ENERGY STORAGE IN IOWA: MARKET ANALYSIS AND POTENTIAL ECONOMIC IMPACT

EXECUTIVE SUMMARY

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IOWA energy office

TABLE OF CONTENTS

INTRODUCTION 4

STATE OF ENERGY STORAGE TECHNOLOGIES TODAY 6

REDUCE ENERGY COSTS AND IMPROVE RELIABILITY 8

POTENTIAL ECONOMIC IMPACT IN IOWA OVER THE NEXT 15 YEARS 9

BARRIERS AND BEST PRACTICES 10

CONCLUSION 12

ABOUT THE AUTHORS 15

INTRODUCTION

Following the recommendation outlined in the Iowa Energy Storage Action Plan (May 2019), the Iowa Economic Development Authority (IEDA) funded a study to evaluate the benefits and potential barriers to expanding the energy storage industry in Iowa. With the results, appropriate and decisive decisions can be applied to capture the desired energy and economic benefits available to all Iowans and businesses in the state.

At the beginning of 2020, IEDA partnered with Synapse Energy Economics (Synapse) of Cambridge, Massachusetts, and and Slipstream LLC of Madison, Wisconsin, to study, analyze and produce a report that would expand the Iowa Energy Storage Action Plan and further examine the economic potential that exists in Iowa as it relates to energy storage. This executive summary provides a high-level overview of the full report located on the IEDA website. Capturing information regarding the application of energy storage is the next logical step in preparing for this new technology to ensure Iowa is positioned to capitalize on the inherent energy and economic benefits.

When this initiative began in early 2020, the global pandemic was on the horizon but its effects on the national economy were yet to be seen. Since it was never included in the original scope of the project, its effects were not included in any of the forecasting. The distinction is important as there are sure to be numerous possibilities as to how the state and nation will adjust to these new challenges.

We expect this assessment will continue to assist the energy storage discussion as we all work toward realizing how Iowa can best utilize this new technology and take advantage of the economic and environmental benefits.

Sincerely,

Debi Durham
Executive Director
Iowa Economic Development Authority
Iowa Finance Authority


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The State of Iowa's interest in energy storage began amongst stakeholders during the formation of the 2016 Iowa Energy Plan. Energy storage intersects with several of the seven key areas of the plan, including:

- Technology-Based Research and Development
- Workforce Development
- Electric Grid Modernization
- Alternative Fuel Vehicles[1]

In early 2018, the Iowa Energy Office[2] convened the Iowa Energy Storage Committee and invited a diverse group of industry stakeholders to participate. The 2019 Energy Storage Action Plan called for a study to analyze the benefits and barriers to the sustainable growth of the storage industry in Iowa. Synapse Energy Economics, Inc. partnered with Slipstream Group, Inc. to produce a final report containing a comprehensive analysis of energy storage technologies and an assessment of the industry's economic development potential in Iowa. The report provides answers to four key questions:

1. What is the state of energy storage technologies today?
2. What services can energy storage provide to reduce energy costs and improve reliability?
3. What is the potential size of energy storage deployments and the potential economic impact in Iowa over the next 15 years?
4. What are the barriers to and best practices for the development of sustainable market opportunities for energy storage in Iowa?

WHAT IS THE STATE OF ENERGY STORAGE TECHNOLOGIES TODAY?

Energy storage is ubiquitous in the modern world, from the small rechargeable batteries that power cell phones to the hot water stored in a tank for washing dishes and showering. Today, there is limited energy storage used in conjunction with the electric power grid. All energy storage systems used in conjunction with the power grid represent a demand for electricity when charging and a supply of electricity when discharging. Energy storage systems are scalable and can be engineered to serve many different applications. Table ES-1 lists the various energy storage systems that can be deployed to potentially reduce energy costs and improve reliability.

[1] Iowa Economic Development Authority and the Iowa Department of Transportation. December 2016. Iowa Energy Plan: Executive Summary. Available at www.iowaenergyplan.org/docs/IEPExecutiveSummary.pdf.

[2] The Iowa Energy Office is housed within the Iowa Economic Development Authority and is responsible for managing a diverse mix of state, federal and utility-funded programs and initiatives that provide energy-economic benefits for Iowa's citizens, businesses and organizations.

