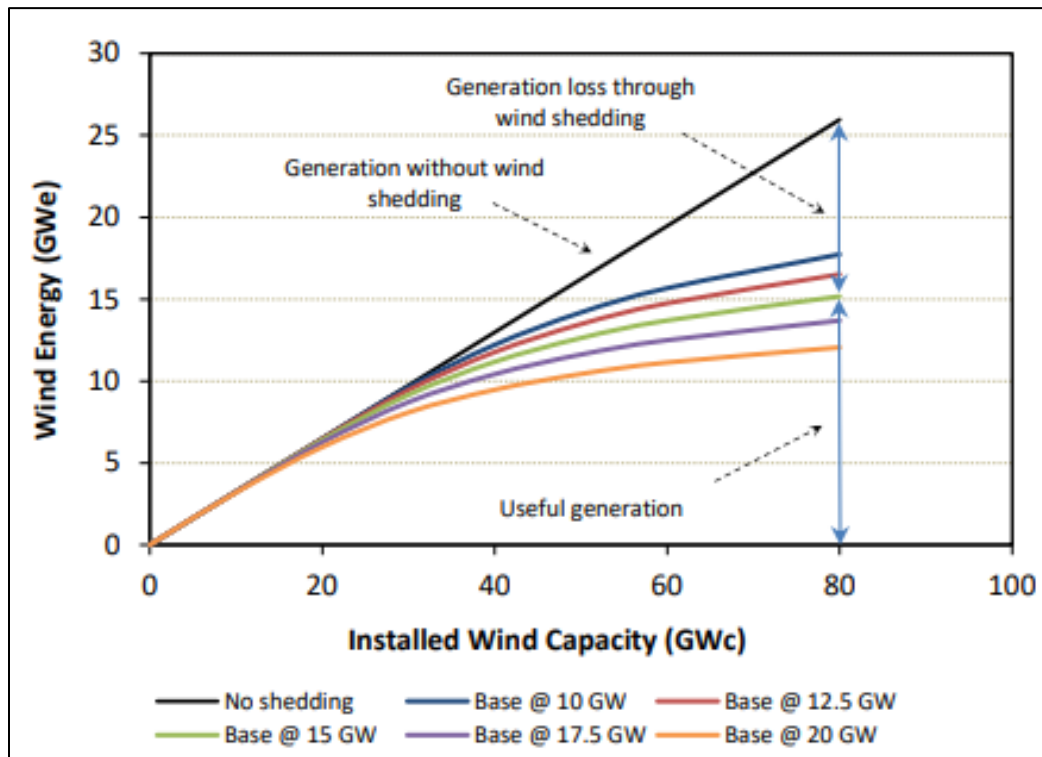


Myth #5: Surplus Wind is Costly

Reality: It is common practice to scale back wind as needed, just as it is with any other generation source.

Sometimes, intermittent resources like wind or solar produce more energy than is needed to meet instantaneous demand. In these instances, grid operators either export the energy (if possible) or reduce the amount of energy being produced from those sources—a practice often called “shedding” or “curtailment” (see Figure 10 below). Curtailment is a commonly used tool in dispatching power systems, and not an operational crisis or financial risk. Fossil fueled power plants are dispatched in a similar way. For example, gas peaker plants are built to serve peak and run less than 10 percent of the time: When they are not needed, grid operators don’t run them. In the same way, when economics and/or system operations call for less wind or solar generation, this excess generation is shed (or not captured) and the only impact is a lower capacity factor (utilization rate) from the resource being dialed back.

Figure 10. Effect of level of base generation on wind generation for different sizes of wind fleets



Source: Reproduced from: Stephens, A.D. and Walwyn, D. November 2016. *Wind Energy in the United Kingdom: Modelling the Effect of Increases in Installed Capacity on Generation Efficiency*. Available at: <https://www.researchgate.net/publication/310235950> *Wind Energy in the United Kingdom Modelling the Effect of Increases in Installed Capacity on Generation Efficiency*.

The market structure of our energy systems already accounts for the intermittent supply of wind and solar generation. The energy market pays for every MWh of energy produced, where every MWh is equal, no matter what resource generated it. The capacity market pays for the guarantee that a plant can run at times of peak need, and intermittent resources receive smaller payments based on their



more limited ability to provide energy at key times. Finally, the ancillary service market pays for other services that the grid may require, like voltage control (which most intermittent resources largely cannot provide).¹⁶ Using this market structure, very high levels of renewable integration are consistent with reliable grid operation. In ERCOT, where the wind share of supply has reached as high as 58 percent,¹⁷ the ancillary services market has been expanded in order to accommodate a high wind share while maintaining the reliability of the grid.¹⁸

As wind grows to take on a greater share of MISO's total supply, the need to periodically shed wind will decrease effective capacity factors and increase the cost of energy per MWh: the increase in cost depends on wind's share of total supply, energy demand in interconnected regions, and the extent of investment in storage. At present, 5 percent of Indiana's electric generation is wind.¹⁹ In the future, if wind were to account for a much greater share of total generation (see Myth #6), cost impacts can and will be calculated. In the meantime, occasional wind shedding is just a normal cost of doing business in the power sector.

