UTILITY-SCALE STORAGE TASK FORCE REPORT

Executive Summary

Energy storage is becoming a key resource that enhances grid flexibility and increases the opportunity to integrate a wide range of generation sources. This report presents the opportunity and options for enhancing storage within Idaho. The report provides an introduction into utility-scale storage for the state but does not provide distinct recommendations. While most recent discussions of storage have focused on battery technologies, this report provides a full overview of options for the state including the integration of mechanical storage technologies including pumped hydro, electrical and electrochemical storage in the form of batteries and supercapacitors, and thermal storage. The report also provides insight into the different scenarios and applications where storage can support grid operation.

Chapters 2 and 3 of the report move into utility scale storage in Idaho. For the content of the report, utility-scale storage is viewed as storage which can directly impact grid operation and would be expected to be operated by one of the main investor-owned utilities in the state or which could directly support the various municipality or cooperatives electric utilities. The chapters include both existing projects, planned projects and areas where future opportunities exist including where battery storage could be closely coupled to emerging renewable energy developments including wind and solar. The chapters directly highlight parts of the state where expansion to the states' existing pumped hydropower storage could occur. This includes identification of regions which are close to existing high voltage transmission lines. Combining energy storage with other distributed assets provides a distinct possibility to increase both the resiliency and reliability of utility operations within the state.

The report closes in Chapter 4 with a discussion on the cost effectiveness of utility-scale storage. This is a complex discussion as storage provides multiple benefits while also augmenting the value of other resources. The chapter includes an explanation of the difference between capacity and energy costs, and how storage is crossing a tipping point of cost effectiveness. A description of "value stacking" and case example then provide context for how various benefits of storage may be analyzed and compared.

This report looks to serve as a resource to aid in the understanding of both existing and future opportunities for utility-scale energy storage in the state of Idaho. It does not provide fine detail on any one aspect but does provide sufficient information and resourcing that it can serve as a guide to further investigation. It is also important to note that the analyses and observations of this report are more generally applicable to southern Idaho than north Idaho.

Idaho Strategic Energy Alliance

In 2009, Governor Otter established the Idaho Strategic Energy Alliance (ISEA) to enable the development of a sound energy portfolio that emphasizes the importance of an affordable, reliable, and secure energy supply. In October 2020, Governor Brad Little, through Executive Order 2020-18, continued the group's operation.

The ISEA is led by a Board of Directors that are selected by and serve on behalf of the Governor. This group and its task forces create opportunities for a wide variety of in-state energy experts to assist with the development of achievable and effective recommendations for improving Idaho's energy future.

The ISEA Board of Directors identified the topic of utility-scale storage as an area where experts and policymakers can further develop their understanding of consumer and industry trends. As power and transportation systems are becoming increasingly integrated and new technologies are being deployed at a rapid pace, it is important to understand how Idaho will be impacted. Consumers, industry actors, and policymakers have been increasingly interested in enhancing energy storage demonstrations and deployment throughout the state to ensure reliable and resilient power is accessible to Idahoans.

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Chapter 1: Technologies and Markets

There are many energy storage technologies at various stages of development which are deployed for different purposes. As of 2021, the U.S. electricity system had about 24 GW of energy storage, 23 GW of which is “pumped storage” technology. Pumped storage is a form of hydroelectric power generation in which off-peak electricity is used to pump water from the lower reservoir to the upper reservoir then is deployed to serve higher cost periods of higher electrical demand. In Idaho, for example, water storage in Brownlee Reservoir provides most of Idaho Power’s peaking and load following capability. Most pumped storage in the U.S. was built before 1990.

Today, technologies and market conditions are transforming the energy sector. Deployment of utility-scale storage is growing rapidly and will include a mix of technologies in the coming decades (Denholm et al., 2021). The emerging cost-effectiveness of batteries, for example, is enabling substantial growth in cost-effective uses of utility-scale storage. Lithium-ion batteries accounted for more than 90% of large-scale battery storage projects in the United States as of the end of 2019 (Energy Information Administration, 2020).

This chapter provides an overview of current and emerging energy storage technologies for grid-scale electricity sector applications. As defined by the Energy Information Administration (EIA), utility-scale storage consists of projects of one megawatt (MW) or greater in capacity (Hutchins, 2019). Whether the storage system is a large, pumped storage reservoir or a modular system of batteries placed closer to customers, a defining aspect of “utility-scale” storage is the ability of the utility to control the storage system in terms of when it’s charged and when energy is dispatched.

1.1 Utility-Scale Storage: An Introduction to Uses & Benefits

Storage technologies offer varying benefits to the grid. This section offers an introduction to the benefits utility-scale storage can provide and is followed by an overview of energy storage technologies. Many of these benefits are expanded on in Chapter 3.1.

- **Peak Reduction.** Customer demand for electricity varies throughout the day and year. Peak demand usually begins to increase in the midafternoon and can last well into the night. Solar systems provide relief during the daytime but start to taper down toward the late afternoon. Utility-scale storage can help relieve system peaks into the late evening hours. The utility is required to build system capacity to meet peak loading. A significant amount of funds is allocated for the required generation and transmission infrastructure that is only required to meet that peak loading for a small percentage of the year. To reliably serve customers, an electric utility plans for sufficient resources to meet the peak level its customers will demand. In southern Idaho, peak loads typically occur on hot summer afternoons. Utilities plan for "baseload" generation to serve the minimum demand on the grid as well as capacity to serve peak loads. Figure 1 illustrates electricity demand through the hours of a hypothetical day, storage enables a reduction in peak demand by storing energy when demand is low and dispatching energy when demand is high. Reducing peak demand requirements optimize generator & transmission capacity and defers the capital costs of peaker plant capacity. Peaker plants are generating facilities that run only when there is high demand for energy.

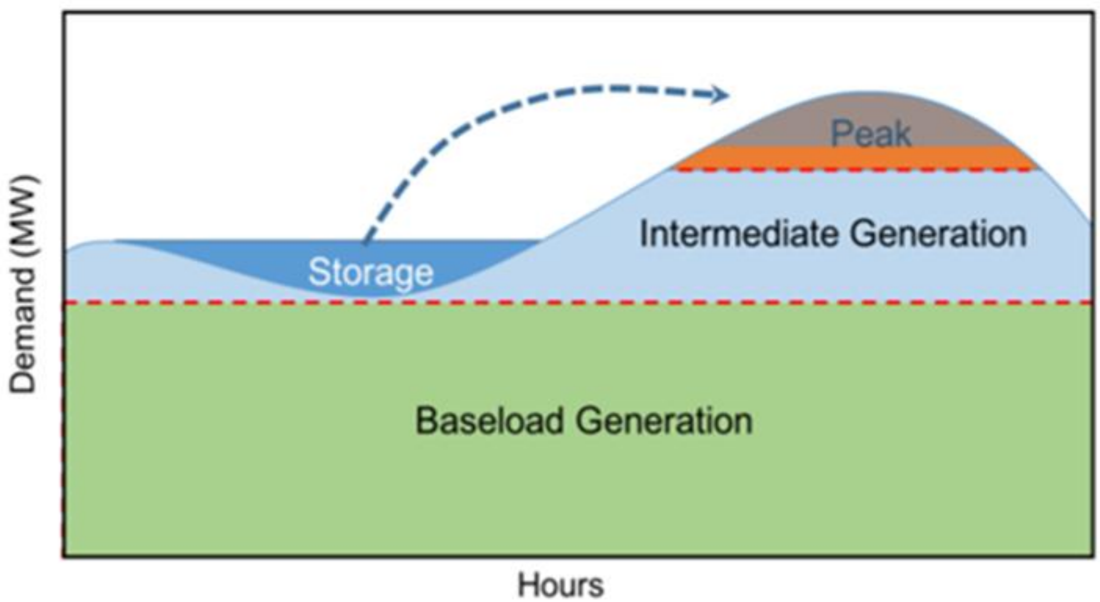


Figure 1: Storage Peak Demand Reduction.

- **Energy Cost Reduction.** The cost of electricity is different at any moment in time. It's more expensive when demand is high, particularly at peak times when higher cost marginal generation resources are dispatched. The cost of electricity generated by peaker plants to serve peak loads, for example, is typically higher than baseload generation costs. Storage can be charged in off-peak periods when costs are low and discharged when the value is higher, thus lowering the average cost of a kilowatt hour (kWh).

- **Arbitrage.** Envision a day trader in the stock market – there would be value in a tool that allows one to buy low and sell high. Unlike the stock market, the timing at which the wholesale price of a kWh is low or high is far more predictable. Storage can enable an electric utility to take advantage of market purchases when energy costs are low, such as times of excess generation from renewable resources, and then discharge/dispatch stored energy when energy value is higher.

- **Renewable Integration**. Solar and wind generation costs have declined and are extremely cost competitive. The EIA reports that on average in the U.S., solar offers the lowest levelized cost of electricity for future new generation resources (Energy Information Administration, 2021). However, outputs are variable and - with solar - limited to daylight hours. Storage allows capacity-constrained utilities to better utilize and integrate low-cost renewable generation.

- **Reliability.** Refers to the avoidance of power disruptions. Storage can be used to reduce the frequency and severity of outages.

- **Resiliency**. Refers to the ability to withstand and recover quickly from disruptions such as power outages. Back-up power, such as that provided by storage, is a form of resilience.

- **Defer or Avoid Transmission and Distribution (T&D) Upgrades.** Storage can be deployed on a geographically targeted basis to avoid or defer the need for some T&D upgrades.

- **Transmission Congestion Relief.** Energy storage can mitigate the impacts of transmission congestion. For example, storage placed downstream of choke points allows electricity to be stored at times of lower consumption for release at peak times. Economic benefits flow from the reduced need for excess power to flow through the congested line, which can reduce transmission capacity requirements and potential congestion charges.

- **Ancillary Services.** Short-duration storage (less than one hour) provides ancillary services which helps grid operators improve the reliability of the electric grid, including –
  - Frequency regulation: moderating the frequency deviation that occurs from imbalances between generation and consumption.
  - Spinning reserves: improve reliability by dispatching to quickly compensate for power shortages or frequency drops.
  - Voltage stabilization: maintaining constant voltage irrespective of changes to the incoming voltage supply.

- **Reserve Adequacy**. Market requirements for reserve adequacy are affected by additional storage. As more storage is added, those resources can be managed to provide hour ahead reserve capacity allowing greater opportunities for utilities to participate in regional markets like the Energy Imbalance Market (EIM) or day-ahead markets currently under development.

1.2 Types of Storage Technology

Current and emerging energy storage technologies for grid-scale electricity sector applications vary in their operational characteristics, which impacts the different benefits these technologies offer. Storage systems are often categorized based on duration – which refers to the average amount of energy that can be charged and discharged for each kilowatt (kW) of power capacity. Roughly, duration is the amount of time that the storage system supplies stored energy. For example, a short duration technology (in the range of seconds) might be used to moderate frequency deviations while a long duration storage system may supply energy at night when solar is not generating. Figure 2 provides an overview of energy storage technologies and the services they can provide to the power system, followed by further details on specific storage technologies.

In addition to duration of discharge, reaction time is a key attribute characterizing storage technology. For instance, electrochemical batteries can discharge at maximum power for a duration of minutes to several hours and can respond when needed (the reaction time) within seconds or less. Conversely, thermal energy storage commonly has several hours of discharge capacity with a reaction time that is typically several minutes.

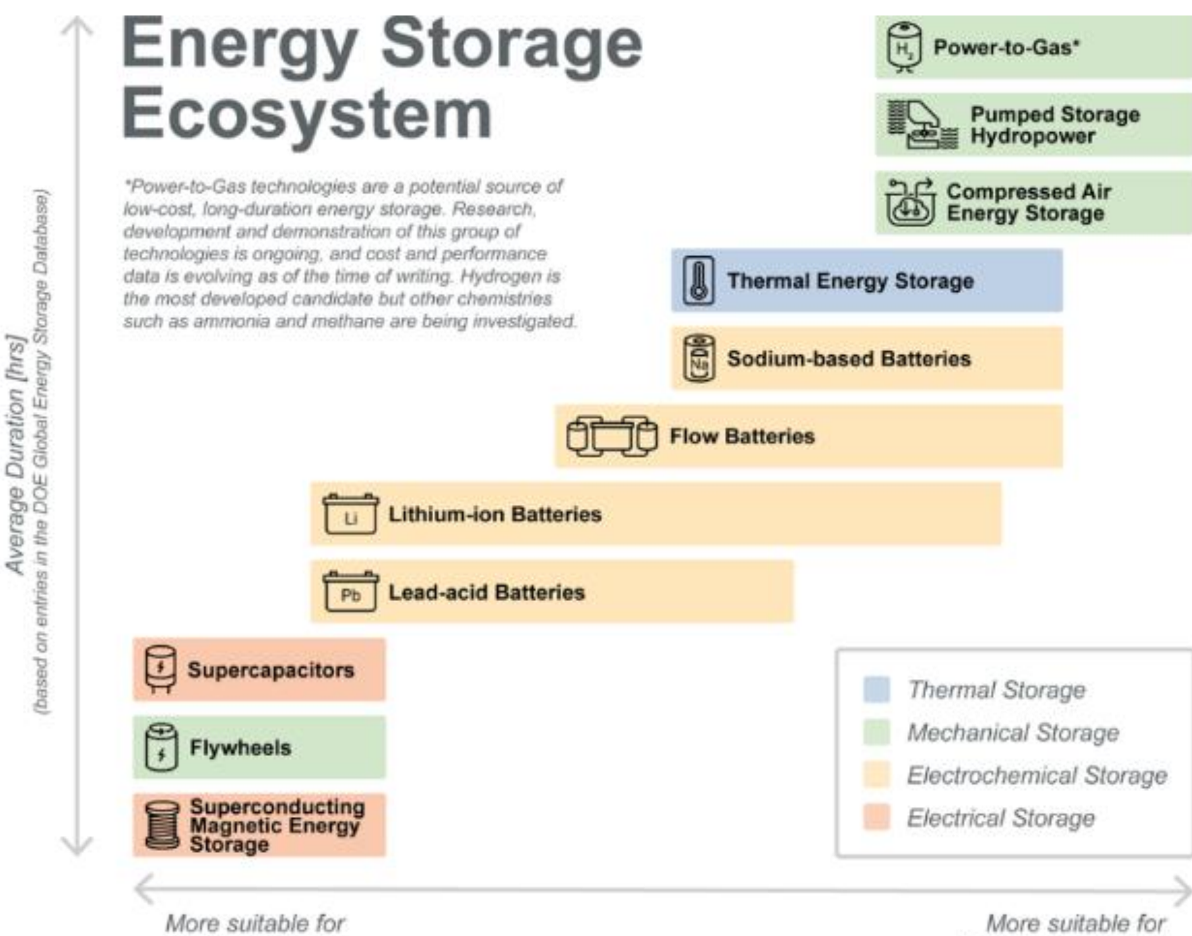


Figure 2: Ecosystem of Energy Storage Technologies and Services. Source: USAID and NREL.

No single storage solution is suitable for every potential application. Three sets of characteristics provide the basis for matching technology with application (Hart et al., 2018).

- **Energy and Power**. At utility-scale, kWh measures the total available stored energy, while the power with which storage energy is supplied is denoted in kW. For example, a storage device rated 5 MWh and 10 MW would supply a half-hour of power at peak output.
- **Reliability and Durability**. Certain storage technologies (namely many kinetic and thermal systems) can operate indefinitely with routine maintenance, while other storage technologies (such as electrochemical cells) typically become depleted over time, necessitating replacement. Storage technologies also vary in their short-term reliability and safety.
- **Cost Efficiency and Value Generation**. Due to the difference in technologies, determining cost efficiency can be difficult. Using assumptions, it may be possible to compute a "levelized cost of storage" (LCOS) value. Levelized costs measure the lifetime costs divided by energy produced.

The grid is designed primarily for one-way flows from generators to customers, but storage, along with other distributed assets, depends on two-way flows that require additional investments in complementary infrastructure.

All storage technologies are net consumers of energy. While some technologies, such as pumped hydro, technically generate electricity, they still consume more energy than they produce/discharge. This is especially important when considering when and how storage is recharged. Prolonged periods of cold, cloudy, and windless weather that is not uncommon during the winter, when reservoir pools are relatively low, are not conducive to recharging short duration batteries using renewable resources.

Mechanical Energy Storage Technologies

Mechanical energy storage systems are currently the most common form of utility-scale energy storage. These systems utilize gravitational or kinetic forces to store energy. Some of the most common mechanical energy systems include compressed air energy storage (CAES), flywheel energy storage (FES), pumped hydroelectric storage (PHS), and gravitational potential energy storage.

- **Pumped-Storage Hydropower (PSH)**. Pumped hydroelectric storage facilities, commonly referred to as pumped-hydro or pumped-storage, store energy by utilizing excess electricity when energy demand and cost is low and when renewable energy generation periods are high. Energy is produced when turbines release water from a lower elevation reservoir to a higher elevation reservoir when energy demand is high. Pumped hydroelectric storage is a form of mechanical storage that provides storage in addition to added reliability or ancillary services (Energy Storage Association, 2022). Pumped hydropower is a proven technology but is limited by geographical requirements, high capital costs, impacts of storage on downstream water uses, and water rights implications (Zablocki 2019). Much of the pumped hydroelectric storage infrastructure across the nation emerged during the 1970s. Today 93% of United States' utility-scale energy storage is pumped-hydro (Water Power Technologies Office, 2021).