Table ES-1. Energy storage technology types

Storage Type	Description
Batteries	Battery storage, also referred to as electrochemical energy storage, stores electricity as chemical energy in its active materials. A battery consists of two electrodes (electrical terminals) and a chemical called an electrolyte in between them. The electricity is released from a battery when a circuit is created between the positive and negative electrodes. Electric vehicles use lithium-ion batteries and can be used as a grid resource using vehicle-to-grid systems.
Hydrogen	While most hydrogen today is produced through steam-methane reforming using natural gas as the source of methane, electricity can be used to power an electrolyzer that will separate hydrogen (H2) from water (H2O) in a process called electrolysis. The hydrogen can be used as a fuel for a variety of applications. One application is to use hydrogen in a fuel cell to generate electricity.
Thermal	Thermal storage involves heating or cooling any type of material with high specific heat and discharging the medium later. The most basic (and ubiquitous) example is a residential storage hot water heater, which can be controlled to take advantage of its inherent storage potential. Thermal energy storage systems have been in use for decades in buildings, yet this approach is still under development for electric grid applications.
Mechanical	Mechanical storage uses physical-mechanical processes to store energy. Pumped hydro storage (PHS) is an example of this approach. PHS has the most installed capacity of any storage technology on the market. As of 2018, the United States had 22.9 GW of installed PHS capacity. PHS requires specific geological features including large elevation differences over a short horizontal distance, which is not common in Iowa. Another form of mechanical energy storage uses electricity to spin up a small turbine, called a flywheel, that releases energy in short bursts as needed.
Compressed Air	Compressed air energy storage (CAES) technology uses compressors powered by electricity to compress air until it is ready to be injected and stored in underground reservoirs. When the compressed air is released, it can spin a turbine to generate electricity. One of the major limitations of CAES is that it relies on existing geological formations such as exhausted salt mines or some other natural reservoir to hold the compressed air before it is released.

The Iowa Energy Storage Plan report focuses on battery energy storage systems. Lithium-ion batteries are the fastest-growing storage technology in the world. Large format lithium-ion batteries are used in a variety of applications, such as electric vehicles, stationary systems used in homes and businesses, and increasingly by electric utilities as part of modernizing the electric grid. Lithium-ion battery system costs decreased drastically over the past few years and continue to decrease rapidly. The decrease is mostly driven by economies of scale in manufacturing to meet the demand for batteries from the electric vehicle market. In less than a decade, lithium-ion batteries experienced an 87% decrease in costs[3]. Costs continue to fall for every component that goes into a complete battery system. This includes cells, modules and balance of system components.[4]

[3] Bandyk, M. December 2019. "Battery prices fall nearly 50% in 3 years, spurring more electrification: BNEF." Utility Dive. Retrieved from www.utilitydive.com/news/battery-prices-fall-nearly-50-in-3-years-spurring-more-electrification-b/568363/.

[4] Balance of system includes the container, the inverter that converts AC electricity to DC electricity, and other power electronics to manage charging and discharging of the battery system.

WHAT SERVICES CAN ENERGY STORAGE PROVIDE TO REDUCE ENERGY COSTS AND IMPROVE RELIABILITY?

Front-of-the-meter (FTM) energy storage applications refer to systems located on the utility side of the meter. These systems are typically owned and operated to provide grid-level services and can be hundreds or tens of thousands of kilowatts (kW) in size with durations from 1–4 hours.

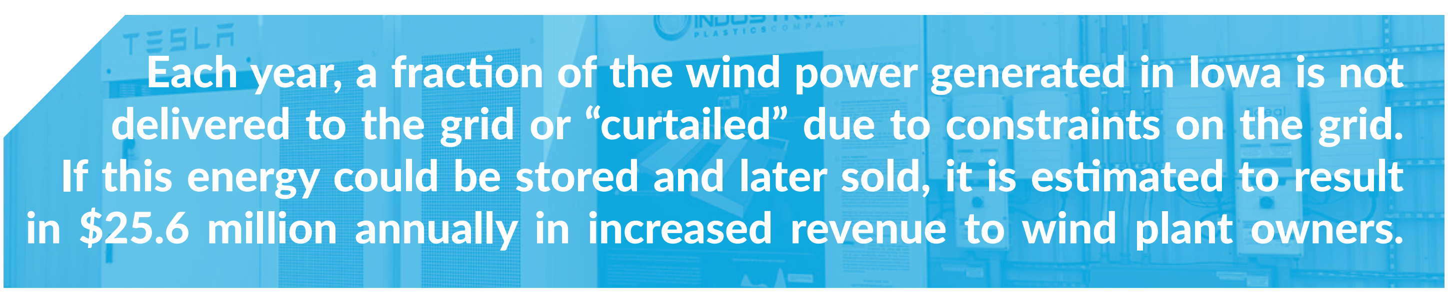
Grid operators require a suite of services from generators to help maintain reliability and the power quality of the grid. These services are commonly referred to as ancillary services. Ancillary services include frequency regulation, voltage support, black start services, reserves and reactive power support. Many storage technologies can provide grid operators with these services. Lithium-ion batteries have proven to be capable of meeting all the technical requirements to provide these services.

