Interested Party Testimony
Ohio House Bill 6

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The Ohio electrical grid is undergoing a very rapid transformation as it powers, cools and heats homes; supports operations at industrial plants and office buildings; and allows schools, hospitals and military bases to function. Baseload coal and nuclear power plants, the foundation of the Ohio's electricity mix, are and being replaced by wind, solar and natural gas generation at an alarming rate. The grid is shifting from a mix of always-on, fuel-secure sources of power, to greater reliance on intermittent sources of generation and a growing network of pipelines.

- What are the policies or lack of policies driving the power grid's shift to new technologies?
- How concerned should Ohioans be at how this transformation is being managed?
- Is Ohio on the precipice of a self-imposed energy crisis?

Solar and wind power have become a greater part of the energy resource mix in Ohio's power grid since the passage of Senate Bill 221 in 2008 that mandated the use of renewable technologies on Ohio's electrical grid. However, these technologies are unpredictable and often force power companies operating coal and gas-power plants to start, stop, ramp up and ramp down to compensate for times when there is little-to-no wind, and the sun shines less. That alternating process is known as cycling.

Cycling often causes steam lines, turbines, boilers and other components to endure large thermal and pressure stresses. In addition, elevated temperatures accelerate creep-fatigue interactions. Cycling increases maintenance on coal and nuclear facilities that are a direct result of intermittent and unpredictable technologies on the grid.

Federal and State subsidies and State mandates for renewables have meant the inclusion of more natural gas peaker plants (Natural Gas Simple Cycle, NGSC) and more Natural Gas Combined Cycle (NGCC) Power plants with fast start technology. These are the technologies that can most easily adapt to unpredictability and intermittency. However, peaker plants are about half as efficient as NGCC plants and NGCC plants with fast start technology are not as efficient as just plain NGCC plants. As goes efficiency so goes energy cost and carbon emissions. As a rule of thumb - peaker plants use twice the fuel and produce twice the emissions to make the same amount of energy as NGCC plants.

Additionally, natural gas can have delivery problems during extreme weather events and may expose Ohio's energy grid to greater risk of attack.

Ohio legislators are left to make very important and vital decisions that are framed by passion and principles rather than based on the very real realities facing Ohio's energy grid. Such decisions should not be taken lightly and made in haste or as a knee-jerk proposition because these decisions will very likely be life or death decisions that have the potential to affect all Ohioans.

To make good decisions - legislators need to be informed - and to make certain that the information is unbiased. This testimony gives a quick background of Ohio's energy grid and information pertinent to making wise energy choices on House Bill 6.

Merchant Power Markets Versus Regulated Markets

There is a fundamental difference between traditionally regulated utility power systems and merchant generation in a wholesale power market. When utilities make long-term decisions about power supply resources (such as retiring coal plants), the utility and the state regulatory commission consider all the effects on the power system, including reliability, system diversity, environmental issues, and minimizing long-term power costs to ratepayers. In a merchant power market, the plant owner has no obligation to consider any factors other than the economics of its power plants and will maximize profitability in compliance with applicable regulations.

What are the Legislative goals of any Energy Grid?

The goal of any energy grid is about ensuring electricity supply meets demand second by second - day by day - year by year - in all types of difficult situations.

To determine the robustness of a grid is to determine what goals and regulations are required, what are the consequences for failing to perform to set standards, the accuracy of audits of the grid and base assumptions, and the accuracy of modeling the grid for reliability and security.

There are some simple rules of thumb that help legislators to balance energy cost and reliability.

- More complexity, results in more costs. Unnecessary complexity, results in unnecessary costs. *(Law of Simplicity)*
- The better and earlier energy demand can be predicted, the lower the cost of energy will be. The worse and later energy demand can be predicted, the higher our energy costs will be. *(Law of Predictability)*
- The better that energy supplies can be depended upon, the cheaper energy costs are. The less that energy supplies can be depended upon, the higher the cost of energy is. *(Law of Reliability)*

Predictability, reliability, and simplification of the grid should be the primary goals of legislation that provides the framework for the operation of Ohio's energy grid.

