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The Economic Potential for Energy Storage in Nevada

PREPARED FOR
Public Utilities Commission of Nevada
Nevada Governor's Office of Energy

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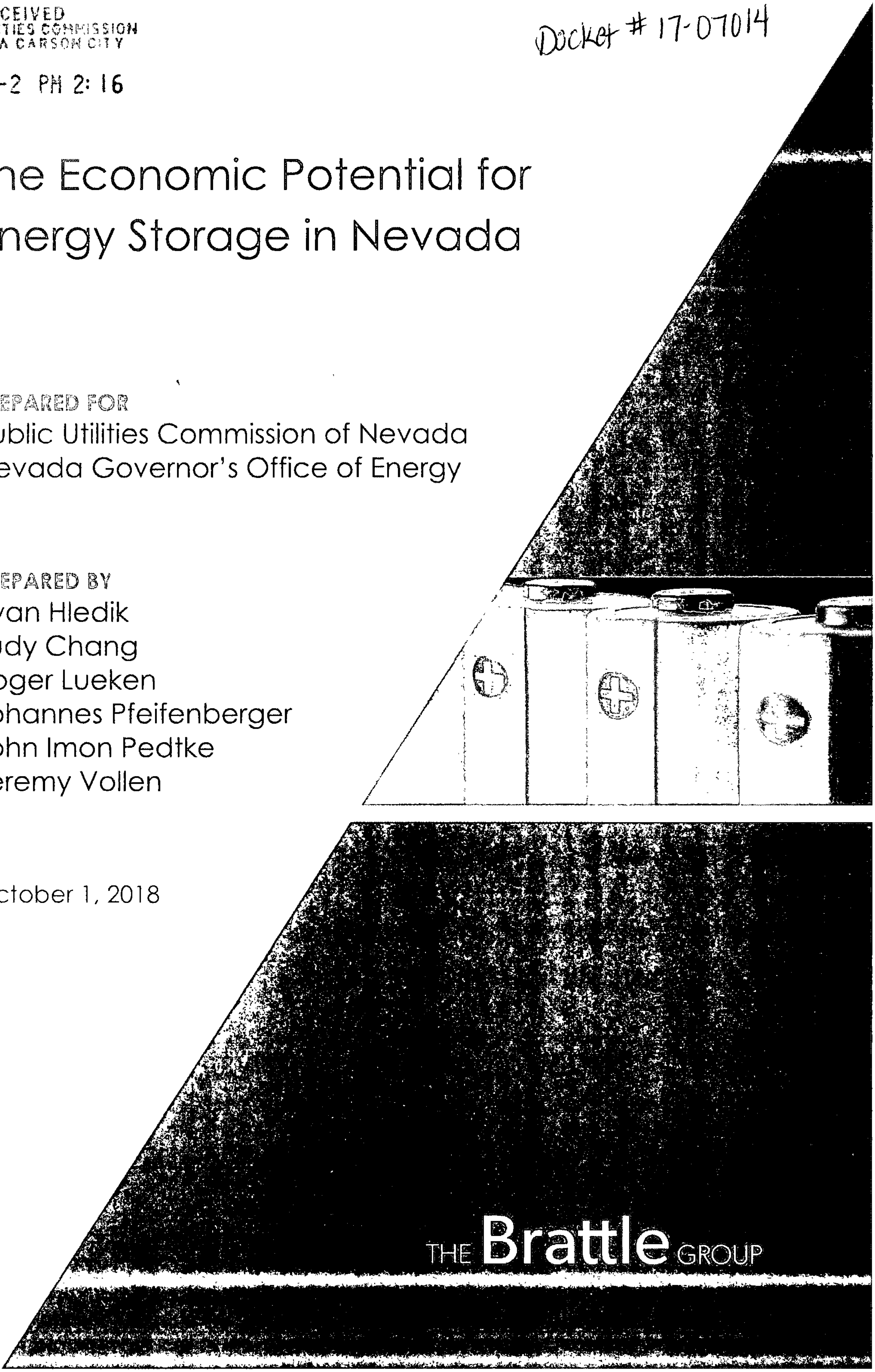

Notice

This report was prepared for Public Utilities Commission of Nevada (PUCN) and the Nevada Governor's Office of Energy (GOE) based on work supported by the Nevada Governor's Office of Energy, and the Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), under Award Number DE-EE0006992. It is intended to be read and used as a whole and not in parts; it reflects the analyses and opinions of the authors and does not necessarily reflect those of The Brattle Group's clients or other consultants.

