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Emerging Policy and Technology Advances on the Resiliency of Hoosier Energy: Assessment of Potential Impacts

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Executive Summary

Policy contributes substantially to uncertainty in the electricity sector. In combination with other fuel, technology, demand and infrastructure dynamics, power utilities face potential risk at all levels of operation. In a shifting energy landscape, changes in local, state and national policy can impact generation portfolios, the marketplace and grid management. This project aims to elevate the Hoosier Energy grid's "regulatory resiliency," its capacity to anticipate, absorb and adapt to policy change. The points below outline the most salient information for Hoosier Energy:

- The development of electric transportation and farming implements has been advancing at a fast pace. If this technology is embraced by the agricultural community, the added demand and change in demand timing could be substantial. The added demand load could range from 11.8 to 118 MW depending on which technology applications are employed, DC-Fast Charging and/or Swappable Batteries.
- The added demand load ranges from 11.8 to 118 MW depending on the technology application between DC-Fast Charging and Swappable Batteries.
- The monitoring of key legislation towards electricity deregulation alongside the proliferation of blockchain as a means of available peer to peer payment.
- If energy deregulation or aggregation become legal, Hoosier Energy must closely monitor customer satisfaction with regards to portfolio generation and price of service. These will be the indicators of a potential succession from the REMC.
- The increased application of distributed energy resources and demand-side management practices will continue to affect the size of Hoosier Energy's total load. Providing DER programs to customers could be a way to remain relevant in an era of low load growth.
- Regulatory uncertainty in several key realms, including environmental protection, natural gas transmission and pipeline build out has the potential to increase the volatility of future coal and natural gas prices. However, few scenarios result in a decreasing cost of coal in the long term. Meanwhile, many scenarios exist that would result in significantly shifting natural gas prices, both increasing and decreasing them in the future.
- Hoosier Energy should monitor trends that would dramatically decrease the cost and accessibility of battery storage systems. Federal- and state-level policies will either be barriers or portals to widespread battery storage since lithium ion technology (soon followed by others) is quickly becoming technically and economically feasible.

Visualisation

The following table provides a guide and explanation of the visuals used to illustrate the results of analyses presented in this report. The intent of this labelling is to give the reader a quick synopsis of the variations in the degrees of magnitude of the potential impact of an event should it occur, the likelihood of occurrence and confidence in the results of the analyses performed in this evaluation. This variability is based on differences in data quality and confidence in the influence of the outcomes. For each scenario the magnitude of impact and likelihood are represented by color gradients of light (low possibility) to dark (high possibility) and the confidence is represented by a simple stoplight array of green (high confidence in analytical results) yellow (medium) and red (low).

Scenario	Magnitude of Impact	Likelihood	Confidence
Electrification of Vehicles/Farm Implementation	🟦	🟪	🟩
Adoption of electric tractors	🟦	🟪	🟨
Adoption of DC-fast charging or swappable batter technology	🟦	🟪	🟨
Carbon Tax	🟦	🟪	🟨
Relaxing Clean Power Plan Requirements	🟦	🟪	🟩
Regulations on Unconventional Gas Development	🟦	🟪	🟩
Delays in Pipeline Buildout	🟦	🟪	🟨
Development of Offshore oil and gas fields	🟦	🟪	🟨

Shifting International Trade Relations	🟦	🟪	🟥
Water Shortage and increasing prices	🟦	🟪	🟨
Battery Storage	🟦	🟪	🟩
Distributed Resources	🟦	🟪	🟩
Community Choice Aggregation	🟦	🟪	🟩

Key to Magnitude of Impact

1	2	3	4
Small Hoosier does not have much if any exposure relative to the scenario.	**Medium-Small** Hoosier has some but not actionable amounts of exposure relative to the scenario.	**Medium-Large** Hoosier has enough exposure to warrant action relative to the scenario	**Large** Hoosier has enough exposure to warrant immediate and corrective action relative to the scenario

Key to Likelihood

1	2	3	4
Small Not likely to occur	**Medium-Small** Less than likely to occur	**Medium-Large** More than likely to occur	**Large** Very likely to occur or has already occurred

Key to Confidence in Analytical Results

1	2	3
High	Medium	Low

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Introduction

Within the utility industry, the term “resiliency” is often used in the context of ability of a system to withstand a catastrophic event, such cyber-attack or natural disaster. In this investigation, the term is coupled with the ability to respond to and sustain business operations in the face of policy and technological changes that might have an impact on a utility. Policy and technological advancement contribute substantially to uncertainty in the electricity sector. In combination with changes in energy sources, technology, demand and infrastructure dynamics, power utilities face potential risk at many levels of operation. In a shifting energy landscape, changes in local, state and national policy can impact generation portfolios, the marketplace and grid management. This project aims to assess and analyse Hoosier Energy grid’s “regulatory resiliency,” for its capacity to anticipate, absorb and adapt to policy or technological change. Through the use of scenarios to frame possible circumstances and driving factors, coupled with qualitative analysis of anticipated effects, the results of this investigation equip Hoosier Energy with a framework for approaching the future uncertainty with grid resiliency in mind.

The disruptive changes associated with new and evolving technologies represented in this report are PV solar, electric farm implementation, and battery storage. The regulatory issues addressed are changes to the price of fuel, as well as the legality of community choice aggregation. There is a complex interplay between events and factors that are now, or could be present in the future, within these two domains. As this dynamic cannot be fully understood or predicted without significant uncertainty, the analyses in this investigation concentrate on evaluating the impacts of possible outcomes in four specific areas in these two domains. Each scenario is assessed qualitatively on the 1) magnitude of impacts, 2) likelihood of occurrence and, 3) confidence of analytical results.

This report synthesizes the research on a given topical area and associated scenario analysis. Each of the four topical areas is represented as a section of this progress report. Conclusions, along with recommendations, are presented at the end of each section along with a chart representing the three aforementioned criteria, which will allow Hoosier Energy to anticipate and adapt favourably to the events that may take place, as portrayed in each scenario. An overall summary and suite of recommendations are presented at the end of the report.

1. Electrification of the Agricultural Implements

1.1 Scenario Description

Considerable advancements within electric vehicle technology has encouraged the agricultural sector to adopt electric agrarian machinery. Furthermore, the idea of electrification in the rural area is not limited to the propulsion system, but rather a wide range of activities that are powered by diesel or propane, such as irrigation engines, grain dryers, building and water heating, and standby generation. The diffusion of electrification technology within the rural community could potentially pose significant stress on the grid due to the additional demand and, the inherent variability of demand pattern for charging activities of different products. To assess this possible impact, the authors focused on the electrification of tractors used for farming activities to explore a more mature application of the electrification technology. In order to ensure the continuation of grid reliability and resilience, a suite of analyses (i.e., risk, sensitivity, economic, etc.) is necessary to ensure that Hoosier Energy is provided the most salient strategy to enable a successful transition to enable its rural customers for the adoption of electric machinery.

1.2 Likelihood of Penetration in the Agricultural Community

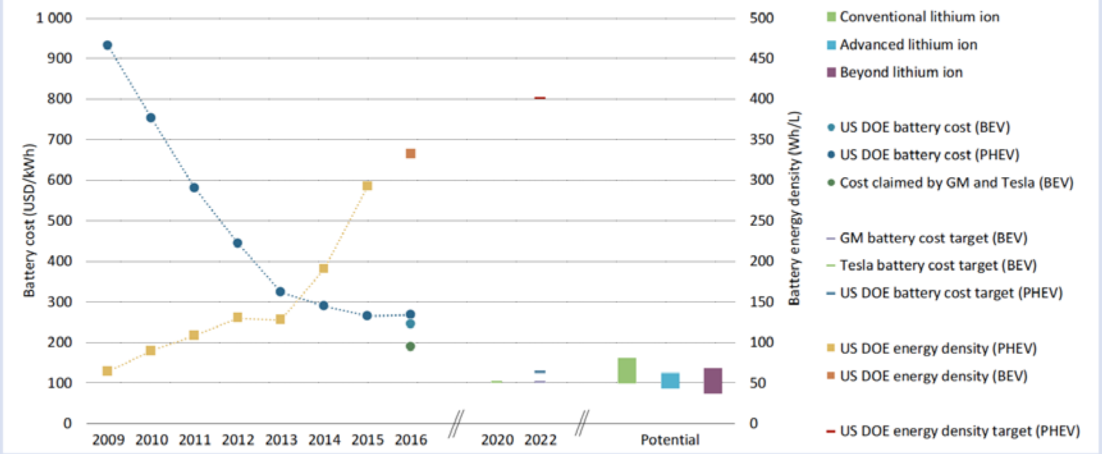
To assess possible impacts to Hoosier's grid, a preliminary analysis of impacts of adaptation of electric transportation and farming equipment to Hoosier Energy is presented. This is important to Hoosier because much of their service territory covers the rural area where farming communities are located and agricultural activities take place. This analysis is placed in context by reviewing the technological advancement of electrification technology in transportation and farming equipment, the farming community characteristics in terms of decision-making criterion and demand, and the financial advantages/disadvantages of this technology. The overall analysis of the likeliness of the adoption for this technology in the rural area takes into account of the factors mentioned above and outlines the potential impacts to Hoosier if widespread adaptation moves forward in the next decade.

Scenarios	**Magnitude**	**Likelihood**	**Level of confidence**
Electrification of Vehicles/Farm Implementation	Medium - large	Medium-large	Medium
Adoption of electric tractors	Small	Low	High
Adoption of DC-fast charging or swappable batter technology	Medium - large	Low(DC)- Medium(Swappable)	Medium

1.2.1 Technological advancement of electric vehicles and electric farming equipment

The technology of electric-assisted hybrid driving systems and the full electric, battery powered electric driving systems in the passenger vehicles has seen tremendous development in the past two decades. From the original and inspirational hybrid vehicles like the Toyota Prius, Honda Insight, to the full electric vehicles like the EV1 from General Motors in the past and now the advanced fleet of Tesla's, the passenger vehicles has gradually realized the electrification of its drivetrain system. According to International Energy Agency (IEA), the global electric car stock has surpassed 2 million in 2016.[1] This advancement in the electrification of drivetrain technology has deep implication for the farming equipment sector. According to US Department of Energy, thanks to the rapid development of electric vehicles, the cost of battery has dropped from $900+/kWh to less than $300/kWh from 2009 to 2016, while the energy density has risen from 50Wh/L to about 300Wh/L.[2] Under such circumstances, the likelihood of making electric farming equipment seemed natural and realistic.

Figure 6 • Evolution of battery energy density and cost



Notes: Contrary to the results assessed for 2009-15, which targeted PHEV batteries, the 2016 estimates of costs and volumetric energy density by the US DOE (costs are to be interpreted as projections for the high-volume production of technologies currently being researched) refer to a battery pack that is designed to deliver 320 km of all-electric range and is, therefore, suitable for BEVs. The latest update of this cost assessment was developed accounting for an advanced lithium-ion technology (with silicon alloy-composite anode). Being a technology that is still being researched today, this is currently deemed to have a greater cost but also a larger potential for cost reductions compared with conventional lithium-ion technologies.

Sources: Howell (2017), EV Obsession (2015) and Cobb (2015a).

Key point: Prospects for future cost reductions from the main families of battery technologies confirm the encouraging signs in cost and performance improvements observed over the past decade.

Source: IEA, Global EV Outlook 2017.

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[1] "Global EV Outlook 2017", IEA, https://www.iea.org/media/topics/transport/Global_EV_Outlook_2017_Leaflet.pdf

[2] Ibid.

As a matter of fact, the electrification of the farming equipment is already available in various forms, such as the diesel electric tractors, the full-electric tractors, and the electric implements of different types. Fendt, a German manufacturer of agricultural tractors and machines, announced their diesel electric tractor, the X concept in 2013. The X concept is a compact tractor powered by a compact diesel engine from AGCO, which allowed for the electrical technology, e.g. the alternator, the power electronics, the wiring and the specialist heat exchanger[3]. This diesel electric tractor is capable of providing up to 174 hp. to implements through a compact power socket, and a series of electric implements are under development by the company. Since the implements and the tractor are connected through the socket only, there is no need for the complicated separate housing, gearbox, or bearings[4].

Other than the diesel electric tractor from Fendt, the same company has also revealed their full-electric compact tractor called Fendt e100 Vario in 2017 with an estimated launch date in 2018[5]. In the announcement, the company claimed the battery-electric compact tractor with an output of 68 hp. (50 kW) and can provide 5 hours of operation per charge with its 650 V high-capacity lithium-ion battery with a 100 kWh capacity[6]. According to the statement, "the battery is charged either with 400 V or up to 22 kW via a standard International Commission on the Rules for the Approval of Electrical Equipment (CEE) outdoor socket, or by a supercharging option with direct voltage. With a standard Combined Charging System (CCS) type 2 plug, the battery can be recharged up to 80% in just 40 minutes." Besides Fendt, the iconic agricultural equipment giant John Deere has also announced their vision of the electric rural future with the introduction of an on-going project called SESAM (Sustainable Energy Supply for Agricultural Machinery) tractor. The SESAM is based on the JD 6R series and has a huge battery bank up front and dual electric motors that develop up to 174 hp. (130 kW) of continuous power with a speed range from 3 km/h to 50 km/h at full power. With a battery capacity of up to 130 kWh, John Deere is claiming 34 miles of road transport work each charge, and the charging time is about three hours.[7]

Furthermore, it's been widely suggested by the engineers of the manufacturers who are developing these electric tractors and implements that the requirement of maintenance will be significantly less comparing to the traditional diesel ones. And the advantages of a much reduced noise level, zero energy consumption during idling, and a great potential of much cheaper electricity with more renewables and distributed generation on the horizon have all contributed towards the transition of an electricity-powered agriculture in the rural area. Therefore, in terms of the development of electrification technology, substantial investment by major manufacturers of the passenger vehicles and agricultural equipment has rendered the likelihood of such technology's availability in the future highly likely.