Obviously, we all want cheap and reliable energy and we want that energy to be environmentally friendly.

Economics versus the Environment

We should always strive to be good stewards of our environment - but the cleanliness of the environment should never come at the cost of human life.

Manufacturing economies depend heavily upon energy and the cost of energy plays heavily in competing in the global marketplace. Cheap energy has always been a hedge against poverty - it attracts energy intensive businesses and allows families to more easily and economically heat, cool, and power their homes. As the cost of education soars it is more important than ever to have low-education / high to medium skill education jobs to maintain the productive output of the economy. These jobs tend to be manufacturing jobs and many of these jobs are energy intensive e.g. steel production, aluminum production, plastic production, and glass production.

A dirty environment may shorten life spans of humans and incur heavy social and healthcare costs.

Equally, poverty can shorten the life spans of humans by imposing heavy social and healthcare costs.

Energy must play a balancing act and neither be too dirty nor cost too much. There is a law of diminishing returns on cleanliness of energy and cost of energy. This balancing act is best and most judiciously determined by State legislators - not unelected bureaucrats.

Frequency (a Grid Metric)

Ohio's energy grid works at a 60Hz frequency as does the rest of America's. This means that the turbines in coal, nuclear, and natural gas plants must rotate at speeds commensurate with 3,600 revolutions per minute. It is important to run within 5% of the 60Hz frequency otherwise motors and other electronic devices can be damaged.

As demand for electricity goes up it is similar to a car going up a hill. In order to maintain the same speed you must press down on the accelerator. For the energy grid think of the frequency as a speedometer on a car. Grid operators must coordinate, in real time across the grid, when the frequency begins to drop they must tell operators to push down on their accelerators. When going down the hill you may need to use the brake and this equates to letting off the accelerator and turning off some generation because it is not needed.

Frequency control is required to maintain a functioning grid.

Inertia (a Grid Metric)

Inertia is an object's natural tendency to keep doing what it is currently doing.

Massive turbines at coal, nuclear, and natural gas plants spin at a speed commensurate with 3,600 rpm, have the advantage of adding inertia to the grid. If for some reason the energy source stops producing heat the turbines will keep spinning for a short time. This spin time is known as inertia. Inertia is very important on the grid in dealing with frequency response and unplanned events.

System inertia determines the initial rate of frequency decline after a sudden loss of generation. As system inertia declines, the Rate of Change of Frequency (RoCoF) after an event increases. Events with very high RoCoF may leave insufficient time for various frequency response mechanisms to deploy and arrest frequency decay above the system's under-frequency load shed set points. This, in turn, may result in involuntarily load disconnection from the grid.

As penetration levels of non-synchronous, inverter-based generation resources (e.g., wind, solar, batteries) increase on Ohio's energy grid, the grid's synchronous inertia will inevitably decline, especially during low load conditions.

The rule of thumb to keep in mind is the more inertia you have on a grid the more time you have to respond to serious problems and adjust to problems caused by intermittent supply.

Voltage Management and Reactive Power (a Grid Metric)

****Reactive power is very complex to try to explain accurately and succinctly without having a background in power generation. The following is a very crude analogy of how reactive power works and depending on your perspective may or may not be accurate. Nevertheless Reactive Power is very important to a functioning grid.*

The electricity that turns on light bulbs and charges phones is what's known as 'active power'. However, getting that active power around the transmission system efficiently, economically and safely requires something called 'reactive power'.

Reactive power is generated the same way as active power and assists with "pushing" the real power around the system but unlike active power it does not travel very far. The influence of Reactive power is local and the balance in any particular area is very important to maintain power flows and a stable system.

This means grid operators must work with generators to either generate more reactive power when there is not enough, or absorb it when there is an excess, which can happen when lines are 'lightly loaded' (meaning they have a low level of power running through them).

The Ohio grid's ability to absorb reactive power is also vital in controlling the grid's voltage.

Ohio's system generally runs at a voltage of 138 - 230 kilovolts (kV), there are some 345,500, and 765kV lines) before it is stepped down by transformers to 120 to 220 volts for homes. The voltage must stay within 5% of norms before it begins to damage equipment.