The authors would like to acknowledge the valuable collaboration and insights of Donald Lomoljo and John Candelaria (PUCN), Angela Dykema (GOE), Patrick Balducci and Jeremy Twitchell (Pacific Northwest National Laboratory), and the contributions of NV Energy staff in providing necessary system data. We would also like to thank Brattle Group colleagues for supporting the preparation of this report, including Jesse Cohen for modeling of behind-the-meeting storage applications.

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Executive Summary

Highlights

- This study identifies the amount of energy storage that can be incorporated cost-effectively into Nevada's future electricity resource mix.
- In 2020, up to 175 MW of utility-scale battery storage (with 4-hour storage capacity) could be deployed cost-effectively statewide.
- By 2030, the economic potential for utility-scale storage increases to a range from 700 MW to more than 1,000 MW, depending most significantly on the extent to which storage costs decline over time.
- Behind-the-meter (BTM) storage could add up to 30 MW of storage capacity by 2030 under favorable conditions, and this could further increase by up to 40 MW through the provision of cost-effective utility-administered BTM storage incentives

Nevada Senate Bill (SB) 204 (2017) requires the Public Utilities Commission of Nevada (PUCN) to "determine whether it is in the public interest to establish by regulation biennial targets for the procurement of energy storage systems by an electric utility."[1] The Nevada Governor's Office of Energy (GOE) commissioned this study to provide information for the PUCN when evaluating at what levels energy storage deployment would be economically beneficial for the state of Nevada, and whether procurement targets for energy storage systems should be set and, if so, at what levels.

To assess the value of energy storage in Nevada, our study considers the range of benefits summarized in Table 1.

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[1] Nevada Senate Bill 204 (2017).

Table 1
Energy Storage Benefits

Value Stream	Description
Reducing the production costs of generating electrical energy	Storage can be charged in off-peak periods, when the cost of supplying electrical energy is low. It can then be discharged during peak hours, reducing the need to produce energy from more expensive peaking units. The fast ramping capabilities of storage can also help system operators manage rapid changes in load or variable generation, thereby reducing production costs by reducing the need for (up and down) ramping of conventional generators.
Reducing the production cost of providing ancillary services	The high operational flexibility often allows storage to provide ancillary services (regulation and operating reserves) more cost-effectively than conventional resources. This can contribute to reducing production costs associated with meeting customer loads and associated system needs
Reducing installed capacity needs for traditional power generation resources	Storage can be charged in off-peak periods, when the cost of providing energy is low. It can then be discharged during peak load hours, reducing the need for new peaking capacity that otherwise would have to be built to serve load in those hours.
Reducing distribution-system customer outages	If located on the distribution system, storage can be used to reduce the frequency and severity of customer outages.
Avoiding or deferring the need for transmission and distribution grid upgrades	Storage can be deployed on a geographically-targeted basis to avoid or defer the need for some transmission and distribution (T&D) upgrades.
Reducing emissions and decreasing the curtailment of renewable generation	Storage can reduce emissions either by reducing generation from high-emitting generators or by increasing output from wind and solar generators that would be curtailed otherwise. Avoiding curtailments reduces the production cost of generating energy. Whether storage reduces emissions depends on the marginal emissions profile of the resource mix and the charging and discharging pattern of the storage technology.
Providing additional grid services	Storage can be deployed where additional grid services, such as voltage support, may be needed, deferring other investments needed to provide the same service.

Methodology

In this study, we account for a number of critical considerations when assessing the value of energy storage:

- **Various value streams**. Capturing one value stream for storage can mean foregoing opportunities to fully capture some of the other value streams. Co-optimizing the operation of energy storage relative to the available multiple value streams is therefore important to accurately estimate total storage benefits. We have utilized Brattle's bSTORE modeling suite to account for these tradeoffs. The resulting "stacked" values estimated in this report are additive because we have considered areas where overlapping usages may not occur consistently.