- **Compressed Air (CAES).** A CAES plant uses ambient air or other gasses which are compressed and stored in an underground cavern or container under pressure until electricity is needed. Once needed, the pressurized air or gas is heated and expanded in a turbine which drives a generator and thus produces power.

Thermal Energy Storage

Thermal energy storage facilities use temperature to store energy. When excess energy is available the energy is used to heat rocks, salts, water, or other materials. These materials in an insulated environment can store energy until needed. When required the heat is used to drive generation capabilities such as turbines. An example of thermal energy storage is energy capture in hot rocks which when ready for energy release are exposed to water to produce steam which drives a turbine. Often thermal energy storage is associated with high temperature energy generation including concentrated solar, nuclear energy or coal-fired power generation. Thermal energy storage can also be used to directly apply heat to processes including manufacturing.

Electrochemical Energy Storage

- **Lithium-ion Batteries**. Lithium-ion batteries are the most popular battery storage option today. Compared to other battery options, lithium-ion batteries have high energy density and are lightweight.
- **Flow Batteries**. Instead of an electrode and electrolyte system, flow batteries use two circulating electrolytes which exchange electrons directly across a shared membrane. These batteries are well-suited to grid-scale storage due to their relatively low energy density and power output. Significant investments in space and equipment are required to operate these batteries. Currently commercial flow battery projects in the United States are rare.
- **Hydrogen**. Electricity can be converted into hydrogen through the electrolysis of water to produce hydrogen and oxygen. The hydrogen can then be stored and eventually used in manufacturing processes or used to generate power using a fuel cell or through a combined cycle gas power plant. Small amounts of hydrogen can be stored in pressurized vessels, and very large amounts of hydrogen can be stored in constructed underground salt caverns. This method of storage can mitigate the grid impacts associated with excess wind or solar production, including seasonal-scale variations (Energy Storage Association, 2022). Hydrogen storage projects have a small footprint and a high energy density (Zablocki, 2019). Projects range in size from 1 gigawatt hour (GWh) to 1 terawatt hour (TWh), while battery projects typically range from 10 kWh to 100+ megawatt hour (MWh) and pumped hydroelectric storage projects range from 10 MWh to 10 GWh.

1.3 Applications of Utility-scale Storage

A defining aspect of utility-scale storage systems is that the utility controls when the storage system is charged and when the energy is dispatched. A utility-controlled storage system can be deployed to provide different benefits depending on the type of storage, particularly the duration of discharge. Table 1: Application of Storage Systems breaks the applications of storage into 3 main categories: power quality and regulation; bridging power; and energy management. Power quality and regulation focuses on short time duration energy storage used to maintain grid quality (with more expansive applications), notably the scale of power needed is generally considered small (<1 MW). Bridging power is on the medium scale (10-100 MW) of power and durations of 1 minute to 1 hour that can serve a variety of bridging applications (i.e., ramps, emergency, peak shaving, etc.) Lastly, energy management spans a large duration from a few hours to a few months and is generally considered only at large scales (300 MW or larger). Short-term storage focuses on a peak shaving application, while long-duration storage focuses on seasonal storage or annual smoothing (balancing summer versus winter loads) (Behabtu et al., 2020).

Category	Applications	Storage Duration	Power Rating
Power Quality and Regulation	Fluctuation Suppression/Smoothing	≤ 1 min	Small Scale (≤1 MW)
	Dynamic power Response		
	Low voltage Ride Through		
	Line Fault Ride Through		
	Uninterruptable Power Supply		
	Voltage Control Support		
	Reactive Power Control		
	Oscillation Damping		
	Transient Stability		
Bridging Power	Spinning/Contingency Reserves	1 min–1 h	Medium Scale (10–100 MW)
	Ramping		
	Emergency Backup		
	Load Following		
	Wind Power Smoothing		
Energy Management	Peak Shaving/Generation/Time Shifting	1–10 h	Large Scale (≥300 *MW*
	Transmission Curtailment	5–12 h	
	Energy Arbitrage		
	Transmission and Distribution Deferral		
	Line Repair		
	Load Cycling		
	Weather Smoothing		
	Unit Commitment	Hours-days	
	Load Leveling		
	Capacity Firming		
	Renewable Integration and Backup		
	Seasonal Storage	≥4 months	
	Annual Smoothing		

Table 1: Application of Storage Systems. Source: Behabtu, et al., 2020

1.4 Future Developments

Energy storage technologies are rapidly improving. In 2021, the U.S. Department of Energy announced its Long Duration Energy Storage Shot which aims to, within one decade, reduce storage costs by 90% in storage systems that deliver 10 or more hours of duration (U.S. DOE, 2021). Moreover, domestic supply chains are developing to support the U.S. storage market.

Utility-scale 4-hour battery systems are projected to decline in cost by over 40% from 2020 to 2030, as shown in Figure 3.

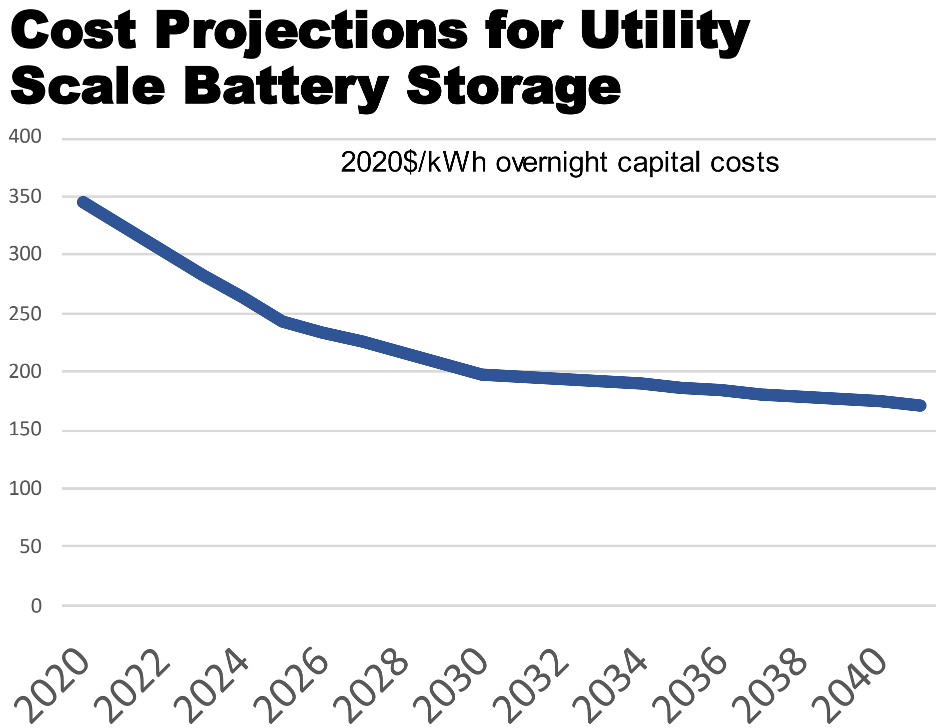


Figure 3: Cost Projections for Utility-scale Battery Storage. Source: NREL

Chapter 2: Energy Storage in Idaho

2.1 Existing Energy Storage Resources in Idaho

As of 2022, Idaho does not currently have any standalone utility-scale storage facilities. Today, most energy storage is found paired with renewable generation. When two or more modes of power are combined such as solar photovoltaic (PV)+Battery or Wind+Battery, this is considered hybrid generation.

Electricity and gas generation, transmission, distribution, management, and sale is managed in Idaho by various investor-owned electric and gas utilites, municipal electric utilities, and cooperative electric utilities. Figures 4 and 5 map the service territories for these entities. Avista Corportation, Idaho Power Company, and PacifiCorp/Rocky Mountain Power, Idaho's three investor-owned utilities (IOUs), fulfill approximately 84% of Idaho's electricity needs. The remaining 16% are served by cooperative electric utilities and municipal utilities, for which information on operational and planned projects are not easily obtained. Most of Idaho's municipalities and cooperatives purchase the bulk of their electricity, over 96%, from Bonneville Power Administration; however, some are beginning to acquire their own power generation resources and enter into Power Purchase Agreements (PPAs) with other energy providers. As such, the analysis in this chapter focuses on the three IOUs in Idaho.

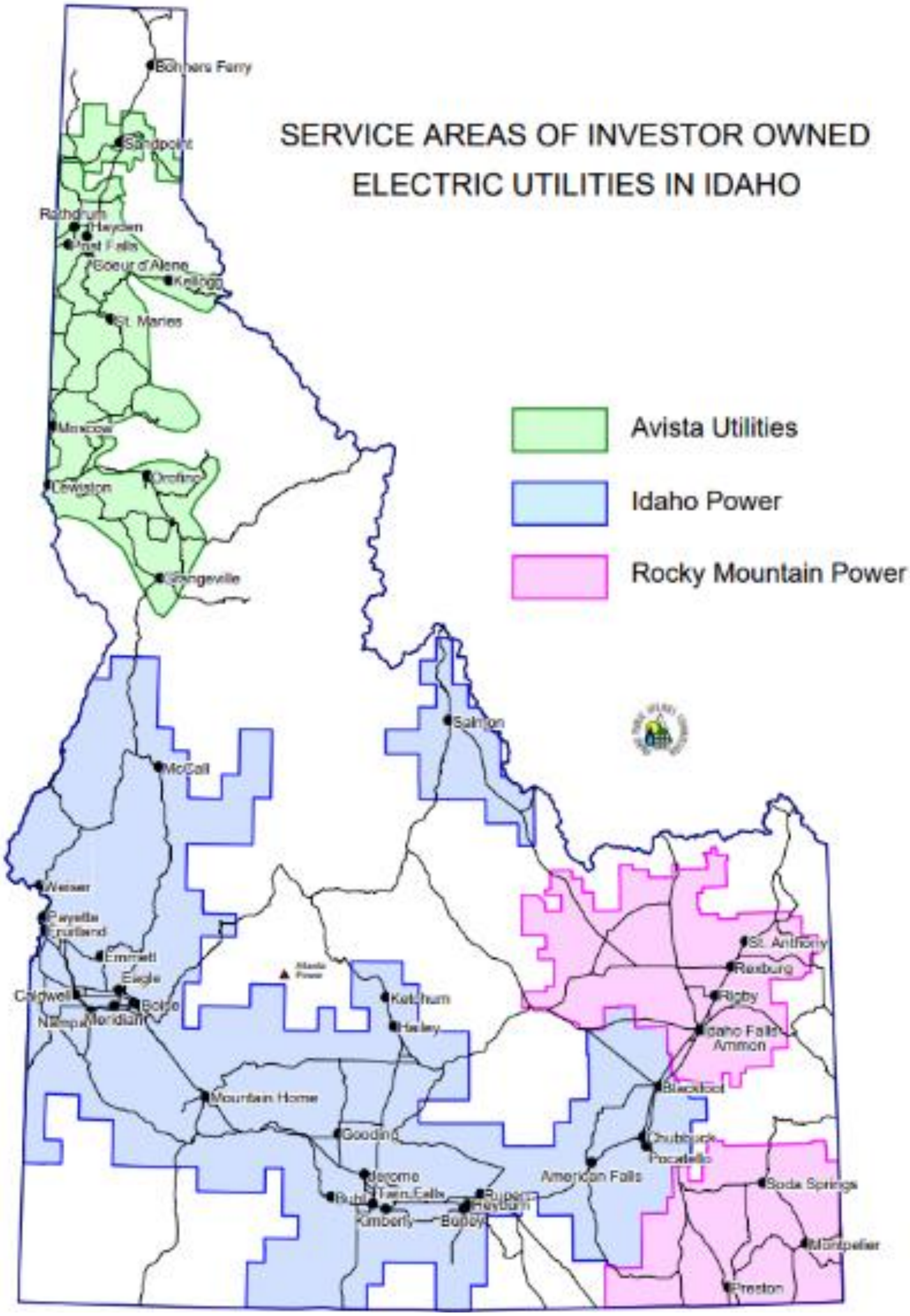


Figure 4: Service Areas of Electric IOUs in Idaho. Source: Idaho Public Utilities Commission.

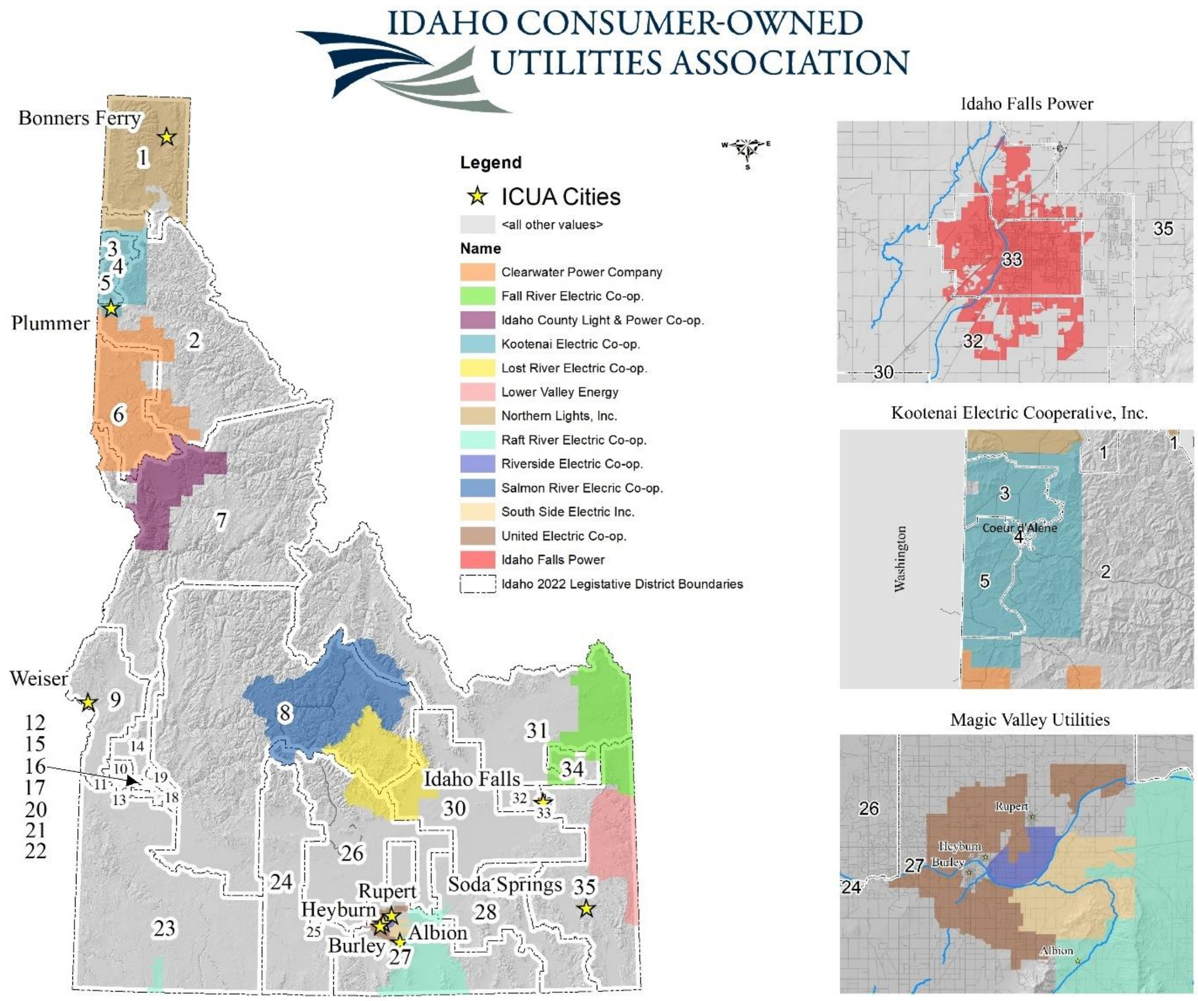


Figure 5: Electric Co-ops, Mutual, and Municipalities within Idaho. Source: Idaho Consumer-Owned Utilities Association