¹⁶ AEP Energy. September 21, 2017. "Ancillary Services – Understanding the Basics." *AEP Energy* Available at: <https://www.aepenergy.com/2017/09/21/september-2017-edition/>.

¹⁷ ERCOT. 2020. "Wind Integration Reports". Available at: <http://www.ercot.com/gridinfo/generation/windintegration>.

¹⁸ Garza, B. June 4, 2018. "Wind Integration in ERCOT". Potomac Economics. Available at: https://www.eia.gov/conference/2018/pdf/presentations/beth_garza.pdf.

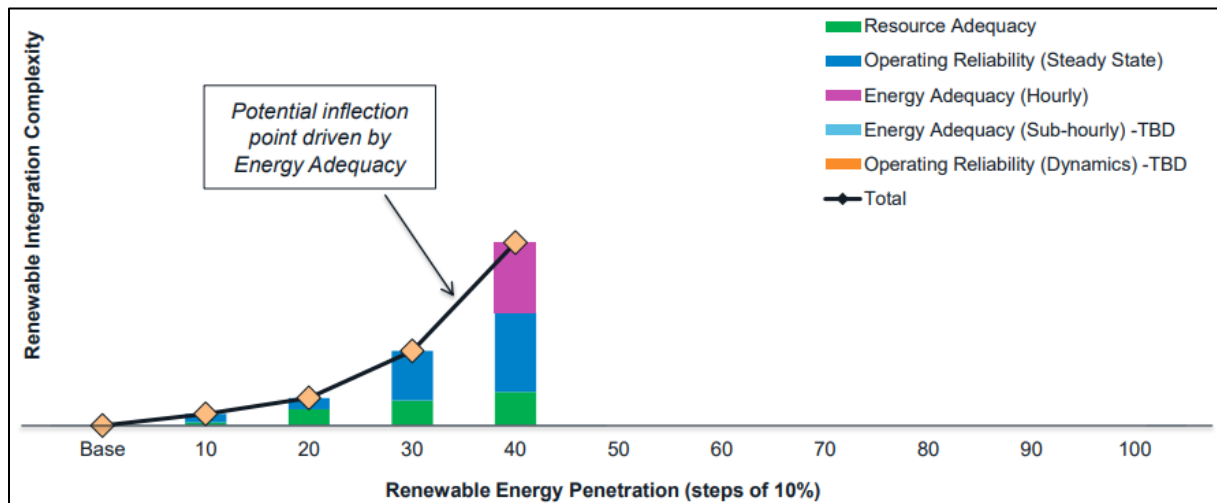
¹⁹ U.S. EIA. 2018. Form EIA 923 detailed data with previous form data: Electricity. Available at: <https://www.eia.gov/electricity/data/eia923/>.

Myth #6: Renewables Need Gas to Integrate

Reality: Renewables integrate easily and do not need back up gas generation.

According to MISO’s 2018 Renewable Integration Impact Assessment,²⁰ changing economics, regulatory environments and technological innovation are driving a “shift away from long standing power system design and operational practices.”²¹ Based on a review of industry studies, MISO found that adding renewables has no impact on the ability of the grid to function reliably until certain renewable penetration levels are reached—what MISO refers to as “inflection points.” The first such inflection point occurs when renewable resources account for between 30 and 40 percent of total generation (see **Error! Reference source not found.**),²² at which point some combination of transmission infrastructure expansion and battery storage are needed to accommodate the addition of more renewables.²³ At no level of renewable integration explored by MISO was gas generation needed as a back up to wind.

Figure 11. MISO’s renewable integration inflection points



Source: Reproduced from: MISO. November 14, 2018. *Renewable Integration Impact Assessment*. Available at: <https://cdn.misoenergy.org/20181114%20PAC%20Item%2005a%20RIIA%20Update292120.pdf>.