By producing reactive power a generator increases the voltage on a system, but by switching to absorbing reactive power it can help lower the voltage, keeping the grid's electricity safe and efficient.

Reserve Power (a Grid Metric)

Humans are creatures of habit. This means the whole State of Ohio tends to load dishwashers, turn on TVs, and have furnaces and air conditioners that run at roughly the same time each day, making the rise and fall in electricity demand easy enough to predict.

However, if something unexpected happens – a sudden cold snap or a power station breaking down – the grid must be ready. For this, It is important that Ohio keeps reserve power on the system to jump into action and fill any sudden gaps in demand and fluctuations in voltage and frequency it could cause.

Quality Management of the Grid

While we have many organizations that make decisions for Ohio's grid these organizations do not necessarily make decisions that are in the best interests of Ohioans. These organizations may be making decisions that are in their best interests and that expand their influence and grow their organization. An argument could be made that Ohio legislators should take an active interest in the grid as decisions about the grid and energy can have profound repercussions on the Ohio economy and Ohioans personal prosperity.

The complexity of the grid is not something that all legislators should be expected to learn but that does not mean that legislators cannot lay a framework for the free market system to work within by setting basic standards on grid metrics that ensure a balance of cost with resiliency and security.

Extreme Cold and the Weakness of Natural Gas

In early January of 2014, the Midwest, South Central, and East Coast regions of North America experienced a weather condition known as a polar vortex, where extreme cold weather conditions occurred in lower latitudes than normal, resulting in temperatures 20 to 30° F below average. Some areas faced days that were 35° F or more below their average temperatures.

The major polar vortex that occurred in January of 2014, the Bomb Cyclone of 2018, and the minor polar vortex that occured in March of 2019 brought to light the weaknesses in the over-reliance on natural gas and how the war on coal made our Ohio electrical grid less dependable in extreme weather events.

During the polar vortex, the cold weather increased demand for natural gas, which resulted in a significant amount of gas-fired electrical generation being unavailable due to curtailments of gas. This drop in natural gas energy generation in the 2014 polar vortex was picked up by nuclear and coal fired power plants.

The advantage that coal and nuclear power plants bring to the grid is that they store their fuel on site. Unlike natural gas, there's no just-in-time delivery via a pipeline. Even coal can be affected by extreme cold as coal piles can freeze and plants may have to use explosives to break up piles of coal to feed the

plants. Cold weather can also halt rail and barge transport of coal. Coal is superior to natural gas in cold weather extremes.

The best guard against extreme cold events are nuclear power plants. Nuclear power plants can keep up to 2 years worth of fuel in their core. Their warm water discharges can melt forming ice so their water intake is never disturbed in producing energy.

Natural gas can be compromised in a number of ways due to extreme cold events.

Freeze-offs

One billion cubic feet of natural gas is enough gas to supply about five million U.S. homes for a day. During a polar vortex the Marcellus and Utica shale plays can reduce production due to weather by one billion cubic feet per day. This happens as the natural gas that comes out of natural gas wells or underground storage facilities has moisture in it. As moisture ladened natural gas gets closer to the surface and weather extremes then the moisture turns to ice and restricts the flow of natural gas as the diameter of the pipe is reduced by ice.

Extreme weather causes extreme use of natural gas to heat homes and produce electricity to keep furnace blowers blowing and to keep homes warm. All of this usage combined with a reduced gas flow from wells and underground storage, can, and has caused, a drop in natural gas pressure during extreme weather events. A drop in gas pressure can cause natural gas plants to reduce in power and go off-line completely.

Security

Any lunatic of modest means - or - any sufficiently financed organization wishing to do America or Ohioans harm could cause a major loss of life during a polar vortex. Natural gas compressor stations are much more vulnerable to attack than are coal fired power plants and nuclear power plants. A coordinated attack on as few as a dozen compressor stations during a polar vortex could have catastrophic consequences for millions of Ohioans.