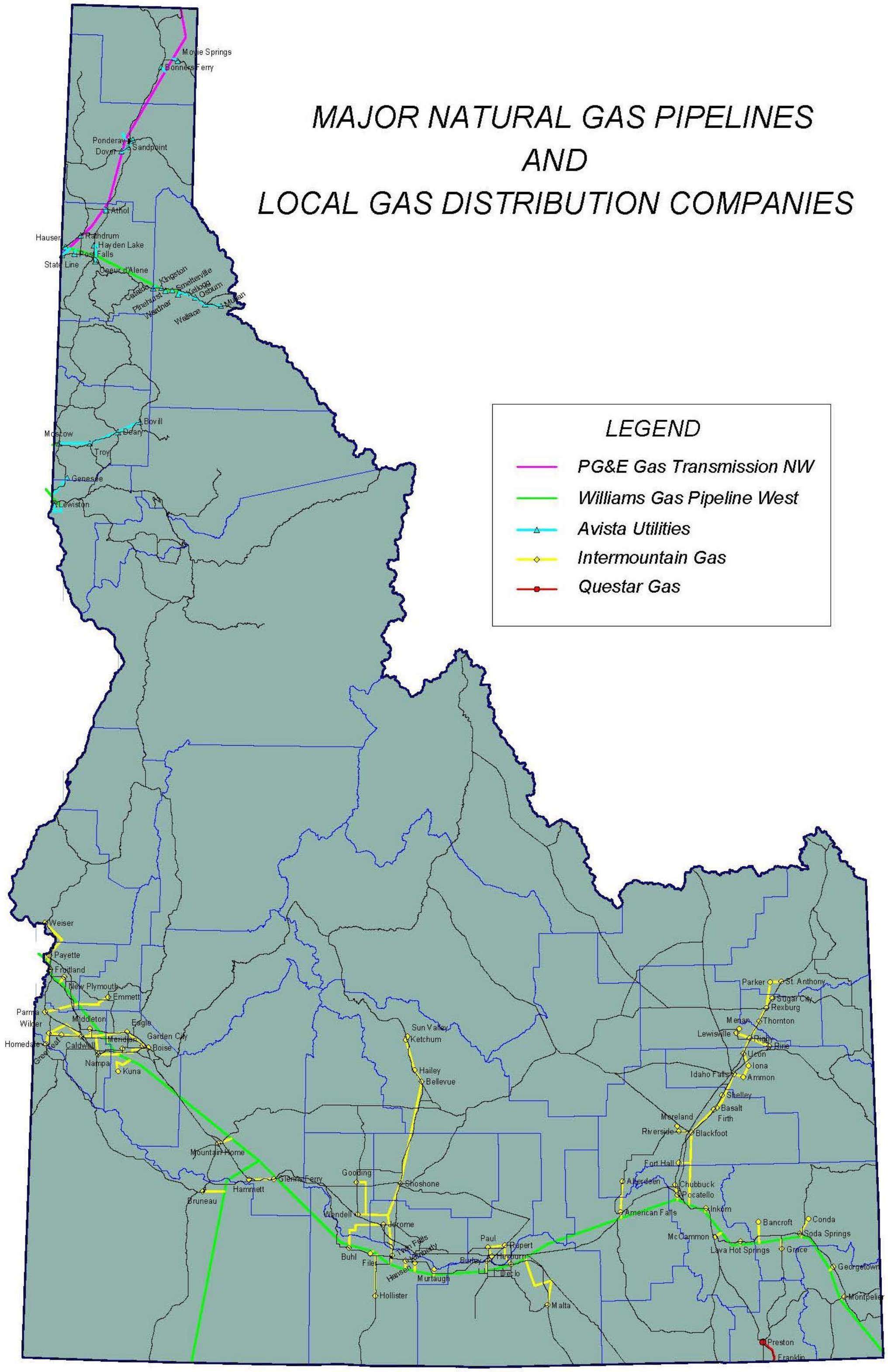


Figure 6: Major Natural Gas Pipelines and Local Gas Distribution Companies. Source: Idaho Public Utilities Commission

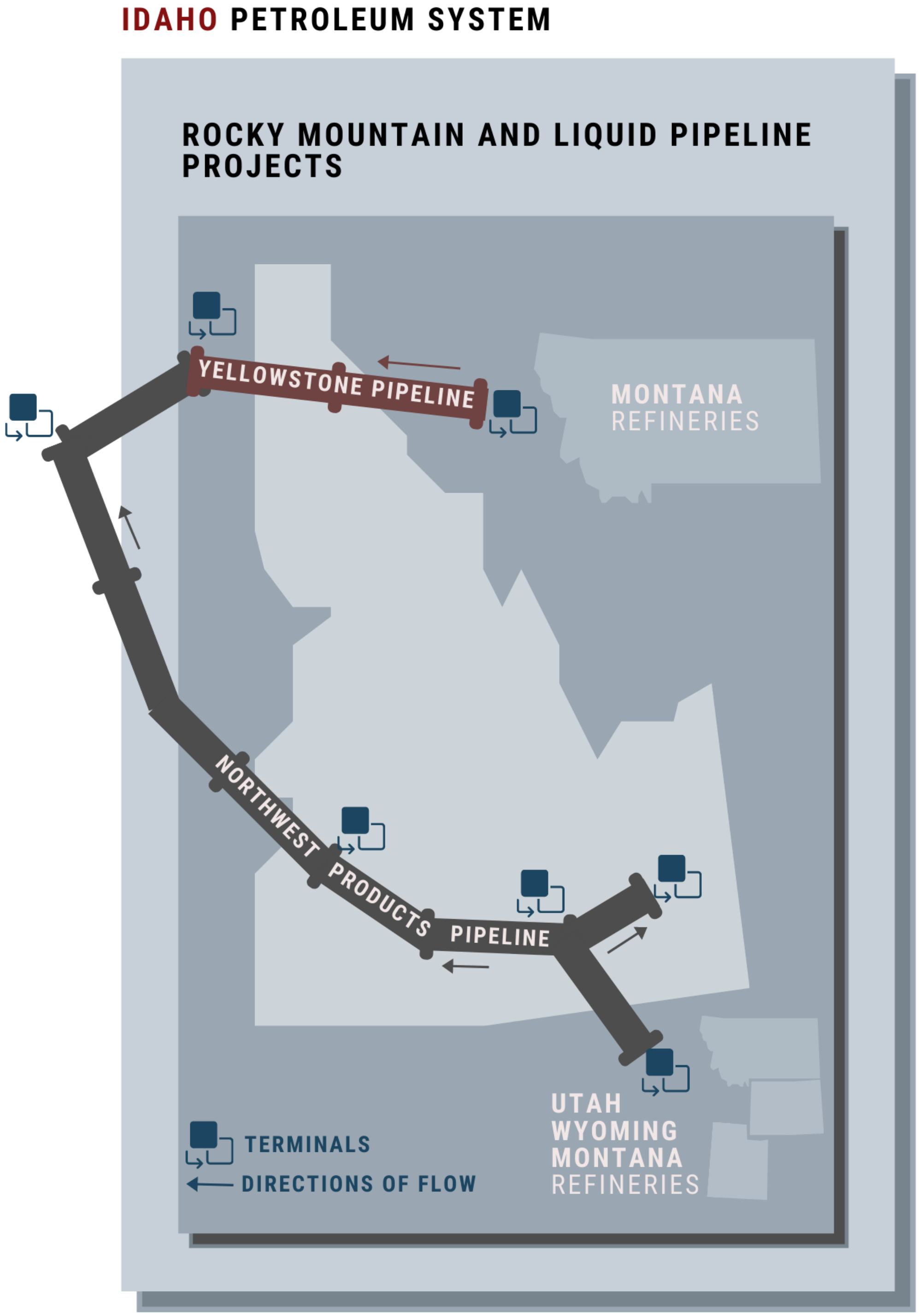


Figure 7: Idaho Petroleum System. Source: Idaho Energy Landscape

2.2 Planned and Proposed Storage Projects in Idaho

As technology advances and as the need for large-scale storage to meet increasing energy demand throughout the West increases, proposals have been submitted for large utility-scale storage projects. In spring of 2022, Idaho Power announced plans to install Idaho's first utility-scale battery storage systems, a 120 MW battery storage project to come online in summer 2023 (Idaho Power, 2022). A 40-MW system may be located at the proposed Black Mesa solar facility in Elmore County, although Idaho Power is still evaluating potential sites. A 40-MW battery can power more than 13,000 average homes for four hours during periods of peak use. The batteries can be completely recharged in about four hours, depending on their energy source. Additionally, there are two proposals under review by the Federal Energy Regulatory Commission (FERC) for utility-scale pumped hydropower projects in southern Idaho, see Table 2.

Table 2: Proposed Utility-scale Pumped Hydropower Projects

Project Name	Description
Cat Creek Energy & Water Storage Renewable Power Station Project (FERC No. P-14655)	745 MW pumped storage hydropower. 110 MW wind. 40 MW solar. 110 MW floating solar. 720 MW large-volume, long-duration (LVLD) energy storage module.
PacifiCorp Dry Canyon Pumped Storage Project (FERC No. P-15240)	1,800 MW closed loop pumped storage hydropower

Resource Plans & Interconnection Requests

Integrated Resource Plans. Idaho's IOUs work with local stakeholders to develop Integrated Resource Plans (IRPs) that must be filed with the Idaho Public Utilities Commission (PUC) every two years. IRPs forecast energy demands over 20 years and evaluate a variety of resources to meet demand, including the addition of generation resources and demand-side measures such as conservation and energy efficiency programs. IRPs typically select a "preferred resource strategy" based on evaluation criteria including cost, risk, reliability, and environmental concerns. In total, the combined projected sales for Idaho's three Investor Owned Utilities' 2021 IRP's reflects the following growth in Idaho.

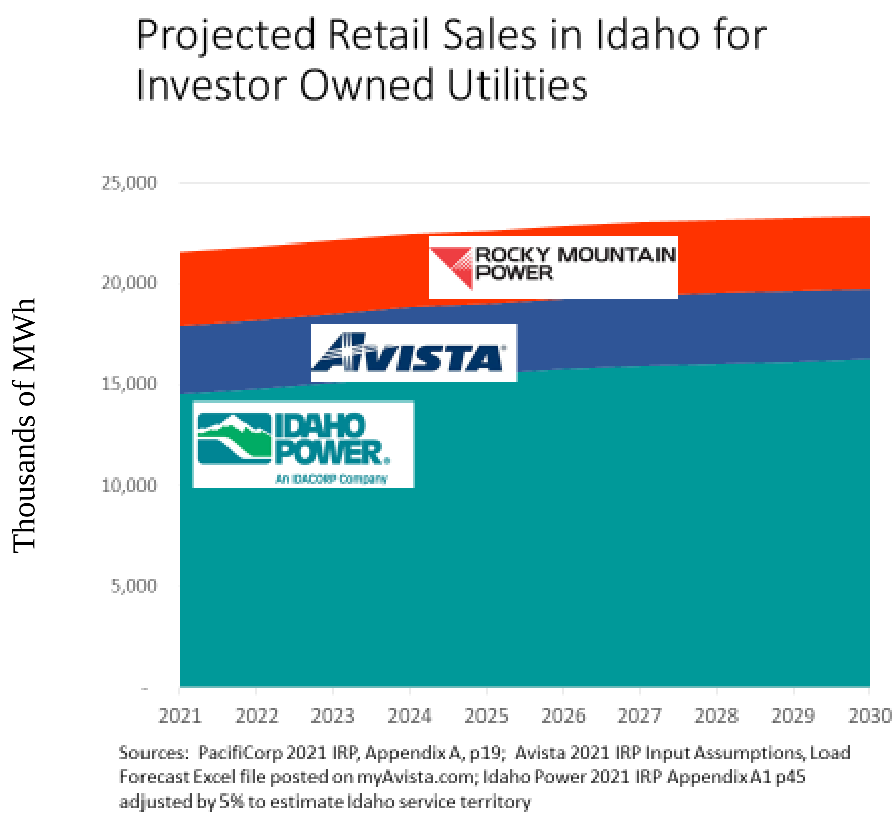


Figure 8: Projected Retail Sales in Idaho for IOUs. Source: PacifiCorp, Avista, Idaho Power.

To reliably and cost effectively serve the substantial growth in their service territory, Idaho Power's 2021 IRP plans for nearly 1,700 MW of battery storage additions by 2040.

Interconnection Queues. Each IOU is required to manage and maintain an Open Access Transmission Tariff (OATT) pursuant to federal requirements. Each OATT outlines the process for a given energy project to interconnect to the transmission system. Links to each IOU's Interconnection Queue is shown below in Table 3, along with a summary of projects with active applications for interconnection service.

In total, Idaho's IOUs have active interconnection requests for 4,000 MWs of planned renewable energy projects co-located with a battery storage component. Note, however, that the amount of storage capacity for co-located projects is unknown (the MWs shown are assumed to reflect the maximum amount of wind or solar energy at a given project). Approximately 134 MW of stand-alone battery storage projects are shown, which do not have any wind or solar generation components.

Table 3: Interconnection Queue Analysis. Source: OASIS OATT Avista, Idaho Power, PacifiCorp

Interconnection Queue Analysis				
Investor-Owned Utility	**Project Type**	**Status**	**Size (MW)**	**Expected Operational Date***
Avista	Solar + Battery	Planned, under development	100	12/31/2021
Avista	Battery Storage	Planned, under development	200	12/31/2025
Idaho Power	Solar + Battery	Planned, under development	100	2/12/2020
Idaho Power	Battery Storage	Planned, under development	40	12/1/2023
Idaho Power	Solar + Battery	Planned, under development	200	11/1/2023
Idaho Power	Wind + Battery	Planned, under development	1050	12/1/2023
Idaho Power	Solar + Battery	Planned, under development	300	11/30/2022
Idaho Power	Wind + Battery	Planned, under development	1050	12/1/2023
Idaho Power	Solar + Battery	Planned, under development	200	10/1/2024
Idaho Power	Solar + Battery	Planned, under development	85	6/1/2023
Idaho Power	Solar + Battery	Planned, under development	80	3/15/2023
Idaho Power	Battery Storage	Planned, under development	3.51	3/31/2023
Idaho Power	Battery Storage	Planned, under development	80	6/1/2023
Idaho Power	Solar + Battery	Planned, under development	100	12/1/2025
Idaho Power	Solar + Battery	Planned, under development	250	12/1/2025
Idaho Power	Battery Storage	Planned, under development	7.02	3/31/2023
Idaho Power	Battery Storage	Planned, under development	3.51	3/31/2023

PacifiCorp	Solar + Battery	Planned, under development	199	12/31/2025
PacifiCorp	Solar + Battery	Planned, under development	200	12/31/2023
Note: The Expected Operational Date may at times change without corresponding updates to Interconnection Queues, which explains why some projects show a date that occurred in the past for projects that are not yet operational.				

Pumped Hydro Storage Potential in Idaho

Figure 6 depicts existing water reserves within 10 miles of high-powered transmission lines. According to industry experts, costs for building new transmission to connect to an existing system can cost approximately $5 million per mile of 500kV line. Additionally, it costs around $80 million to build a new substation for a 500 kV system. Due to these costs, it is more likely to and most economical to find existing water storage sites that are within 10-20 miles of an existing 500 kV transmission line. Each point represents reservoirs that could potentially be used for pumped storage hydropower. The figure does not suggest that these locations be utilized for storage, but rather demonstrates the resources and areas for potential development.

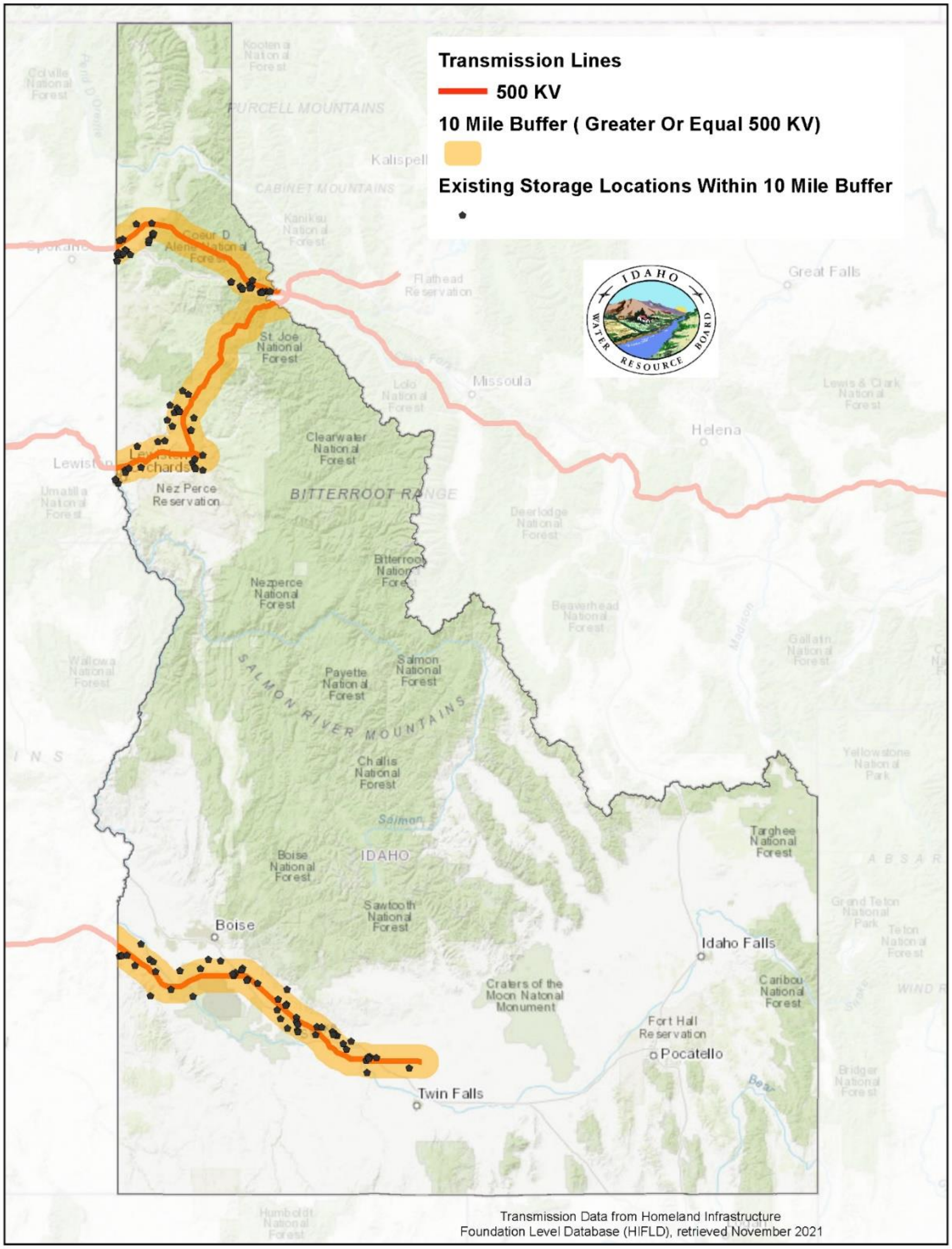


Figure 9: Potential for future pumped storage hydropower in Idaho. Source: Idaho Water Resources Board.

