PNNL-28060

Pacific Northwest
NATIONAL LABORATORY

Energy Storage Seminar for Western State Regulatory Commission Staff

Report on Proceedings

August 2019

JB Twitchell
RS O'Neil
K Mongird

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

DISCLAIMER

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

Available to DOE and DOE contractors from the Office of Scientific and Technical Information,
P.O. Box 62, Oak Ridge, TN 37831-0062
www.osti.gov
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@osti.gov

Available to the public from the National Technical Information Service
5301 Shawnee Rd., Alexandria, VA 22312
ph: (800) 553-NTIS (6847)
or (703) 605-6000
email: info@ntis.gov
Online ordering: http://www.ntis.gov

PNNL-28060

Energy Storage Seminar for Western State Regulatory Commission Staff

Report on Proceedings

August 2019

JB Twitchell
RS O'Neil
K Mongird

Prepared for
the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

On November 6, 2017, the U.S. Department of Energy (DoE) sponsored an Energy Storage Seminar for Western State Regulatory Commission Staff in Salt Lake City. The summit took place at the offices of the Western Electric Coordination Council, with training provided by staff from DoE, Pacific Northwest National Laboratory (PNNL), and Sandia National Laboratories (SNL). Staff from regulatory commissions in 10 western states attended.

The seminar was designed with three key purposes in mind: to facilitate a discussion among regulatory staff about the challenges they face in current regulatory proceedings involving energy storage, to provide training to establish a baseline understanding of current energy storage technology and economics, and to solicit feedback from program participants about how future DoE-funded research and training on the topic of energy storage can be designed to meet state needs.

To accomplish the discussion objective, a representative from each state in attendance was asked to summarize recent policy developments in their state and answer questions from other participants. Four themes emerged during the resulting discussion: challenges related to the rapid growth of behind-the-meter energy storage in certain states and how those states are managing them, the difficulty of complying with legislative mandates to evaluate the benefits of energy storage and establish procurement targets, the different drivers for regulatory proceedings involving energy storage in different states, and the lack of drivers for energy storage in some states at this time.

To accomplish the training objective, representatives from DoE and the labs presented on the various facets of the Office of Electricity's Energy Storage Program. Dr. Imre Gyuk of DoE provided an overview of the program and some of its recent accomplishments; Dr. Vince Sprenkle of PNNL discussed energy storage technology; Patrick Balducci of PNNL, Dr. Michael Kintner-Meyer of PNNL, and Dr. Ray Byrne of SNL presented on the economics and evaluation of energy storage; and Rebecca O'Neil and Juliet Homer of PNNL shared recent developments in policy and regulatory models for energy storage.

Feedback was provided in two forms: during a live discussion near the conclusion of the seminar and through an online survey provided to attendees after the event. Twelve individuals, representing 67 percent of participants, took the survey. Feedback was generally positive, with seven respondents rating the event "excellent," one rating it "very good," and four rating it "good." Participants also provided constructive criticism on ways in which future seminars could be improved.

Four overarching themes became clear in the feedback received. For each theme, this report identifies implications at two levels – those that should be considered in planning future seminars, and those that should be more broadly considered in program design and research prioritization. These lessons may be generally applied to other DoE programs that provide technical assistance to states.

1. **Regulators are keenly interested in learning about the practical implications of energy storage on the work they do.** While the technology section was favorably reviewed in general, a majority of survey respondents said that the seminar was too heavily focused on technology, and that there should have been a stronger focus on practical topics such as valuation and regulatory models. Information related to the specific challenges regulators face as they include energy storage in regulatory processes, such as access to the proper tools and models to evaluate utility proposals, verifying cost assumptions, and designing procurement standards, were specifically requested.

Implications for seminar planning: Technological presentations should be streamlined and condensed in future seminars, with more of the information shifted into the take-home materials provided to participants. Future seminars should give more time to discussion of energy storage valuation and emerging regulatory models, and specific case studies of how states are including energy storage in regulatory proceedings should be added to seminar content.

Implications for program design: Research programs should invest resources into studying the policy and regulatory implications of technological advances, with an emphasis on identifying potential barriers in current regulations and options for addressing them. While the Energy Storage Program and other DoE programs do not provide policy recommendations to states, feedback suggests that state representatives view DoE and the national labs as an objective source of information, tools, and ideas that can inform state policy development. Program research efforts should be designed to gather and disseminate objective and detailed policy research through reports and in-person seminars.

2. **Participants want more content from the Energy Storage Program**. Whether asking for follow-up seminars or additional research on specific topics, attendees expressed a clear desire for additional program offerings.

   Implications for seminar planning: The Energy Storage Program should repeat the seminar in other regions and plan a follow-up seminar in the west. In light of the feedback received, future seminars should be extended to at least 1.5 days, with the morning of the first day dedicated to state discussions and technology, the afternoon of the first day dedicated to valuation, and the morning of the second day dedicated to regulatory models. Additional details and case studies on the valuation and regulatory models sections may be added to extend the seminar to two full days.

   Implications for program design: Seminar participants asked for more specific information about how energy storage can be effectively included in resource planning and procurement proceedings. Future work products should provide detailed case studies of the specific challenges entailed in accounting for energy storage in planning and procurement activities, and present emerging options for addressing those challenges. Providing energy storage cost benchmarking data would also be a useful effort.