- **Uncertainty in costs and benefits**. Energy storage technology is rapidly developing, and the value streams that it can capture are similarly in a state of evolution. It is important to account for uncertainty in the costs and benefits of storage when establishing future storage procurement targets. We use a range of costs to consider the possibility of relatively rapid versus slow cost reduction for storage. We use a scenario-based approach to consider a range of future developments influencing the benefits storage can provide.
- **The relationship between storage quantity and benefits.** The incremental cost-effectiveness of energy storage decreases as its market penetration grows. This is because the opportunities to provide services such as frequency regulation and local distribution capacity deferral saturate as more storage is added to the power system. In prior energy storage research, we have found that capturing the decreasing marginal value of adding storage is a critical consideration when quantifying overall value and cost-effective storage potential.[2] Our approach accounts for this relationship.
- **Degree of foresight in battery utilization**. Modeling approaches often rely on optimal operation of the storage technology, assuming perfect foresight of system conditions. Our approach accounts for real-world limitations on foresight of future system conditions, and considers how imperfect foresight affects storage operations.

Our methodology is applicable to a broad range of energy storage technologies including, for example, various battery technologies, flywheels, compressed air storage, hydroelectric pumped storage, or thermal storage. To focus the analysis on a representative range of storage costs and performance characteristics, we simulate storage deployment of lithium-ion batteries, which are the predominant energy storage technology currently being deployed and contracted. More specifically we analyze lithium-ion batteries with 4-hour storage capacity.

Consistent with the applicable current law and NV Energy's 2018 Integrated Resource Plan (IRP), our study assumes NV Energy remains the utility responsible for serving most retail customers in Nevada. We assume that: (1) generating resources currently dedicated to serving Nevada loads at their cost of service would continue to be used to serve loads even if they will be subject to competitive pressures in the future, (2) new generation additions and retirements are consistent with NV Energy's IRP, and (3) the transmission available without wheel-out charges between balancing areas remains limited to that available in today's Energy Imbalance Market (EIM) footprint.

If Nevada retail customers were able to choose their power suppliers in the future, the total amount of generating resources needed to serve Nevada's electricity demand would not change. Thus, we do not need to assume that all of the current retail customers must be served by NV Energy or that all generating and new storage resources must be owned by NV Energy. Rather, we focus primarily on how Nevada, as a state, will supply its electricity customers and how the state as a whole may use energy storage as a resource to help meet state-wide system needs and policy objectives. When analyzing the benefits of storage, we evaluate the cost of producing electricity to serve Nevada

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[2] For further discussion, see Chang *et al.* (2015).

electricity users, regardless of who are the retail suppliers. Any changes to the cost of producing electricity account for the costs of operating power plants located inside Nevada (regardless of ownership) and the net costs of purchased power from other entities to serve electricity users in Nevada.

Findings

Energy storage can be incorporated cost-effectively into Nevada's future power supply mix. Under the assumptions used in this study, a statewide deployment of up to 175 MW of utility-scale storage could be cost-effective in 2020 if storage costs are at the lower end of the expected cost range. By 2030, declining battery costs and evolving system conditions increase this estimate of cost-effective potential to at least 700 MW and possibly exceeding 1,000 MW at the high end. The development of these estimates accounts for constraints that limit the operation of the storage devices relative to that of a peaking unit, in particular limits on battery storage discharge duration.

Within these ranges, the optimal storage procurement target will depend on the state's evolving actual need for new generating capacity. Thus, the incorporation of similar storage scenarios into NV Energy's resource planning process would be valuable to further confirm these conclusions.