Chapter 3: Analysis of Utility-scale Storage Potential in Idaho

Utility-scale storage presents opportunities for Idaho to capture system benefits to the grid, diversify its electricity resources, and create economic development benefits. Chapter 3 covers benefits of utility-scale storage and challenges to deployment.

3.1 Benefits to the Electric Grid

Increase Grid Resiliency and Reliability

As greater portions of Idaho's energy load are placed on the electric system (for example, through electric vehicles and building electrification), the need for reliable electric service rises along with the need to minimize the harm associated with system outages. Moreover, as the region is experiencing a decline in baseload generators (e.g., coal-fired power plants) and an increase in intermittent resources (e.g., solar and wind), storage is integral to improve reliability and resiliency.

Microgrid. Microgrids are localized grids that can disconnect from the central power grid to operate autonomously. They can improve both reliability and resiliency by mitigating grid disturbances as well as providing a resource for faster system response and recovery. In scenarios where there is significant or widespread outage due to either equipment failure or natural events, such as widespread storms or fires, segregating the electrical power system into microgrid systems can help to maintain local electrical service while system repairs are addressed. Dependent on the amount of utility-scale storage and its locations, system(s) could be divided into new multiple independent or separate systems, allowing for continuous operation while minimally impacting customer service. Utility-scale storage, especially if it is combined with other renewable energy, such as wind or solar, can supply alternative energy to the traditional energy supply system. The amount of time that the energy supply would last is dependent on the customer load and the alternative energy system capacity. The alternative energy system could be designed for long term operations or for emergency loads/operations, allowing impacted customers emergency services or an orderly and safe transition.

Once an outage event has been resolved, the independent systems could be reconfigured to the original system or intermediate system configurations minimizing customer impacts. During microgrid operation, initial and ongoing system capacity and load assessments would be required for normal and emergency operation.

Voltage Stability. Transmission system configuration that incorporates utility-scale storage can prevent voltage sag and maintain voltage stability. Intermittent events, such as voltage sags and voltage stability issues, can create overall stability issues. These issues which can include line outage can cascade from isolated to broad system issues. Instabilities range from short blinks on the utility grid to long sags that may drop sensitive loads. As such, voltage sags and voltage instabilities can be a significant impact for commercial and industrial customer.

For intermittent events, voltage sags and voltage stability issues that customers experience will depend on the severity of fault and the proximity to customers. The utility-scale storage response should be fast enough to limit interruption due to voltage sags or voltage fluctuations.

Sustained faults on the transmission system will initiate system protective action. Based on the protection scheme, part of the system could become isolated and other systems would be fed from another radial source. Based on the radial source’s design and loading, voltage sags often occur.

Volt-Amperes Reactive (VAR) Control. Utility-scale storage, with its sub cycle VAR response, can provide the required reactive compensation to correct voltage sags and instabilities. Commercial and industrial customers have load requirements that result in reactive power requirements. The reactive power flows reduce system efficiency and may result in high or low voltage conditions. Depending on the severity of VAR flow, voltage can easily exceed its required operational limits. The different load types and sizes result in reactive power flows that can incur significant voltage swings.

Resiliency. While reliability refers to the avoidance of disruptions, resiliency is the ability to withstand and recover quickly from disruptions. Back-up power, such as that provided by storage, offers a form of resilience. According to S&P Market Intelligence, the need for resiliency combined with increased cost effectiveness has driven a surge of utility-scale storage installations in summer 2021 (Hering & Rosario, 2021). This surge is centered in California and Texas and consists mostly of four-hour lithium-ion battery systems designed to discharge during critical periods of peak demand:

> With generating capacity reserves tight and a range of severe conditions, ranging from heatwaves, drought and wildfires to tropical storms, looming, America's power grid is at high risk of experiencing outages this summer and fall. In response, builders of utility-scale battery storage stations are racing to get new projects up and running (Hering & Rosario, 2021).

In Idaho, outages can be particularly costly to many industries. Storage presents several opportunities, including–

- Collaborations between utilities and large customers to optimize storage as both a resource to the grid and a form of back-up power to the customer.
- Options for utility customers (targeted at commercial users) to pay an additional charge to be included in a “high reliability zone” provided through a combination of distributed generation and energy storage (Hering & Rosario, 2021).
- Resource planning closer to the customer.
- Some states have established Community Resiliency Grants for critical Commercial & Industrial customers (e.g. hospitals) which include storage.

Enable or Enhance Peak Load Shifting

Transmission and Generation Deferral. Peak loads are periods of highest energy demand. Load peaks occur based on the types of loads and their percent of the total load. A utility system would consist of normal mixed load types such as: residential, commercial, agricultural, and industrial combinations. The use of utility-scale storage for peak shaving/shifting can defer millions of dollars of large-scale transmission and generation projects. These deferral funds along with other revenue streams build a persuasive case for utility-scale storage systems.

The duck curve represents the amount of solar electricity available throughout the day compared to energy demand. Utility-scale storage can level the amount of energy utility companies need to ramp to meet peak demand in later parts of the day that have less solar power generation.

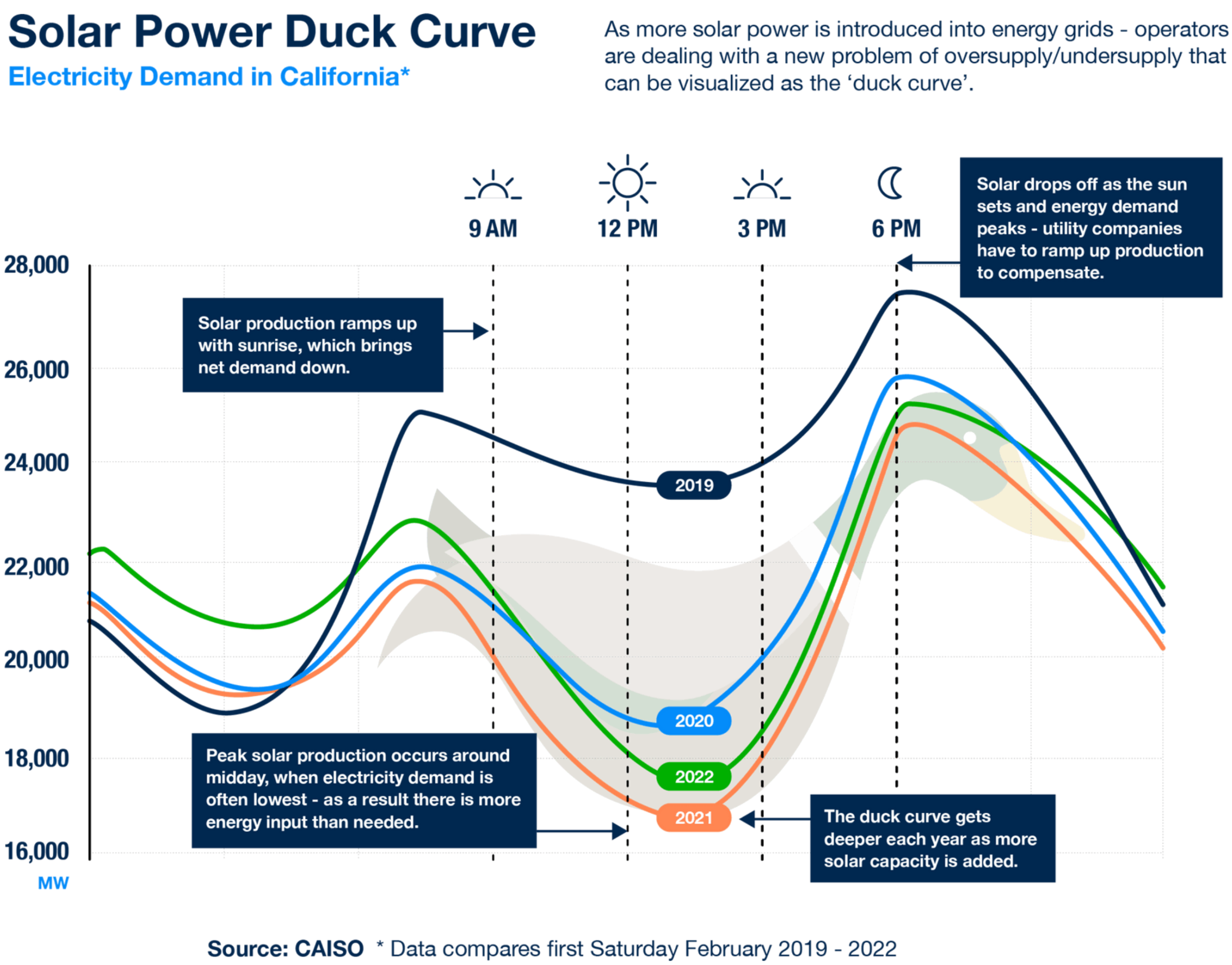


Figure 10: Solar Power Duck Curve. Source: PacificGreen.

Radial Line Loading. Radial systems in mountainous areas can become very long systems. These areas are often popular for recreational activities or seasonal festivities. The loads on radial systems become significant as the residents' load expectations are like highly concentrated load centers. The mountainous load centers typically don't have access to natural gas and are heavily dependent on electrical utilities. The increased concentration of load over a short period of time can create peak loading that the radial system might not be equipped to handle. Utility-scale storage installed on these radial systems can relieve the line loading and save millions of dollars of transmission line rebuild. The deferral of the transmission line rebuilds, along with other value streams, enable the opportunity to pay for utility-scale storage systems.

Rural Radial Loading. In Idaho, there is a significant amount of rural load centers. Rural load centers are often on a radial system that is located a substantial distance from their source station. Even though this may be a rural low growth area, the load will eventually exceed what the system can support and will experience voltage minimum value violations. These violations usually occur during the peak loading on this section of the grid. Traditional capacity expansion, such as new or upgraded transmission and generation systems, for the rural load centers can become extremely costly due to their remoteness. Many times, the amount of load to shave/shift is relatively small compared to the system area load. Utility-scale storage installed for peak load shaving/shifting can relieve the system and support system voltage operations.

Integrating Variable Renewable Resources

Certain renewable energy resources such as wind and solar are considered variable. Variable resources are resources that do not consistently produce energy. For instance, solar energy is not generated when the sun is not shining, and wind energy is not generated when the wind is not blowing.

Excess Energy Storage Opportunity. Variable renewable resources can produce power during minimal system loading. This situation could be the result of nighttime wind generation or springtime solar generation. Even during the daytime when loading can be substantial, solar generation can exceed the load due to significant amounts of installed solar generation. As solar generation continues to increase, excess energy can result in reverse flows on the system that can lead to over voltage conditions. Utility-scale storage can absorb the excess generation providing localized voltage and system capacity support. It probably should be pointed out that interconnection process will limit this exposure (e.g. by forced curtailment) under certain conditions.

Voltage Flicker. Due to the variable nature of certain generation resources, such as wind and solar, erratic current flows develop into erratic voltage fluctuations similar to a light switch switching on and off. Utility-scale storage systems have the capability to compensate for voltage variations. This would help to limit unnecessarily strain and possible damage to expensive infrastructure/equipment and minimize the impact on sensitive electronic loads.

Spinning Reserve Requirement. Systems with significant variable renewable resources have the capability for sudden changes in generation. If the change in generation is substantial enough it can impact the frequency, voltage, and stability. The North American Electric Reliability Corporation regulates a portion of spinning reserves to maintain system stability. These spinning reserves are usually spinning generation units that have reserve capacity which can be brought online without delay. Generator reduced capacity operational mode is inefficient and costly. Utility-scale storage can provide near instantaneous spinning reserve with reactive compensation to meet regulation requirements at significant savings.

Reduce Transmission & Distribution (T&D) Infrastructure Cost

Getting electricity from where it’s generated to where it’s consumed requires a web of transmission and distribution (T&D) infrastructure scaled to reliably serve peak demand at any moment and location. Battery storage presents opportunities to defer and to better utilize investments in T&D infrastructure.

Avoided Costs. Regarding serving electric demand, value is created when an incremental amount of storage can delay or avoid a much larger T&D upgrade. Consider the scenario where a distribution circuit is experiencing load growth and next year's peak might possibly exceed the circuit rating. A small battery energy storage system might provide additional generation near the loads on peak days and avoid a costly upgrade.

For example, distribution feeder lines are typically sized to carry 10-20 MWs. Utility-scale storage products can be installed at the feeder system level. Charging these storage packs during non-peak load hours allows improved utilization of existing centralized generation and bulk transmission assets. Additionally, adding multiple relatively small storage sites to the total resources available to serve peak loads reduces the exposure to an "N-1" (potential outage of single biggest resource) outage when measured as a percentage of total load served.

Idaho Power, for example, in its 2021 20-year IRP, includes 17 selections of 5 MW grid-located storage projects intended to defer transmission and distribution investments in addition to meeting system resource needs (Idaho Power, 2021).

Scalability. Utility-scale storage has the advantage that it can be deployed in a modular fashion, which offers value for risk mitigation in planning for growth. Batteries can defer a T&D investment for several years or extend the expected life of existing equipment by reducing the peaks the equipment would have to serve.

> Case example: In Arizona, Punkin Center is a town of about 600 people. Growth was threatening to overload the transmission line serving the town. Arizona Public Service found it more cost effective to use batteries rather than invest in a line upgrade. "It will enable us to defer the transmission investment for a considerable amount of time, anywhere from three to six years," described the director of transmission and distribution technology innovation and integration at APS (Utility Dive, 2017).

Transmission Congestion Relief. Transmission systems can become congested for many reasons, including difficulties in siting rights-of-way, which can result in higher transmission access fees and congestion charges at times when the grid is in highest demand. Energy storage can mitigate the impacts of transmission congestion, such as "choke points" where particularly high congestion occurs on the electric grid. For example, storage placed downstream of choke points allows electricity to be stored at times of lower consumption for release at peak times. Economic benefits flow from the reduced need for excess power to flow through the congested line, which can reduce transmission capacity requirements and potential congestion charges.

> Case Example. The Massachusetts Energy Storage Initiative presents the following (Storage Provide Critical Power System Reliability) to describe its analysis of storage to avoid transmission overloads and provide flexibility to respond to outages. This role of storage was part of the $305 million in T&D cost reductions estimated over a 10-year period.

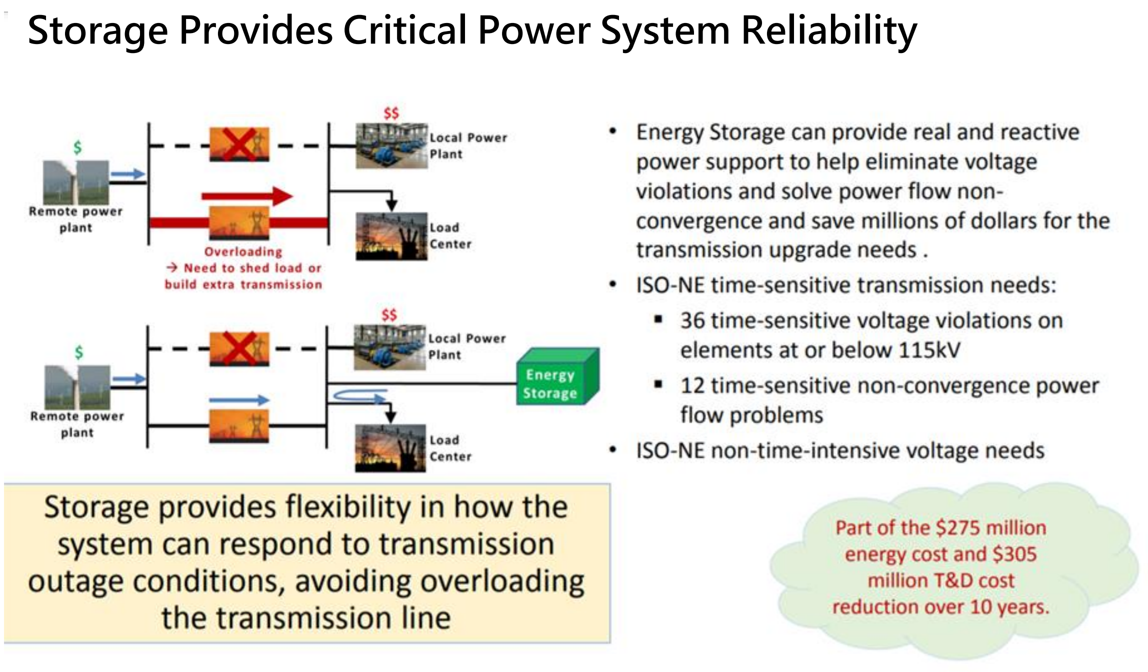


Figure 11: Storage Provides Critical Power System Reliability. Source: Massachusetts Energy Storage Initiative – State of Charge.