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[3] Fendt X Concept, https://www.fendt.com/us/2466.html

[4] Jessie Scott, 3/29/2017 "IMPROVING TRACTORS, IMPLEMENTS WITH ELECTRIFICATION", https://www.agriculture.com/machinery/tractors/improving-tractors-implements-with-electrification

[5] "Fendt to launch e100 Vario battery-electric compact tractor in 2018", New Atlas, https://newatlas.com/fendt-e100-vario-battery-electric-compact-tractor/52276/

[6] Fendt e100 Vario: The battery-powered compact tractor, https://www.fendt.com/int/fendt-e100-vario.html

[7] "Electric John Deere tractor runs for 4 hours on a charge", Agriland, http://www.agriland.ie/farming-news/electric-john-deere-tractor-runs-for-4-hours-on-a-charge/

1.2.2 Brief on the characteristics of the farming community

The farming community are often characterized as a group of individuals who are highly sensitive to the financial bottom line of their accounts, with a tendency to be reluctant to changes and adoption of new technologies due to trust issues. The tried and tested methods of conducting farming activities has been one of the key characteristics identified by agricultural specialists Tanner and Chad interviewed by the authors.

In addition, from a recent article by Kuehne et.al (2017)[8], in which a tool named ADOPT (Adoption and Diffusion Outcome Prediction Tool) was developed by the researchers and the questionnaire was responded by a group of participants from the Australian farming community. The major lesson from this paper is its inventory of the key factors that could affect the adoption of new technologies for the farming community members. These factors are: profit motivation, environmental motivation, risk orientation, reversibility of the practice and, the ease and convenience of the using the technology. So from this report, we can arrive at a conclusion that these factors would also hold true to be important for the farming communities of the Hoosier Energy's service area and beyond. Furthermore, in a study done by Cavallo et.al (2015), the authors in this study was also able to collect responses from more than two hundred responders of a questionnaire designed to evaluate multiple technologies in tractors, and in the response, safety, comfort, east of maintenance and assistance, and environmental impacts were rated very much important in majority of the responses. This study revealed and confirmed the importance of ease of maintenance and environmental impact, which are the factors that could be addressed by the adoption of electric tractors. These studies have provided a network of important factors that determine the decision making of technology adoption by the farming community, while also presented the basic framework for the adoption analysis.

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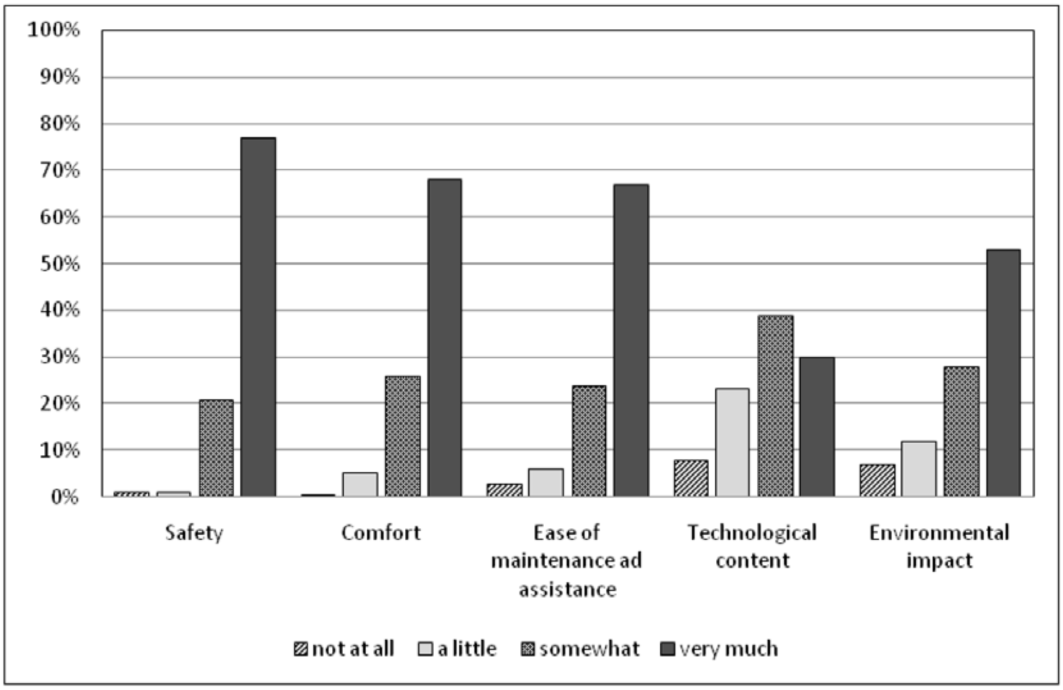
[8] Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy https://www.sciencedirect.com/science/article/pii/S0308521X16304541

Figure 5 Aspects considered important in agricultural tractor usage



Source: “Likely technological trajectories in agricultural tractors by analysing innovative attitudes of farmers”, Cavallo et.al (2015).

Also, the farming community’s daily schedule and special needs for their tractors as well as other power implements, diesel or battery powered, are very important factors that would determine the technological adoption. As mentioned before, the electric powered tractors are lower cost to run with almost no energy requirement during idling, and the simplified drivetrain system of the electric tractors will require much less maintenance, which effectively cut down the cost of ownership. According to a study by Iowa State University, the accumulated cost of repair for a two-wheel drive tractor could be 25% of its listed price after 6,000 hours of use.[9] More about the financial potentials of the electric tractors are further explored in the next sector. With the now available technologies, the electric tractors may still be an attractive option for farmers despite its potentially short operation time (4~5 hrs) from a single charge of battery, but this could be easily remedied with different technological applications that are discussed in the section discussing technology applications for the energy replenishment.

Overall, the adoption decision made by the farming community will mostly rely on the financial outcome of the technology after its maturity, and how well will the actual products being produced by the manufacturers satisfy the farmers’ demands. But starting from analysing the major characteristics of the electric farming equipment, its ease of maintenance and lack thereof, and the potential for financial savings from the distributed power generation and lowered electricity price all provide a positive note for the adoption of this technology by the farming community. Therefore,

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[9] “Estimating Farm Machinery Costs”, https://www.extension.iastate.edu/AgDM/crops/html/a3-29.html

the likeliness of farming communities adopting the electrification technology is high if the product available in the future is capable of achieving the parity in energy replenishment speed and provide the promised benefits such as fuel/energy savings and lower maintenance costs.

1.2.3 Financial analysis of the electrification for farmers in comparison to the conventional diesel counterparts

1.1.1.1 *Background and Assumptions*

The analysis of electric vehicle technology in agrarian tractors is particularly timely, given the evolving state of federal regulations and the recent automotive manufacturing developments of this particular technology[10]. The United States Environmental Protection Agency has gradually increased the emission standards for Tier 4 diesel engines (i.e., farming equipment). Additionally, increasing trends in adverse global warming, social outlook, rising cost, and financial incentives from both the state and federal government have subsequently propelled innovation and nudged micro trends in automotive technology to displace from petroleum-based systems to increase the reallocation of capital investments into electric vehicle technology. Several prominent firms such as John Deere, Cummins, and Fendt have made significant commitments to production of an array of electric vehicle products (i.e., agrarian machinery, engines, and batteries) for consumers within a few years.

Electric vehicle technology imposes significant initial costs in exchange for the benefit of long-term savings. Due to the relatively early developmental status of electric vehicle tractors, some relevant information is not available. However, based on the available information, this analyses will be derived by assessing benefits and costs on a per unit basis (e.g., a single electric tractor). Lastly, this report posits that these technological advancements could provide significant cost savings over a tractor ownership horizon of twenty years given a low rate of electricity.

This analysis is operating on the following twelve assumptions.

- The suggested retail price (i.e. MSRP) for electric tractors will be $147,067.25, which is the market price for the latest generation of John Deere 6R series of small and mid -frame diesel tractors.
- The sales tax rate is equal to seven percent.
- The cost for diesel fuel is $2.96 per gallon.
- The cost for electricity is $0.12 per Kwh.
- The lifespan for a tractor is twenty years.
- The lifespan for the battery systems is ten years.

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[10] Krutilla, K. and Graham, J. D. (2012), Are Green Vehicles Worth the Extra Cost? The Case of Diesel-Electric Hybrid Technology for Urban Delivery Vehicles. J. Pol. Anal. Manage. 31: 501-532.

- The overall productivity of the electric and diesel tractors are identical.
- In regard to externalities, we are operating on the assumption that CO2 and NOx emissions will not be a significant driving factor for farming communities (e.g., who are our primary stakeholders, parties who either benefit from cost savings or a reduction in externality damages) investment decisions. Therefore, we will exclude externalities costs from this analysis).
- This note will exclude regulatory changes (i.e., no action) to emissions or fuel.
- Future advancements in electric technologies will reduce operational cost and increase the adoption of government assistance for renewable technologies.
- Exogenous changes in the economy, demographics, and regulations by government entities (i.e., exogenous changes are not limited to the aforementioned variables) will be held constant. It is important to note that the aforementioned would significantly alter the model’s cost and benefits (e.g., as a consequences of consumers reactions to policy changes).

1.1.1.2 *Accounting Domain*

A properly executed analysis will offer insight about the potential ramifications and economic effects of a project or policy within a specified accounting perspective (i.e., a federal or state level domain)[11]. This report estimates the potential effects within Hoosier Energy's service area.

1.1.1.3 *Baseline*

A baseline is defined as the best assessment of a world absent of the proposed action (i.e., counterfactual), in this case an investment into electric tractors[12]. The baseline will measure potential benefits and cost (e.g., in nominal dollars, 2018) of investing in agrarian electric tractors in lieu of diesel systems beginning in year 2018 and ending in 2038. The following dimensions are concerning uncertainties, due to the restricted data access and immaturity of electric tractors, we were not able to establish the market price per electric tractor, and the productivity rates and operational costs are unambiguous. We acknowledge that economic forecast in the short-term are more sensible than figures generate in the long-term, due to the variability of investors' innate bias against deferred gratification.

1.1.1.4 *Fuel Savings*

This segment discusses the impacts of electric vehicle technologies on the operational expenditures of tractors. The premise with electrification is a reduction in fuel consumption and maintenance costs. As shown in Table 2. Fuel Savings, users will receive an annual fuel savings of $36.18. The net cost reduction is insignificant, consequently users will most likely not adopt this technology based on fuel-saving criterion in the near term. However, we are confident that the refinement of electrification and battery technology will significantly increase subsequent cost savings on fuel in the long-term, and we expect the fuel-saving to be magnified by the incorporation of distributed generation adoptions by the potential adopters of the technology.

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[11] National Center for Environmental Economics Office of Policy U.S. Environmental Protection Agency. (2010). *Guidelines for Preparing Economic Analysis*.

[12] National Center for Environmental Economics Office of Policy U.S. Environmental Protection Agency. (2010). *Guidelines for Preparing Economic Analysis*.

Table 2. Fuel Savings per Year

Vehicle Type	Diesel	Electric
Miles driven per year	1000	1000
Gallons of fuel consumed	166.66	111.11
Price of diesel fuel per gallon and electricity Kwh	$2.97	$0.12
GPM (100 miles)	16.6667	16.6667
Kwh per 100 miles	0	382.35
Kwh consumed per year	0	3823.5
Annual fuel cost	$495.00	$458.82
Annual Fuel savings	$36.18	

1.1.1.5 *Market Prospect of Electrification Technologies*

Currently, electric agrarian machinery manufacturers advertise a horsepower range of 174 to 402. As previously mentioned, battery capacity is only 4 hours and this technology constraint makes its penetration into more intensive applications such as large-scale commercial agriculture operations unlikely. Alternatively, market penetration within smaller agriculture operations that require less continuous duty cycles (i.e., seasonal lot clearing) is viable. The advancement of electrification applications within the agriculture sector is at the forefront of manufactures renewable technology initiatives, and the overall idea of self-supplied energy to run farmers' own equipment still stands to be an attractive idea. However, due to limited fuel savings and ambiguous savings from maintenance, we assess the probability of market penetration to be low and the magnitude of energy disruption or demand to be low therefore insignificant. To conclude, the best course of action for Hoosier Energy is to monitor these technologies, develop rapport with these manufactures, and evaluate forthcoming public policy implication.

1.3 Impact of Added Charging Demand

In this section, the authors ~~will~~ briefly discuss the current available technology applications in the electric transportation realm for the charging execution. After that, the authors conduct a parallel comparison between the applications and arrive at an initial recommendation for the most likely scenario for the charging technology application. At last, the authors refer back to the Hoosier Energy's customer and estimate a potential load addition to the grid under different technology application at different penetration rates of the technology.

1.3.1 Technological application of the charging technology

When it comes to the electrification of the transportation and farming equipment, the execution of charging technology is crucial to both the usability of the electric vehicles and electric farming equipment, and the final adoption of such technologies. As of now, there are multiple charging technologies available, such as Alternate Current chargers using home sockets and dedicated Direct Current Fast Charging stations. However, in consideration of the different needs of different applied scenarios of the electric technology, the actual implementation of the charging technology would be wildly different.

Recall in the previous section, the authors had briefly discussed the farming community's characteristics in terms of its expectation for the adoption of new technologies and the need for the farming equipment such as the tractors. According to the farming community, in order to convince them to adopt electric tractors, they will need to be at least as good as its diesel counterparts. Assuming the electric tractors are as productive as the diesel ones, the only difference left would be the way they replenish the power/fuel. In order to remedy the aforementioned challenge to achieve comparable performance in terms of quick replenishment of the energy for the electric equipment, different technology implications to achieve fast replenishment are evaluated. In this section, the authors will attempt to analyze the two proposed applications, DC-fast charging and swappable batteries. By analyzing the charging time, implementation difficulty and potential grid stress to determine which would be the more likely scenario for the electric future of the rural area.

1.3.1.1 DC – Fast Charging stations

Direct Current (DC) Fast Charging stations refers to the high power, high voltage, and high current dedicated charging stations that will be built as infrastructure sprinkled across the land. Comparing the current charging technologies in the realm of EV, the major charging rates are standard charging with single-phase AC sockets outlets (230V/110V) that charges at the rate of about 1.5kW, semi-fast charging with 3-phase AC sockets that charges at the rate of 7 to 22kW, and fast charging with DC current provided by an off-board charge that could charge at a rate of up to 140 kW[13]. Considering the needs for the farming communities of the electric farming equipment are similar to the diesel-

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[13] Bauer et.al, "Charging of Electric Vehicles and Impact on the Grid"

powered counterparts, a fast replenishment of the batteries is the top priority to ensure a similar user experience comparing to the conventional diesel-powered equipment. Hence, DC fast charging appears to be the most applicable technology application to achieve replenishment parity for electric equipment.