The findings of our analysis are summarized in the figures below. Figure 1 illustrates the *total* state-wide ratepayer benefits and costs at various levels of storage deployment as well as the composition of the major storage-related value streams that affect utility ratepayers:[3] (1) avoided generating capacity investments; (2) production cost savings (related to supplying energy and ancillary services as well as avoided curtailments of renewable generation); (3) the benefit of deferred T&D investments; and (4) avoided distribution-system customer outages. Not included in Figure 1 are (5) societal emissions-related impacts (since they do not affect utility rates currently), which result in societal-emissions-cost decreases of $0.7 to $10.6 million in 2020 and decreases of $1.6 to $27.0 million in 2030; and (6) other benefits, such as voltage support and T&D energy losses, which are too small to affect the conclusions about cost-effective levels of storage deployment in the state.

As shown, total 2020 benefits exceed total costs only at the low end of deployments analyzed, and only if the low end range of installed storage costs can be realized.[4] In 2030, total benefits exceed total costs across the full range of cost projections and deployment scenarios, although the net benefit of incremental additions in 2030 drops to zero at 700 MW for the high battery cost scenario, as shown below.

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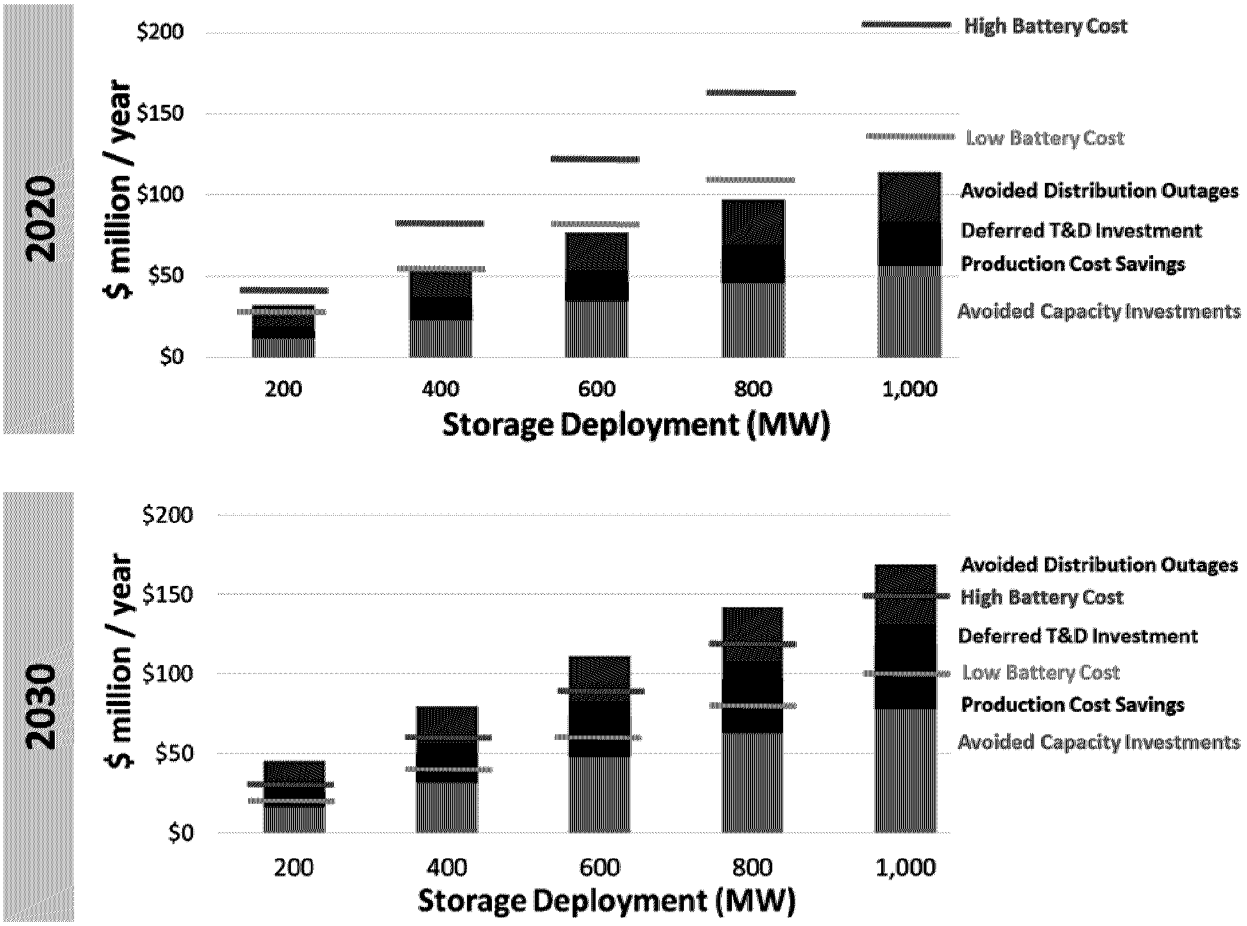
[3] The GOE and PUCN specified that the Ratepayer Impact Measure (RIM) test be used to evaluate how average retail rates will change as the result of Nevada utilities' storage investments.