3. **Regulators highly value the ability to network with counterparts in other states.** The state discussion section was the most highly rated component of the seminar and the most frequently mentioned thing when participants were asked what they liked about the seminar. Interstate discussion should be a key component of any future seminars.

   Implications for seminar planning: Providing a structured opportunity for seminar participants to talk about current proceedings in their state and challenges they are facing facilitates discussion and networking, and should be given more time on the agenda in future seminars. Organizers should consider reaching out to participants in advance to identify common themes in current proceedings.

   Implications for program design: Networking and discussion among program stakeholders provides opportunities for the practical learning that participants desire from the Energy Storage Program. It also provides an opportunity for program managers to identify emerging issues and research opportunities. Group discussions – through in-person seminars, webinars, or phone conferences – should be a regular component of program design.

4. **Involving participants earlier in the planning process may improve participation and outcomes.** Some participants suggested that future seminars solicit topic suggestions from participants beforehand, as such an approach would increase the likelihood of meeting state needs. Seminar organizers did attempt to solicit input from participants prior to the event, but did not receive responses. It is possible that participants did not have enough baseline knowledge about the Energy Storage Program and seminar content to know what to suggest.

   Implications for seminar planning: Seminar planners should consider circulating more in-depth information about the seminar agenda and supporting materials further in advance to facilitate more participant feedback. More targeted outreach to key staff in states with active regulatory proceedings involving energy storage may help identify specific topics that should be emphasized in the seminar.

   Implications for program design: Involving stakeholders in the development of program objectives and research projects may facilitate participation and increase the applicability of research efforts. Program managers should consider conducting peer reviews of reports with external stakeholders to lend additional perspective.

This report will present the proceedings of the seminar and the insights it provided into the needs of regulatory staff as they adapt planning and regulatory mechanisms to account for the unique capabilities and challenges of energy storage. These findings will be of use generally in directing the Energy Storage Program's efforts, and specifically in planning future seminars and program research priorities.

Acknowledgments

This report and the event described herein were made possible by funding provided by the Office of Electricity in the U.S. Department of Energy, through Energy Storage Program under the direction of Dr. Imre Gyuk.

The authors additionally acknowledge the support of the Western Electric Coordinating Council (WECC) for hosting the event and the national laboratory presenters who shared their expertise.

Finally, the authors wish to acknowledge and thank the event attendees, who took time out of their busy workloads to attend and provide valuable feedback on the Energy Storage Program's research and outreach efforts.

Acronyms and Abbreviations

DoE	United States Department of Energy
IRP	integrated resource plan
PNNL	Pacific Northwest National Laboratory
RFP	request for proposals
RTE	round-trip efficiency
SNL	Sandia National Laboratories
SOC	state of charge

Contents

Figures

1.0 Introduction

Through the Office of Electricity, the U.S. Department of Energy (DoE) operates the Energy Storage Program, which is designed to "reduce the cost of energy storage technology and power electronics and to accelerate market acceptance."[1] The program's structure is based on a 2013 DoE report that identified the potential grid benefits of energy storage and four specific areas of research need:

1. Cost-competitive energy storage technology;
2. Validated reliability and safety;
3. Equitable regulatory environment; and
4. Industry acceptance.[2]

The Energy Storage Program is organized around those four topic areas, with the goal of conducting research into those topics and sharing its findings with a broad audience of regulators and policymakers. Funded by DoE, the national laboratories are charged with implementing the program. Through the Equitable Regulatory Environment area, the labs provide technical assistance to states as they work to better understand energy storage technology and identify how it fits within state objectives and policies.

On November 6, 2017, DoE convened an Energy Storage Seminar for staff members of public utility commissions in the western United States. The seminar was convened within the Equitable Regulatory Environment thrust area of the Energy Storage Program, which assists states in reducing regulatory and institutional barriers to energy storage through research and, where requested, direct technical assistance.

Staff members who served as leads on proceedings related to energy storage and resource planning in their respective states were invited to attend the seminar. Hosted by the Western Electric Coordination Council (WECC) at its headquarters in Salt Lake City, the event drew participants from 10 state utility commissions.[3] Staff from DoE, Pacific Northwest National Laboratory, and Sandia National Laboratories presented the work they have conducted in the Energy Storage Program. The purpose of the seminar was to provide regulatory staff with a baseline understanding of energy storage technologies and economics and facilitate an exchange of information about regulatory proceedings throughout the participating states. From a program perspective, the event also provided insight into the different views that states take of energy storage, the information gaps that exist, and a better understanding of how to better tailor future research and outreach efforts to meet state needs.[4]

Upon arrival, each attendee received a binder of information that contained relevant orders and decisions on energy storage from each participating state, and recent laboratory publications on energy storage research activities. Following the seminar, attendees were asked to respond to a survey to provide feedback on the event. Twelve attendees, representing 67 percent of participants, responded.

This report is divided into three areas. Section 2 describes the proceedings of the seminar, including a summary of the presentations and the key themes that emerged during the state discussion. Section 3 presents the survey responses, and Section 4 provides a summary and conclusions for consideration in planning future program activities.

---

[1] "Energy Storage," U.S. Department of Energy. Available at https://www.energy.gov/oe/activities/technology-development/energy-storage. Retrieved 3 July 2018.