If a railroad bridge that is used to deliver coal is knocked out - coal has the advantage of being able to be delivered by truck and many times by barge or ship. Nuclear normally has its fuel assemblies delivered every 2 years or so and this is done with armed escorts.

Unlike coal and nuclear power plants, a compressor station can take down a natural gas generating station almost immediately. Coal and nuclear has fuel onsite that can normally sustain them until more fuel can be delivered.

Dependency

Since the last major polar vortex in 2014 - Ohio has only grown more dependent upon natural gas. In 2019 the polar vortex did not dip low enough into Ohio to cause 2014 conditions but wreaked havoc for Michigan and Minnesota. The closure of Davis Besse and Perry nuclear power plants would undoubtedly

be replaced by natural gas. The closure of any coal fired power plants in Ohio will almost undoubtedly be replaced with natural gas.

As our more secure and resilient forms of energy are replaced with less resilient and less secure forms of energy - this increasingly puts Ohioans at risk during extreme cold weather events.

Market Dynamics

The dynamics of Ohio's deregulated markets do not place a substantive value or requirement on the reliability or resiliency of electricity. This is because the market does not have intelligent oversight and accountability that the public can hold a specific organization accountable for poor planning and decision making.

- PJM (Pennsylvania, Jersey, Maryland Interconnection) is an RTO (Regional Transmission Organization) it is to provide for fairness in transmission markets and facilitate energy producers working together to reliably supply energy on the grid.
- NERC (The North American Electric Reliability Corporation) is a not-for-profit international regulatory authority whose mission is to assure the effective and efficient reduction of risks to the reliability and security of the grid. NERC develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the bulk power system through system awareness; and educates, trains, and certifies industry personnel. NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico. NERC is the electric reliability organization (ERO) for North America, subject to oversight by the Federal Energy Regulatory Commission (FERC) and governmental authorities in Canada. NERC's jurisdiction includes users, owners, and operators of the bulk power system, which serves more than 334 million people.
- FERC (The Federal Energy Regulatory Commission), is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil. FERC also reviews proposals to build liquefied natural gas (LNG) terminals and interstate natural gas pipelines as well as licensing hydropower projects.

FERC oversees both NERC and PJM - yet, while each of these organizations oversee facets of reliability and security of the grid no - one organization focuses wholistically on the Ohio Energy Grid. This is the responsibility of the Ohio State Government. This is also one of the reasons why it is so hard for legislators - post deregulation of our electric and gas infrastructure - to get realistic answers on grid management decisions. Too many legislators are under the impression that this is the responsibility of FERC, NERC, and PJM. Ultimately, this responsibility falls to the State of Ohio.

Another thing to keep in mind is that the more complex the Ohio grid is the more FERC, NERC, and PJM are needed. So rarely, will you see these organizations talk about or promote grid simplification.

Impartiality

Only, as government agencies, do the DOE (Department Of Energy) and NETL (National Energy Technology Laboratory) have the wherewithal to unbiasedly comment on the Ohio energy grid and its infrastructure. FERC, NERC, and PJM do not answer to the DOE or NETL as they are independent organizations. FERC, NERC, and PJM currently manage our grid. One could argue that these organizations have a motive to add complexity to the grid and have state legislators become more reliant on them to manage an increasingly complex resource. This allows them to grow their organization and have greater influence.

NETL has been very open since 2018 in talking about the dangers of an over-reliance on natural gas in its report "RELIABILITY, RESILIENCE AND THE ONCOMING WAVE OF RETIRING BASELOAD UNITS"

I would encourage this committee to reach out to Peter Balash Ph.D. Senior Economist Systems Engineering and Analysis at the NATIONAL ENERGY TECHNOLOGY LABORATORY (Peter.Balash@NETL.DOE.GOV) if unconvinced of the dangers of the over-reliance on natural gas.

In Deciding on HB6

Market dynamics as they are currently shaped, due to a lack of direction to maintain grid metrics, do not value resiliency or reliability of the grid. This is because the free-market was not given a framework of quality metrics to meet in providing power to our grid.