Grid operators must make sure sufficient generation, transmission and distribution capacity is available to serve customers and provide a reserve margin in case part of the system fails. Investments in FTM storage systems can provide capacity for grid operators, thereby avoiding investments in traditional grid technologies that provide the needed capacity.

As electric grids integrate more variable forms of renewable energy, energy storage will almost certainly play an important role. FTM energy storage systems can help manage the intermittent production of wind and solar to ensure energy is available when needed. Given the large amount of wind generation that exists in Iowa, FTM systems have the potential to play an important role for storage in the state. Each year, a fraction of the wind power generated in Iowa is not delivered to the grid or “curtailed” due to constraints on the grid. If this energy could be stored and later sold, it is estimated to result in $25.6 million annually in increased revenue to wind plant owners.

FTM energy storage systems can provide many additional benefits. Energy storage can be used to store low-cost energy and then discharge that energy during high-price periods, referred to as energy arbitrage. FTM energy storage systems can also provide resilience benefits if integrated with larger microgrids that can support city blocks or neighborhoods during prolonged power outages. Battery storage systems sited in a home or business are referred to as behind-the-meter (BTM) systems, which means the battery system is on the customer-side of the meter providing benefits primarily to homeowners and businesses themselves. BTM system owners charge the battery by purchasing electricity from the local power company and then use the stored energy to provide economic or resilience benefits. Residential battery storage systems are typically 5–10 kW in size with 3–4-hour durations. Battery storage systems for a commercial or industrial business can be as big as 200 kW or more with 2–4-hour durations.

For commercial and industrial (C&I) customers, electric bills may contain a demand charge component. Utility demand charges are stated in $/kW and are applied to the peak usage of a facility. For example, a building with peak energy use of 100 kW under a utility with a demand charge of $20/kW would see demand charges totaling $2,000 per month.[5] Battery storage systems can be used to reduce the peak use of a building, thus reducing demand charges. In this case, a 50 kW battery used to shave a building’s peak demand would save $1,000 per month. The opportunity to reduce demand charges is the main factor driving interest in BTM systems within the C&I sectors.



Each year, a fraction of the wind power generated in Iowa is not delivered to the grid or “curtailed” due to constraints on the grid. If this energy could be stored and later sold, it is estimated to result in $25.6 million annually in increased revenue to wind plant owners.

5 This is a simplified example for illustrative purposes. A battery energy storage may not perfectly offset demand and demand charges based on the rated capacity of the system. Also, the effect on the demand charges can vary depending upon, among other considerations, the specific tariff structure that the customer is under.

Another use of BTM battery storage is to reduce overall energy costs by storing low-cost energy for use during periods when the price of energy is higher. This is made possible by electricity rate structures that vary the price of energy throughout the day, so-called time of use (TOU) rates or dynamic pricing. Today, most residential customers pay the same price per kWh regardless of the time of day.

Adding a battery to a solar energy system allows the system owner to store solar energy produced during the day for later use, which is particularly valuable when net energy metering is not available. Net energy metering allows a solar customer to spin their meter backward when energy production is greater than energy use, resulting in bill credits that can be used during the evening and on cloudy days when solar production is low. Net energy metering is not available in some Iowa utility service territories; and, thus, solar paired with storage could emerge as an important BTM application.

One of the primary values of BTM battery storage is for increased reliability and resilience. During a power failure, stored energy from the battery can be used to power critical loads, such as home heating and cooling systems or a refrigerator. Businesses benefit from having an emergency source of back-up power by avoiding lost productivity due to a power outage. In larger regional outages, an emergency shelter powered with a battery can provide critical emergency services. In the event of a long-duration power outage, a micro-grid combining energy storage with a source of generation including solar or a gas-fired generator can provide emergency power for days or months as needed.

Some utilities have been experimenting with aggregating individual BTM battery storage systems for use in applications typically served with FTM systems. These systems are referred to as “virtual power plants” that rely on software controls and communication systems managed by the utility to aggregate and control hundreds or thousands of devices.