In 2018, wind and solar accounted for just 9 percent of total generating capacity (2.5 GW) in Indiana. Even if Indiana were operating alone—instead of as a small part of the MISO transmission area—the state’s energy supply could accept another 6 GW of renewable capacity before needing any additional batteries or transmission upgrades to support integration. The National Renewable Energy Laboratory

²⁰ MISO. 2017-2018. “Renewable Integration Impact Assessment.” Available at:

<https://www.misoenergy.org/planning/policy-studies/Renewable-integration-impact-assessment/#nt=%2Fria%3Abackground%20and%20results&t=10&p=0&s=FileName&sd=desc>.

²¹ MISO. September 2017. “Renewable Integration Impact Assessment Concept Paper.” Available at:

<https://cdn.misoenergy.org/20170927%20PAC%20Item%2003i%20Renewable%20Integration%20Impact%20Assessment%20Assumption%20Concept%20Paper89948.pdf>.

²² MISO. November 14, 2018. “Renewable Integration Impact Assessment.” Available at:

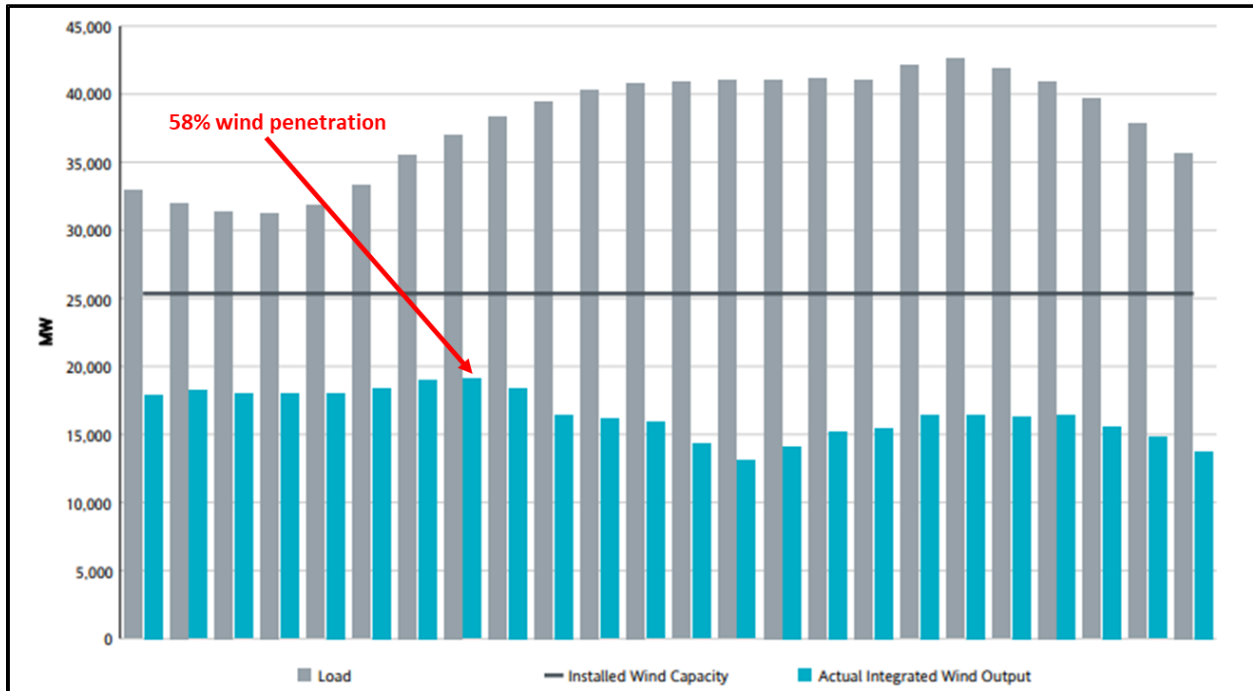
<https://cdn.misoenergy.org/20181114%20PAC%20Item%2005a%20RIIA%20Update292120.pdf>.

²³ EnerNex Corporation. February 2011. “Eastern Wind Integration and Transmission Study.” Prepared for The National Renewable Energy Laboratory. Available at: <https://www.nrel.gov/docs/fy11osti/47078.pdf>.

(NREL) has found that expanding transmission infrastructure “helps reduce the impacts of the variability of the wind, which reduces wind integration costs, increases reliability of the electrical grid, and helps make more efficient use of the available generation resources.”²⁴ Battery storage, meanwhile, can offset some of the transmission expansion need²⁵ and NREL has found that it “act[s] symbiotically” with transmission expansion—meaning that their value is greatest when both technologies are utilized.²⁶

High levels of renewable penetration are not theoretical—Texas’ ERCOT, for example, reached an all-time high wind penetration of 58 percent (19 GW) on November 26, 2019 (Figure 12).²⁷

Figure 12. ERCOT hourly average actual load vs. actual wind output, November 26, 2019



Source: Reproduced from: ERCOT. 2019. November 26, 2019 Wind Integration Report. Available at: <http://www.ercot.com/gridinfo/generation/windintegration>; with red overlay added by AEC.