If we closely examine the factors that could determine the adoption of the technology application, the DC-Fast Charging scenario is still not very attractive in the rural settings for farming communities given the available technology. From the perspective of charging time, the DC fast charging still takes much longer time to charge the batteries in their tractors comparing to pumping diesel into the tank. According to Tesla, whose superchargers are the fastest charging technology available today for electric vehicles. For these superchargers which are at the power rating of 120 kW[14], it could replenish 80% of the battery charge for an 85 kWh Model S in 40 minutes. If farmers will need to drive their tractors to a charging station, and then wait for more than half an hour before being able to go back to work, their adoption of this technology would be unlikely. As the best technology available today, this is not a promising picture for this application in the rural area.

Furthermore, high power DC-fast charging stations are not a desirable load for any grid due to its unpredictability and steep demand addition. Since the farmers will be running their tractors and doing different activities with their equipment throughout the day, it would be difficult to form a pattern of charging demand under the DC-fast charging station scenario. In other words, there is a substantial possibility of concurrently charging with the DC-fast charging, and this could be high. This stochastic nature of the charging pattern leads to an almost completely random but incredibly high demand addition to the grid that could severely hinder the grid's stability and performance[15]. From the perspective of the power service provider, this will lead to more expenditure on the spinning reserve costs and the spot market purchases in order to satisfy the charging demand from DC fast-charging.

Also, the electrification does not only limit to the tractors, but also the passenger vehicles such as the electric pickup trucks and SUVs, which will be utilizing the DC fast-charging technology more often for longer distance travels. Hence, even if fast-charging isn't the top priority for electric equipment or tractors, its impact to the grid will still be a tangible one that resembles the randomness and steepness of fast-charging for tractors discussed above. Therefore, the preparation for such added demand on the load should be expected regardless the spreading of the electric farming equipment.

However, on the flip side, the implementation of DC fast charging need not to be something to fear, but an opportunity to grow if managed properly. One must recognize that the unpredictable load on the grid with concurrent fast-charging activity is based on the premise of substantial adoption of electric vehicles and electric equipment with gas-station like distribution of the fast-charging stations. This means the added load from charging will only grow as the charging stations gets built, which should give adequate signalling to the utilities like Hoosier Energy to prepare and response to

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[14] "Tesla quietly upgraded its Superchargers for faster charging, now capable of 145 kW", electrek, https://electrek.co/2016/07/20/tesla-supercharger-capacity-increase-145-kw/

[15] "Integrating Ultra-Fast Charging Stations within the Power Grids of Smart Cities: A Review", Danielle Meyer, Jiankang Wang

this potential load with infrastructure upgrades. In addition, there is substantial opportunity in time-of-use pricing scheme to manage the charging load and redistribute the charging load to off-peak hours.

1.3.1.2 Swappable Batteries

The technological application of using swappable batteries that are standardized amongst the major manufacturers for the electric vehicles and farming equipment could be the most applicable and popular option for electrification. This application would be especially attractive to the farming community for its almost instant replenishment of energy by simply swapping the spent battery with a pre-charged one. In addition, this application would be especially attractive to the utility companies as well due to the more stable and predictable load addition to the grid demand. For the pre-charged batteries to be constantly ready for farmer's day of work, a regional/home charging station will be established to charge a fleet of batteries that are standardized at a rapid but constant load.

However, this application establishes itself upon a huge assumption, which is the standardization of batteries between the manufacturers of farming implements and equipment. If we turn to the automotive industry, it's easy to find that there is rarely a standard for electric vehicle batteries, and there has not been any widely adopted swappable batteries applications for electric vehicles. The US company, Better Place, pioneered in swappable battery network for EVs and began installing battery stations in 2008 in Israel.[16] But it quickly went bankrupt in 2013 with only Renault producing one model for this network. Therefore, despite the prospect of equivalent replenishment rate for energy, the swappable battery implementation is not a guaranteed future.

On the flip side, the agricultural equipment market is different from the automotive industry because it has much less participants in the industry, and the products are more similar from one manufacturer to another. This allows the possibility of a standardized battery system to be more achievable if the major manufacturers were willing to participate and cooperate. Furthermore, the possibility of a technological standard mandate from the federal government could be a much welcome signal for the agricultural equipment market, which doesn't have any established battery technologies yet from any manufacturer.

Other than the benefits of instant replenishment of energy, swappable battery implementation also appear to be a welcomed implementation of electrification technology for its potential as energy storage. Considering the sheer size of the farming equipment, it's only natural to infer/assume the batteries on these machines are relatively large. The prototype electric tractor made by John Deere, which is modelled on John Deere's 6R series tractors, has a battery with a capacity of 150 kWh[17], and it takes up the whole front of the tractor where its diesel counterparts have their engines. Given the current information provided by the prototypes of the electric tractors, we can confidently assume the battery size in the future will likely be of the same physical size with improved capacity. The real estate of the battery posts a substantial challenge of battery swapping process that is more

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[16] "What happened to swappable batteries for electric vehicles?", MAKE WEALTH HISTORY, https://makewealthhistory.org/2017/04/24/what-happened-to-swappable-batteries-for-electric-vehicles/

[17] "John Deere's first fully electric tractor sounds like a jet engine", The Verge, https://www.theverge.com/2016/12/7/13874576/john-deere-sesam-electric-tractor-150kw-battery

demanding than switching out a battery from a phone from before. But this challenge could be easily remedied by a system of battery swapping mechanism with forklifts and proprietary equipment, which potentially posts a business opportunity. If this design was sustained in the future production of the electric tractors, it means the batteries for these machines will call for the ancillary service of battery swapping with robots or proprietary tools and machineries.

Potential of Battery to Grid services from swappable battery system.

The substantial capacity of the batteries at the charging hub could be a potential storage facility for the grid to provide different ancillary services. As a storage facility, the huge capacity of charged batteries could be individually called upon by the utilities for emergency dispatch for economic optimization purposes or for reliability responses. In addition, the charging hub could enter the market for long-term contracts and spinning reserve depending on the availability of the regulation. In February 2018, the participation of battery storage in the energy market has been approved by Federal Energy Regulatory Commission (FERC), this could be an important factor that could lead to the wider adoption of swappable batteries which provides the energy replenishment service for electric vehicles and equipment, and the service as generation asset for the electric grid.

As for the potential load addition under the application of a swappable battery system, it would mostly be determined by the charging speed of the charging hub for the batteries. The general understanding of the charging rate for these batteries will likely be a slower rate for each battery for maximum battery life. Since the charging process of the depleted batteries will tend to be a constant process with less variation in demand, it posts a very predictable added load to the grid. Even though the likeliness of concurrent charging of multiple batteries is high considering tractors running should be depleted in a more concentrated time frame given the farming community schedule, the much slower charging rate and power load comparing to the DC-fast charging technology made swappable battery to be a more preferable application for both the farming community and the utilities alike.

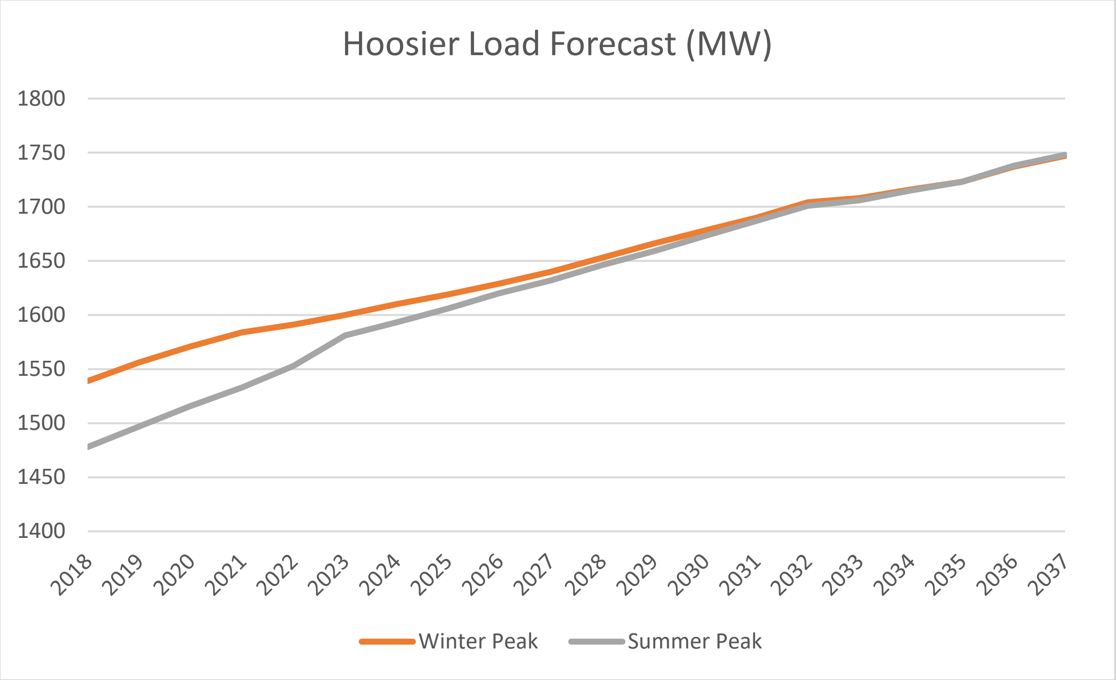
1.3.2 Impact analysis of electrification on Hoosier Energy

In this section, the authors will combine a series of assumptions and data provided by Hoosier Energy's Customer Survey data and the Integrated Resource Plan (IRP) for year 2017 to estimate the potential charging load that could be added to the grid and how it will impact the peak demand for the service area of Hoosier Energy.

By incorporating the data of different specifications of the currently available technologies and interviews with farming community individuals, the authors established the following assumptions to conduct a sensitivity test with the added load from fast-charging:

- The fast charging technology is charging the batteries at the rate of 120 kW for each charger, and the battery station is charging all the batteries at a maximum load of 120 kW;
- The adoption rates of electric tractor are 20%, 40%, and 60%;
- All of the HE customers who responded in the Hoosier Energy 2017 Residential End-Use Survey and identified themselves as the farming community are counted as the base population for the adoption;

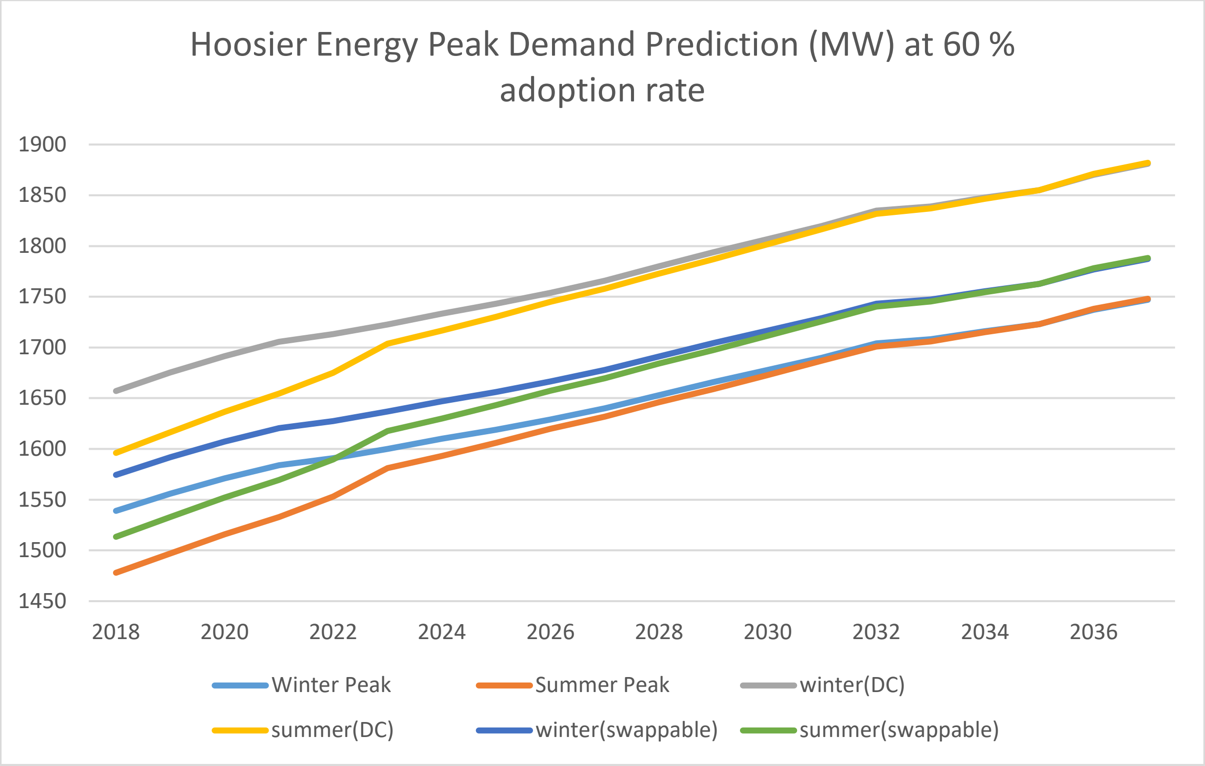
- The tractor to farmer ratio is assumed to be 2:1, the tractor to fast-charging station ratio 3:1, and the tractor to battery station ratio 10:1;



In this sensitivity analysis, the authors devised the following equation to estimate the potential added load for peak demand assuming concurrent utilization of the charging technology in both scenarios:

$$Est.\,Added\,Load = \frac{Charger\ Power_i * (Farming\ Consumer * Adoption\ Rate_j) * Farmer\ Tractor\ Ratio}{Charger\ Tractor\ Ratio_i}$$

With 20%, 40%, and 60% penetration rate for the adoption of electrification, we estimated for year 2015, an added load ranging from 11.8 to 118 MW could be added to the peak load. By adopting the same rate of increase as the peak load from Hoosier Energy’s IRP, we multiplied the added load by the same factor and added the additional load from the charging activity to the peak load of both summer and winter period. Overall, Hoosier Energy could be facing an added load ranging from 11.8 to 134 MW from 2018 to 2037.