WHAT IS THE POTENTIAL SIZE OF ENERGY STORAGE DEPLOYMENTS AND THE POTENTIAL ECONOMIC IMPACT IN IOWA OVER THE NEXT 15 YEARS?

To evaluate the economic development impact of a growing battery storage system industry in Iowa, the researchers developed projections for low and high deployments between 2020 and 2035. Data from a 2019 study of the energy storage potential in Colorado were adapted for Iowa. Table ES-2 provides the estimated deployments for the low and high scenarios. Energy storage deployments are projected to range from just over 1 GW in 2035 to over 2 GW. The projection is that over 90% of energy storage systems will be deployed in utility-scale FTM applications. Without future price declines or supportive policies and regulations, actual energy storage deployments in Iowa in 2035 could be less than the low scenario.

The scale and pace of energy storage deployments in Iowa will depend on many factors, including future capital and maintenance costs for battery storage systems. Reforms within Midcontinent Independent System Operator (MISO) wholesale energy markets that impact the ability of storage to generate revenue providing grid services will impact the rate of energy storage deployments. The degree to which state regulators incentivize utilities to consider storage as an alternative to traditional utility investments is also a factor. Finally, the degree to which energy planning in Iowa considers the importance of reducing carbon emissions and the value of resilience will impact the battery storage market in the coming decade.

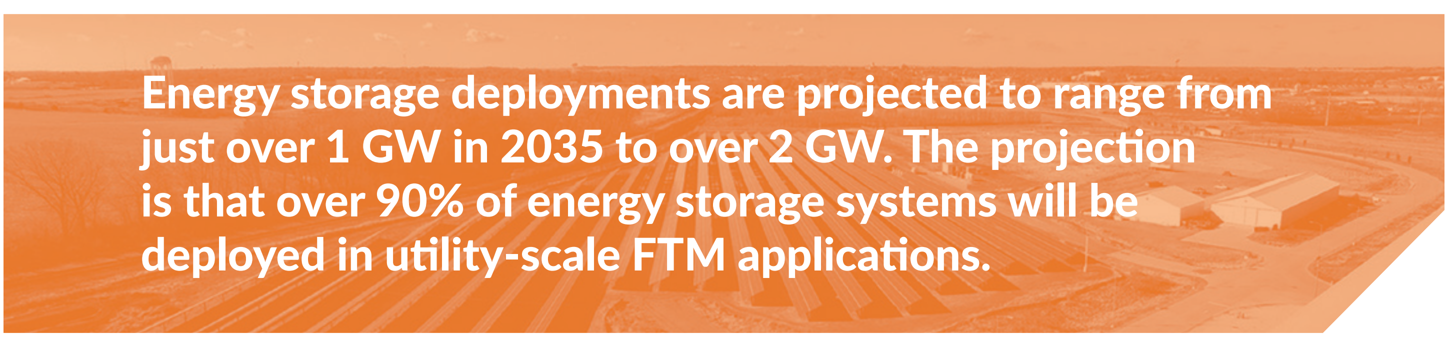


Table ES-2. Estimated low and high deployment scenarios for energy storage in Iowa

Scenario	Projected Storage Capacity (MW)				Projected Storage Energy (MWh)			
	2020	2025	2030	2035	2020	2025	2030	2035
High (Storage Generation + BTM)	1	60	1,900	2,130	3	220	7,510	8,320
Low (Load + BTM)	1	240	1,090	1,260	3	940	4,290	4,810

Currently, the battery storage supply chain in Iowa is rather limited. The state economic impacts of a growing battery storage industry are estimated to be limited, but positive. The report finds net job impacts ranging from 298 to 595 full-time equivalent jobs and state gross domestic product impacts from $13 million to $24 million per year. This could change, however, if Iowa attracts new businesses to the state that are part of the battery storage supply chain. In addition, the overall economic impact on the state could be much greater when battery storage systems are used to enable other opportunities. This includes expanding the use of wind and solar generation in the state, as well as the potential role that battery energy storage systems can play in enabling the use of in-state generation to displace imported fuels.

The report finds net job impacts ranging from 298 to 595 full-time equivalent jobs and state gross domestic product impacts from $13 million to $24 million per year.

WHAT ARE THE BARRIERS AND BEST PRACTICES TO THE DEVELOPMENT OF SUSTAINABLE MARKET OPPORTUNITIES FOR ENERGY STORAGE IN IOWA?