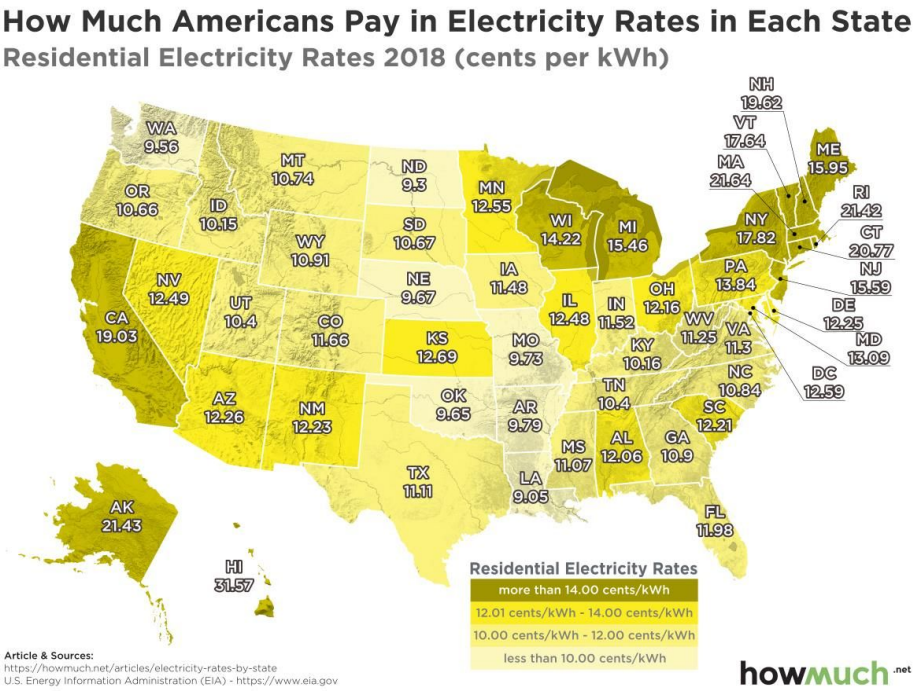
A reliable and resilient grid will not form organically in Ohio under the current legislative framework that shapes the way our grid operates or through existing external regulating bodies.

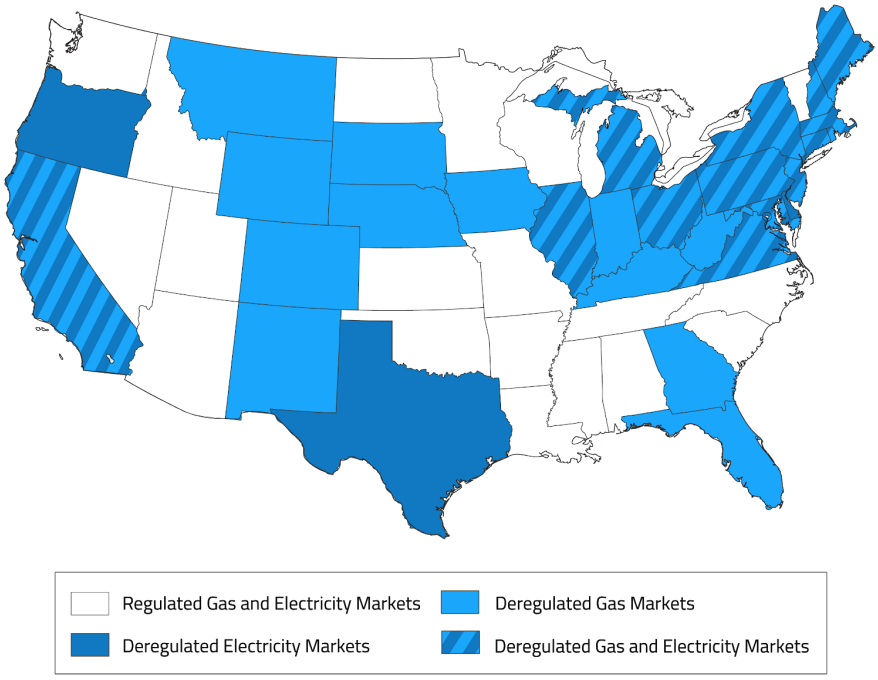
The free-market has been in play from the early 1800's in America's energy markets and helped the market arrive at a regulated state system. The competition of energy markets evolved in the macro to be between the states. The decisions that legislators made in a regulated state system regarding their grid - influenced their State's competitiveness. This evolution largely came about due to the public wanting the legislators balancing energy costs with environmental concerns and reliability and resiliency concerns - not corporations.