[2] U.S. Department of Energy, 2013. "Grid Energy Storage," at pages 5-6.

[3] See Appendix A for a list of attendees.

[4] See Appendix B for a seminar agenda.

2.0 Event Overview

2.1 Introductions and state review

Dr. Imre Gyuk of the Office of Electricity opened the event with a welcome and brief overview of the Energy Storage Program. Following additional welcomes from WECC and laboratory representatives, a representative of each state took some time to discuss the status of energy storage in their jurisdiction, including relevant policies, current challenges, and project developments. This provided each state the opportunity to expound on the information provided in the binder, and for state representatives to ask follow-up questions of each other and share ideas.

Several themes emerged during the state review:

1. **Behind-the-meter storage:** Attendees asked Hawaii's representatives several questions about the drivers for Hawaii's rapid growth in behind-the-meter storage and how the utility and commission were handling it. The Hawaiian delegation explained that the island's power costs are heavily dependent on oil prices, and can vary significantly as a result. That unpredictability, coupled with rapid declines in solar system costs, resulted in a rapid expansion of solar PV development from 2011-2013.

   In response to the increase in solar, regulators changed the net metering program to incent customers to either consume all of their own solar generation or to only export it to the grid during the evening peak – both of which create a strong signal for behind-the-meter energy storage. To help manage the influx of distributed resources, the commission had recently approved Hawaiian Electric's acquisition of a demand response management system and a pilot demand response program, as well as voluntary time-of-use rates.

   Representatives from Arizona stated that behind-the-meter storage was growing rapidly in the state, driven by changes to net metering and a recent rate case decision that directed the state's largest utility, Arizona Public Service, to develop rates for large commercial customers that provide a price signal for them to install energy storage to cost effectively reduce their peak demand.

2. **Storage valuation is uniquely challenging.** Several attendees stated that they were finding it challenging to identify the benefits of energy storage. In Oregon and Nevada, commission staff were working under legislative mandates to analyze energy storage for the purpose of applying a procurement target set by the legislature (in Oregon) or determining whether it would be appropriate to establish a procurement target (in Nevada). Oregon representatives stated that the tight timeline of their proceeding limited the depth of the analysis that could be done, leaving regulators with the challenge of balancing analytical needs with time constraints.

   Specific challenges that the group discussed related to the barriers to energy storage created by current resource planning models. Those models use an hourly approach to identifying resource dispatch and generation needs, but the value of a flexible resource that can quickly respond to grid needs within the hour – a resource like energy storage – cannot be captured in such a model. Additionally, IRP models only look at resource values at a system level, while a scalable resource such as energy storage can be sized and located to meet situational needs at specific locations on the grid. Those modeling obstacles foment additional challenges in the regulatory process, as

resource acquisition and regulatory reviews are predicated on the IRP analysis. Identifying how much energy storage should be placed on the grid and where it should be located requires a fundamentally different type of resource analysis than what is done in a traditional IRP, and conducting such an analysis on a tight legislative timeline was proving highly difficult.

3. **Analytical needs differ among states.** From legislative mandates in Oregon and Nevada, to regulatory orders in Washington and New Mexico, to pilot projects in Colorado and Utah, energy storage is developing along different paths throughout the West. As a result, state representatives identified different analytical approaches and needs. As noted above, regulatory staff in Oregon and Nevada were working under legislative mandates to identify the benefits of energy storage and either implement or establish procurement targets, while staff in Hawaii and Arizona were more focused on managing growth in customer-sited storage.

   In Washington and New Mexico, commissions had recently adopted rules (in New Mexico) or policies (in Washington) that directed utilities to include energy storage in resource planning activities, on equal footing with other resource options. Representatives from those states indicated that their challenges are in identifying whether integrated resource plan (IRP) models are accurately capturing the benefits of energy storage and determining whether utilities are using accurate cost assumptions.

   In Colorado and Utah, demonstration projects were underway to better understand the operational characteristics and value propositions of energy storage. In Colorado, regulators were evaluating two utility-led demonstration projects designed to test various use cases of energy storage, and trying to identify lessons to inform potential legislation on energy storage policy.[5]
   In Utah, legislators authorized a demonstration project that, while not subject to traditional cost-effectiveness requirements, would still require regulators to approve a project using a public interest standard.[6]

4. **Some states have not yet reached a tipping point on energy storage.** Representatives from Idaho and Montana stated that energy storage had not yet become a topic of significant interest in their states. In Montana, there had not been any legislative activity on energy storage, and while the topic wasn't really on the radar at the commission, staff was beginning to look at it a bit more closely in the IRP process. In Idaho, commission staff said the commission's responsibility is to look at resources in terms of cost and reliability, and that energy storage would have to be selected within those terms. Staff cited abundant hydropower and the advent of the Energy Imbalance Market (EIM) as sources of low-cost ancillary services that limit the opportunities for energy storage on the Idaho grid.

The agenda only set aside one hour and fifteen minutes for the state discussion section. However, based on the level of discussion that was taking place and the ideas that were being shared, event organizers elected to extend the discussion phase to about two hours. As will be discussed later in this report, attendees found significant value in this section of the seminar, but its extension required a reduction to

[5] Colorado has since adopted legislation that directs the Colorado PUC to develop mechanisms for utilities to acquire energy storage. See HB 18-1270, available at https://leg.colorado.gov/bills/hb18-1270.
[6] Utah's SB 115 (2016) directs the Utah Public Service Commission to authorize up to $17 million in utility expenditures on "innovative utility programs" that are in the interest of utility customers for investigating or analyzing new programs in one of eight areas, including battery energy storage.

the regulatory models section later in the day, which left participants feeling that not enough time was spent on the latter section.