Stakeholder interviews revealed common concerns about barriers to battery storage deployments in Iowa. A key challenge for FTM energy storage deployment in Iowa is the inability of owners to capture the various value streams that storage can provide. Optimizing value streams takes effort in any storage project, but it is exacerbated in Iowa by lack of alignment between MISO and the multiple market participants, as well as a lack of regulatory clarity in general. In addition to the difficulty in capturing the value energy storage provides, the high upfront cost of battery energy storage serves as a barrier to installations. While the cost has been falling in recent years, the current cost continues to be an obstacle to the widespread deployment of energy storage.

The initial cost is also a barrier for BTM installations. Stakeholders stated that batteries are not currently economical as a back-up source of power when compared to fuel-powered generators, and energy rates are typically not high enough to justify the installation of BTM storage. Specifically, utilities mentioned energy rates are not high enough in their territory for solar-plus-energy storage to save enough to offset the cost. Battery energy storage is still viewed as a relatively new technology, especially when compared to traditional generation or transmission solutions. The infancy of the technology serves as an additional barrier to widespread adoption—both due to uncertainty around the technology's performance and the potential future changes to market and regulatory frameworks.

Because of the broad range of capabilities of energy storage systems, regulatory bodies have struggled to apply existing policies clearly and consistently. As a result, states started developing new policies (and policy reforms) specifically targeting electrical energy storage systems. Table ES-3 presents the range of policy and market reforms that various states pursued to address the barriers to battery storage investments.

Table ES-3. State policy and market reforms to address battery storage investment barriers

Policy type	Brief description	States with this and other policies	States with this policy only	Total
Procurement targets	Requires utilities to install specific amounts of energy storage	CA, CO, MA, NJ, NV, NY, OR		7
Regulatory requirements	Varying requirements for utilities to evaluate and/or plan for energy storage installations, among others	AZ, CA, CO, HI, MA, MD, MO, NJ, OR, VA, VT, WA	CT, ME, MN, NC, NM, TX	18
Demonstration programs	Funding for, state-led pilots of, or regulatory allowance for, individual storage projects	MA, MD, NH, NY, VA, WA	UT	7
Financial incentives	Establishment of discount rates, net metering allowances, tax rebates, or cash payments for BTM storage installations	AZ, CA, HI, MA, MD, MO, NH, NV, NY, OR, VA, VT	SC	13
Consumer protection	Provides interim allowance for BTM energy systems while standards are being developed	CO, NV		2

The Iowa Energy Storage Final Report identified three key barriers to broader implementation of storage in Iowa:

1. **Lack of current alignment between storage value and markets**
2. **The relatively high capital cost of battery systems**
3. **Uncertainty in the future (for markets, regulation and battery technology)**

Each of the five policy types described in Table ES-3 could address these barriers to some extent; however, the most successful and widespread approaches seen in other states are **regulatory requirements** and **financial incentives**.

CONCLUSION

Battery energy storage is a relatively new technology that offers significant potential as part of an overall effort to modernize the nation's electric grid.

Utility-scale FTM applications can defer or reduce investments in traditional utility infrastructure, generate revenues providing wholesale market services and increase resilience as part of microgrid systems. The researchers estimate that the utility-scale FTM potential in Iowa is between 1 GW and 2 GW over the next 15 years. The scale and pace of energy storage deployments in Iowa will depend on many other factors even with new energy policies. This includes reforms within MISO wholesale energy markets that impact the ability of storage to generate revenue providing grid services. The degree to which state regulators incentivize utilities to consider storage as an alternative to traditional utility investments is also a factor. Finally, the degree to which energy planning in Iowa considers the importance and value of resilience will impact the battery storage market in the coming decade.

Perhaps one of the most important roles energy storage can play in Iowa is to support the expansion of renewable energy generation. Battery energy storage systems can help manage the variable production of wind and solar generation. Battery energy storage systems can be charged from wind farms in Iowa during periods when the wind generation would otherwise be curtailed due to constraints on the regional grid. It is estimated that the lost revenues from wind curtailment in Iowa is approximately $25.6 million each year. This is one form of energy arbitrage, whereby a battery storage system charged during low-cost/no cost periods and then discharged back to the grid during high-price periods.

Perhaps one of the most important roles energy storage can play in Iowa is to support the expansion of renewable energy generation.