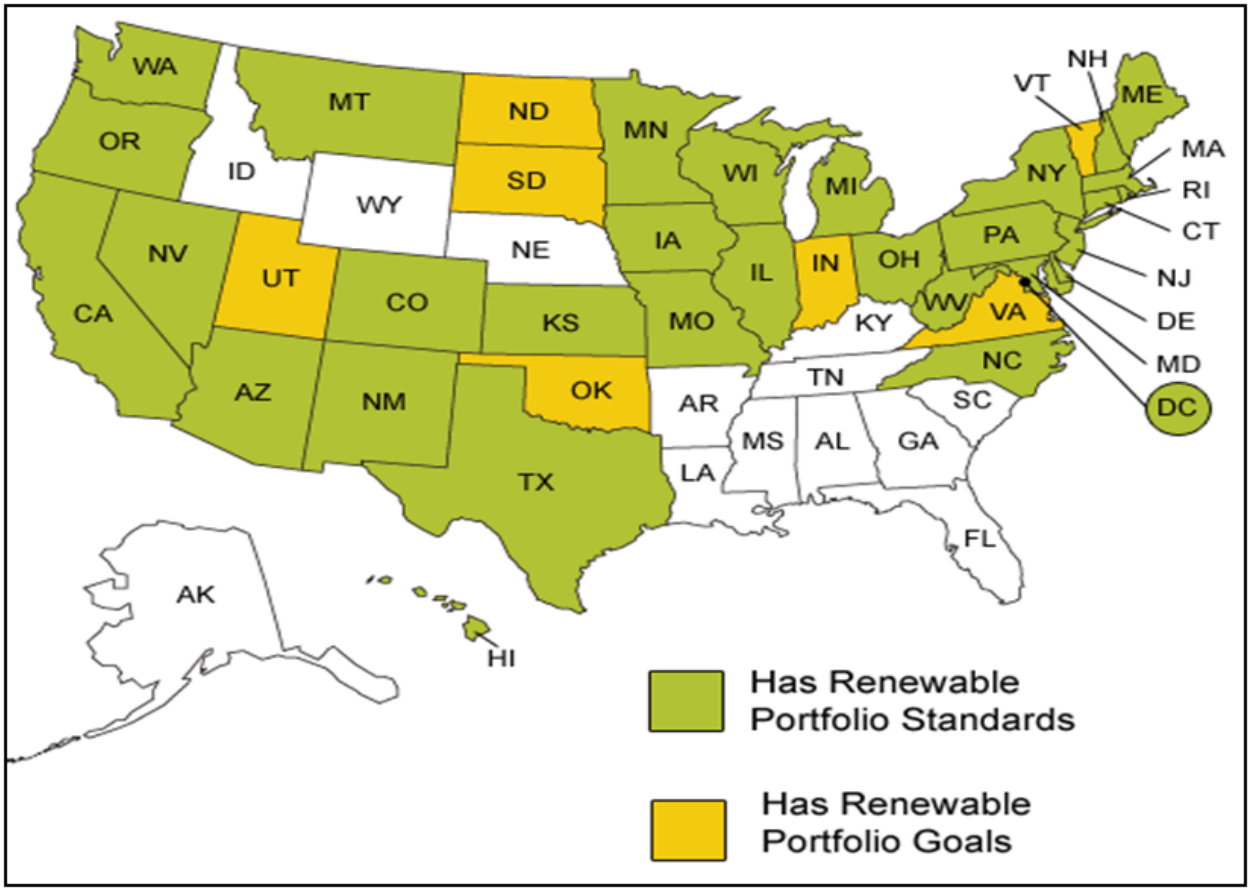
Ohio's government interfered with the natural order of the free-market through forced deregulation in 1999 that took effect in 2005.