2.2 Presentations summary

Energy Storage Program – Overview

Dr. Gyuk briefly explained the focal areas of the Energy Storage Program: technology development, safety, evaluation, and regulatory environment. He provided overviews of recent laboratory analyses of energy storage capability and benefits, including recent work by Sandia to analyze the benefits of energy storage under various market structures around the U.S.

Dr. Gyuk also discussed the findings of a demonstration project in Sterling, Massachusetts that was built and studied with DoE assistance. He explained that by using analytical tools to optimize the dispatch of the storage system, it was able to maximize revenue and achieve a simple payback in less than seven years.

Attendees asked questions about how the analyses were performed and whether the analytical software was standardized for broader use. Dr. Gyuk explained that the analyses were based on historical price data from each market, and that the model that Sandia built for the Sterling analysis was not yet ready for standardization. He also responded to questions regarding the ability of batteries to provide frequency response and the applicability of the analysis to other fast-responding resources.

Energy Storage Program – Technology

Dr. Vincent Sprenkle of PNNL provided a technological overview of energy storage, including its functionality, technical characteristics, and terminology. He explained the various types of energy storage and the advantages and disadvantages of each, with a particular focus on the differences between lithium-ion batteries and flow batteries. For lithium-ion batteries, he explained that they had the advantages of having higher power density as well as being lower in cost and more technologically mature, but the disadvantages of fire hazards and limited recyclability.

Dr. Sprenkle explained that flow batteries have the advantages of being able to decouple their power and energy components, having a longer life, posing no fire hazard, and being highly recyclable. But they also have the disadvantages of being more expensive and less technologically mature. He explained the research that PNNL has done to improve the performance of flow batteries and reduce their costs.

Audience questions for Dr. Sprenkle revolved around three themes:

1. **Safety and environmental impacts of energy storage**. Attendees questioned Dr. Sprenkle about the safety and environmental impacts of energy storage, both during its use (including hazards such as leaking and fires) and at the end of its useful life (recyclability). Dr. Sprenkle explained that while the industry has taken steps to manage the risk of fires or leaking, those risks should be taken into account when siting storage. He also explained that materials that are recyclable are more expensive up front, which is one reason that flow batteries remain more costly (the vanadium that most flow battery technology depends on is fully recyclable).

2. **Cost data**. Regulatory staff also expressed a need for reliable cost data about energy storage to check against the cost assumptions used by utilities in resource planning, and asked about the

availability of such information. Dr. Sprenkle explained that one approach to verify cost assumptions is to call energy storage providers and ask them directly. Developers usually won't provide exact cost data, he said, but are usually willing to state whether a particular assumption is reasonable. Dr. Sprenkle said that DOE is funding a study of cost data to help identify reasonable ranges, but said that the most effective way of verifying cost assumptions is to allow storage vendors to bid on utility requests for proposals.

3. **Future assumptions.** Since utility resource plans are looking into the future, regulatory staff asked about reasonable assumptions for cost declines and performance improvements of future storage installations. Dr. Sprenkle explained that cost declines are difficult to predict, due to uncertain adoption rates, diverging applications (grid and vehicle) that may result in diverging manufacturing capacity investments, and global commodity markets for battery components.

Energy Storage Program – Valuation

Patrick Balducci and Dr. Michael Kintner-Meyer of PNNL and Dr. Raymond Byrne of SNL presented a detailed overview of the work they have done to value energy storage. They began summarizing the various use cases and applications that energy storage can provide. Figure 1 contains a summary slide from the presentation, which presents the findings of a literature review that identifies the various use cases of energy storage, the grid levels at which they manifest, and the range of values that have been identified for each use case.