The results appeared to be highly volatile to the actual rate of adoption and the technology application chosen for the charging activity. Nonetheless, the general conclusion from the previous sections still hold true in this analysis. The DC fast-charging technology is adding more demand when used concurrently with an over 100 MW addition to the demand. In comparison, the swappable battery application of charging hubs of batteries and its modest addition to the demand load appear to be the more benign situation.

This addition load from charging could be substantial to the grid overall. If not prepared for with demand-side management measures and the acquisition of generation capacity, it could result in substantial cost to Hoosier Energy to satisfy such added load in the spot market. Therefore, the overall estimated impact of electrification is medium to high given the initial analysis of the added load from the newly introduced charging activities from electric farming equipment only. There could still be other facets of the electrification such as the displacement of activities that originally utilize propane with electrification. Hence, the potential impact from electrification is more substantial than first glance due to its ripple effect that penetrates into almost any facets of energy use that posts the potential of electrification.

Nonetheless, the time frame of the electrification would be longer than 5 years and considering there is no commercialized electric tractors at current stage, this is not an imminent threat to Hoosier Energy. Furthermore, the adoption of the electrification technologies will be incremental over time, which will allow sufficient preparation in infrastructure construction for Hoosier Energy to prepare for the provision of complementary services for the customers. Hence, this should be viewed as a potential opportunity instead of a challenge for Hoosier Energy.

1.4 Conclusions and Recommendations

1.4.1 Conclusions

Given the information available today regarding the technological development of the electric tractors and the analysis on the financial implications of the electric tractor at today's specifications and performance, the likelihood of a substantial adoption in the immediate future by the farming community is low due to limited fuel savings and lack of trust for the new technology. Hence, the low likeliness of adoption also renders the magnitude of the impact of such a disruption on Hoosier Energy to be low. However, the electrification trend is approaching and full of potential in the rural area such as the electric vehicles and the electrification of now propane-powered activities. Furthermore, considering the vested interest of the major manufacturers of the agricultural machineries into the electric equipment, the commercialization could be in the prospect and hence require close attention to its development. Overall, the confidence level of the analysis in terms of its likelihood and impact magnitude is high based on the information given.

1.4.2 Recommendations

- Hoosier Energy should actively follow the development of the key electrified agricultural implement manufacturers and monitor the battle of technologies between fast-charging and swappable batteries to prepare ahead for the potential disruption from the new charging demand;
- Hoosier Energy should consider adopting demand side management and the promotion of distributed generation with smart grid as the more economical option to prepare for this added load;
- Hoosier Energy should adopt "time of use" pricing scheme specific to charging activities to properly manage the load from the demanding fast-charging activities;
- Hoosier Energy should plan for capacity acquisition in the forms of battery storage combined with renewable resources to achieve financial optimality and maintain the grid stability in the face of added load;

1.4.3 Potential business and ancillary service opportunities for Hoosier Energy

Hoosier Energy could develop future charging stations with a built-in energy storage function for the Swappable Battery station scenario to better harness the potential of the large capacity of storage from the batteries. Hoosier Energy could be the service provider for the battery charging and swapping and charge a fee for each battery charged and switched. With the huge capacity built-in with the swappable battery charging station, Hoosier Energy can invest in renewable energy sources and leverage the storage capacity to harness the energy that won't be deployed and sell it for profit in the form of charged batteries. In addition, the charged batteries can also serve as a storage for Hoosier Energy to participate in the energy market for additional revenue.

2. Shifting Fuel Prices

2.1 Scenario Description

In this section of the report, a series of policy events that could potentially take place are considered for their possible impact to Hoosier Energy's ability to conduct its business. These factors and/or circumstances are considered to be potential disrupters that could change the fuel prices (coal and natural gas) that Hoosier uses in its generation. Changes in fuel prices will cause changes in economics and may lead to changes that ultimately pose threats to Hoosier Energy's grid resiliency. By analyzing data and synthesizing information, we seek to determine (1) the likelihood each event will occur, (2) potential impacts of each factor, as well as, the synergistic impacts of multiple factors occurring in combination, and (3) recommendations that the company could take to tackle the potential risks associated with these events.

While Merom Power Plant makes up only 58% of the Hoosier Energy generation capacity, its use as a traditional, base-load generator has led to it generating 75% of Hoosier Energy's electricity in 2016. As a result, Hoosier Energy and its member are susceptible to increases in the price of coal. However, Hoosier Energy has adopted, as the energy sector shifts away from coal-fired generation, more use of natural gas in its generation portfolio. While the rapidly increasing domestic production of natural gas has led to low prices, natural gas industry may face further regulation impacting unconventional gas development, access to supply, or creation of new markets. When these factors are combined they provide uncertainty in the price moving forward.

2.2 Likelihood of Occurrence

2.2.1 Carbon tax

In April, 2017, the Trump administration announced that they were not considering a carbon tax as part of a tax reform plan[18]. In addition, the administration also withdrew from the Paris accord. These actions from the White House illustrated that a federal carbon tax will not possibly appear in the US, at least next four years. At this time, due to political factors, the probability of a federal carbon tax is low.

Figure 2.1 from Bauman and Komanoff (2017) shows the qualitative probability each state will impose a carbon tax ranging from very challenging to promising. Indiana was ranked at the very challenging level.

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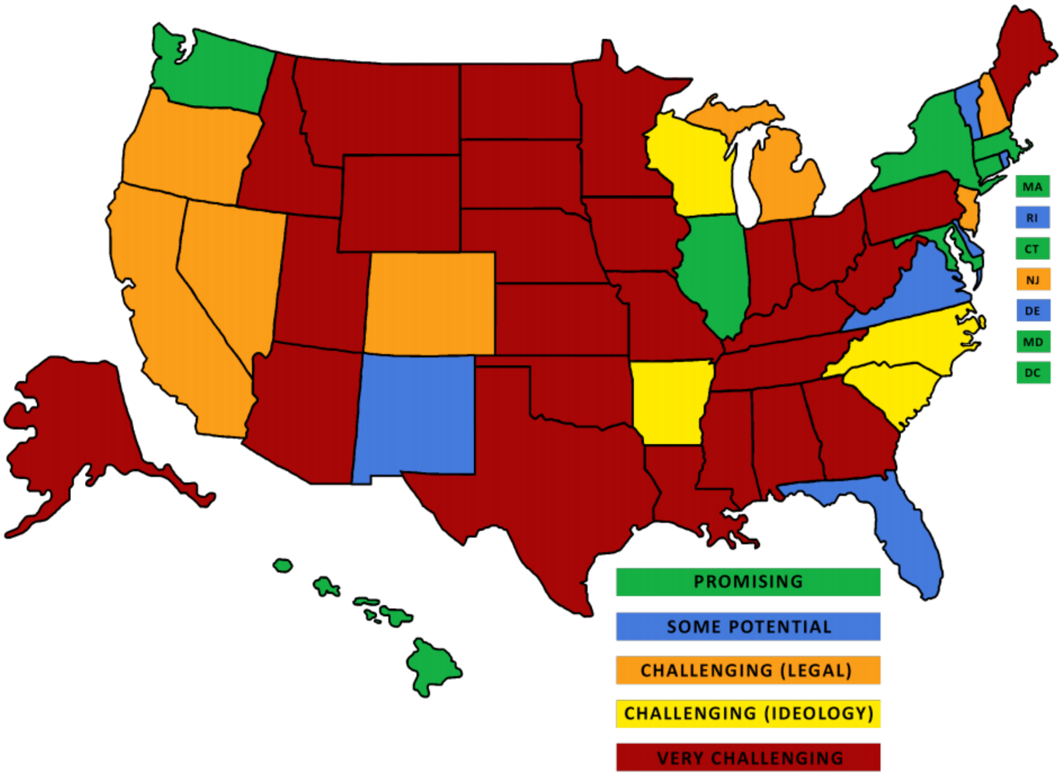
[18] http://thehill.com/policy/finance/327268-white-house-denies-its-considering-carbon-tax-value-added-tax

Figure 2.1. Opportunities for carbon taxes at the state level



Bauman and Komanoff (2017) cite legal, ideological and economic constraints leading to the very challenging opportunity for a carbon tax. Due to these limiting factors in Indiana we have determined a low likelihood of a state or regional level carbon tax being implemented.

2.1.2 Changes in the Clean Power Plan

The U.S. EIA reference case offers a relatively consistent forecast for the price of coal generation, with only a nominal increase from now through 2050 as shown in Table 2.1. Even under the scenario with the Clean Power Plan (CPP) implemented, the EIA forecasts coal prices will go up gradually over time.

Table 2.1. Coal price forecast

Year	***2016***	***2020***	***2025***	***2030***	***2035***	***2040***	***2045***	***2050***
Steam Coal Electric Power (Ref. Case 2017 $/MMBTU)	*2.20*	*2.24*	*2.28*	*2.31*	*2.35*	*2.41*	*2.44*	*2.46*
Steam Coal Electric Power (Clean Power Plan 2017 $/MMBTU)	*2.20*	*2.23*	*2.27*	*2.24*	*2.26*	*2.30*	*2.31*	*2.31*

Source: U.S. EIA

In June 2017, President Trump announced that America will withdraw from the Paris Accord. On April 4th, 2017, the Environmental Protection Agency issued a review of the CPP. Following this review, a proposal to repeal the CPP was published on October 10th, 2017. In addition, the EPA Administrator intends to replace the CPP with weakened regulations[19]. The current administration is actively working towards changing and repealing the CPP, as a result, we have assigned a high likelihood.

2.2.3 Regulations impacting natural gas development

Unconventional gas development [jar1] can pose threats and impact water, air, and land. An example of an enhancement to regulatory oversight of natural gas development was the proposed *Oil and Gas; Hydraulic Fracturing on Federal and Indian Lands* Bureau of Land Management rule. This proposed regulation was introduced by the Obama Administration to address concerns about environmental protection on federal lands. However, the Bureau of Land Management was sued as it took the final steps to implement this regulation and the retraction of the proposed rule was finalized on December 29th, 2017. The likelihood of increased regulation in the short term, at the federal level, upon the development in general and, on the practice of hydraulic fracturing in particular, appears to be low.

In total, there are 32 states administering their own laws and associated regulations to control hydraulic fracturing activities and associated practices[20]. More aggressively, New York, Vermont, and Maryland have outlawed the practice of hydraulic fracturing entirely due to environmental concerns. The likelihood additional states, with significant natural gas reserves, to outlaw hydraulic fracturing is low. The impact of these policies will depend on their design and implementation. When constructed, in conjunction with industry and best practices, these regulations can cultivate

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[19] https://insideclimatenews.org/news/18122017/clean-power-plan-trump-epa-repeal-replace-obama-climate-change-power-plant-emissions

[20] https://www.theregreview.org/2018/02/07/kang-farewell-fracking-regulations/

innovation, cost-effectiveness, and lead to further development of unconventional natural gas. However, when poorly constructed these regulations can slow development and may lead to increased costs for production. Considering all of these factors, there is a medium likelihood on increased regulations related to unconventional gas development.

2.1.4 Delays in pipeline buildout

Likely the costliest to oil and gas companies, and therefore natural gas users, delays to pipeline development due to public disapproval, regulatory holdup for permitting, or increased regulation, may impact natural gas prices in both the short and long term. Many state officials in the Northeast are working to delay the construction of pipelines due to concerns of carbon lock-in and additional fossil fuel consumption. For example, New York state regulators did not permit projects of pipeline buildout as an effort to reduce green gas house emissions. However, the Trump Administration intervened in this process and granted developers the permit with an aim of increasing jobs and exports[21]. The conflicting approaches between federal and state - level extend the time it takes for pipeline projects to receive approvals. Atlantic Coast Pipeline running from West Virginia to North Carolina, for instance, took more than two years to complete this process. In August, 2017, the Court of Appeals for the District of Columbia Circuit Court appealed FERC's approval of the Southeast Market Pipelines Project which transports gas to Florida due to its contribution to climate change[22]. Due to legal, political, and activist delays, the likelihood of these factors impacting the price of natural gas are medium.

2.1.5 Development of offshore oil and gas fields

The Trump administration has proposed opening federally controlled offshore gas reserves that are technically recoverable for development. In the beginning of this year, the National Outer Continental Shelf Oil and Gas Leasing Program (National OSC) for the period 2019-2024 was proposed. This program will take 90 percent of total OCS available for future exploration and development and will influence the gas production as well as electricity generation[23].

While there has been a variety of pushback against these policies, if implemented, they would significantly expand the supply of natural gas and drive prices down. Because it is unknown how the politics will develop in regards to this issue, as the situation develops, it is assigned a medium likelihood.

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[21] https://www.houstonchronicle.com/business/article/Trump-officials-examining-states-authority-in-12413291.php

[22] https://www.reuters.com/article/us-usa-pipeline-natgas/climate-activists-delay-u-s-gas-pipeline-approvals-regulator-idUSKBN1DU35J

[23] https://info.drillinginfo.com/us-offshore-drilling-announcement-unleashes-oil-gas-development-potential/

2.1.6 Shifting international trade relations

United States changed from a net importer of liquefied natural gas (LNG) to exporting a net of 2.7 Bcf as the LNG export terminal was established in Sabine Pass, Los Angeles, California. Additional LNG projects are under construction, these have been estimated to quadruple the export capacity of LNG by the end of 2019. Besides LNG, natural gas exporting tripled from over 663 Bcf in 2006 to 2.25 Tcf in 2016. The fast growth in natural gas exports and decline in imports have led the United States to be a net exporter of natural gas[24]. To support LNG export, in November 2017, The U.S. Trade and Development Agency (USTDA) introduced an initiative which connects American companies and new export opportunities in other nations as well as provide USTDA's expertise in marketing and networking in foreign markets[25]. As the natural gas industry grows within the United States the development of LNG exports would increase demand for natural gas and reduce the supply available to domestic consumers, as a result, price increases for natural gas.

Alternatively, recent policy developments could impact trade relations with Canada and/or Mexico. A reduction in export of natural gas to our main partners would increase domestic supply and reduce cost for customers. It is likely that further developments in the export of natural gas will occur, however, it is unclear how these developments will interact and impact price. Due to the number of factors potentially expanding or shrinking the international trade of natural gas, that may counteract or increase the impact of each other, this factor has a medium likelihood.