[4] The range of storage costs accounts for variations across several industry reports, discussions with storage developers, public cost data from recent utility solicitations, and potential variation in costs across specific installations.

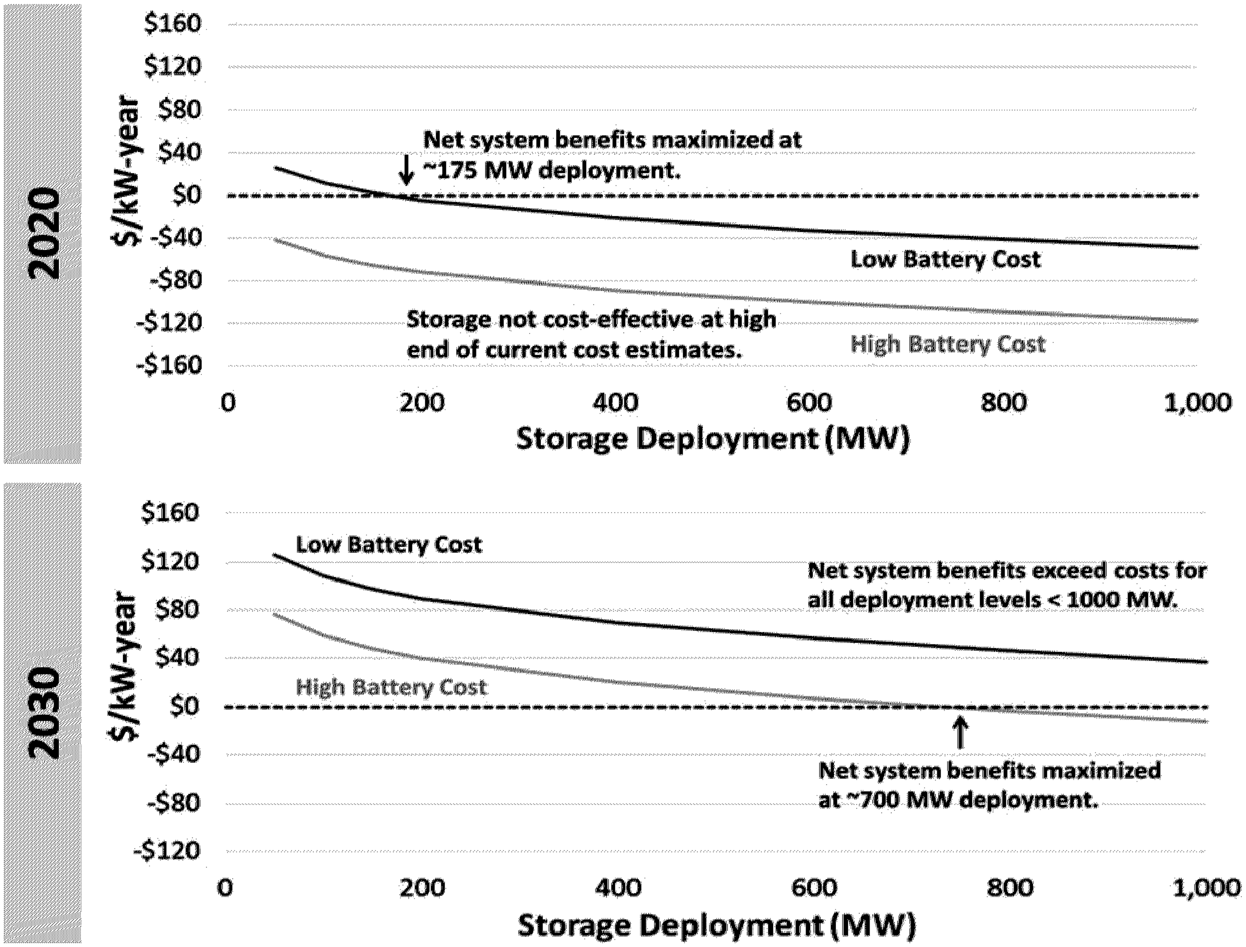
Figure 1
Total System Benefits and Costs of Storage at Various Deployment Levels