3.2 Opportunities: Diversify Idaho's Electricity Mix

Diversifying Idaho's energy mix is an objective of ISEA. Storage is a catalyst to develop in-state resources that can provide diversity in Idaho's electric resources. The majority of energy in Idaho comes from hydropower resources. Idaho has potential for low-cost solar and wind energy, but utilities still need capacity to serve peak demands. By bridging the timing of when electricity is available versus when it is needed, and by improving the firmness of resources, storage enables Idaho to benefit from the cost-effective development of in-state solar and wind resources and to diversify Idaho's energy mix.

The section below provides context regarding Idaho's current electricity mix, then -- for each resource -- addresses the potential for storage as it relates to risks and diversification of resources.

Current Diversity of Idaho's Electricity Mix. Figure 8 describes the energy mix for each of Idaho's three Investor-Owned Utilities, excluding purchased electricity. These resources are not specific to Idaho – PacifiCorp, for example, draws on these resources to serve several states, including a portion of eastern Idaho operating as Rocky Mountain Power.

Overall, Idaho relies on hydro, coal, and natural gas, and to a lesser degree wind and solar. Utilities also rely on market purchases, typically imported from other states. The future impact of storage relative to each of these resources is summarized here and described further below.

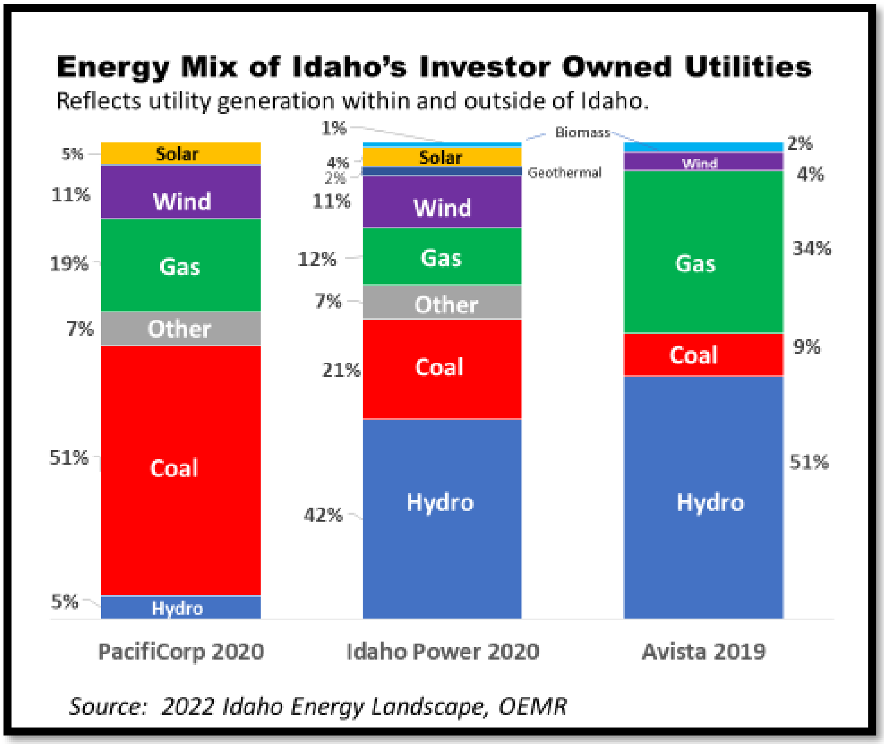


Figure 12: Energy Mix of Idaho's Investor Owned Utilities. Source: Idaho Energy Landscape

1) Hydroelectricity

Dependent on water supplies, Idaho's electric mix hovers around 50% hydropower. This has provided Idaho a history of competitively low electricity costs, enabling energy-intensive industries to thrive.

In a year when the supply of electricity from hydro is low, Idaho relies more on imports to meet demand. Storage deployment in Idaho offers two related advantages to mitigate risks associated with low water years. First, in southern Idaho, in-state storage can enable time shifting of in-state solar generation, which provides a substitute for imports. For example, the number of imports needed to meet demand on a hot summer afternoon is less if storage enables local energy generated earlier in the day to be consumed later in the day. Second, storage gives the utility latitude to import during non-peak hours. For example, transmission capacity is built to handle imports at peak times but may be under-utilized during off-peak hours. Storage enables the utility flexibility to import more during non-peak hours, which creates options to better utilize infrastructure and reliably serve in-state demand.

Acute droughts or reduced snowpack as well as changes to water management practices can impact the capability of hydropower. Idaho utilities are planning for wider ranges of uncertainty regarding hydropower resources given wider ranges of uncertainty surrounding climate projections, thus the value of storage to mitigate the risks associated with hydropower is growing.

2) Imports of Electricity From Other States

Idaho requires imports to serve its electricity needs. In 2020, 28% of the electricity used in Idaho was imported from out of state, see Figure 10. Those imports are comprised of market purchases and out-of-state generating resources owned by Idaho utilities, primarily coal. Idaho's utilities generate approximately 46% of the energy utilized in-state, and 26% is provided by combined heat and power (CHP) or independent power producers (IPP). As described earlier, storage can be deployed to better enable in-state generation to substitute for imports.

Regarding market purchased imports, storage deployed outside of Idaho can impact Idaho. For example, electricity might currently be purchased quite cheaply at times when western states export excess solar generation to the grid. When storage is deployed, excess electricity can be stored and consumed locally. When that occurs outside of Idaho, it can reduce supply and increase prices for market purchases available to import into Idaho. A decline in the attractiveness of market purchases increases the cost effectiveness and reliability value of developing in-state storage resources.

Currently, Idaho imports electricity from states with excess electricity generated by intermittent resources, such as solar and wind from Washington, Oregon, and California. The deployment of storage in those states will substantially increase given:

- Short-duration utility-scale storage has become cost-effective.
- State policies are encouraging the deployment of storage.

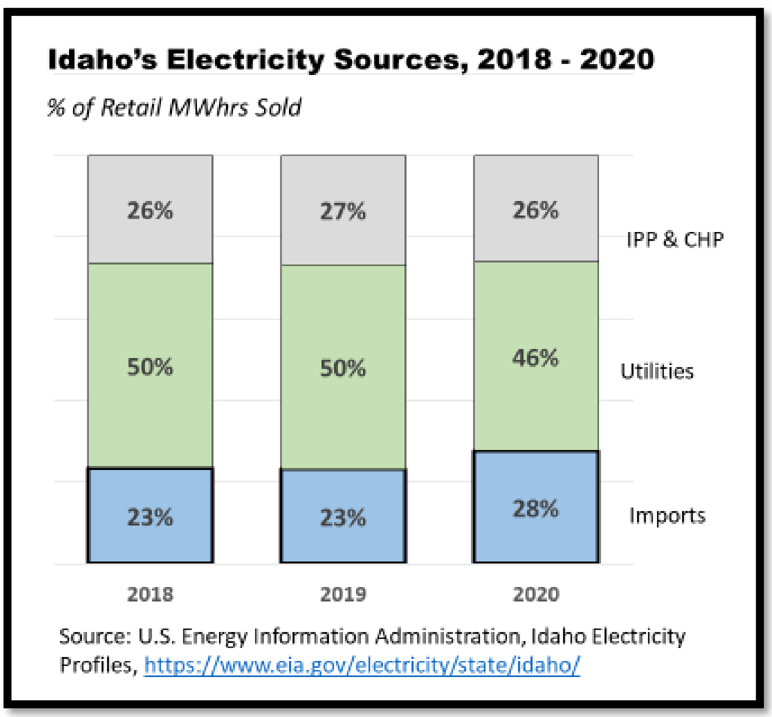
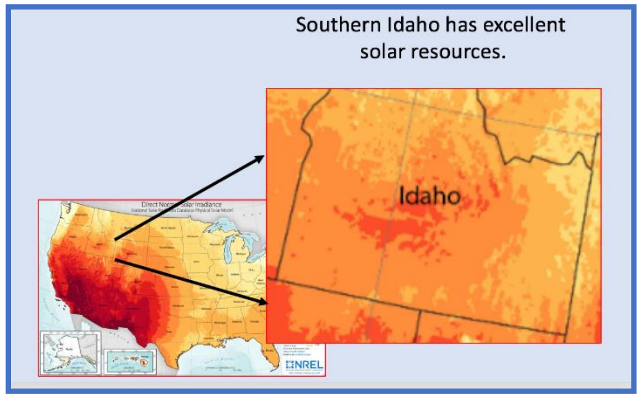


Figure 13: Idaho's Electricity Sources, 2018-2020. Source: EIA.

3) Carbon-based Fuel Sources (Coal & Natural Gas)

As shown earlier in Figure 8 - Energy Mix of Idaho's Investor-Owned Utilities, Idaho's electric utilities rely in part on carbon-based resources such as coal and natural gas. Future fuel prices are uncertain, as has been demonstrated by the recent escalation of natural gas prices. Marginal supply sets the price in deregulated wholesale markets. Natural gas is the most common marginal fuel, which means natural gas prices set the locational marginal pricing for other generators. Renewable fuel is "free" from the sun, wind, etc, but under the current structure they get paid whatever the most expensive plant needed is paid, when tends to be natural gas in the Pacific Northwest. When natural gas prices are high, then vertically integrated states have cheaper prices because their generation is not paid a single price. The nature of a resource alternative such as Solar+Storage is that the costs are mostly up front, and the fuel is "free". To the degree storage enables renewables to provide competitive alternatives to carbon-based resources, it can enable Idaho to reduce potential financial risks associated with carbon-based resources.

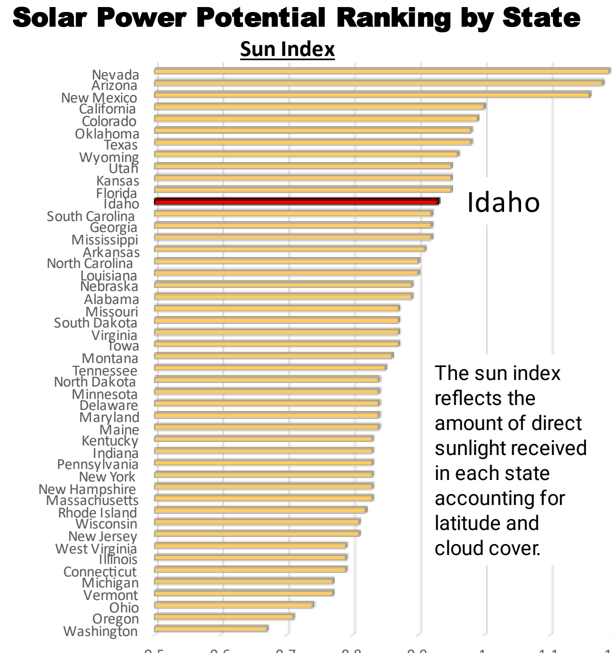
Figure 14: Idaho Solar Rating. Source: NREL



4) Solar

Quality of Sunlight. Southern Idaho has excellent solar resources. In terms of the energy available from sunlight, and accounting for cloud cover and latitude, Idaho's "sun index" is similar to Florida and Texas (see Figure 13).

Solar PV Cost Competitiveness. Since 2010, there has been an 82% reduction in the cost of utility-scale Solar PV systems (NREL, 2021). On average in the U.S., the EIA reports in 2021 that solar offers the lowest levelized cost of electricity for future new generation resources (EIA, 2021b).



Sc*Figure 15: Solar Power Potential Ranking by State. Source: NREL*

Development in Idaho. In 2020, solar in Idaho represented 2% of Idaho's electricity (EIA, 2021a).

The changing cost effectiveness of solar and storage has recently enabled the combination to become an advantageous alternative for serving peak demand (See Chapter 4). By enabling Idaho's solar energy potential to be better aligned with the timing of electric load, utility-scale storage provides an opportunity to reduce Idaho customers' reliance on imported electricity. Utility-scale storage can dramatically increase utilization of solar resources in southern Idaho to enable a more diversified and in-state portfolio of energy resources. Further, with rising emphasis on clean energy targets in Oregon and Washington, utility-scale storage could help enable Idaho solar electricity to become a new export product.

5) Wind

Quality of Wind Resources. Idaho has excellent wind resources. In terms of the amount of wind power that is technologically feasible, Idaho's potential relative to population is relatively high, see Figure 14.

Development. Similar to the discussion above regarding solar, utility-scale storage improves the cost-effectiveness of developing in-state wind resources.

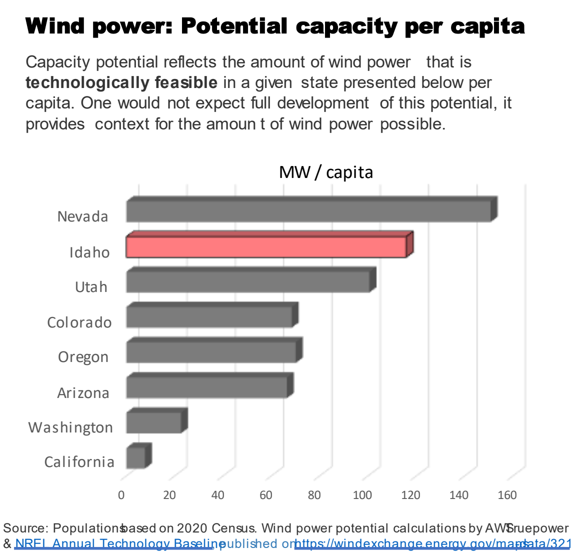


Figure 16: Wind power: Potential Capactiy Per Capita. Source: NREL

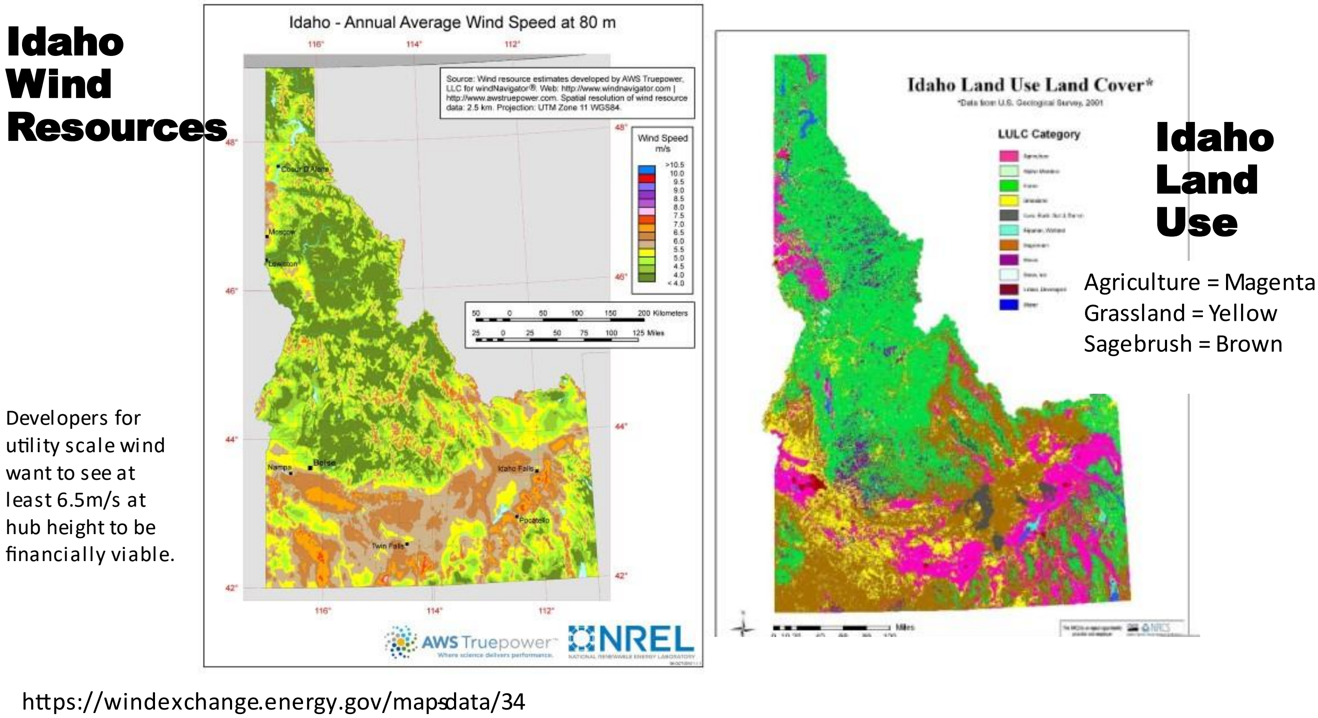


Figure 17: Idaho Wind Resources. Source: NREL

3.3 Opportunities

Specific opportunities for Idaho to capture economic value are at the intersection of Idaho's strengths and the enabling benefits of utility-scale storage. The most substantial economic development benefits are not necessarily the direct impacts associated with specific storage investments, such as the jobs associated with a storage project. Rather, storage technology can enable Idaho to better leverage its resources to yield broader economic development benefits. Thus, many of the economic development benefits below relate to the heightened return storage enables for Idaho-based renewables.