2.1.7 Water shortages and increasing prices

Development of natural gas resources using hydraulic fracturing uses large volumes of water which can impact the local water supplies, as well as water prices. If water price increases, this trend will affect negatively on the costs of hydraulic fracturing and generating electricity from natural gas. Graph 2.2 illustrates the industrial bill for 10,000,000 gallons in the fifty biggest United States cities. It is obvious that water bills for the same amount of water for industrial use increased gradually from 2001 to 2013 and the growth was more significant since 2005.

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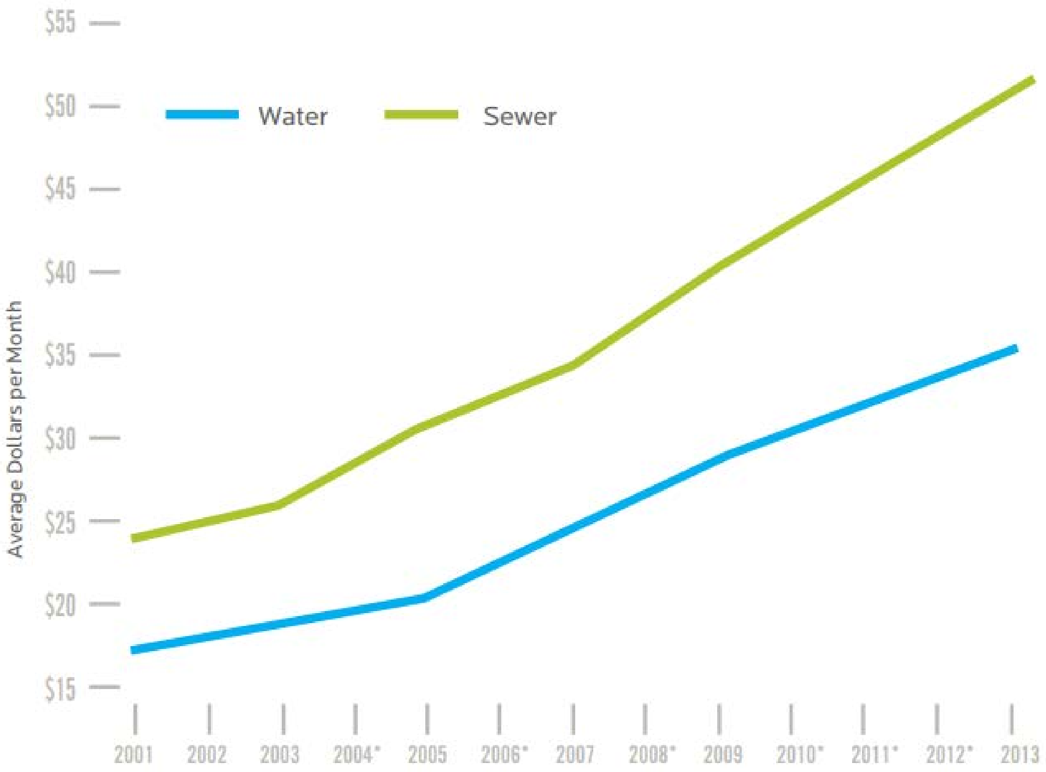
[24] https://www.energyindepth.org/u-s-oil-and-natural-gas-exports-projected-to-soar-in-2018/

[25] http://www.naturalgasintel.com/articles/112491-us-trade-and-development-agency-launches-lng-exports-initiative

Figure 2.2. Fifty largest cities trending industrial typical bill

10,000,000 gallons billable usage



Source: 50 largest cities water/wastewater rate survey

While unconventional natural gas uses a significant amount of water the cost of water will not significantly impact the cost of development and production. Therefore we see this scenario resulting in a low impact. Based on the current trend, we predict that the likelihood this scenario happens is medium.

2.3 Impact of Occurrence

This section discusses and ranks the magnitude of the potential impacts to Hoosier Energy associated with each factor, should they occur, as well as, appending each with a confidence level of the analytical results.

2.3.1 Carbon Tax

Implementation of a carbon tax will lead to an increase in the prices of coal fired electricity generation, which is the main resource Hoosier Energy use to produce electricity. In 2017, coal generation accounts for 75% of total energy produced and 58% of total capacity in Hoosier Energy's portfolio. Because of this, the magnitude of the potential impact of any carbon tax implementation would disproportionately impact Hoosier Energy. While able to recover the additional costs associated with a carbon tax, this disruptor's direct impact to consumer electricity bills leaves Hoosier Energy more susceptible to additional disruptors. Overall, given the above analysis, we conclude that the likelihood of enactment of a carbon tax in the near term is low. And based on the amount of information and discussion on this topic, our confidence in this analytical result is high.

Overall, given the above analysis, Hoosier Energy will likely need alternative solutions if this scenario happens such as increasing the percentage of natural gas or renewable energy in their resource mix.

2.3.2. Relaxing requirements in the Clean Power Plan

Relaxing requirements contained in the CPP may lead to extended deadlines, decreased emission reduction requirements, or even elimination of all requirements. This scenario allows Hoosier Energy to operate in a business-as-usual case and maintain cost-effectiveness of current generation resources. Hoosier Energy already has a plan to meet their member energy requirement at 10% by 2025 by starting a 200 MW Solar PPA program [IRP 2017]. Thus, even this scenario does not happen, Hoosier Energy can face with potential risks and would be impacted marginally. Additionally, the size of Hoosier Energy may reduce demands placed upon Hoosier Energy.

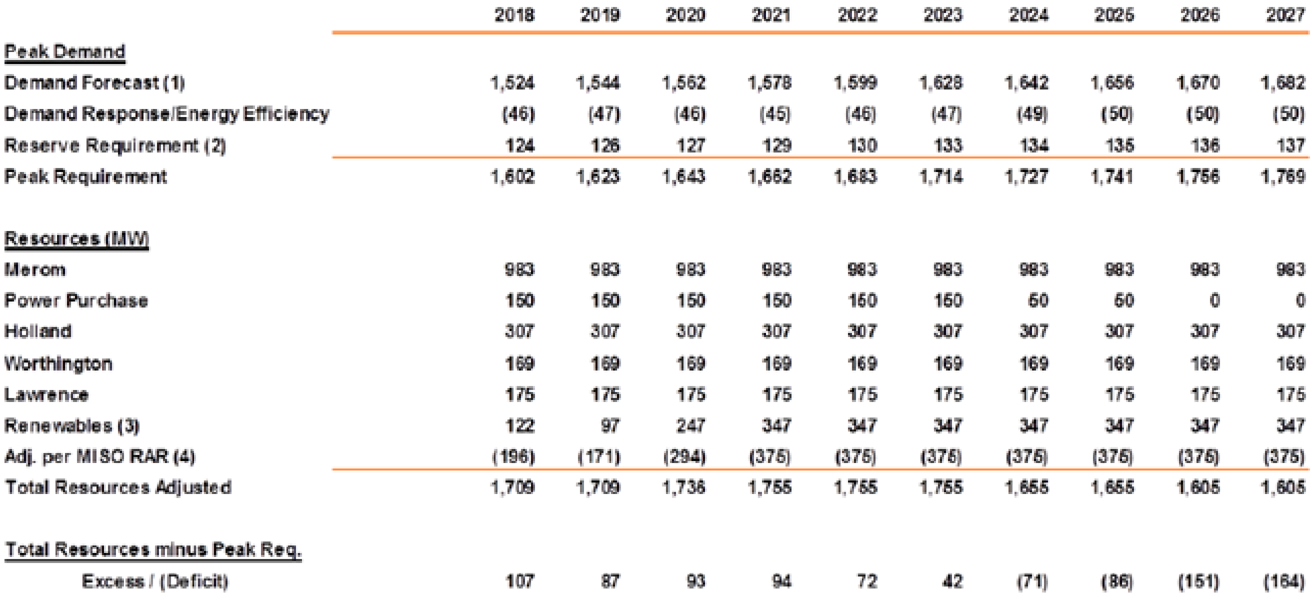
Generally, less strict requirements in the CPP offers Hoosier Energy opportunities to improve their operation without quickly changing their resource portfolio and offers minimal risk for Hoosier Energy resulting in a small impact. Based on the amount of information and discussion on this topic, our confidence in this analytical result is high.

2.3.4. Regulations on unconventional natural gas development

According to the IRP 2017, Natural Gas Combined Cycle (NGCC) is operating with relatively low variation costs and high capital costs. The annual capacity should be above 25-30% to recoup fixed costs.

Table 2.2 indicates the generation capacity expansion plan for Hoosier Energy and the total capacity expansion includes three natural gas plants (Holland, Worthington and Lawrence).

Table 2.2. Capacity Expansion Plan – Summer Peak



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Peak Demand										
Demand Forecast (1)	1,524	1,544	1,562	1,578	1,599	1,628	1,642	1,656	1,670	1,682
Demand Response/Energy Efficiency	(46)	(47)	(46)	(45)	(46)	(47)	(49)	(50)	(50)	(50)
Reserve Requirement (2)	124	126	127	129	130	133	134	135	136	137
Peak Requirement	1,602	1,623	1,643	1,662	1,683	1,714	1,727	1,741	1,756	1,769
Resources (MW)										
Merom	983	983	983	983	983	983	983	983	983	983
Power Purchase	150	150	150	150	150	150	50	50	0	0
Holland	307	307	307	307	307	307	307	307	307	307
Worthington	169	169	169	169	169	169	169	169	169	169
Lawrence	175	175	175	175	175	175	175	175	175	175
Renewables (3)	122	97	247	347	347	347	347	347	347	347
Adj. per MISO RAR (4)	(196)	(171)	(294)	(375)	(375)	(375)	(375)	(375)	(375)	(375)
Total Resources Adjusted	1,709	1,709	1,736	1,755	1,755	1,755	1,655	1,655	1,605	1,605
Total Resources minus Peak Req.										
Excess / (Deficit)	107	87	93	94	72	42	(71)	(86)	(151)	(164)

Source: IRP 2017

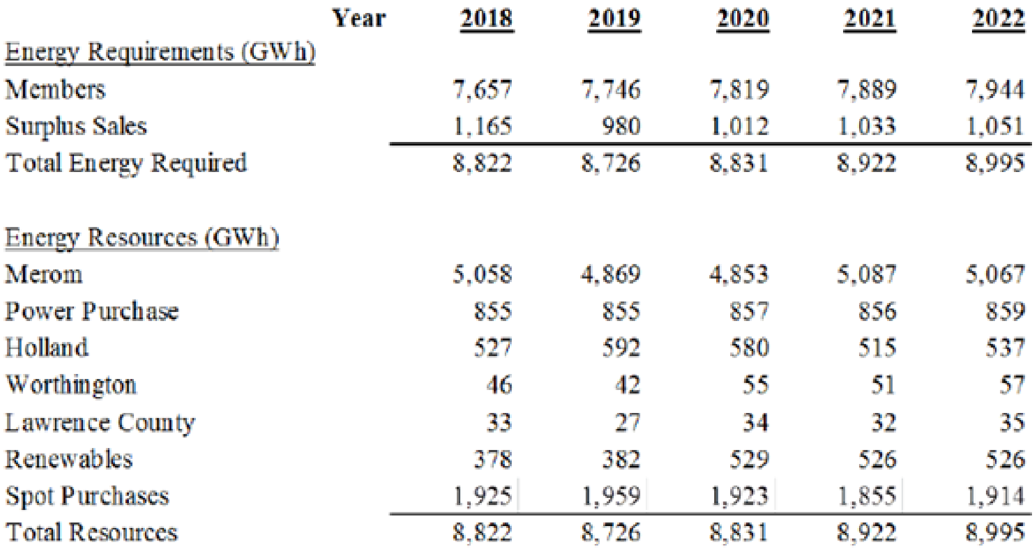
Table 2.3 shows the important roles of natural gas as alternative energy for coal in the future. These figures and the capacity expansion plan demonstrate that Hoosier Energy will lean on coal and natural gas in their future development besides and consider natural gas as a main resources in case of higher environment regulations.

Regulations on hydraulic fracturing will increase fixed costs in natural gas supply and lead to three potential impacts: (1) natural gas supply will not change significantly but the prices are higher, (2) natural gas supply will decrease with similar prices compared to before introducing these requirements.

If the natural gas supply maintains stable but with higher prices, Hoosier Energy will face with higher variation costs. In this case, the profit from their three natural gas - fired power plants will go down. In this case, Hoosier Energy may increase the proportion of natural gas in resource portfolio or increase power purchase.

If the natural gas supply drops sharply while the price does not change much, the lack of supply gradually boosts the natural gas prices. Given this condition, Hoosier Energy will face higher variation costs while their natural gas plants would not operate at large capacity to cover high fixed costs. Consequently, natural gas plants turn economically ineffective. Worthington and Lawrence's capacity is much lower than Holland, therefore, the risks they face is lower than Holland. However, if this factor happens, they cause high risks to Hoosier Energy.

Table 2.3. Annual Energy Requirements 2018-2022



Year	2018	2019	2020	2021	2022
Energy Requirements (GWh)					
Members	7,657	7,746	7,819	7,889	7,944
Surplus Sales	1,165	980	1,012	1,033	1,051
Total Energy Required	8,822	8,726	8,831	8,922	8,995
Energy Resources (GWh)					
Merom	5,058	4,869	4,853	5,087	5,067
Power Purchase	855	855	857	856	859
Holland	527	592	580	515	537
Worthington	46	42	55	51	57
Lawrence County	33	27	34	32	35
Renewables	378	382	529	526	526
Spot Purchases	1,925	1,959	1,923	1,855	1,914
Total Resources	8,822	8,726	8,831	8,922	8,995

Source: IRP 2017

The greatest impact upon unconventional gas development is the enactment of statutes that either prohibit hydraulic fracturing practices or policies that significantly curtail natural gas development in general. Although the likelihood of this scenario is low, its impacts are huge when implemented in a state with significant potential for unconventional gas development. In this scenario, natural gas supply is cut significantly. The impacts of this policy implementation are high to Hoosier Energy.

The more likely scenario is state or local governments implementing more stringent environmental regulations on hydraulic fracturing and gas development practices. This scenario opens many possibilities for the impact of policy implementation. Because of the wide-range of impacts, ranging from none to high, an overall impact of medium is assigned to these scenarios.