Although solar installations are limited in Iowa today, declining costs make solar a cost-effective alternative to traditional sources of generation. If solar production increases significantly in Iowa, battery energy storage systems can support increased solar deployments by managing the variable production, particularly during the morning and evening hours as the sun is rising and setting, which requires traditional sources of generation to ramp up and down respectively.

For households and businesses in Iowa, energy storage provides opportunities to manage energy use and provide resilience during major grid failures. In utility service territories without net energy metering, pairing solar with energy storage offers benefits. Stand-alone energy storage or storage incorporated into a microgrid can offer valuable resilience benefits but are often difficult to quantify. Researchers project that BTM market opportunities are more limited than those for FTM systems. Based largely on the market opportunity for demand charge reduction for C&I customers, the BTM energy storage market could reach 114 MW by 2035, based on projections on the annual growth rate for BTM systems.

Today, the battery storage supply chain in Iowa is limited. The state economic impact of a growing storage industry is estimated to be finite, but positive. This could change if Iowa attracts new businesses within the battery storage supply chain. In addition, the overall economic impact could increase when battery storage systems are used to enable other opportunities, such as wind and solar generation expansion. This also includes the role battery energy storage systems could play in enabling the use of in-state generation to reduce imported fuels.

There is no oil or gas production in Iowa due to limited crude oil and natural gas reserves; in 2018, Iowa was the fourth-largest consumer of hydrocarbon gas liquids, mostly propane. The propane is used for drying the state's large harvested corn crop and for heating one in eight Iowa households[6]. Energy storage paired with Iowa's abundant renewable resources offers a pathway to electrify the transportation, buildings, industrial and agricultural sectors. Using in-state, low carbon energy generation to reduce imported fuels used in these sectors could provide a significant impact on Iowa's overall economy.

[6] U.S. Energy Information Administration. 2019. Iowa State Profile and Energy Estimates. Available at www.eia.gov/state/?sid=IA.

It is worth considering the relatively large share of energy flow in Iowa that is ethanol. Using electric agricultural machinery to reduce fossil fuel resources in the production of corn-based ethanol could also serve to improve the energy balance of this renewable source of motor vehicle fuel. Reducing petroleum fuels in this process with renewable energy paired with energy storage provides an opportunity to make ethanol an even more environmentally superior fuel relative to gasoline. Furthermore, electrification of agricultural machinery with large battery packs could provide V2G (vehicle-to-grid) services when not in use for farming.

Iowa is home to several top-tier university research centers that could play a critical role in evaluating the opportunities to realize the full potential that battery energy storage offers. The Iowa Energy Storage Committee provides an excellent mechanism to support the development of energy storage in the state to maximize the economic and reliability benefits of battery energy storage. The committee could expand its stakeholder process to address the three key barriers to energy storage identified in this report. For example, the committee could evaluate the efforts other states are taking to support the development of the energy storage industry or engage with wind and solar industry stakeholders to explore how energy storage could reduce wind curtailments and support the growth of solar energy installations. Greater use of in-state renewable energy sources through electrification of the transportation, buildings and agricultural sectors could support regional economic development while reducing the environmental impacts of energy consumption.

Estimated that the lost revenues from wind curtailment in Iowa is approximately $25.6 million each year.


Fuse replacement chart
Li-ion
Li-ion

ABOUT THE AUTHORS

Synapse Energy Economics, Inc.

Cambridge, Massachusetts-based Synapse Energy Economics is an independent research and consulting firm specializing in energy, economic and environmental topics. Since its inception in 1996, Synapse has grown to become a leader in providing rigorous analysis of the electric power sector for public interest and governmental clients.

Synapse's staff includes experts in energy and environmental economics, resource planning, electricity dispatch and economic modeling, energy efficiency, renewable energy, energy storage, transportation and building sector electrification, transmission and distribution, rate design and cost allocation, risk management, benefit-cost analysis, environmental compliance, climate science, and both regulated and competitive electricity and natural gas markets. Synapse is committed to the idea that robust, transparent analyses can help to inform better policy and planning decisions.

Slipstream Group, Inc.

Slipstream, a 501(c)3 nonprofit organization, is mission-driven to advance economic and environmental sustainability through engineering, education and research. Slipstream's staff brings a diverse skillset to a broad variety of services supporting the mission.

Slipstream has 40 years of industry experience. Their credentials include applied research, building science and engineering and energy efficiency program development and delivery. This combination of skills and experience creates dynamic synergies to address the energy challenges we face.

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