While not comprehensive, this report highlights four areas of opportunity:

1) In-sourcing Idaho's energy needs
2) Attracting, retaining, and supporting businesses in Idaho
3) Opportunities at the intersection of Idaho's ag sector, solar, and storage
4) Idaho's potential as a storage technology hub

In-Sourcing Idaho's Energy Needs

Serving the Need for New Resources. Idaho needs resources to serve forecasted growth in demand for electricity due to population growth and electrification of loads, such as electric vehicles. In addition, as coal has become less cost effective than alternatives, Idaho utilities are identifying new least-cost resources to backfill coal exits. Among the options for new resources, the increasing cost effectiveness of storage combined with Idaho's excellent solar and wind potential enable Idaho to better leverage in-state resources to backfill coal exits and serve its growing electric loads.

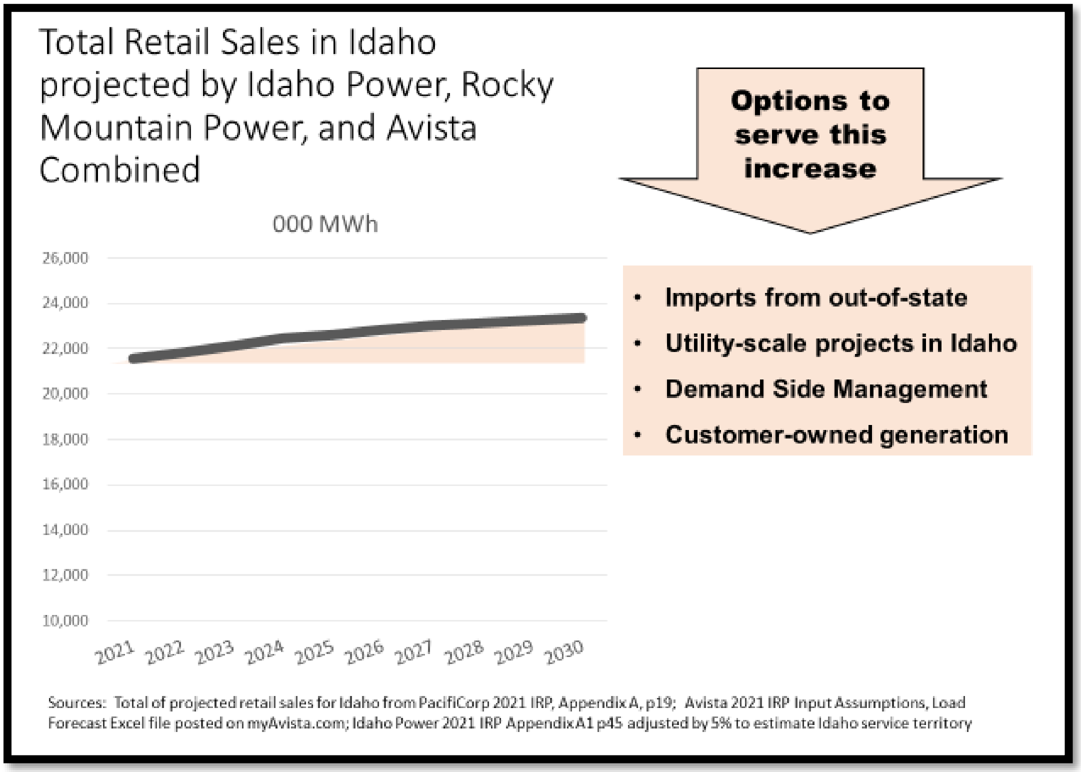


Figure 18: Total Retail Sales in Idaho Projected by Idaho Power, Rocky Mountain Power, and Avista Combined. Source: Idaho Power, Rocky Mountain Power, Avista.

Supplying Renewable Energy. Not only is the demand for electricity in Idaho growing, but also the demand for clean energy is rapidly growing. Each of Idaho's three investor-owned utilities have clean energy goals. Idaho Power has a goal to reach 100% clean energy by 2045, Rocky Mountain Power has a goal to add 12,000 MW of renewable energy by 2040, and Avista has a goal to reach 100% clean energy by 2045.

Municipalities. Municipalities in Idaho are setting goals to accelerate the transition to clean energy (see Figure 17) Idaho can benefit from serving that demand via in-state resources.

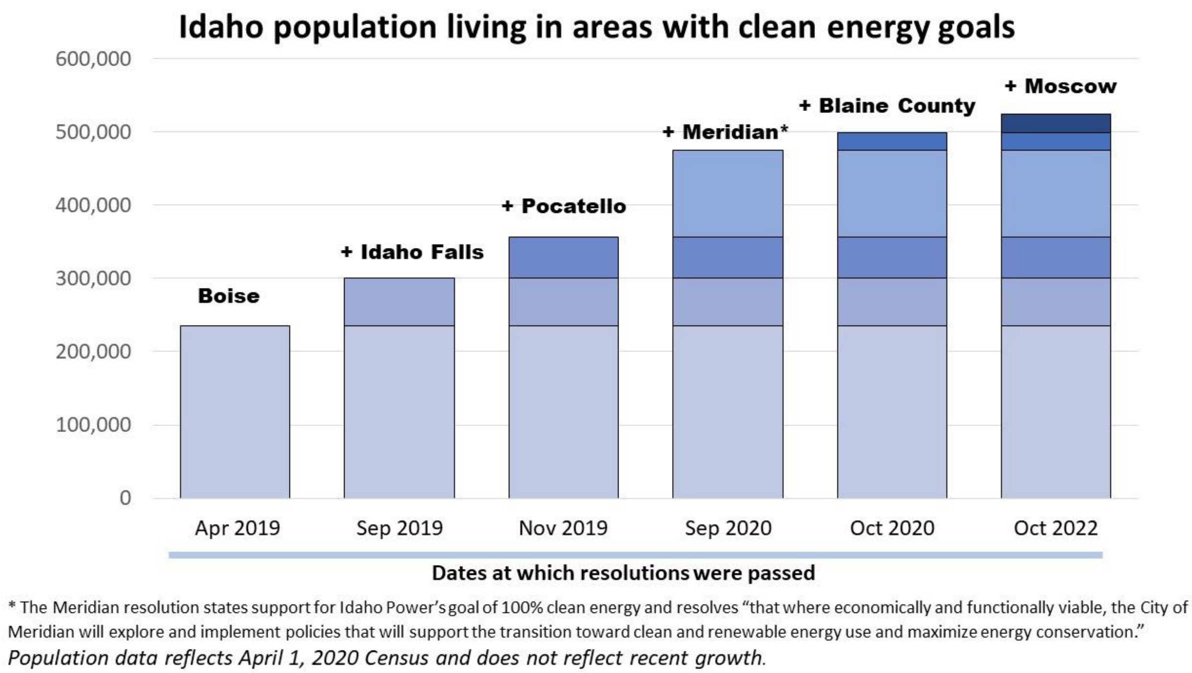


Figure 19: Idaho Population Living in Areas with Clean Energy Goals.

Utility-controlled storage augments the value of renewable energy resources such as wind and solar and better enables Idaho to meet the growing demand for renewable energy with in-state resources.

Rural Areas. One of the synergies between supply and demand for renewable energy is that Idaho's urban populations are creating higher demands for electricity sourced from renewables such as solar, wind, and storage. While rural areas may benefit from tax revenue and direct jobs, it is important to note that these communities also bear the weight of hosting energy facilities.

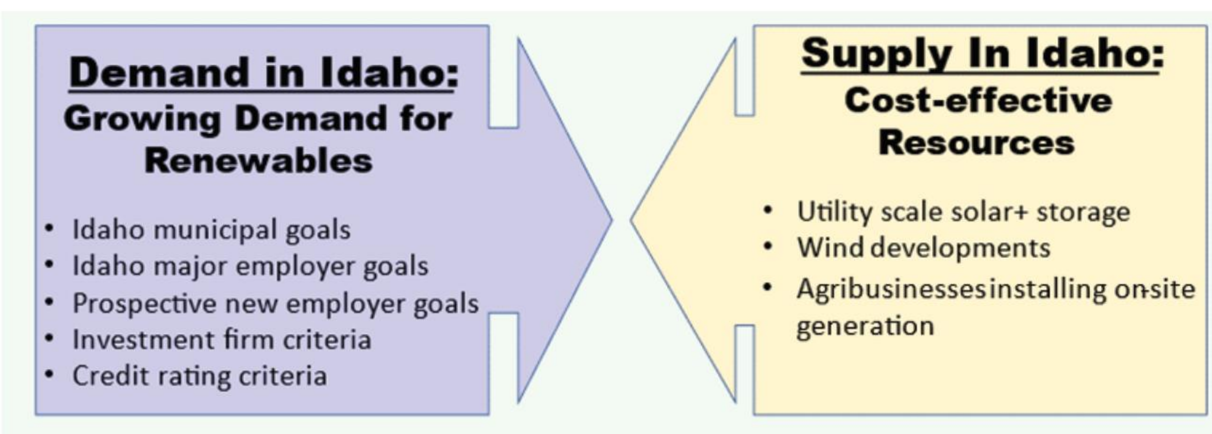


Figure 20: Supply and Demand in Idaho. Source: Clean Energy Opportunities for Idaho.

Longevity of Revenues. The longevity of tax revenues and lease payments is notable. Idaho levies a 3% tax on wind and geothermal energy producers' earnings and a 3.5% tax on solar energy producers' earnings. This is known as Payment in Lieu of Taxes (PILT) and these taxes go towards counties. Revenue generated from alternative energy leasing provides vital funding to endowment beneficiaries, including Idaho's public schools (Idaho Department of Lands, 2023). The quality of solar resources in southern Idaho is comparable to Texas (see Figure 13). With regard to Texas, the Rocky Mountain Institute reports:

> "The continued strong growth of renewables in the state is good news for rural counties and residents, which stand to receive an additional \$3.4–\$4.3 billion in lifetime tax revenues and \$3.2–\$5.8 billion in lifetime land lease payments from the new wind and solar projects in the development pipeline (Siegner et al., 2021).

In sum, storage enhances Idaho's ability to in-source its electricity needs.

Attracting, Retaining, and Supporting Businesses in Idaho

Among Idaho's top 15 employers, the majority have renewable energy goals. The trend has been toward an increased interest in sustainable energy. Companies across the U.S. are pledging to source their operations from 100% renewable energy by certain dates, such as Microsoft, Apple, Google, Walmart and Amazon. Energy-intensive companies more commonly have specific clean energy goals. Manufacturing, data centers, and food processing operations are common types of businesses that find Idaho an attractive option and are looking for paths to low-cost and clean energy resources.

In Utah, for example, Rocky Mountain Power is providing Facebook's Eagle Mountain data center 100% renewable energy. Facebook says, "We are now partnering with them to identify potential solar projects in various locations in rural Utah. These projects will represent hundreds of millions of dollars of investment across the state." (Idaho Business Review, 2018*)*

Idaho most often competes with Utah, Arizona, Nevada, and, at times, Oregon to attract new commerce. Idaho has historically been able to tout its relatively clean energy portfolio as a competitive advantage in attracting commerce to the state. The landscape is changing, and other states have visible policies which appeal to companies looking to locate where there's a path to clean energy.

Idaho has the existing hydro and renewable resources to serve commerce which values clean energy. Storage can enhance the cost-effective development of those resources. Support for technologies to transition to renewable energy as rapidly as economically feasible can aid in Idaho's attraction of new commerce.

Opportunities at the Intersection of Idaho's Agriculture Sector, Solar, and Storage

Idaho's economy is one of the four most agriculture-intensive in the nation in terms of contribution to GDP. Agriculture and energy are interdependent. The agriculture sector in Idaho is a large consumer of electricity, and it has potential to be a substantial generator of electricity.

As stated in a representative comment to the Public Utilities Commission, “I and my agribusiness friends are ready to invest in producing energy as another way to save money and become more energy efficient.” (Hooley, 2021) . When Idaho agribusinesses invest in renewable energy, there are ripple effects that create long-term economic benefits to Idahoans. Storage presents opportunities to encourage and integrate these projects, and to optimize the benefits to agribusinesses, ratepayers, and Idaho:

Cost Control for Agribusinesses. The economic resilience of Idaho agribusinesses relies on the ability to manage energy costs. Idaho growers, for example, compete in national markets yet have disproportionately higher electricity costs for irrigation. Some Idaho growers are finding that installing solar in the unused pivot corners of farmland can be a cost-effective means of managing energy costs as well as mitigating risks of future rate increases. Idaho dairies are also energy intensive operations, and many are turning to solar to control costs. Utility-controlled storage can augment the value to the grid of solar installations.

Figure 21: Picture of Solar Panels

Defer Future Infrastructure Costs. Optimizing the overall cost of utility-supplied electricity in Idaho is linked to managing the peak demands on the grid. As described by Public Utility Commission staff in a docket studying fixed costs for Idaho Power, “Staff notes that secondary level irrigation customers account for approximately 23% of summer peak demand, so any reduction in irrigator's demand could help defer the need for future generation and transmission plant.” (IPUC, 2020). In other words, solar and storage technologies present opportunities not only for agribusinesses to manage their own electricity costs but to lower peak demand on the grid and mitigate future costs for other ratepayers.

Preservation of Agricultural Land. Population growth in Idaho is driving the loss of farmland. For Ada and Canyon counties, for example, a Boise State University study projects that - under the “Business As Usual scenario” -- 190,000 acres of ag land will be lost to urban encroachment by 2100, as shown in this “Loss of Farmland” figure. (Narducci et al., 2017). Coexisting renewable energy on farmland, such as customer-owned solar in the unused corners of irrigated fields, improves the value of agricultural land; utility-scale storage can augment the value of those renewable energy

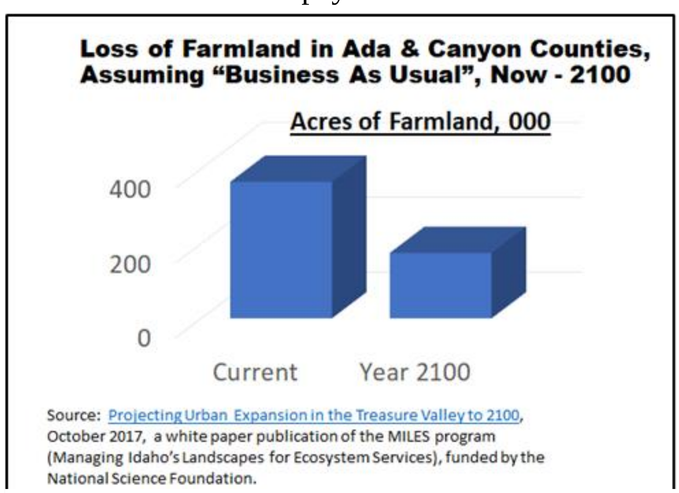


Figure 22: Loss of Farmland in Ada and Canyon Counties. Source: Projecting Urban Expansion in the Treasure Valley to 2100.

resources. Storage combined with distributed generation could be a component of strategies to prevent the irreversible loss of Idaho's agricultural land.

The improving economics of solar and storage present opportunities to control costs, mitigate risks, improve land values, and create value synergistic with Idaho's agriculture sector.

Idaho's Potential as a Storage Technology Hub

The growth potential for the storage industry is attracting global interest. Currently, the U.S. has little presence in the sectors of battery mining, materials processing, and cell manufacturing. These sectors are central to federal goals of building up a domestic supply chain for electric vehicles and grid storage. Among the benefits to those sectors in the current infrastructure deal are $3 billion in grants for battery material processing, to be disbursed through DOE's Office of Fossil Energy, and another $3 billion for battery manufacturing and recycling grants, through the Office of Energy Efficiency and Renewable Energy. Battery manufacturers are among those that could claim a new 30% investment tax credit.