Note:
All values are in nominal dollars.

Figure 2 below shows the incremental *net* benefits of storage at various deployment levels. This perspective is useful for identifying the point at which the benefits of incremental storage additions equal the costs of those additions. Storage additions beyond that deployment level are uneconomic, as incremental costs will exceed incremental benefits. As shown, up to 175 MW of storage deployment are cost effective in 2020 at the low end of the storage cost range. By 2030, the cost effective deployment level exceeds 1,000 MW at the low end of projected cost, with 700 MW being cost effective at the high end of projected costs.

Figure 2
Incremental Net Benefits of Storage Deployment in Nevada



Note:
All values are in nominal dollars.

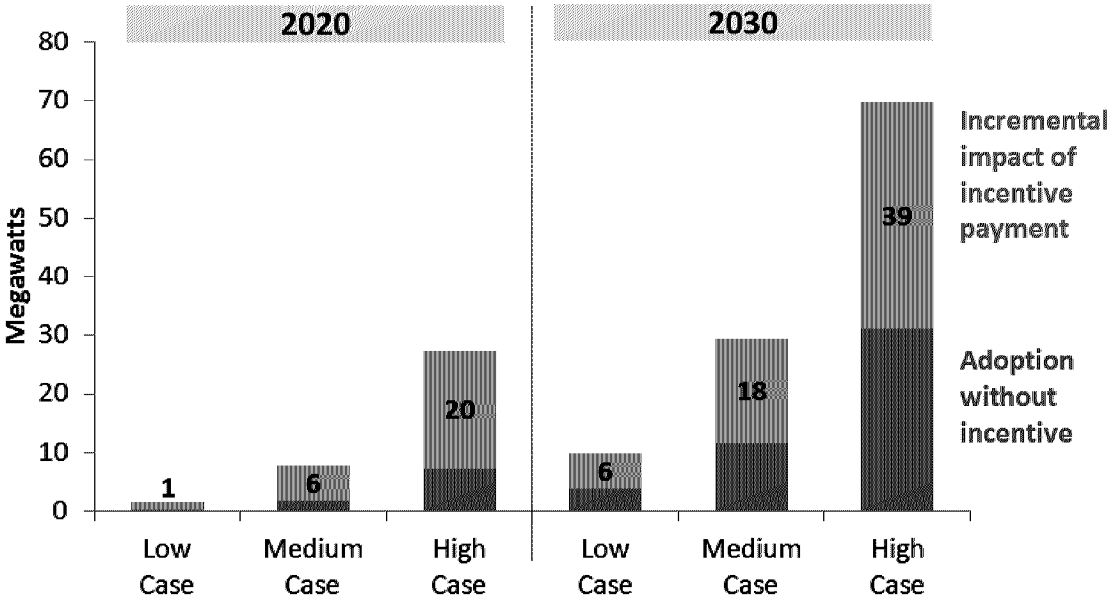
The estimates of cost-effective storage potential are based on quantitative analyses that capture the primary drivers of storage value at the grid level: avoided generation capacity costs, reduced energy costs, reduced ancillary services costs, avoided T&D capacity costs, and reliability improvements (*i.e.*, customer outage avoidance). We do not include the value of estimated avoided emissions when evaluating the amount of storage that would be cost-effective from a system perspective.