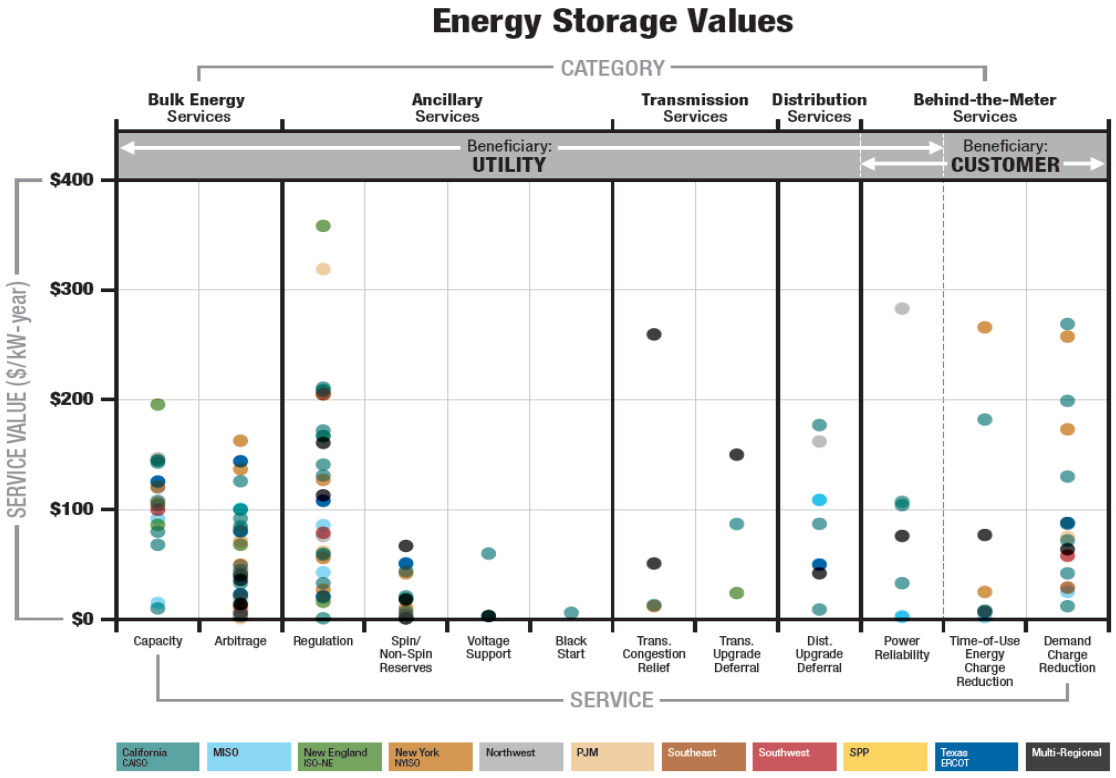

Figure 1: Energy Storage Values by Function and Location

The key lesson from the figure, the presenters explained, is that the value of energy storage resources can accrue at multiple levels of the electric grid. They then highlighted and briefly described seven use cases for energy storage that are readily monetizable:

1. Arbitrage: the ability to move energy through time by charging the storage system during low-cost periods and discharging it during high-cost periods. While it is one of the most widely recognized use cases for energy storage, it also typically has a small value.
2. Capacity/Resource Adequacy: The ability to use the energy storage device to discharge during peak periods to meet system generation and reserve needs.
3. Transmission and Distribution Deferral: The ability to use an energy storage system to provide location-specific services at a targeted location on the transmission or distribution system to delay the need for infrastructure investments.
4. Frequency Regulation: The ability to rapidly respond to changing grid conditions by switching between charging and discharging to add or remove power from the system, as needed, to maintain frequency within prescribed limits.
5. Volt-VAR Support: The ability to improve transmission and distribution system efficiency by injecting real power locally, thereby reducing the need to inject power from a distant generator whose output would be diminished by line losses.
6. Demand Charge Reduction: The ability of a customer to use a behind-the-meter storage system to meet a portion of the customer's energy needs during high-demand periods and reduce utility demand charges in the process.
7. Outage Mitigation: The ability of an energy storage device to reduce or eliminate an outage to a customer or set of customers.

The presenters also discussed five emerging use cases for energy storage that are not yet readily monetizable: renewable energy time shift, small signal stability, frequency droop, synthetic inertia, and renewable capacity firming.

After describing the various benefit streams and use cases, the presenters explained that while energy storage can do many things, it cannot do them all at once. The challenge in successfully deploying an energy storage system, then, becomes identifying the optimal mix of uses (co-optimization), subject to system capabilities and charging/discharging constraints, then correctly sizing and dispatching the system to achieve the optimal mix of uses.

To illustrate how analytical software can address those challenges, the presenters shared analyses of several real-world storage projects. The analyses were designed to identify the optimal usage of demonstration projects, by using models capable of looking at sub-hourly and locational values to maximize system value across multiple functions. In some cases, the analysis was conducted beforehand to optimally size the device and develop its dispatch logic; in other cases, the analysis was conducted after the fact to evaluate the sizing and dispatch of an existing system and identify lessons learned to inform future deployments.

In addition to identifying the optimal dispatch for each modeled system, the analyses collectively demonstrated that the performance of a battery storage device can change dramatically based on its state of charge (SOC), and that different output levels will decrease SOC at different, non-linear rates. It is important to remember that the power and energy ratings for an energy storage system are independent of one another and, in most cases, are mutually exclusive. For example, a 1 MW/4 MWh battery should be read as a 1 MW "or" 4 MWh battery. It can provide a maximum of 1 MW of power output instantaneously, but cannot provide 1 MW on a sustained basis for four hours. Rather, a battery can be discharged at an optimal but lower power level for a longer period, which will enable it to provide 4 MWh of energy.

To account for this, PNNL began developing a non-linear battery model, which adds a variable for SOC to the sub-hourly and locational variables in the model, to more accurately reflect how SOC will change at different levels of power output, and how the battery's performance, availability and longevity will shift. Figure 2 presents a slide demonstrating the relationship between output and state of charge:

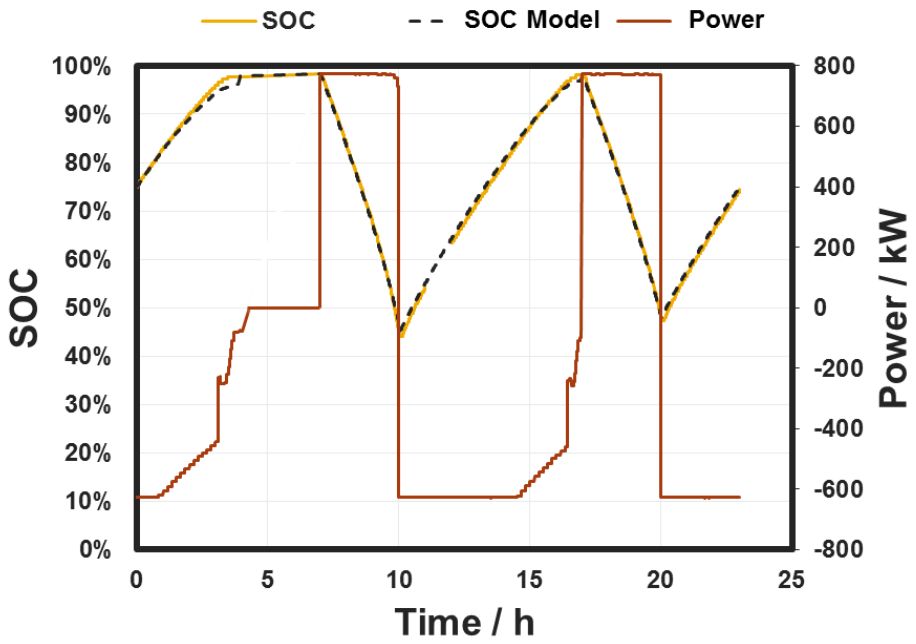

Figure 2: Non-linear Battery Model Validation

As an example, the presenters said that deploying a non-linear model for a demonstration project in Washington State increased arbitrage revenues by 50 percent. The surprising finding, they explained, was that instead of pursuing the highest-value arbitrage windows, the model identified a larger number of low-margin windows that worked better with the battery's operational characteristics, thereby increasing battery life and allowing for more arbitrage opportunities. So despite earning less revenue in each arbitrage window, the increased number of windows led to an increase in overall revenue.

Other broad takeaways from the project analyses include:

1. A power conversion system (PCS) should be carefully designed and selected. Multiple tests were cut short because of PCS failures.
2. The relationship between power and energy must be carefully understood. As explained above, power and energy ratings for a battery device are independent of one another, and different power levels will result in different energy levels.
3. Round-trip efficiency (RTE) is a tricky metric. Depending on how it is defined (including auxiliary loads such as the PCS and battery management system or not) and how quickly the battery is discharged, RTE can widely vary even for the same system.
4. Although capable of instantaneous responses, battery devices may be slowed by communications lags that should be accounted for in the analysis.
5. State of health metrics, which measure a battery's functionality over time, are heavily dependent on internal resistance.

The final section of this presentation discussed recent analytical efforts to optimally size and configure microgrids. Using work done for a military base as an example, the team explained how it used an iterative planning process to identify the least-cost mix of diesel generation, solar photovoltaics, and energy storage to allow the base to survive an outage of up to two weeks. By matching the generation profile of the resources to the load profile and utility rates of the base, the team identified a resource mix that would remain within the base's $9 million budget and would generate an estimated $60,000 in annual net benefits.

Energy Storage Program – Regulatory Models

Juliet Homer of PNNL presented research that she and Lisa Schwartz of Lawrence Berkeley National Lab were conducting on state approaches to distribution system planning. As the role of energy storage and other distributed energy resources (DER) continues to grow on the grid, she explained, it is becoming increasingly important to understand the costs and benefits of those resources. Doing so, however, requires analytical tools that can assess operating conditions and needs more granularly – both physically and temporally – than traditional IRP models.

Ms. Homer identified several benefits that states could achieve by using such tools in distribution system planning efforts:

1. Increased transparency of utility investments in the distribution system, thereby facilitating regulatory review;
2. Increased opportunities for utility commission and stakeholder engagement in utility planning and investment decisions;
3. Improved modeling capability to consider a broad range of potential futures;
4. Enabling additional resource options for achieving a least-cost, least-risk portfolio; and
5. Informing customer and third-party grid investments.

In pursuit of those potential benefits, states have begun to develop a number of new planning practices, such as locational load forecasting and hosting capacity analysis, which identifies how much distributed generation a particular circuit can hold before upgrades are required. Other approaches include proceedings to calculate locational values for DER and requirements for utilities to consider DER ("non-wire") alternatives to infrastructure upgrades.[7]

As utilities and regulators develop these tools, an additional challenge remains in incorporating those tools into existing planning and regulatory review processes. Figure 3 presents a conceptual picture of an integrated distribution planning process:

[7] For a more detailed discussion of state approaches to distribution system planning, see the final report by Homer et al, "State Engagement in Electric Distribution Planning."