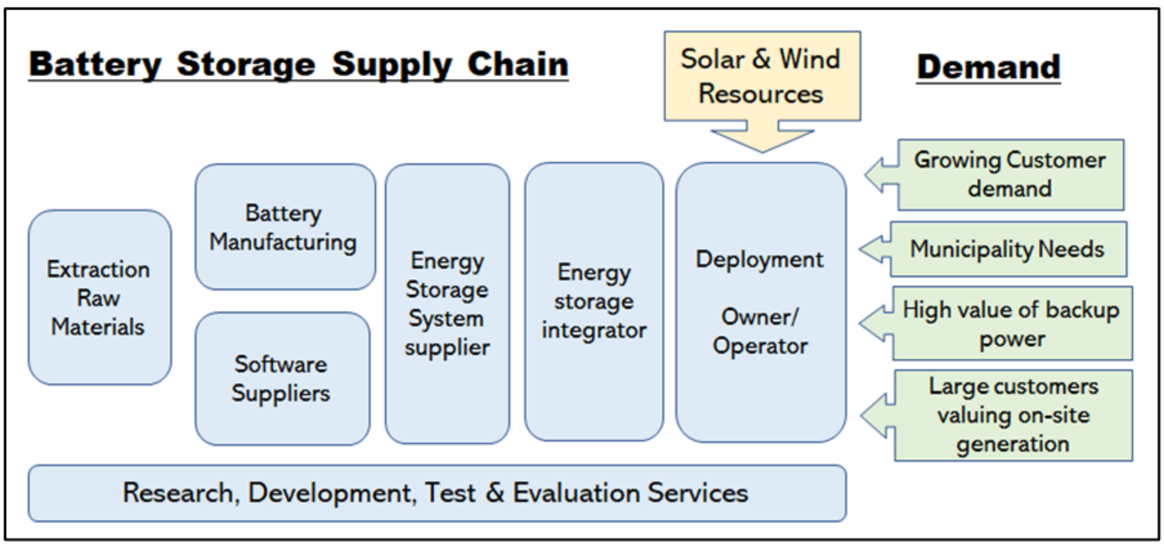


Figure 23: Battery Storage Supply Chain. Source: Clean Energy Opportunities for Idaho.

In 2022, a new ISEA Energy Infrastructure Task Force was created to advise the state on opportunities to pursue through the Bipartisan Infrastructure Law. The greater opportunity for Idaho is the multiplier effect of leveraging statewide resources to establish a hub more so than the economic benefits specific to any single entity. The state also has several of the conditions needed to build a virtual incubator enabling growth of storage-related businesses:

Research. Idaho National Lab (INL) seeks to enable clean energy deployment and offers research, test, and evaluation services in a supporting role to the energy storage industry. As part of these efforts INL is actively involved in validating storage performance and life analysis to reduce the risk of adoption. INL is also engaged in development of technologies related to critical materials including battery materials.

Solar & Wind Resources. As described in Chapter 3, Idaho has solar and wind resources to be captured by future projects.

Deployment. Utility-scale storage is an established technology, yet opportunities for pilot programs are key to early adoption and continued innovation. Idaho's co-ops and municipalities are particularly well positioned for pilot programs.

Collaboration. Idaho's Center for Advanced Energy Studies (CAES) is a well-established consortium including the University of Idaho, Boise State University, Idaho State University and INL for coordinating across research and industry players throughout the state. Unlike more populated states, Idaho is exceptionally able to collaborate across entities and hold forums with meaningful dialogues among stakeholders.

Funding Opportunities

The Infrastructure Investment and Jobs Act of 2021, or the Bipartisan Infrastructure Law (BIL), is a once-in-a-generation investment towards the United States' infrastructure, including power and resilient infrastructure. The Inflation Reduction Act of 2022 (IRA) aims to improve clean energy technology, manufacturing, and innovation. The BIL and IRA created several financial incentives for utility-scale storage.

BIL Opportunities

The BIL will expand the Smart Grid Investment Matching Grant Program by $3 billion to improve grid flexibility. This will include the deployment of energy storage technology.

The Long-Duration Energy Storage Demonstrations funding opportunity appropriates $505 million for the development of long-duration energy storage demonstrations to test new technologies. This creates an opportunity for customers and communities to integrate gird storage effectively and efficiently. The Office of Clean Energy Demonstrations is accepting applications until 3/3/2023.

The Pumped Storage Hydropower Wind and Solar Integration and System Reliability Initiative funding opportunity will support studies that facilitate the licensing, construction, and commissioning of new pumped storage hydropower facilities in an effort to increase the amount of utility-scale energy storage in the U.S. Applications for this opportunity were due in December 2022 and selections are anticipated in spring of 2023.

IRA Opportunities

26 U.S. Code § 48E is a tax code that provides a technology-neutral tax credit for investment in facilities that generate clean electricity and replaces the investment tax credit for facilities generating electricity from renewable sources. This tax credit is eligible for facilities with qualified storage technologies.

The Tribal Energy Loan Guarantee Program supports tribal investments in energy-related projects via direct loans for tribal energy projects including but not limited to energy storage technologies.

3.4 Challenges

This section summarizes potential technology and regulatory barriers to utility-scale storage in Idaho. An overview is provided on the regulatory framework for storage and questions/issues associated with integration of storage into utility electrical systems.

Regulations

Over the past decade, the need for electrical storage raised numerous issues regarding the regulatory framework governing energy generation, transmission, and marketing (Hart et al., 2018; Fitzgerald et al., 2015):

- Rules should be revised so that storage assets can participate fully in electricity markets.
- Products and price formation processes should be designed so that storage can compete on a level playing field with generation and demand response assets.
- Regulations should allow storage asset owners to receive compensation through multiple value streams.
- Laws and regulations may classify storage devices as generation assets and thus arbitrarily limit the services that they can provide and who may own them.

Actions taken in recent years by the Federal Energy Regulatory Commission (FERC) addressed a number of these issues (Campbell, 2019). On a national level, under the Federal Power Act (FPA), FERC has authority over several aspects of the energy system in the United States including the sale and transmission of wholesale power, the reliability of the bulk power system and to ensure that wholesale electric power rates are "reasonable, nondiscriminatory, and just to the consumer." The Energy Policy Act of 1992 opened wholesale electricity markets to competition by allowing wholesale buyers to purchase electricity from any generator, requiring transmission line owners to transport (or "wheel") power for other generators and purchasers of wholesale power. FERC, in 1996, issued Order No. 888 to ensure that these transactions could take place efficiently and allow access to the transmission grid through the regional transmission organizations (RTOs) and Independent System Operators (ISOs). Idaho's utilities are not in an RTO or ISO but do participate in the Western Electricity Imbalance Market administered through the California Independent System Operator.

Two recent FERC Orders that directly address the regulation and inclusion of electrical storage in the energy generation, transmission, and RTO/ISO markets are Orders 841 and 845.

Order No. 841 defined an energy storage resource as "a resource capable of receiving electric energy from the grid and storing it for later injection of electric energy back to the grid." The practical effect of this Order was for each regional grid operator to revise its tariff to establish a participation model for electric storage resources that consist of market rules that properly recognize the physical and operational characteristics of electric storage resources.

Order No. 845 changed the definition of "generating facility" to explicitly include electric storage resources. Also, the Order changed the interconnection rules so that potentially some electric generators could add storage capacity to their facility and use that storage capacity to send energy to the grid. This may provide an opportunity for renewable generators to sell power when the renewable capacity is unavailable.

Pace of Change

The pace of change in the energy sector has accelerated. The term “disruptive technology” is used to describe an innovation that significantly alters the way that consumers, industries, or businesses operate. Storage is widely recognized as a disruptive technology of this decade. This challenges utilities, regulators, and policy makers to adapt at an accelerated pace.

Complexities are Difficult to Model and Regulate. The sheer volume of pages and analyses reflected in IOUs’ integrated resource plans of this decade versus last decade are indicative of diligent efforts to plan for a changing energy landscape. Each utility’s decision to deploy storage then impacts the assumptions of other utilities in the region regarding the cost and availability of energy via market purchases. The growing complexities create challenges for utilities to model and for regulators to oversee.

Financial Interests of Investor-owned Utilities. An investor-owned utility has a responsibility to create shareholder value via the opportunity to earn a return on the company’s investments, and regulators provide oversight on behalf of the public interest. With greater complexities and uncertainties, there is greater risk that a misalignment of financial interests can result in missed opportunities. As utility-scale storage enables opportunities to create value in the public interest of Idahoans, the roles of regulators and policy makers are increasingly essential.

Adaptive Strategies. In the face of rapid technological changes such as utility-scale storage, the future is increasingly unlike the past. This increases the value of several strategies:

- **Experimentation.** Pilot programs and platforms that enable experimentation better position Idaho to adapt.
- **Venues for Innovation and Collaboration.** Regulatory proceedings play an essential role but are not designed to foster innovation. New forums can enable collaboration and innovation complementary to regulatory proceedings.
- **No Regret Moves.** The range of risks associated with resource alternatives varies widely. Resource planning models are programmed to select the lowest cost resources based on input assumptions, yet the price of risk is difficult to model into the cost of those resources. For example, the risks of fuel price changes and carbon cost changes is high for coal and gas, not for solar plus storage. The value of scenario planning, judgment, and regulatory support for the selection of no-regret resource planning are increasingly valuable.
- **Rapid Following and Learning From Others.** Leveraging the lessons from programs in other states is of growing value.
- **Nudging.** The science of change recognizes that one can have both the motive and ability to adapt yet still need a prompt. For example, video conferencing platforms were widely available in 2019, yet it took a pandemic to prompt widespread use. The assignment of this report creates an exemplary prompt to evaluate opportunities related to utility-scale storage. Idaho leaders can help accelerate the pace of adaptation and better capture the potential of utility-scale storage through additional nudges and thoughtful creation of venues for building shared understanding, crafting options, and enabling new paths forward.

Chapter 4: Cost Effectiveness of Utility-Scale Storage

The cost effectiveness of utility-scale storage is complex. It is important to note that different technologies have different costs and operational efficacies. In some circumstances gas peakers, depending on the cost of gas, can be more cost effective than storage technologies (although an escalating cost of carbon, if implemented, would affect the economics of gas peakers vis-à-vis other options). Storage is not the only solution to meet peak demands; demand response, rate incentives (i.e., Time-of-Use (TOU)), and other options may be more cost-effective, based on the multitude of factors utilities must evaluate in their resource decisions.

4.1 Valuing Storage Systems

Capacity vs. Energy. In weighing energy resource alternatives, there's a difference between the cost of *energy* and the cost of *capacity*. One could think of energy costs in terms of the average cost of each unit of kilowatt hours. "Levelized costs" are a means of valuing the cost of electricity over time. The EIA, for example, reports in 2021 that solar offers the lowest levelized cost of electricity for future new generation resources (EIA, 2021). The challenge, is that the timing of when energy will be generated from a new resource doesn't perfectly line up with the timing of potential shortfalls between supply and demand -- the utility needs *capacity* to meet peak demand.

The Effective Load Carrying Capacity (ELCC) is a measurement of a resource's ability to produce energy when the grid is most likely to experience electricity shortfalls. How close does the resource get to providing energy at the perfect time to meet the targeted reliability goal? An ELCC of 30%, for example, for a resource representing 100MW of nameplate capacity, would mean that the resource project could contribute 30MW to meet reliability requirements at the time needed. The ELCC is not simple math, it requires probabilistic modeling of a resource -- such as solar, wind, storage, etc -- under certain assumptions.

Every 2 years Idaho utilities develop 20-year Integrated Resource Plans using modeling techniques that select the most affordable resources needed to meet load forecasts. In its 2021 IRP modeling, Idaho Power calculated that the ELCC applicable to future storage projects was 87.5% for 4-hour and 97% for 8-hour battery storage systems. While the costs vary for different durations, these high ELCC reflect that storage when paired with a low-cost resource such as solar can optimize both energy and capacity values to the grid. Nationally, EIA anticipates most large-scale battery energy storage systems to come online in the next three years are to be built at power plants that also produce electricity from solar photovoltaics.

Crossing the Tipping Point. Grid-scale battery storage applications have crossed a tipping point to become cost effective new resources, typically replacing gas for various applications (Robertson, 2020). Given the dramatic decline in battery storage prices, short-duration (4 hour) storage has become cost-effective (Goldman School of Public Policy, 2020). In Idaho, evidence can be seen in comparing Idaho Power's preferred portfolio in 2021 relative to 2019 (See Figure 22: Storage has crossed the tipping point in Idaho).

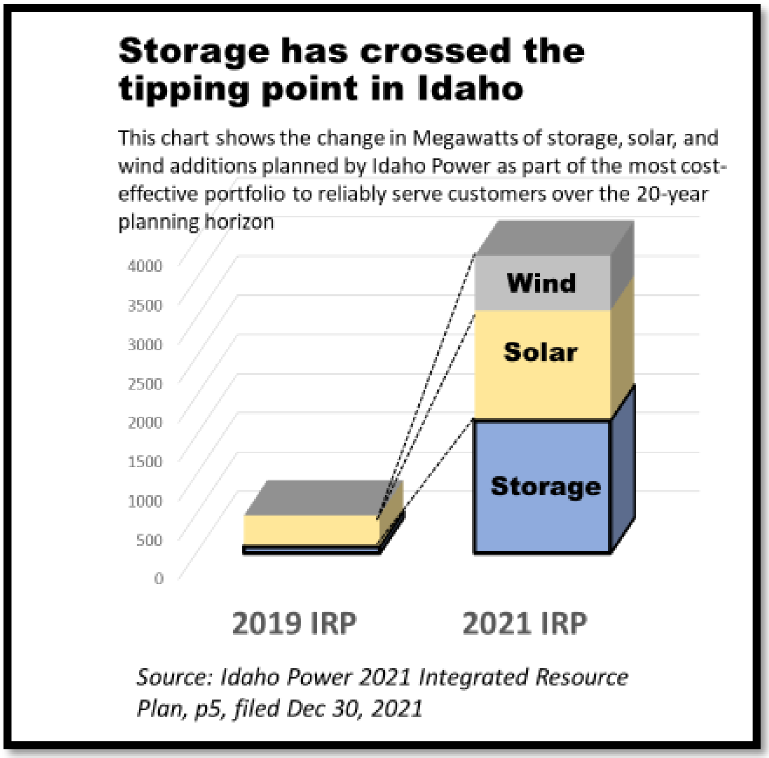


Figure 24: Storage has crossed the tipping point in Idaho. Source: Idaho Power IRP.

In the 2019 IRP cycle, Idaho Power's modeling projected that the preferred, least-cost portfolio of resources to reliably serve customers should include the addition of 80 MW of battery storage over the 20-year planning horizon. In its 2021 IRP, the preferred portfolio now plans for 1,685 MW of additional storage, over 20 times the amount previously planned. Storage augments the value of solar and wind, which the 2021 modeling also determined to be more cost effective than in the 2019 planning cycle.

This transition in Idaho is consistent with national projections. The EIA expects the following:

> Electric power markets in the United States are undergoing significant structural change that we believe, based on planning data we collect, will result in the installation of the ability of large-scale battery storage to contribute 10,000 MWs to the grid between 2021 and 2023—10 times the capacity in 2019 (EIA, 2021).

The National Renewable Energy Lab (NREL) has modeled the future role energy storage in the electrical grid through 2050 across a range of assumptions and scenarios. The lab reports in its summary:

One Key Conclusion: Under all scenarios, dramatic growth in grid energy storage is the least cost option. (NREL, 2021)

The Value Components of Storage

While the section above describes the increasing cost-effectiveness of storage systems, this section describes the composition of those economic benefits.

"Value stacking" is a method of analyzing the components of value added by a resource in comparison to costs to determine cost effectiveness of the resource. As described in Chapter 1, utility-scale storage systems may provide different forms of benefits to the grid (see Figure 23). Each of these may represent a component in the value stack. This table focuses on value to the grid and does not include other potential forms of benefits, such as customer benefits covered further below.

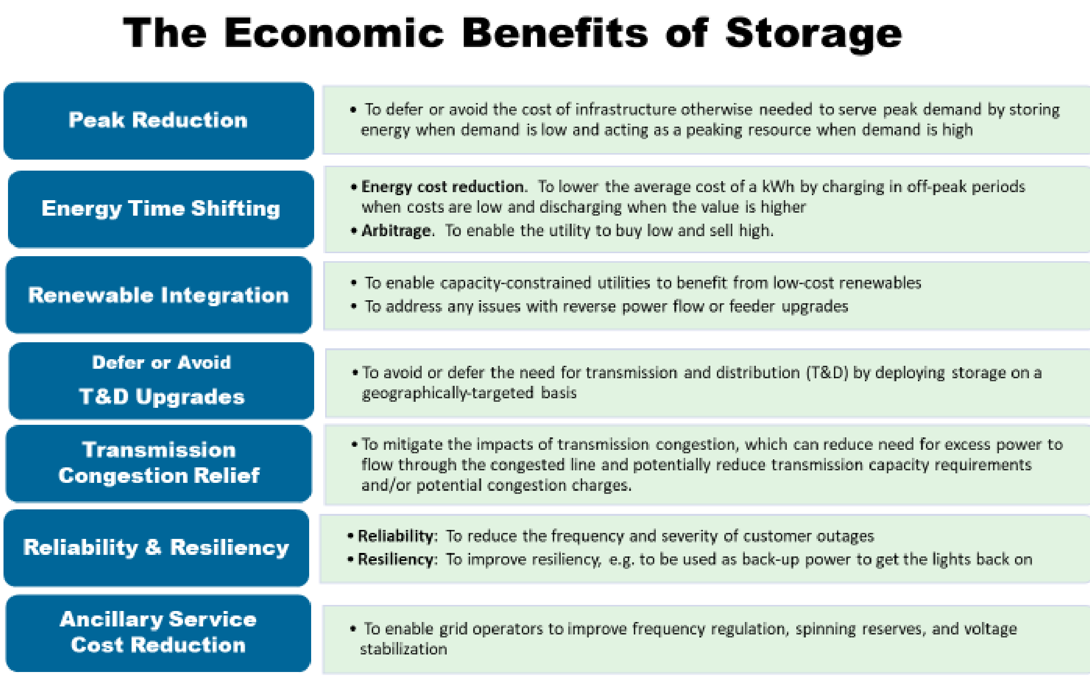


Figure 25: The Economic Benefits of Storage. Source: Clean Energy Opportunities for Idaho.