Much of this integration has been facilitated by a \$7 billion expansion of ERCOT’s transmission system completed in 2013.²⁸ This project strategically added transmission capacity in areas where it was limited but had high wind capacity factors. In addition, ERCOT has made its suite of ancillary services products

²⁴ EnerNex Corporation. February 2011. “Eastern Wind Integration and Transmission Study.” Prepared for The National Renewable Energy Laboratory. Available at: <https://www.nrel.gov/docs/fy11osti/47078.pdf>.

²⁵ Ibid.

²⁶ Jorgenson, J., Denholm, P. and Mai, T. 2018. “Analyzing storage for wind integration in a transmission-constrained power system”. *Applied Energy*, 228, 122-129.

²⁷ ERCOT. 2020. “Wind Integration Reports”. Available at: <http://www.ercot.com/gridinfo/generation/windintegration>.

²⁸ Woodfin, D. April 19, 2016. “Lessons Learned From Wind Integration in ERCOT”. *POWER Engineering*, Issue 4, Volume 120. Available at: <https://www.power-eng.com/2016/04/19/lessons-learned-from-wind-integration-in-ercot/#gref>.



more flexible in order to account for real-time output variations and to facilitate renewable resources to provide these services.²⁹

²⁹ Garza, B. June 4, 2018. "Wind Integration in ERCOT". *Potomac Economics*. Available at: https://www.eia.gov/conference/2018/pdf/presentations/beth_garza.pdf.



A New Energy Landscape: Conclusions

Indiana's electric grid is supplied by a diverse portfolio of resources. No single resource or fuel type can reliably supply Indiana's energy needs; the most reliable strategy is to invest in a mix of different resources, each with complementary characteristics. Putting all your eggs in one basket is not a way to ensure the reliable supply of electricity, especially in the midst of a nation-wide shift away from coal-fired generation: 2019 saw the largest annual decline in U.S. coal generation on record, the retirement of over 10 GW of coal-fired capacity, and in April and May, renewable energy provided more power than coal for the first time in U.S. history.³⁰ According to Matt Preston, research director of North American coal markets at Wood Mackenzie: "we've turned the corner in terms of what utility planning has in store for coal...utilities have decided that coal is not in their future and we're going to see more announcements on retirement" in 2020."³¹

Detailed research by unbiased analysts at U.S. national laboratories and independent electric system operators has shown that an electric system powered with 30 to 40 percent renewable energy resources needs no special efforts to operate. Today, just 9 percent of Indiana's electric generating capacity is wind and solar. More importantly, the larger MISO grid in which Indiana operates is supplied by 12 percent wind and solar. When MISO's electric supply surpasses 40 percent renewable measures such as battery storage and transmission improvements will become necessary. In Texas, wind resources alone have supplies 58 percent of electric demand in some hours, supported by investments in transmission system upgrades alone. The addition of battery storage would enable even greater amounts of renewable energy to be added to the grid while maintaining reliability.

To be clear: Indiana is years, perhaps decades, away from needing to do anything at all to integrate additional renewable energy. Replacing all of Indiana's coal with wind and solar today would bring renewables up to 64 percent of Indiana's supply but only 21 percent of MISO's supply—far below the threshold that would necessitate additional integration investments.

Finally, operating existing coal is more expensive than installing and operating new wind and solar. Our analysis to determine the per MWh cost of Indiana's existing coal capacity focused on plants that are fully depreciated. Existing coal plants that are not fully depreciated have the same levelized (per MWh) costs as the new coal plants shown above in Figure 8: this levelized cost of \$66 to \$152 per MWh includes financed capital expenses. If plants are retired that are not yet fully depreciated, all remaining capital costs can and should be refinanced on more favorable terms for ratepayers. Given the much higher per MWh costs of existing coal in comparison to wind and solar (\$28 to \$54 per MWh) the less expensive option for most Indiana legacy units is likely to be retirement, refinancing of any remaining capital costs, and building new wind and solar.

³⁰ Morehouse, C. January 14, 2020. "2020 Outlook: Coal faces headwinds from aging plants, adverse market signals and high remediation costs." *UtilityDive*. Available at: <https://www.utilitydive.com/news/2020-outlook-coal-faces-headwinds-from-aging-plants-adverse-market-signal/569732/>.

³¹ Ibid.