Resilience and reliability in extreme weather events has measurable value. During the 2019 "bomb cyclone" of the Eastern seaboard, those in the New England states saw the spot prices of natural gas rise from $3/mmbtu to $92/mmbtu for two days of abnormally cold weather. With the elimination of nuclear and coal-fired power plants that will take place without the passage of HB6 and the already announced closures of coal-fired power plants due to the Obama administration's "War on Coal" - Ohio will voluntarily place itself in an unnecessarily risky and precarious situation by its over-reliance on natural gas.

What has PJM's management of the grid meant for Ohio? Our costs for energy have come to **<u>not</u>** resemble a state with large energy intensive manufacturers.







From 1990 to 2005 (15 years prior to deregulation) Ohio's residential electricity rates hovered right around $8.50/MWhr. Since then, we have had an unprecedented rise in energy costs. The costs of fuels such as natural gas, coal, and uranium have all went down in price while inflation has not substantively reared its ugly head during this same time frame. Leaving everyone to ask how has deregulation benefited Ohioans?

- 2006 - $9.34/MWhr Residential Cost of electricity
- 2007 - $9.57/MWhr Residential Cost of electricity
- 2008 - $10.06/MWhr Residential Cost of electricity
- 2009 - $10.67/MWhr Residential Cost of electricity
- 2010 - $11.31/MWhr Residential Cost of electricity
- 2011 - $11.42/MWhr Residential Cost of electricity
- 2012 - $11.76/MWhr Residential Cost of electricity
- 2013 - $12.01/MWhr Residential Cost of electricity
- 2014 - $12.50/MWhr Residential Cost of electricity
- 2015 - $12.80/MWhr Residential Cost of electricity
- 2016 - $12.47/MWhr Residential Cost of electricity
- 2017 - $12.62/MWhr Residential Cost of electricity

- 2018 - $12.16/MWhr Residential Cost of electricity

An argument can be made that our only reduction in electrical costs came when President Trump took action to end the federal “War on Coal.”

Ostensibly - deregulation made the market dynamics of the grid much more complicated and added additional layers of middle-men that have resulted in skyrocketing costs for Ohioans.

In addition to deregulation, Ohio took steps in 2008 to place technology mandates on generators forcing them to invest into renewable technologies against their will. These renewable technologies have added considerable complexity to the grid and their environmental benefits, if any, are dubious and almost impossible to directly and accurately quantify.

If I were a legislator these are the questions I would be asking of grid regulators.

- If HB6 does not pass - can you show me the modelling of our natural gas infrastructure that the additional natural gas plants needed to replace our two nuclear power plants and coal fired power plants will not negatively impact our grid resiliency and reliability during extreme weather events?
- Has the modelling data of our natural gas infrastructure been audited by an unbiased third party?
- How will extreme weather events affect the spot price of natural gas? How much would a natural gas company stand to gain during a polar vortex? What are the legalities of the state of Ohio pursuing price gouging irregularities?
- How many natural gas plants will Ohio need to maintain grid metrics such as inertia, reserve power, reactive power etc...etc…?
- What type of a security risk do we open ourselves up to with an over-reliance on natural gas for accidents, vandalism, and terrorism?
- If Ohio does allow natural, and most likely temporary, market dynamics to displace coal and nuclear generation assets - is there a way for Ohio to lock-in decadal pricing of natural gas through a power-purchase agreement?
- Very soon, many have theorized, Ohio and Pennsylvania gas in the Marcellus and Utica Shale plays will be on the world market due to increased LNG shipments overseas. What have Marcellus and Utica Shale natural gas companies shared with their stockholders on the expected rise of natural gas prices due to LNG shipments and the increased domestic reliance on natural gas?
- Is giving natural gas and wind and solar a near monopoly good in the long-term for our environment and for our economy?

- How do the closures of out-of-state coal fired power plants affect the quality and resiliency of Ohio's power grid?

Just how bad are the Retirements of Resilient Plants?