2.3.5. Delays in pipeline buildout

Hoosier Energy is the owner of three natural gas-fired power plants (Holland, Worthington and Lawrence). Hoosier Energy transfers natural gas to Worthington by current agreements with CIMA, and Texas Gas Transmission (TGT) [IRP 2017]. In September 2015, FERC approved the Northern Access Supply to provide an additional 384,000 million British thermal units per day in a north-to-south direction including Indiana. Recently, TGT asked for a two-year extension to complete this project[26]. This delay in pipeline buildout will affect natural gas transportation to the Worthington plant, as a result, this may affect Hoosier Energy in expanding the capacity of natural gas plants or even result in a supply shortage when generating electricity during peak times. Although Hoosier Energy has diversified their partners in natural gas supply and transportation, Hoosier Energy will face challenges if delays in pipeline buildout become a widespread problem. As mentioned above, natural gas is a key

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[26] https://marcellusdrilling.com/2017/04/texas-gas-asks-ferc-for-extra-2-yrs-on-northern-supply-access-proj/

alternative to coal and helps to reduce power purchase, therefore, the impacts of this scenario would be more serious if Hoosier Energy want to expand capacity of natural gas power plants. Again, because of the complexity of possibilities and ranges in impacts, an overall impact of medium is assigned.

2.3.6. Development of offshore oil and gas fields

This scenario will lead to an increase in the domestic natural gas supply, consequently, natural gas prices will go down. Hoosier Energy will face good opportunities to expand their capacity of natural gas power plants. Table 2.2 shows that from 2018 to 2027, Hoosier Energy does not require an expansion of their capacity, therefore, this factor just impacts variable costs associated with fuel costs during this period. To be more specific, the lower natural gas prices will encourage Hoosier Energy to run as much as their capacity to cover high fixed costs and take advantage of large scale economics, especially in peak season. Generally, this factor could influence Hoosier Energy in a positive manner, at the medium level.

2.3.7. Enhanced export of natural gas

The development of unconventional gas has opened a number of new markets for the United States to participate within. In response, the United States may work to further develop international trade of LNG. However, current international trade relationships, under certain policy scenarios may be strained and halt export of natural gas via pipeline or LNG. Reducing exports will have a medium impact as prices drop and producers adjust to the new market price. An expansion of exports will have a small impact to Hoosier due to the gradual pace of the possible increase in export that will provide producers time to increase production in anticipation.

2.3.8. Water shortages and increasing prices

Water is not only necessary for extracting natural gas but also for cooling in natural gas generation. Therefore, water shortage or increasing water prices will increase costs for Hoosier Energy.

This trend will impact Hoosier Energy through two channels: procurement and generation. A water price increase leads to an increase in operating costs for extracting, as a result, price of natural gas goes up and fuel costs for natural gas power plants increase. In addition, Natural Gas Combined Cycle needs a large amount of water for cooling, thus, a rise in water prices contributes to increase in variable costs. Water price increase affects Hoosier Energy twice in the operating process.

For water shortage, this phenomenon likely drives to two outcomes: (1) boost water prices and (2) cut down water usage. The first outcome will impact Hoosier Energy as we mentioned in the above paragraph. The second outcome may pose more risks on Hoosier Energy because there is not enough water supply for extraction (impacts on input supply) and generation electricity (lack of water to run the cooling stage). In these situations, Hoosier Energy may need to change their resource mix to increase proportion of renewable sources or an increase in purchased power. In peak season, Hoosier Energy may not meet the demand under this scenario.

Based on the above analysis, we conclude that this scenario will pose medium impacts on Hoosier Energy.

A summary of the likelihood, magnitude of impact and confidence level of analysis are presented in table 2.5

2.4 Sensitivity to Factors

The unique consideration, when considering the all of these scenarios, is that any and all of the potential outcomes may occur at the same time. In turn, these scenarios cannot and will not operate independently but rather with levels of interaction and dependency. In this section, we seek to determine the interaction of the scenarios that may amplify impacts and, identify scenarios that may reduce the overall impact to the company when various factors interact with each other.

For carbon tax, this factor will impose stronger impacts on Hoosier Energy when it is combined with stricter unconventional gas development regulations and increased water price. In this scenario, both prices of coal and natural gas increase. This leads to substantial cost increases in Hoosier Energy's electricity generation. A combination of carbon tax with either of pipeline buildout delays or water shortage will also lead to higher risks. In these situations, coal price is high with a lack of natural gas to use as an alternative source of generation. Consequently, Hoosier Energy may not provide enough affordable electricity to members. However, if carbon tax happens with offshore oil and gas development, the impact is less significant because Hoosier Energy can expand capacity of natural gas plants as an alternative solution to coal given a lower price of natural gas.

For relaxing CPP, this factor provides opportunities for Hoosier Energy to maintain two coal plants. Therefore, when negative factors related to natural gas happen at the same time with this factor, their impacts do not become more serious. In addition, both relaxing CPP and offshore oil and gas development happen will offer good conditions to maintain coal plants as well as increase proportion of natural gas in resource remix, as a result, their coal and natural gas plants is cost-effective for a longer period.

The combination of stricter fracturing regulations and water shortage/increase water price will drive the natural gas price increases sharply. This scenario will cause big risks to Hoosier Energy because the variation costs in NGCC grow sharply.

Pipeline buildout delays will lead to lack of natural gas for power plants. The impact of this factor and water shortage/increasing water price will cause difficulties for Hoosier Energy in procurement and generating electricity from natural gas, therefore, their impacts are more serious than individual impacts.

Combination of offshore oil and gas development and water shortage/ increasing water price may cancel out their individual impacts on natural gas price, however, variation cost is likely to go up in this scenario because water is one of input in electricity generating process in NGCC.

In the scenarios considered, natural gas prices are most favorable when federal offshore reserves are developed, there is little LNG or other export development, no significant state or federal regulations on hydraulic fracturing practices are implemented, and pipeline buildout is able to proceed consistently. With all of these scenarios occurring simultaneously, natural gas prices will remain low and likely fall further.

However, and perhaps equally as likely, prices will increase significantly when the opposite scenarios occur together including no development of federal offshore reserves, extensive export and LNG development, significant state and federal regulation on natural gas practices, and pipeline buildout is interrupted.

Long-term contracting for the acquisition of coal protects Hoosier Energy from seeing increasing coal prices over the length of the contract. A carbon tax or cap-and-trade program would increase electricity generation costs for the Merom Power Plant most significantly. In the near-term coal generation at Merom will remain cost-effective in all policy scenarios considered. Natural gas prices will dictate how long Merom is able to remain cost-effective and when a transition of the generation portfolio ought to occur.

Table 2.4, below describes how these policy scenarios may interact together. Those situations in which impacts work to negate one another, are considered to be a business-as-usual case. However, a number of policy scenarios interact to expand impacts and may have a substantial impact on Hoosier Energy.

Table 2.4. Interaction of Policy Scenarios

Scenario	**Carbon Tax**	**CPP Relaxed Clean Power Plan Requirements**	**Increased regulations on Unconventional Gas Development**	**Delays in pipeline buildout**	**Offshore oil and gas development**	**International trade shift**	**Water shortage and increasing price**
Carbon Tax		Unlikely to happen	Significant - High costs for coal and natural gas	Significant - lack of natural gas and high costs for coal	Neutral - High costs for coal, low cost for natural gas	Significant - Potential for increased natural gas and coal prices	Significant - High costs for coal and natural gas
Relaxed Clean Power Plan Requirements	Unlikely to happen		High costs for using natural gas but coal plants are cost effective	Lack of natural gas but coal plants remain cost effective	Positive impacts for using both coal and natural gas	Business as usual	Natural gas prices rise, coal remains cost effective
Increased regulations on Unconventional Gas Development	Significant - High costs for coal and natural gas	High costs for using natural gas but coal plants are cost effective		Significant impact on natural gas prices	Business as usual	Potential for increased natural gas prices	Natural gas increases significantly
Delays in pipeline buildout	Significant - lack of natural gas and high costs for coal	Lack of natural gas but coal plants remain cost effective	Significant impact on natural gas prices		Business as usual	Potential for increased natural gas prices	Lack of natural gas and variation costs increase
Offshore oil and gas development	Neutral - High costs for coal, low cost for natural gas	Positive impacts for using both coal and natural gas	Business as usual	Business as usual		Business as usual	Natural gas price change marginally. Variation costs increase
International trade shift	Significant - Potential for increased natural gas and coal prices	Business as usual	Potential for increased natural gas prices	Potential for increased natural gas prices	Business as usual		Potential for increased natural gas prices
Water Shortage and increasing price	Significant - High costs for coal and natural gas	Natural gas prices rise, coal remains cost effective	Natural gas increases significantly	Lack of natural gas and variation costs increase	Natural gas price change marginally. Variation costs increase	Potential for increased natural gas prices with additional exports	

2.5 Conclusion and Recommendations

2.5.1 Conclusions

The policy scenarios that are considered within this section all have the potential to impact fuel prices for Hoosier Energy. As factors outside the control of Hoosier Energy, it is essential to be prepared for all of the potential implications. This requires Hoosier to remain flexible in how they are able to provide affordable and reliable electricity to their members. Table 2.5 summarizes the findings of this section. Areas of concern include increased regulation on unconventional gas development and delays in pipeline buildout.

2.5.2 Recommendations

Based on above analysis, we suggest some recommendations to tackle to potential risks Hoosier Energy may face if above factors happen

- Hoosier Energy should gradually have plan to increase proportion of renewable energy in resource portfolio anticipating that requirements in a CO2 emission policy (a relaxed CPP-like policy) will be introduced in the not too distant future. These resources are more stable because inputs are not traded in the market. Therefore, using them as alternative for coal and natural gas will improve resiliency.
- Long term and short-term contracts should be maintained for coal to minimize the impacts of increase coal prices on Hoosier Energy. In addition, this strategy also should be applied to natural gas. Currently, Hoosier Energy already diversified suppliers to avoid potential risk, however, Hoosier Energy should establish long-term contracts with most of partners to protect against volatility and reduce costs over the long-term as natural gas costs rise.
- Hoosier Energy does not have plan to expand the coal based generation at the Merom plant while the fixed cost to establish natural gas fired power plants is very high. Therefore, major investments in large-scale generation is inappropriate at this time. Any additional generation needed should be acquired through Power Purchase Agreements. Establishing long-term contracts with supplier like Duke is necessary to meet demands on peak season.

Table 2.5. Likelihood, Impact, and Confidence of scenarios

Scenarios	**Likelihood**	**Impact**	**Level of confidence**
Carbon Tax	Small	Medium - large	Medium
Relaxing requirements in the Clean Power Plan	Large	Small	High
Regulations on unconventional natural gas	Medium - small	Medium - large	High
Delays in pipeline buildout	Medium - large	Medium - large	Medium
Development of offshore oil and gas fields	Medium - small	Medium - small	Medium
Shifting international trade relations	Medium - small	Medium - small	Low
Water shortages and increasing prices	Small	Medium - large	Medium

3. Battery Storage, Distributed Energy Resources and Energy Efficiency

3.1 Scenario Description

This scenario outlines a situation where the effect of various demand-side factors significantly contributes to a net-negative effect on the size of the total load. Considered here are battery storage (the use of chemical technology to preserve electrical energy for use over time), distributed energy resources (generating capacity deployed at the customer level), and energy efficiency practices (techniques and changes to reduce the size of the overall load). This section will outline these factors, their causes and potential repercussions.

3.2 Impact of Battery Storage

According to the Energy Storage Association (ESA), a leading trade organization for the storage industry, storage comes in a variety of forms that range from “scalable banks of advanced chemistry batteries and magnetic flywheels, to pumped hydro-power and compressed air storage.” ESA emphasizes that storage is energy neutral, i.e. that it does not discriminate against the original source of power.[27]

Battery storage could be considered the silver bullet that will usher in an area of renewable energies, many of which technically and economically operate in vastly different ways than traditional fossil fuels. Renewable energies exhibit high upfront costs and low to negligible operating costs. These aspects, combined with high intermittency of reliable supply, make battery storage a necessary requirement to cost effective and reliable electricity. It would behove Hoosier Energy to monitor trends at the national, local and energy power association level so that it can appropriately respond to possible changes that may affect the operation of MISO, IURC regulations, behind-the-meter usage, and power purchase agreements.

At this time of writing, battery storage in its current economic- and technological-development does not pose a substantial threat to Hoosier Energy's status quo. Primarily because Hoosier Energy is a part of MISO, which has massive energy reserves and can easily and quickly dispatch energy across its service area, battery storage is less necessary since MISO has the ability to "bank" excess energy. Additionally, based on data from the "2017 Residential End-Use Survey," a large portion of Hoosier Energy's customers are retired, fall within a middle-class income bracket, do not own electric vehicles, and use propane for a primary fuel—meaning that they are less likely to adopt costly battery storage systems. I speculate that the confluence of income and low cost electricity hinder behind-the-meter battery storage application for in-home systems. Finally, a federal-level ruling such as FERC Order 841 that requires RTOs/ISOs create economic models to electric storage systems will not have much impact on Hoosier Energy, as long as it stays within a large grid operator. As a primary advantage of MISO is that its breadth and management of resources mitigates

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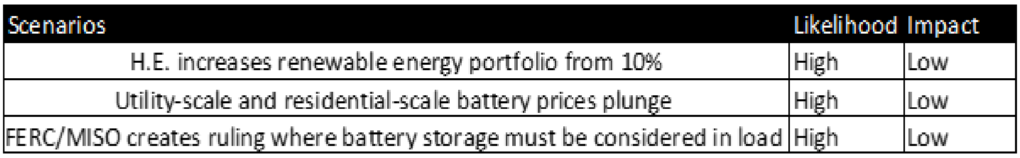
[27] http://energystorage.org/energy-storage

swings in not only the flow of electrons, but in overcoming rules that reduce market barriers. MISO dispatches energy in a fuel-neutral and market-competitive way.

3.2.1 Qualitative risk assessment of three battery storage scenarios

To assess possible impacts that enhanced utilization of batteries could have to Hoosier Energy, three scenarios were considered.