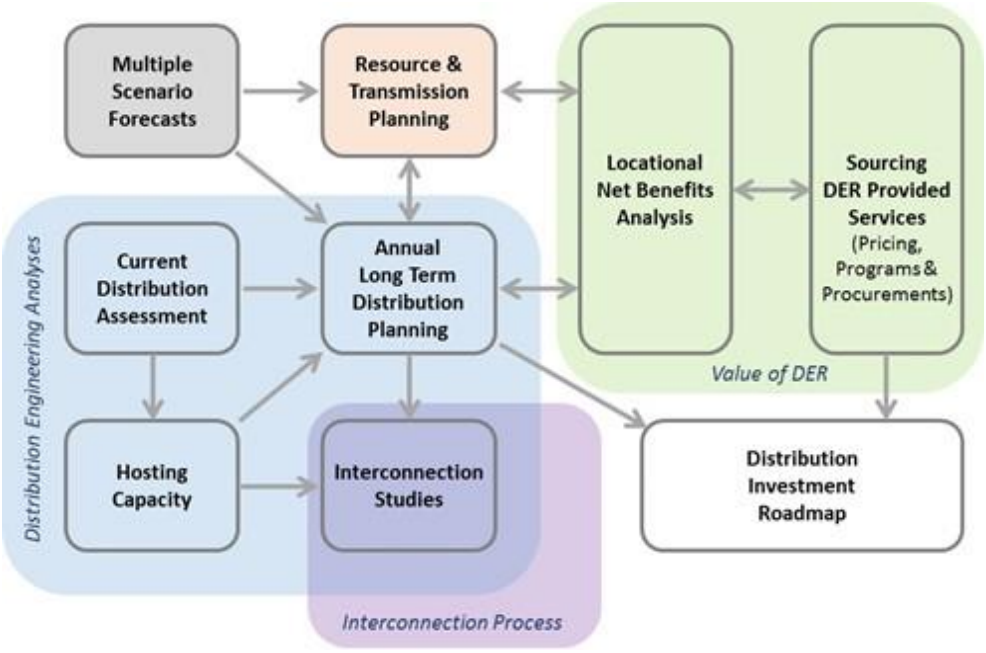

Figure 3: Integrated Planning Across the Transmission, Distribution, and Customer Domains

In their study of how states are approaching this issue, the research team found that most states had yet to engage in distribution planning, and even the states that had done so were still generally early in the process. To assist states in deciding where to begin the process, the team distilled several foundational components of integrated distribution planning that could serve as starting points:

1. **Take early integration steps**: establish consistent inputs and assumptions across generation, transmission, and distribution planning processes.
2. **Account for all resources**: Ensure that energy efficiency, demand response, distributed generation, and energy storage resources are accurately considered alongside traditional distribution solutions.
3. **Specify DER attributes**: Establishing a common understanding of DER characteristics and benefits can facilitate their inclusion in the planning process.
4. **Foster an atmosphere of measured experimentation**: Use pilot programs and demonstration projects to test new technologies, ratemaking, and procurement practices.
5. **Analyze multiple possible futures**: Use stochastic forecasting practices to analyze plans under a variety of potential rates of load growth, DER penetration, and market conditions.
6. **Phase in hosting capacity analysis**: Begin by analyzing problematic circuits to develop utility and regulatory capabilities for larger-scale implementation.
7. **Pilot exploration of locational impacts**: A focused approach to identifying the grid impacts and benefits of distributed resources in a series of targeted projects can inform planning assumptions.
8. **Plan integration of utility systems in advance**: Advanced metering infrastructure, distribution management systems, and other forms of advanced monitors and controls should be deployed with detailed business plans describing how those investments will interact with one another, inform planning, and be leveraged to benefit customers.
9. **Engage stakeholders**: Formalize processes for stakeholders to provide input to the planning process.

10. **Pursue education and training opportunities**: Regulatory staff should take advantage of opportunities to learn about new technologies and planning tools.

The presentation concluded with a review of the status and recent policy developments of active distribution planning proceedings in 15 states and territories.

3.0 Participant Feedback

Seminar participants were given two opportunities to provide feedback on the event – once in a free-flowing discussion during the final session of the day and again through a structured, online survey circulated after the event. Their responses provided invaluable insight into the challenges that regulators face as they work to understand the unique characteristics of energy storage and accurately account for those characteristics in planning and procurement activities. They are also valuable in helping DoE and the labs in tailoring future research and educational efforts to meet the specific needs identified by states.

3.1 Seminar Discussion

In the discussion section, feedback fell into one of four themes: appreciation for the technical presentations, the value of interstate networking, additional research and information needs, and lingering questions about the role of energy storage.

State representatives expressed gratitude for the seminar and the information shared. Several commenters expressed particular appreciation for the valuation section of the seminar, stating that real-world examples of installed projects and detailed economic evaluation of their uses was helpful in understanding how the technology works and the specific values that need to be considered in resource planning. The potential role of energy storage in resilience-focused microgrids was also mentioned as a valuable takeaway.

Attendees also stated that they found value in hearing firsthand from other states about the challenges they were facing and the projects that were being developed. As noted above, event organizers decided to significantly extend the state discussion section of the agenda due to the exchanges that were occurring.

As they processed the information provided in the seminar, state representatives were already thinking about how to apply it in practical terms, and identifying remaining information gaps. Lingering questions identified by representatives from several states related to the details of translating the information into improved IRPs and applying it to reviews of pilot projects being developed in their respective states. In Utah, representatives discussed an energy storage pilot project that would be coming in for review in the near future and identified a need to improve utility IRPs to include the benefits discussed in the seminar. Representatives from Arizona similarly stated that the information learned would be useful in evaluating proposed energy storage projects. A representative from Washington explained that the state was trying to develop requests for proposal (RFP) rules that would lead to all resource options being fairly considered, and that the information would be useful in crafting rule language that ensures that the benefits of energy storage are included in the process.