Case Example: Massachusetts conducted a broad study to model the financial value proposition of storage for the state and to identify the amount of storage which would optimize systems benefits to ratepayers. The model analyzed 1,497 nodes (where two or more wires meet) and 250 substations in Massachusetts that included generator, transmission, and load substations where storage could be located. The model simulated the electric system to estimate that 1,766 MW of storage would provide net benefits to ratepayers with a benefit-cost ratio ranging from 1.7 to 2.4. (State of Charge Executive Summary, Massachusetts Energy Storage Initiative, 2016, page xi). The results of this Massachusetts study are summarized in Figure 24. The model reflects a common approach for valuing storage benefits called "value stacking" to assess the financial value of the different types of benefits. While these results are specific to Massachusetts, the study points to the scale of potential net value and the significance of peak reduction.

Idaho Power is planning for a similar level of storage capacity (1,685 MW of storage vs. 1,766 MW modeled above); the situations are different and by no means an apples-to-apples comparison, yet the size of the ballpark is relevant.

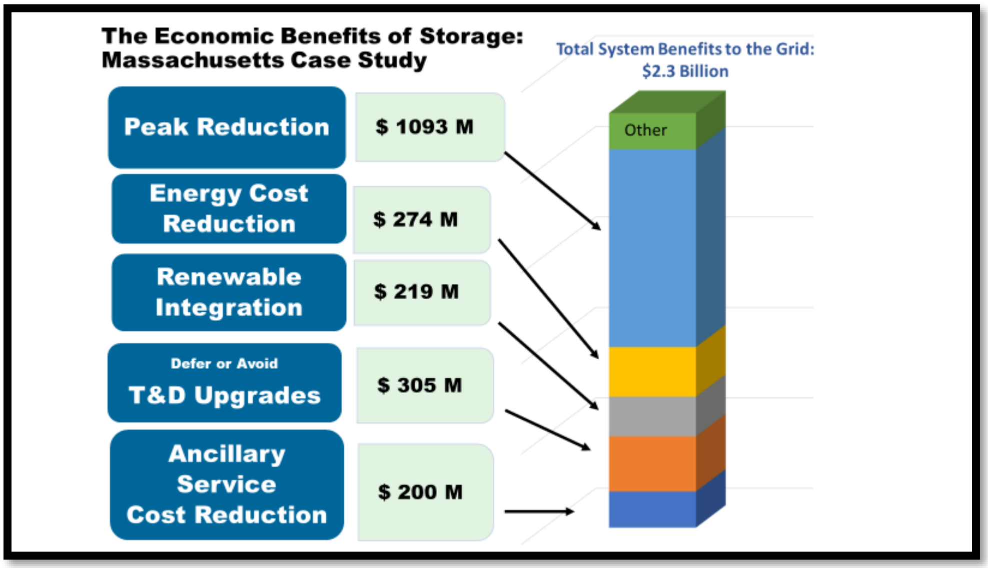


Figure 26: The Economic Benefits of Storage: Massachusetts Case Study. Source: Massachusetts Energy Storage Initiative

Cost/Benefit Analysis. The Massachusetts study also modeled a case example of storage assets deployed by an IOU to compare both the costs and the value stack of benefits for 2016-2020.

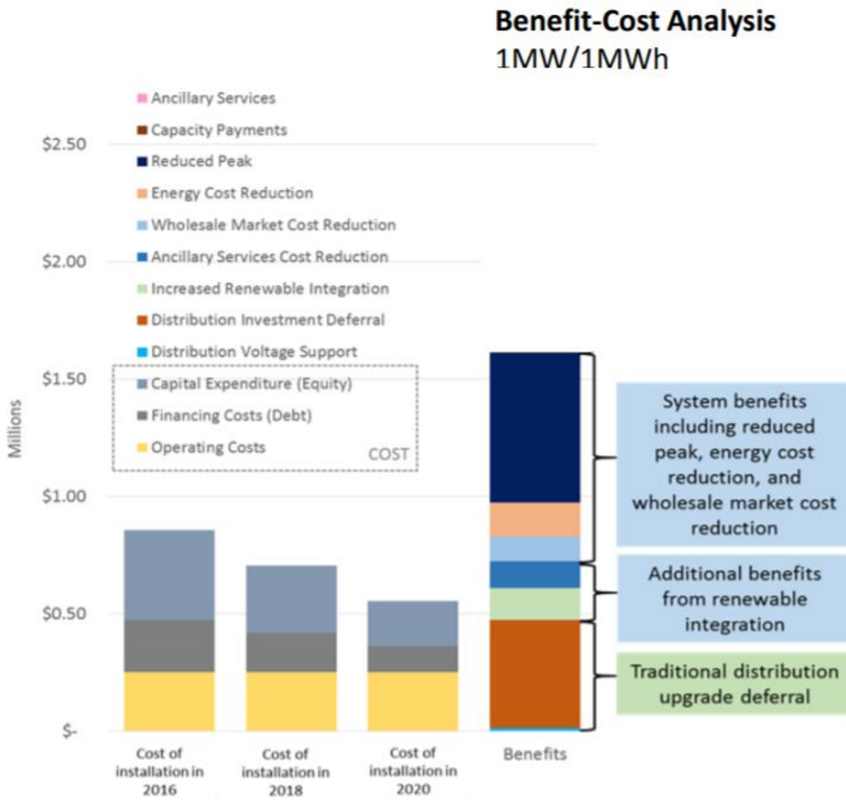


Figure 27: Benefit Cost Analysis. Source: Massachusetts Energy Storage Initiative.

4.2 Value Associated with Customer-owned Generation

As previously described, there are numerous financial benefits to the grid achieved by combining resources with utility-scale storage of varying sizes. Benefits to the grid flow to ratepayers who receive affordable and reliable services. In addition to the grid perspective, there are additional forms of value from customer perspectives associated with customer-owned generation.

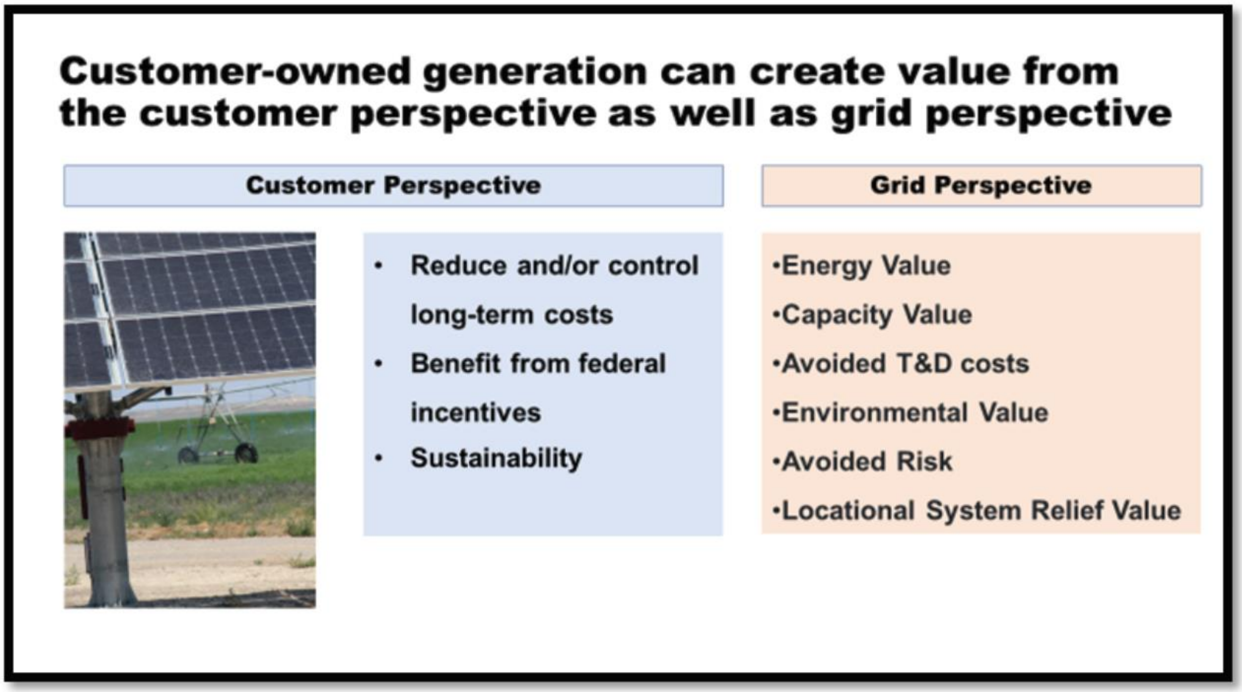


Figure 28: Customer-owned generation can create value from the customer perspective as well as grid perspective.

Year by year residential and commercial solar installations have increased over the past ten years (Solar Energy Industries Association, 2022).

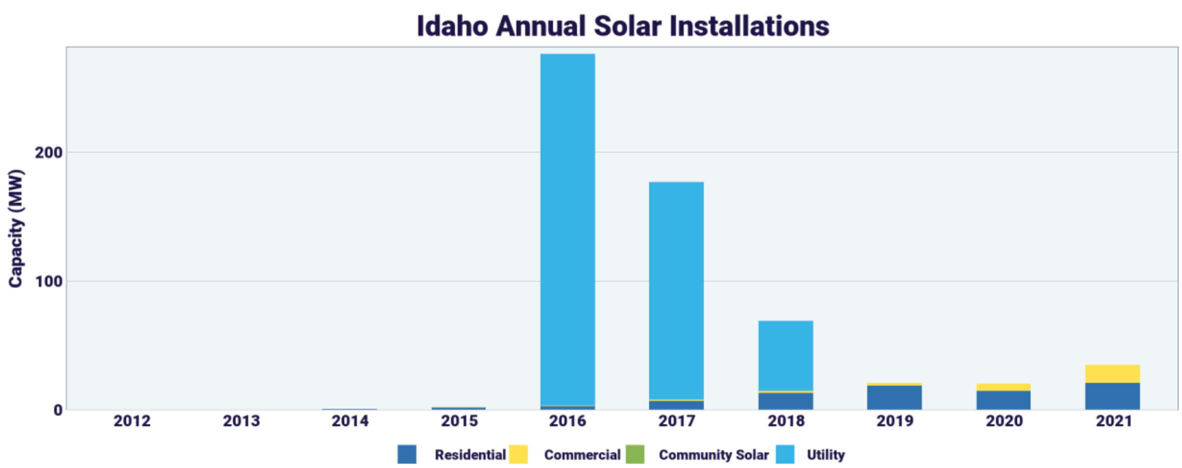


Figure 29: Idaho Annual Solar Installations. Source: Solar Energy Industries Association.

The cost effectiveness of solar particularly has been enabling energy-intensive businesses, such as farmers and dairies, to create value and reduce energy costs through investments in customer-owned solar generation. A commercial customer, for example, may see opportunities to not only reduce costs but also to gain greater long-term control over electricity costs via an investment in solar generation.

Utility-scale storage is synergistic with customer-owned generation in two ways: 1) Utility-controlled storage can augment value to the grid of customer-owned generation. 2) Utility-controlled storage can better enable *customers* to capture the value they seek from customer-owned generation.

4.3 Idaho Conditions Which Improve the Value of Utility-Controlled Storage

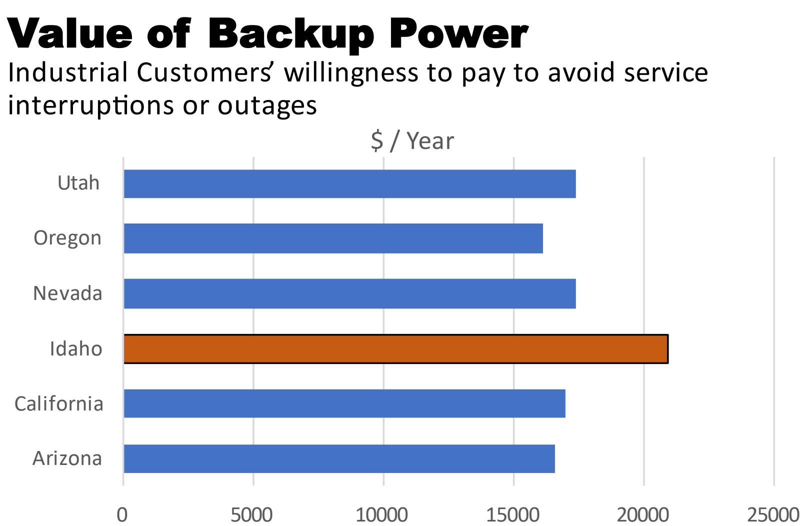
Several factors increase the cost-effectiveness of utility-scale storage in Idaho:

- **Peaky Loads.** A load factor is a measure of how "peaky" the load on the grid is, specifically the average load relative to the peak load. Loads in southern Idaho are particularly "peaky" given the steep demands for AC as well as high electric loads for agricultural irrigation during hot summer afternoons. This high difference between our peak load and our average load increases the value of storage technology which can bridge that difference.

- **Excellent Renewable Resources**. As previously described, Idaho has excellent solar and wind energy potential.

- **Back-up Power Highly Valued**. The value of resilience is difficult to model in resource planning because is not an easily quantified cost. Much of the value of resiliency is from a customer perspective. A NREL report combined 34 data sets from customer surveys to assign values based on customers' willingness to pay for back-up power (NREL, 2021).

  Customers in Idaho place an exceptionally high value on backup power, see Figure 28. The value of backup power to Idaho customers was estimated at $21 thousand/year for industrial customers, $926/year for commercial, and $6/year for residential. In particular, Idaho hospital networks and food processors, among other industries, value back-up power. Storage provides a synergistic solution and opens the door to new forms of collaboration for utilities and customers to leverage storage both as a dispatchable resource to the grid and a source of backup power to large customers.



Source: NREL. Storage Futures Study, Appendix: Backup Power Calculation. "This value stream is intended to reflect the monetized value provided by the battery storage system as a source of backup power to customers. **We assign the value for backup power to equal a customer's willingness to pay to avoid service interruptions or outages"**

Figure 30: Value of Backup Power. Source: NREL

- **Favorable Cost Multiplier**. In calculating and project utility-scale storage costs, NREL applies a multiplier to each region to reflect local land costs, labor costs, design requirements, and other factors. This multiplier is high west of Idaho and in the Northeast, relatively low for Idaho, see Figure 29 (NREL, 2019).

  There are additive values created depending on how centralized or decentralized the storage is deployed. Opportunities exist for collaboration with customers to enable both the utility and customer to optimize and share the full range of benefits.

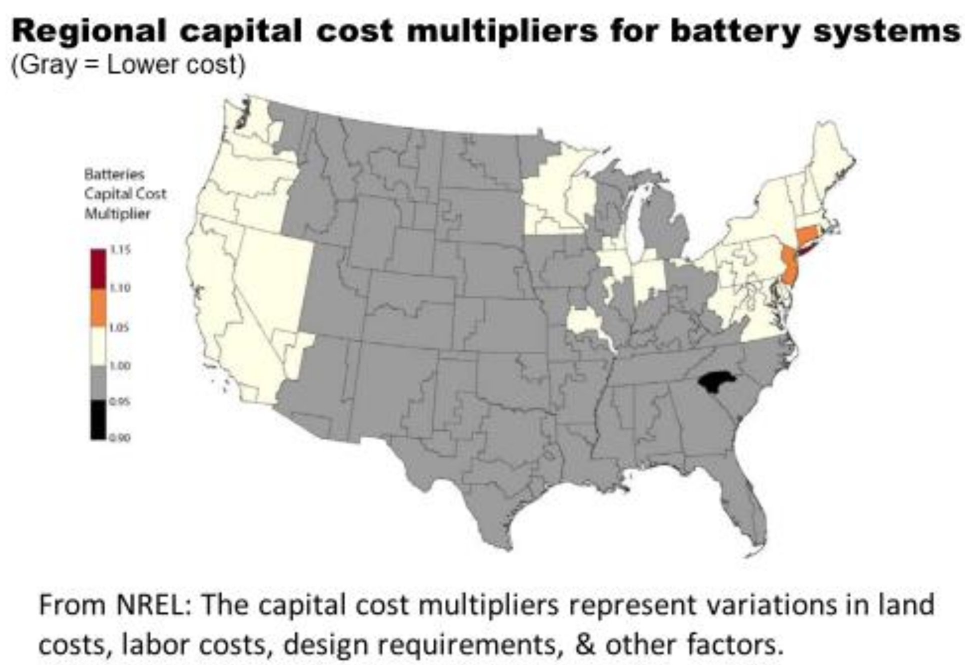


Figure 30: Regional Capital Cost Multipliers for Battery Systems. Source: NREL

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