Scenarios	Likelihood	Impact
H.E. increases renewable energy portfolio from 10%	High	Low
Utility-scale and residential-scale battery prices plunge	High	Low
FERC/MISO creates ruling where battery storage must be considered in load	High	Low

3.2.2 H.E. increases renewable energy portfolio from 10%

There is a high likelihood that Hoosier Energy will increase its usage of renewables from its current level to 10% of its overall electricity supply. Even though the mandate was established in 2014, Hoosier has added on 7% renewable Energy by 2016. By 2025, the goal is to reach 10% renewable sources. This will likely happen as costs keep falling and as customers increasingly demand cleaner and cheaper electricity sources. This increase in renewable sources will have a low impact on H.E. mainly because of MISO's ability to act as an electricity bank. Specifically, MISO's control of electron scheduling shields Hoosier from massive swings energy supply stemming from increased use of renewable energies. Additionally, instead of building its own solar or wind farms, Hoosier could enter into PPAs, which would reduce power volatility because they stipulate a certain amount of megawatt hours required from the supplier.

Hoosier Energy has two main ways to think about battery storage in terms of increased power reliance on renewable energies: First, the use and economics of battery storage is a larger issue for MISO since FERC mandates it must include storage solutions in its grid operations. So for now, Hoosier should simply stay abreast of federal- and MISO-level regulations. Second, battery storage becomes a unique issue for Hoosier Energy if it decides to build and/or invest in physical renewable energy power plants. If Hoosier must maintain and operate these plants (without strong guarantees of power reliability from MISO or PPAs), then battery storage becomes a viable solution to storing excess renewable energy.

3.2.3 Likelihood of Utility-scale and residential-scale battery prices plunge

There is a high likelihood of this occurring. The international arms race to make cheaper batteries is already ongoing for EV lithium-ion batteries (and this is also happening to utilitysized ones too).[28] [29] Overall, we predict a low impact on H.E. According to a Bloomberg New Energy Finance report, lithium-ion batteries (so far the most promising and available technology) suffer from a poor supply chain for battery components while oversupply is suppressing prices, decreasing revenues and making it harder to find investment. Additionally, the widely varying price of li-ion batteries lessens the likelihood of adoption and thus lowers impact on Hoosier. According to Holger C. Hesse et.al. in “Lithium-Ion Battery Storage for the Grid…” $/kWh ranges wildly meaning much more R&D needs to be performed before 1TWh capacity is technically and economically feasible.[30] Based on the 2017 Residential End-Use Survey data, many Hoosier customers fall within categories typically not deemed to be early technology adopters. Regardless, however, is the fact that many customers live in rural areas typically prone to more blackouts. These people may be more inclined to adopt a battery system if it lessens the frequency and severity of a power outage.

In summary, as long as Hoosier relies upon MISO for controlling the flow of electrons in its large service territory, the price of battery storage systems is insignificant. However, if large enough numbers of Hoosier customer begin installing their own battery storage systems (i. e. agricultural consumers find in-home use for their large farm equipment batteries), then Hoosier should consider economic schemes that would prevent these customers from dropping off the grid for hours/days at a time. A proposed solution could be Hoosier-leased battery systems that would lock in users to paying monthly installments of the upfront cost. Additionally, such units would require some kind of grid interconnection, meaning that Hoosier Energy could still monitor them from in-front-of-the-meter to ensure a stable power supply load.

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https://www.eia.gov/analysis/studies/powerplants/capitalcost/pdf/capcost_assumption.pdf “Capital Cost Estimates for Utility Scale Electricity Generating Plants” EIA, 2016

[30] “Furthermore, this work points to a dramatic uncertainty in resulting cost for Lithium-Ion Battery (LIB) based storage systems: a vague range of 75–1130 US$/kWh has been derived from cost projections at a potential future production capacity of 1 TWh [12]. It can be concluded, that there is need for increased attention and further R&D on the storage system level to lower cost and improve the performance at the system level, where the application-specific value creation takes place.”

Pp2 From “Lithium-Ion Battery Storage for the Grid—A Review of Stationary Battery Storage System Design Tailored for Applications in Modern Power Grids” *Energies*, 2017

3.2.4 Likelihood FERC/MISO creates ruling where battery storage must be considered in load planning

There is a high likelihood of this occurring, and the newest FERC order is a great example of such a policy change. FERC order 841[31] aims to "removes barriers to the participation of electric storage resources in in the capacity, energy and ancillary services markets operated by Regional Transmission Organizations and Independent System Operators." RTOs/ISOs have 270 days to submit compliance filings and 365 days to implement tariff revisions. However, there is already pushback by RTOs to clarify the ruling; MISO wondered if storage could be treated as transmission; international power company AES (Indiana Power and Light is a subsidiary) asked for a rehearing to go over issue of how IPL's battery storage theoretically can operate without even being dispatched through an RTO[32] and questioned why 100kW threshold was given; MISO wants clarification for state and local laws (similar to PG&E's fear of customers opting out because of storage[33]). In essence, RTOs/ISOs want clarity over rules.

The impacts of battery storage ruling could affect Hoosier Energy in different short and long-term ways. In the short term, there is a low impact while in the long term, there is a high impact. Short term: the likelihood of effective date coming in 90 days (this marks beginning of 270-day window to submit compliance filings) very low since many RTOs/public power associations have clarity and implementation questions. Long term: depending on how well state and local jurisdictional rights are respected, Order 841 could devastate the monopoly power utilities and cooperatives hold on electricity. If this power is diminished, then behind-the-meter usage by retail and residential customers could explode. For the short term, Hoosier Energy should wait until further FERC and MISO clarifications come about. In the long term, H.E. should work with MISO and power associations to ensure monopoly control over flow of electrons stays in hands of utilities and is not devolved to consumers. Signs Hoosier should worry about decentralized control of power resources would be seen in high adoption of home battery storage systems, CCA schemes, and a proliferation of various DERs.

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[31] https://www.ferc.gov/media/news-releases/2018/2018-1/02-15-18-E-1.asp#.WraWmS7wbX5 FERC order 841

[32] https://www.rtoinsider.com/ferc-order-841-energy-storage-89016/ RTOs/ISOs pushback on FERC order 841

[33] "The company [PG&E] warned that 'if the commission were to conclude that the state no longer has this authority, then a retail customer could use its behind-the-retail-meter storage resource as a means to completely bypass retail rates for its onsite electricity consumption. The customer could simply claim that all electricity flowing through his/her retail meter went into the storage device for later discharge into the wholesale markets, even if the power were never returned to the wholesale market but instead used to meet on-site electricity demand.'" https://www.rtoinsider.com/ferc-order-841-energy-storage-89016/ RTOs/ISOs pushback on FERC order 841

3.3 Growth of Distributed Energy Resources and Demand Side Management

3.4 Scenario Description

This section analyzes the effects of changes in two factors affecting the size of Hoosier Energy's total demand. The first is the growth of residential small-scale energy production resources, such as rooftop solar photovoltaic installations. Ratepayers can use these systems to account for shares of their electricity demand and also to send excess electricity back onto the grid. The second is demand-side management practices, a catch-all term referring to the various techniques utilities can implement to influence consumption behaviours. These strategies are typically employed to pursue the twin goals of increasing energy efficiency, reducing overall demand, and shifting usage habits to "trim" peak loads and achieve a smoother overall load curve. Both goals contribute to lower rates for customers, as well as a more efficient and sustainable energy system.

Both distributed energy resources and demand side management practices have the similar effect of changing the size and shape of the load base that Hoosier Energy needs to supply for. This section outlines the likely repercussions of growth in each of these arenas.

3.4.1 Impact of increases in energy efficiency continue to reduce load

Following the 2014 repeal of Indiana's rules setting targets for demand-side management, the state initially saw a 40% decline in energy savings. Since then, critics have argued that demand-side efficiency efforts face institutional bias relative to the installation of new generating capacity.[34] The state's utilities, despite this setback, have continued to express interest in pursuing the programs and have worked with the IURC to do so. Hoosier Energy has seen significant improvements through its efforts to promote energy efficiency, totalling 57,800 MWh of energy savings in 2016.[35]

Still, the state's regulatory environment continues to harm efficiency programs. Along with the policy repeal in 2014, legislators greenlighted an opt-out for a wide range of industrial customers to avoid paying into efficiency programs. The result is that 40-50% of Indiana's total load is not contributing to these programs on their electricity bills. While other states have opt-out programs for industrial customers, Indiana's program is unique because it allows for a much wider range of industrial customers to qualify.[36] Critics point to the

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[34] Brooks-Gillies, J. (2017) "Efficiency on the upswing in Indiana, but slower after the repeal of key policy." *Energy News.* November 2, 2017.

[35] Hoosier Energy 2018 Integrated Resource Plan.

[36] Brooks-Gillies, J. (2017) "Efficiency on the upswing in Indiana, but slower after the repeal of key policy." *Energy News.* November 2, 2017.

regulatory situation and specifically the industrial opt out as a significant limiting factor in the total effectiveness of energy efficiency programs.

Figure: Midwestern States with and without energy efficiency requirements and whether industrial customers have the option to opt out of program participation.
Source: Midwest Energy Efficiency Alliance

The result is an energy efficiency situation in Indiana that shows significant room for growth. Utilities including Hoosier Energy have expressed serious interest in continuing to grow the effectiveness of their programs, and other states have shown that significant progress is possible. On the customer side, ratepayers will continue to be more mindful of their electricity use, through various educational programs and incentives. Appliance technology efficiency requirements have increased in stringency in the last decade due to federal rule changes, and as consumers continue to replace old appliances these benefits will become more pronounced. As integrative home technologies spread in prevalence, appliances will see fresh gains in coordinating with the power supply network.

As a function of limited progress so far relative to other states, increased consumer awareness and technological improvements, is it considered likely that Hoosier Energy will continue to see improvements in reducing overall load due to energy efficiency and other demand-side management programs.

3.4.2 Impact of distributed energy resources contribute to intermittent load

While utility-scale solar photovoltaic capacity installations have been popular in Indiana and continue to make up a significant portion of Hoosier Energy's load, residential installations have seen less progress. The share of Hoosier Energy's customer base with their own distributed generation systems is still only 1.5%,[37] significantly lower than other states. This points to the potential for significant growth in distributed energy resource installations, specifically rooftop solar. Other factors contributing to the possibility of distributed energy resource expansion include the continually falling cost of solar installations and increasing consumer demand, as well as the noted potential for home battery storage prices availability to become more favorable.

The effects of increases in distributed energy resource installation will be similar to those of demand-side management and other energy efficiency practices: a downward effect on load. Generation from the renewable sources also has the potential to contribute to the exaggeration of the daily load curve known as the "duck" curve, accentuating the ramp-up of demand in the late afternoon. This may result in a decreased though more complex demand situation.

3.4.3 Likelihood of Occurrence

The likelihood of demand-side management practices and distributed energy resources continuing to play a significant role in affecting the size and shape of Hoosier Energy's load is high. These are trends that are only being paid more attention, not less. Changes in the regulatory environment are unlikely but could allow for even further incentivizing of load-shifting.

The magnitude of this impact is expected to be low. Many other factors also contribute to the size and shape of the load demand, including consumer demand, economic activity within the service area, population growth and technological changes such as transportation electrification. Demand side management and distributed energy resource proliferation will continue to push down overall demand, but the strength of this effect will likely be overshadowed by other factors.

The confidence in this assessment is high. These are established trends that have withstood a volatile regulatory environment. Prices continue to fall for distributed energy resources such as solar photovoltaic installations. These factors will continue to play a role in Hoosier Energy's demand for years to come.

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[37] Hoosier Energy End-Use Survey Data, 2017

3.4 Conclusions and Recommendations

3.4.1 Conclusions

This section analyzed the potential effects of several scenarios within the realms of battery storage, demand-side management and distributed energy resources. Hoosier Energy’s renewable energy portfolio increasing above 10%, a fall in battery storage prices and FERC/MISO considering battery storage in load were all considered to have high likelihood and low overall strength of impact. The spread of distributed energy resources and energy efficiency program success at the end-user level are also expected to have a high likelihood of occurrence and low overall magnitude of impact.

3.4.2 Recommendations

- Hoosier Energy should pay close attention to MISO and IURC's efforts to understand and comply with FERC Order 841 since the ruling leaves unclear state- and retail-level challenges to broader use of battery storage.[38]
- Hoosier Energy should monitor trends that would dramatically decrease the cost and accessibility of battery storage systems. Federal- and state-level policies will either be barriers or portals to widespread battery storage since lithium ion technology (soon followed by others) is quickly becoming technically and economically feasible."
- Hoosier Energy should pay attention to the warning signs of aggregator schemes and distributed energy resources and be prepared to pre-emptively act, which may require investing in new energy sources (including battery storage) to maintain its rate base. By adopting new technologies consumers want and/or buying and leasing out battery storage systems, Hoosier will make it harder to customers to leave its electrical grid services.
- Hoosier should continue to pursue demand-side management strategies, including the spread of DER and energy efficiency programs in order to manage load and total system efficiency.
- Hoosier should consider developing programs to facilitate the provision of DER opportunities for customers.
- Hoosier should consider the potential for lower all-else-equal load than may be currently predicted.