Appendix: Methodology for LCOE of Existing Coal

To estimate the total cost per MWh of existing U.S. coal plants, AEC performed a detailed levelized cost of energy (LCOE) calculation that includes ongoing capital, operations, and maintenance as well as estimated:

- capital costs for major upgrades and maintenance associated with the aging of plants (past their expected economic lifetime and, therefore, fully depreciated);
- increased operational costs due to these plants' use as peakers rather than constant base load (called "cycling"); and
- capital and operating costs associated with environmental mandates related to sulfur dioxide, nitrogen oxides, mercury, and particulate air pollution.

The LCOE for existing coal plants is \$47 to \$88 per MWh calculated as the net present value of total costs across an assumed 20-year depreciation period divided by the net present value of total generation (in MWh) over the same period.³²

The total cost of an existing coal unit is based on the following assumption values:

- Lazard 13.0's marginal operating costs (\$/MWh)³³ of existing coal plants (i.e., fuel, variable, and fixed);³⁴
- U.S. Energy Information Administration's (EIA) ongoing capital costs (\$/MW)³⁵ for aging coal plants as calculated by Sargent and Lundy;
- National Energy Technology Laboratory's marginal operating costs (\$/MWh)³⁶ due to cycling;
- Regulatory Assistance Project's (RAP) capital costs (\$/MW)³⁷ for pollution control retrofits;
- RAP's fixed operating costs (\$/MW) for pollution control retrofits;
- RAP's variable operating costs (\$/MWh) for pollution control retrofits.

The ongoing capital costs for aging coal plants were calculated using the following formula:

$$\text{Ongoing Capital Costs} = \$17,241 + (\$131 \times \text{age}), \text{ in 2019 } \$/\text{MW}$$

In the formula above, AEC increased the age of the assumed coal plant over the 20-year depreciation period. The original formula given by EIA included a third cost adder for a flue gas desulfurization (FGD) unit, which AEC replaced with the more detailed RAP cost estimates. All ongoing capital and operating costs were escalated over the assumed 20-year depreciation period at a 2 percent rate. The capital cost

³² All dollar values presented in 2019 dollars, converted (when necessary) using the CPI-U.

³³ Lazard. 2019. "Levelized Cost of Energy Analysis Version 13.0". Available at:

<https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf> p.6

³⁴ AEC calculated the total cost and generation using a representative 500-MW coal plant throughout.

³⁵ U.S. Energy Information Administration. February 2019. "Assumptions to the Annual Energy Outlook 2019: Electricity Market Module." Available at: <https://www.eia.gov/outlooks/aeo/assumptions/pdf/electricity.pdf> p.14

³⁶ Grol, E., & Tarka, T.J. June 2015. "Impact of Load Following on Economics of Existing Coal-Fired Power Plant Operations." National Energy Technology Laboratory (NETL). Available at: https://www.eenews.net/assets/2017/11/21/document_gw_08.pdf pp.4-5

³⁷ Lazar, J., & Farnsworth, D. October 2011. "Incorporating Environmental Costs in Electric Rates: Working to Ensure Affordable Compliance with Public Health and Environmental Regulations." Regulatory Assistance Project (RAP). Available at: <https://www.raponline.org/wp-content/uploads/2016/05/rap-lazarfarnsworth-incorporatingenvironmentalcostsinelectricrates-2011-10.pdf> p.11



for pollution control retrofits is the depreciated balance plus the rate of return on the undepreciated balance (using an assumed pre-tax rate of return of 9.5 percent) over the assumed 20-year depreciation period.

This calculation included various pollution control retrofits for environmental mandates related to sulfur dioxide, nitrogen oxides, mercury, and particulate air pollution (see Table 3).

Table 3. Pollution control retrofits

Pollutant	Compliance Technologies
Sulfur Dioxide (SO ₂)	Selective Catalytic Reduction (SCR)/Selective Non-Catalytic Reduction (SNCR)
Nitrogen Oxides (NO _x)	Flue Gas Desulfurization (FGD)/Dry Sorbent Injection (DSI)
Mercury	Activated Carbon Injection (ACI)
Particulates	Fabric Filters

AEC made various assumptions to construct the low- and high-end estimates for the existing coal LCOE (see Table 4). The low-end estimate assumes an existing coal plant of 40 years with DSI, SNCR, and ACI pollution control retrofits. The high-end estimate assumes an existing coal plant of 64 years (the current age of Indiana’s oldest coal plant) with FGD, SCR, ACI, and fabric filter pollution control retrofits. Cycling costs were also included in the high-end estimate.

Table 4. AEC assumptions

	Low End	High End
Starting Age of Coal Plant	40 years	64 years
Pollution Control Retrofits	DSI, SNCR, ACI	FGD, SCR, ACI, Fabric Filters
Cycling Costs	Excluded	Included