Table 2B. Ten largest plants by generation, 2017
Ohio

	Plant	Primary energy source	Operating company	Generation (MWh)
1	Gavin Power, LLC	Coal	Gavin Power, LLC	15,630,916
2	Cardinal	Coal	AEP Generation Resources Inc	10,498,733
3	Perry	Nuclear	FirstEnergy Nuclear Operating Company	9,812,376
4	W H Zimmer	Coal	Dynegy W H Zimmer	8,172,642
5	Davis Besse	Nuclear	FirstEnergy Nuclear Operating Company	7,875,413
6	Hanging Rock Energy Facility	Natural gas	Dynegy Hanging Rock Energy Facility	7,833,855
7	J M Stuart	Coal	Dayton Power & Light Co	6,909,396
8	Miami Fort	Coal	Dynegy Miami Fort	6,744,234
9	FirstEnergy W H Sammis	Coal	FirstEnergy Generation Corp	6,219,685
10	Waterford Power, LLC	Natural gas	Waterford Power, LLC	6,000,227

Source: U.S. Energy Information Administration, Form EIA-923, Power Plant Operations Report and predecessor forms.

Perry (Lake Erie), Davis Besse (Lake Erie), and Sammis Power Plants (Ohio River) are all expected to close. These are three of Ohio's top 10 in-state generators of electricity. Additionally, Kyger Creek (Ohio River), which is one of the top ten plants by capacity is expected to close.

Ohio also gets significant energy from Beaver Valley Nuclear Power Plant (Ohio River), and Bruce Mansfield Power Plants (Ohio River) in Pennsylvania and from the Pleasants Power Plant in West Virginia (Ohio River).

The Clifty Creek Plant in Indiana that supplies Ohio is expected to close.

The retirements of these power-plants (only Davis Besse, Perry, Kyger Creek, and Clifty Creek plants) would be saved by HB6.

Coal-fired power plants Retired since the Polar Vortex in 2014
(Ohio) Beckjord 4, 5, 6
(Ohio) Miami Fort 6
(Ohio)Eastlake 1, 2, 3
(Ohio) Muskingum River 3, 4, 5
(Ohio) Picway 5
(Ohio) Hutchings 1, 2, 3, 4, 5, 6
(Ohio) Avon Lake 7
(Ohio) Stuart 1, 2, 3, 4
(Indiana) Tanner's Creek 1, 2, 3, 4
(West Virginia) Kammer Mitchell 1, 2, 3

Conclusions

An independent report found that closing coal-fired power plants would dramatically increase electricity costs.

https://nma.org/wp-content/uploads/2018/07/EVA-Report-on-Coal-Plant-Retirements-final.pdf

This is a reminder that just because the market will not support a specific asset does not necessarily mean the asset will be replaced by a more competitive asset.

As resilient technologies such as nuclear and coal are closed it puts Ohio in a precarious position in exposing itself to risk during an extreme weather events that have become more commonplace in the midwest. Is this risk acceptable or unacceptable? This is for legislators to determine.

When a merchant power producer decides to retire a coal-fired power plant, doing so will have significant impacts on the power system. The amount of available generating capacity will be reduced, which will reduce the reserve margins and increase the market price for generating capacity. Also, the marginal price of electric generation will be higher, increasing the average energy costs across the system. Further, the loss of coal capacity will reduce the system reliability and resilience to respond to the demand for electricity.

Regional transmission organizations (RTO) like PJM rely on the market to provide the lowest-cost power over time. However, the market structure and significant government interventions in the market (federal subsidies in the form of tax credits for wind and solar power and state laws which designate market shares through renewable portfolio mandates) have created a system that penalizes unsubsidized coal plants, because of their higher fixed costs, while not rewarding the value of their reliability, resilience and fuel security attributes.

All of these incursions into Ohio's energy markets and many legislators not understanding their responsibilities within the energy market have bastardized any sense of free market economics and pushed out resilient generators due to market conditions created by PJM.

A true free-market would consumers of energy to determine if resiliency is a value-added proposition that they are willing to pay for. To date - it is the State of Ohio that must make that determination.