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[38] For example, the 2013 Transmission, Distribution, and Storage System Improvement Charge (TDSIC) is a rate adjustment mechanism makes it easier for utilities to make infrastructure investments without having to "await consideration for cost recovery in a base rate case." http://www.in.gov/iurc/files/IURC%20annual%20report%20web.pdf

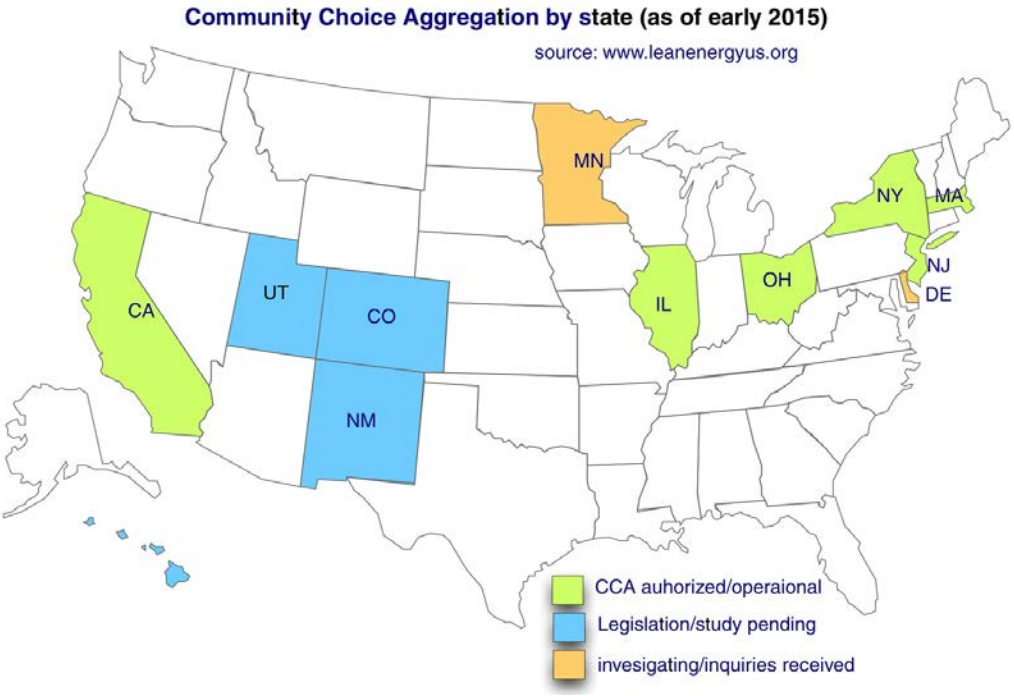
Indiana Utility Regulatory Commission 2017 Annual Report

4. Community Choice Aggregation

4.1 Scenario Description

Recent shifts in energy independence schemes has been augmented by an increase in complimentary technology. The most salient of these independence schemes has been the Community Choice Aggregation (CCA). CCA's are an alternative to the typical utility paradigm. Instead of getting power from an investor owned utility, public utility or REMC, customers aggregate and allow this aggregation to decide where they receive their power generation. This could include a power purchase agreement with a generation resource or a bid into an RTO/ISO market.

Figure 4 – Map of CCA legalization across the United States



Although CCA's have been in existence for over two decades[39], it has seen a rise in popular usage over the last half decade, with California leading the way. The path of policy diffusion will be an important trend to follow. The ability for Hoosier to track the diffusion rate of policies incentivizing CCA's will allow them to make the changes necessary to adapt. Currently CCA's provide energy for 5% of Americans[40]. CCA's have been especially popular with Ohio, where the largest CCA in the country serves more than 500,000 customers. The

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[39] "Power Play". *fastcompany.com*. 1 September 2008. Retrieved 26 April 2017.

[40] "Community Choice Aggregation - Definition by CCA Inventor Local Power Inc". *localpower.com*. Retrieved 26 April 2017.

section below will outline the potential for CCA's to disrupt Hoosier Energy, the markers of aggregation and recommendations to avoid member defection.

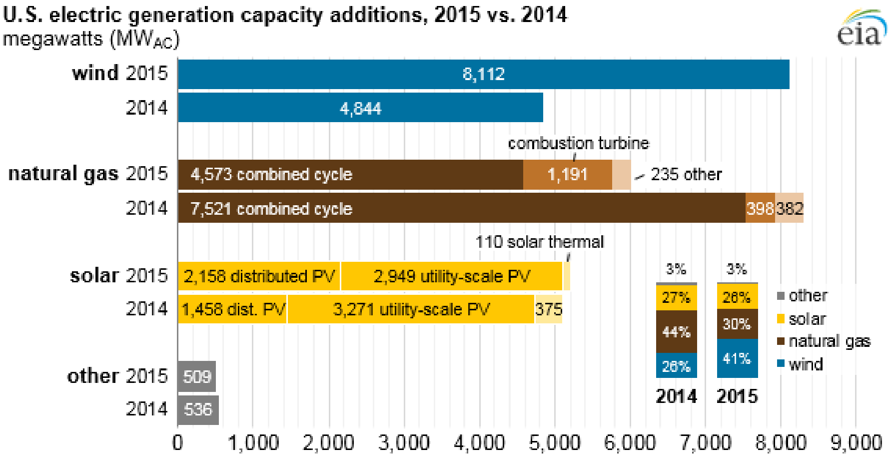
4.2 Impact Technological Shifts

One of the more nascent technologies has been blockchain. Blockchain is a decentralized ledger which necessitates self-verification for transactions. This allows all participants in the blockchain to see what transactions are being made, and at what price. This prevents fraud, and eliminates information asymmetry. Initially being used as a way to verify cryptocurrency transactions, blockchain has since gained momentum with influential tech companies[41] including Microsoft and IBM. Since these early adopters it has been functionally used by large market players like Kodak and Cisco[42].

The rise of blockchain has not been limited to the logistics, banking and technology sectors. It has more recently entered the energy market through start-ups like LO3 energy which seeks to use blockchain as a way for individual who produce energy through roof-top solar or other distributed energy resources to sell it to their neighbours[43]. Safe, verifiable, peer to peer payment for energy generation coupled with CCA's presents a clear and present threat to the traditional utility model.

Blockchain in the energy sector is often mentioned being utilized with distributed energy resources. Wind and solar are the two most abundant DER's in the United States and their installations have increased as shown below:

Table 4.1.1 – US Electric Generation capacity Additions



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[41] https://azure.microsoft.com/en-us/solutions/blockchain/.

[42] https://www.prnewswire.com/news-releases/5-companies-moving-blockchain-to-the-next-level-675263553.html.

[43] https://www.siliconrepublic.com/machines/brooklyn-microgrid-blockchain-energy-networks.

DER's provide the opportunity for customer to become producer, while having a market created through a blockchain. DER's also allow power producers in deregulated states to have direct access to their customers. In the Marin County CCA, which is run through the municipality, the consumers decided they wanted more renewable energy in their power supply and went outside of the utilities through a PPA to achieve this.

Blockchain and distributed energy resources are both currently mature technologies that have grown in popularity and deployment over the last five years. These technologies can be used in isolation or in concert to disrupt traditional utility function, including that of Hoosier Energy. Both of these technologies can be leveraged by a CCA to provide incentive for a non-renewal of the evergreen contracts and formation of a customer owned or municipality owned aggregator.

4.2.1 Likelihood of Legal Occurrence

Community Choice Aggregation is not available in all states. It requires legal precedent. The states which have allowed CCA's are all in deregulated markets. This is a natural outcome of a market that separates the various stages of the energy sector. The current legal state of CCA's is displayed in the table below:

Table 4.1.2 – Legal Standing of CCA schemes in selected states

Legal Authorization for Community Choice Aggregation			
State	**Year**	**Authorizing Legislation**	**Authorizing Legislation Name**
Massachusetts	1997	M.G.L. ch.93A §1	Utility Restructuring Act of 1997
Ohio	2001	Local Ballot Measure	N/A
California	2002	Assembly Bill 117	N/A
Illinois	2002 (residential)	220 ILCS 5/Art. XVI	Electric Service Customer Choice and Rate Relief Law of 1997

New Jersey	2003	Assembly Bill 2165	Government Energy Aggregation Act of 2003
New York	2016	PSC Case 14-M-0224	Order Authorizing Framework for Community Choice Aggregation Opt-Out Program
Rhode Island	1996	RIPUC No. 8124	Utility Restructuring Act of 1996

Utah, Colorado, and New Mexico all have CCA legalization on this year's ballot. Delaware and Minnesota have commissioned studies to assess the impact of legalization. Utah and Minnesota are particularly interesting in this list as they are regulated energy markets and would be the first of such to legalize CCA's. The structuring of these CCA's would be important to note as Indiana could choose to adopt a CCA with deregulation and use these two states as laboratories for that project.

Although California has completely legalized CCA's they have been more rapidly adopted in the last few years with large counties including Los Angeles, San Diego, and Fresno anticipated to debut CCA's this year.

The cases of Ohio and Illinois should be particular important for Indiana, and Hoosier Energy. These states are deregulated energy markets which is an important and necessary legal predecessor to aggregator schemes. Ohio and Illinois have both enjoyed success with their CCA programs with Ohio holding the largest single CCA in the US. With neighbouring states finding benefits in a new energy paradigm, CCA's could become a catalyst for renewed talk of deregulation and legality of aggregators.

4.3 Conclusions and Recommendations

4.3.1 Conclusions

In order to assess the exposure of Hoosier Energy to a CCA, a framework of impact, likelihood and confidence was used. These metrics were ranked from low to high, giving an indication of their relative magnitude to Hoosier Energy.

The space of utilities is rapidly changing in the energy world. New technologies, both energy specific and economic are the catalysts of a new energy paradigm. This new economy depends on the mobility of energy resources, consumer choice and the bypass of traditional utility models. Community Choice Aggregation is the natural outcrop of these characteristics. It is the final outcome of many preceding events.

Proliferation of blockchain technology coupled with deregulated markets are the two largest hallmarks for CCA ripe municipalities or communities. The former allows consumers to pay one another for electricity generated on their own (i.e. Roof-top solar, run of the river hydro). The latter sets the legal precedent for aggregation schemes to form as many states have regulations in place which specifically disallow the formation of such schemes. If these two pieces were to become realized at a national level, or at the state level of Indiana it would most certainly spell the creation of an aggregated energy community. Every state which has legalized the practice has seen an aggregator form. The policy diffusion of multiple new technologies and practices is key in understanding the potential for CCA formation in Indiana.

The table below summarizes the three scenarios mentioned in this section. It includes their impact, likelihood of occurrence and the confidence in assessment.

Table 4.2 – Table of summary of scenarios

Scenario	Impact	Likelihood	Confidence
Community Choice Aggregation legalization	Very High	Medium-low	Medium
Market Deregulation	High	Med	High
Adoption of Blockchain by Energy Sector	Medium-Low	Med	Low

4.3.2 Recommendations

- Closely follow the policy diffusion for electricity deregulation. With the current administrations push for free market solutions in other sectors, energy could be next.
- If the energy market is deregulated in Indiana, watch for accompanying legal language allowing aggregation or not outlawing it.
- Assess customer interest in blockchain technologies as a way to pay for electricity. It presents an opportunity for Hoosier Energy to get a head of the technological curve.
- Offer customers a storage option, whether it is through vehicles, or a dedicated storage facility run by Hoosier Energy. This will alleviate grid congestion and allow Hoosier to charge for the service rather than lose out to individual customers who may install storage capacity.
- Monitor the progress of all of the trends in battery storage, DER's and aggregation legality with respect to the evergreen clauses in the utilities agreement. If several of these factors become a reality near the end of an evergreen, this would be the ideal time for a utility to defect.

5. Discussion and Summary

A major theme presented in this assessment of policy and technological disrupters impacts on Hoosier Energy's overall resiliency is the need to pay attention to legal and policy, as well as, technological changes that are happening at a fast pace within the electricity sector. The majority of scenarios—ranging from the electrification of agricultural implements and equipment to carbon pricing and to energy aggregator schemes and storage—all reflected unexpected tumult in energy regulations and technological disruption from the development and adoption of new technologies. FERC Order 841, which mandates RSOs/ITOs create tangible plans for the addition of storage systems into electricity load planning is one such example of a regulation shaping the future path of utility operations. In the case of electrified agricultural vehicles, laws regarding grid operation and the decisions on standards made by the major manufacturers will help to determine what kinds of technology application would be used. When looking at the economics and reliability of the Merom generating station, a price on carbon, emissions regulations, and vacillating approaches to oil and natural gas pipeline siting and E&P all cloud a G&T's decision to continue utilizing coal as a fuel or to discontinue its use. The technologies and practices associated with battery storage, DERs, and CCA, are all highly subject to rapidly evolving state and federal rulemakings. The most important thing Hoosier Energy should pay attention to is a possible confluence of policies and associated regulations that create a runway through which various energy regulatory schemes harmful to Hoosier's bottom-line could take flight.

Another important change to monitor is politics surrounding different energy technologies and consumer preference. As mentioned before, with the changing of federal administrations, new priorities are created and such initiatives could either help or hurt Hoosier Energy's grid resiliency goals. We therefore recommend Hoosier Energy pay attention to and, if necessary, join a lobby organization that shares its ideas of a well-functioning energy industry. In addition to the importance of the changing tide of politics, new consumer demands for different energy sources is very important for all utilities, but especially for cooperatively-owned utilities. According to the 2017 Residential End-Use Survey, a majority of Hoosier Energy customers are not likely to be strong early adopters of immature and expensive new energy systems; however, as prices plummet and if deregulation of the electricity market continues, more customers may adopt CCA, solar panels, battery storage, etc.

Finally, the impact of technological change cannot be forgotten in terms of how it is shaping the energy industry. However, surprisingly, technology seems to lag behind legality and politics in terms of how strongly Hoosier Energy could be impacted. Currently, Hoosier Energy's ability to rely on MISO for energy "banking" and its relatively non-activist customer base protects it from the slapdash rate of technological change. Rather than hedging future energy power plant build out on the price of battery storage or customers' demands for more renewables, Hoosier Energy is in a comfortable place that allows it to assess the rapidly changing energy economic and technological environment and then make conclusions.

It is also important to consider the potential for intersectionality among the various scenarios we discuss here. The reality of life is that none of these individual scenarios would operate in a vacuum and that the interactivity of several could compound the impact to Hoosier. In each scenario, the critical role of state-level policy is identified. If the state of Indiana were to pass a significant energy bill incorporating a number of policy changes at once, the result could be rapid change in multiple arenas. An example of this includes the passing of a federal carbon tax, which would not only lead to a significant rise in the costs associated with Merom, but would also accelerate the electrification of the transportation and agricultural sectors and incentivize the spread of storage technologies and distributed energy resources. At the state level, legalizing community choice aggregation schemes and tightening the rules for energy efficiency could together significantly reduce the overall demand for power within Hoosier Energy's service territory over the course of just a few years. These examples point to the importance of considering the ramifications of policy changes that reach far across Hoosier Energy's various concerns.

In summary, we have found that Hoosier Energy currently has a resilient position and the company has the ability to continue to prosper while assuring its ratepayers with low-cost and reliable electricity, while at the same time, providing flexibility and enhanced options for obtaining this critical resource in the face of ever increasing technical and policy complexities.