Implementation of and Nevada's participation in a regional power market may reduce the value of storage due to lower production cost savings associated with increased resource diversification that would be achieved through having a market that spans a larger region. The resource adequacy needs associated with serving Nevada loads may not be reduced and other value streams are unlikely to be affected. If the implementation of a regional market were to reduce the production cost savings by half and not affect other value streams, the cost-effective level of storage deployment in 2030 would fall from a range of 700 MW to greater than 1,000 MW (without a regional market) to a range of 400 MW to greater than 1,000 MW (with a regional market).

In addition to the utility-scale and distribution-system-level applications discussed above, storage could add value as a customer-side, behind-the-meter (BTM) application. The avoidance of demand charges and peak-energy charges in the retail electricity bill of large (commercial and industrial) customers likely will be the primary driver of BTM storage adoption within the study's 2030 time horizon. Some "baseline" level of BTM storage adoption would happen irrespective of any utility storage procurement initiatives based on specific targets. To remain consistent with the scope of this study, we quantified the cost-effective *incremental increase* from this baseline BTM storage adoption level that could result from a utility-administered BTM storage incentive program offered to retail customers. In return for an incentive payment, customers would allow the utility to control their storage device for a limited number of hours of the year to address resource adequacy (*i.e.*, generation capacity) requirements.

We considered a range of assumptions that would influence BTM storage adoption, such as battery cost, adoption rate, magnitude of utility incentive payments, and the composition of the commercial and industrial (C&I) customers in the state. At estimated 2020 BTM storage costs, BTM storage adoption in the absence of a utility incentive program could be up to 7 MW. The introduction of cost-effective utility incentive programs could incrementally increase these estimates by up to 24 MW. At 2030 BTM storage costs, baseline BTM storage adoption is estimated to be up to 31 MW without the incentive program, which would incrementally increase between 6 MW and 39 MW with availability of cost-effective utility incentive programs. Results of these BTM storage potential cases are summarized in Figure 3. These values are incremental to the adoption potential estimates for utility-scale storage (including front-of meter distribution-level storage) described above.

Figure 3
Cost-Effective Incremental BTM Storage Potential with Utility Incentive Programs



Notes:
The potential estimates represent long-run adoption potential based on assumed storage costs for the years shown in the figure. It would take several years to reach these adoption levels.

In addition to the assumed utility incentive payments for resource adequacy, it is possible that BTM storage could provide additional sources of value, such as ancillary services or avoided T&D costs. Third party aggregators, utilities, or customers could monetize greater value under these conditions, thereby leading to increased BTM storage investments.

As these results show, energy storage can be a cost-effective addition to Nevada's future mix of electricity resources, reducing system costs and benefitting consumers as a result. It can provide value across a range of applications and use cases, whether for resource adequacy, renewables integration, T&D investment deferral, or some combination of these and other benefits streams. This conclusion is robust across a range of modeled scenarios. The economically optimal levels of future deployment depend most significantly on the trajectory at which energy storage costs decline and new generating resources are needed to meet Nevada's electricity demand.

I. Introduction and Background

A. Study Purpose and Scope

Nevada Senate Bill 204 (2017) requires the Public Utilities Commission of Nevada (PUCN) to "determine whether it is in the public interest to establish by regulation biennial targets for the procurement of energy storage systems by an electric utility."[5] The Nevada Governor's Office of Energy (GOE) has commissioned this study to provide information to be used by the PUCN when evaluating whether procurement targets for energy storage systems should be set and, if so, at what levels energy storage deployment would be economically beneficial for the state of Nevada.

This study evaluates the potential economic value of storage for Nevada. The study examines the period between today and 2030, considering multiple "use cases" for energy storage. We document the assumptions made and analyses conducted to assess whether energy storage would provide value to Nevada customers in excess of its costs.

The analyses conducted for this study focus on the value of stand-alone battery energy storage systems located on the transmission and distribution system, as well as on utility-operated behind-the-meter (BTM) storage programs. However, the general observations about the value of storage from this analysis of battery storage devices apply to other types of technologies such as hydro-electric, thermal, and compressed air storage.

B. The Potential Value of Electricity Storage

Due to rapidly falling costs and unique operational flexibility, energy storage is increasingly viewed as a valuable electricity system resource. Storage systems connected to the transmission and distribution grid have the potential to provide a range of services that could ultimately reduce power system costs and create value for consumers, including:

- **Reducing the production costs of generating electrical energy.** Storage can be charged in off-peak periods, when the cost of providing energy is low. It can then be discharged during peak load hours, reducing the need to operate expensive peaking units. The fast ramping capabilities of storage can help system operators manage rapid changes in load or variable generation, thereby reducing the production costs associated with the (up and down) ramping of conventional generators.

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[5] Nevada Senate Bill 204 (2017).

- **Reducing the production cost associated with providing ancillary services.** The operational flexibility of storage may allow it to provide regulation and operating reserve services more cost-effectively than conventional resources.
- **Reducing capacity needed from traditional power generation resources.** By discharging during peak load hours, storage can reduce the need for peaking capacity that would otherwise have to be built to serve load in those hours.
- **Deferring transmission and distribution investment costs.** To the extent that storage can be used to meet local peak loads, the loading on the transmission and distribution system would be reduced. In such cases, storage can help defer certain transmission and distribution upgrades.
- **Distribution-system customer outages.** If located on the distribution system, the deployment of storage can be targeted to reduce the frequency and severity of customer outages.
- **Reducing emissions and decreasing the curtailment of renewable generation.** Storage can potentially reduce emissions either by reducing generation from high-emitting generators or by increasing output from wind and solar generators that would otherwise be curtailed. Reducing the curtailment of renewable generation will reduce system-wide production costs. Whether or not storage reduces emissions depends on the marginal emissions profile of the resource mix and the charging and discharging pattern of the storage technology.
- **Providing additional grid services.** Storage can be deployed where additional grid services, such as voltage support, may be needed, thereby deferring other investments needed to provide the same service.

In addition to operating storage as a utility-scale and distribution-system resource, it can be located behind-the-meter (BTM) at customer sites or be co-located with wind and solar generation facilities. BTM systems can create additional value to end-use customers by providing the customer with the ability to avoid time-varying volumetric charges or demand-based charges in their retail rate. Other BTM storage applications include operating the technology as backup generation or participating in a demand response program.

Co-locating storage with wind and solar plants can provide value by reducing curtailments and firming the generation output before it reaches the grid. This correspondingly increases the capacity value of the renewable resources.[6] At the time this report is written, NV Energy has

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[6] In addition, the storage component of such co-located systems may qualify for the federal renewable energy Investment Tax Credit (ITC).

contracted with some storage facilities that are co-located with solar and those contracts are subject to Commission approval, as a part of the company's 2018 Integrated Resource Plan.[7],[8]

C. The Nevada Context

NV Energy currently is the primary wholesale power supplier and the transmission and distribution provider in Nevada, serving approximately 90% of Nevada's population.[9] NV Energy's retail electric utility businesses are regulated by the PUCN and are operating in two service territories. As shown in Figure 4, Sierra Pacific Power Company (SPPC) serves northern Nevada including Reno and Carson City and Nevada Power Company (NPC) serves southern Nevada, including Las Vegas. The remainder of the state is served by smaller municipalities, power districts, and cooperative utilities that are not subject to PUCN rate regulation.[10]

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[7] NV Energy (2018a).

[8] Both the benefits and costs of storage co-located with solar generation may be lower than those of stand-alone storage devices. Benefits will tend to be lower due to decreased flexibility in operations and siting. Costs will tend to be lower due to co-location synergies and potential ITC eligibility. The degree to which co-location of storage with solar generation affects the cost effective potential of storage in Nevada will depend on these benefit-cost tradeoffs.

[9] Lateef and Reyes (2017).

[10] The PUCN regulates certain energy, water, wastewater, and telecommunications service providers. It does not regulate cable, satellite, cellular, internet, or trash removal services. The PUCN does not rate-regulate municipally-owned utilities. The PUCN has limited authority over cooperative utilities, but does not regulate the rates or service quality of cooperative utilities.