Another information need mentioned by several participants was a source of reliable information on energy storage system costs. Between the rapid cost declines for energy storage and the highly competitive nature of the industry, which often results in project costs being kept confidential, participants said it has been difficult to gage the accuracy of cost assumptions used by utilities in resource planning. Some representatives said they were surprised by the cost data presented in the seminar, and suggested that a worthwhile endeavor for DoE and the labs to consider would be to provide energy storage benchmark costs.

Finally, at least one state representative remained skeptical of the role of energy storage. While the information presented was helpful and appreciated, the individual stated that the policies and experiences of the states presented were not directly relevant to that individual's state, and that a number of hurdles remained before energy storage would be seen as a cost-effective investment.

3.2 Survey Reponses

A short time after the seminar, PNNL circulated an online survey to participants to provide more structured feedback. The survey consisted of 10 questions; four of them with multiple-choice responses and six of them with open-ended responses. Twelve of the 18 state-level seminar participants responded.

Feedback in general was positive. Seven of 12 respondents rated the event "excellent," while one rated it "very good" and four rated it "good." Most (eight) agreed that the daylong seminar was the correct length, and that the amount of time devoted to the state discussion and technology sections of the seminar was just right (eight and nine, respectively). However, a majority of respondents also felt that the valuation and regulatory models section were too short (seven and nine, respectively). Figure 4 presents participant responses when asked to rate the quality of each seminar:

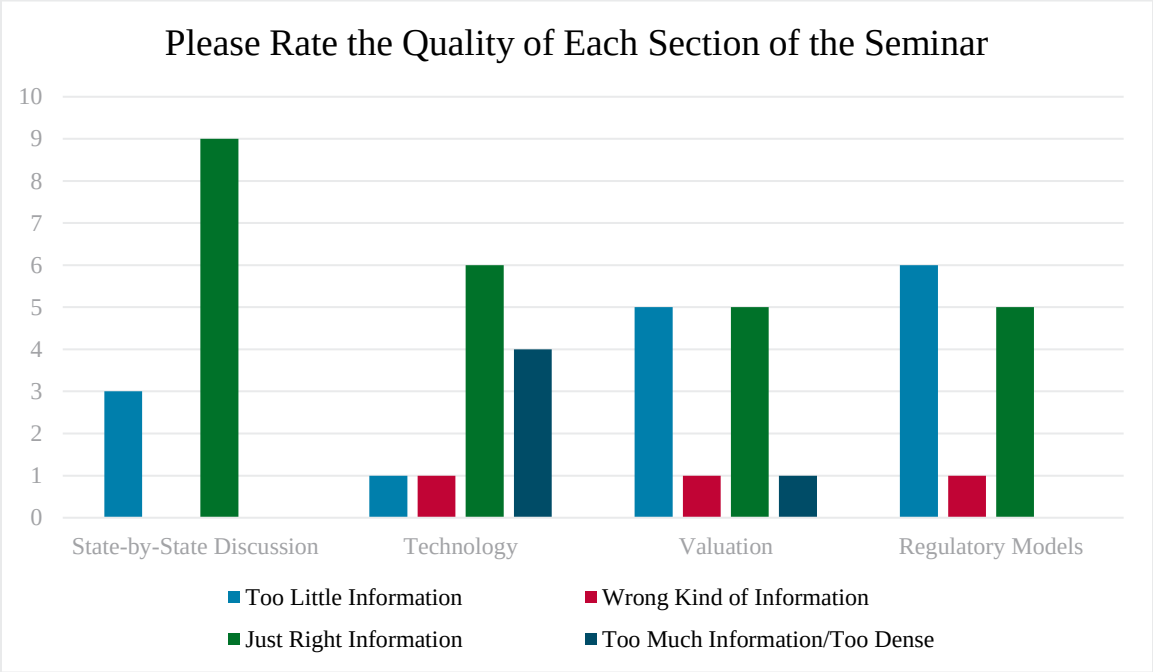

Figure 4: Responses to Survey Question 3 (Please Rate the Quality of Each Section of the Seminar)

Participant ratings of the content of individual seminar sections tracked closely with the previous responses. Respondents generally gave favorable reviews to the sections that they had indicated had the right amount of time dedicated to them; nine participants said the state discussion section had the right amount of information, while six respondents said the same for the technology section. It is worth noting, however, that four respondents indicated that the technology section was too dense, and reinforced that message in free-form responses. Respondents were more divided in their opinion of the remaining sections. For the valuation section, five said it had the right amount of information and five said it had too little. For the regulatory models section, five indicated that it had the right amount of information, and six indicated that it had too little.

In the remaining questions, participants were asked to provide qualitative feedback about the seminar – what was done well, what needed improvement, and what additional information or assistance would be of use to regulators in the future. Appendix C contains a summary of the qualitative responses.

4.0 Conclusion

As the first event of this type within the Energy Storage Program, there are several lessons to be drawn from the Energy Storage Seminar for Western State Regulatory Staff. Those lessons can be divided into two classes: those formed from the program's perspective of the seminar and those formed from the participants' perspective.

From the program's perspective, the seminar served as a proof of concept. Engaging with a small, targeted group of regulatory staff allowed program staff working in the Equitable Regulatory Environment area to engage directly with a key constituency. Through that engagement, researchers could test assumptions and get feedback on research priorities and program direction from one of the program's primary audiences. Providing travel assistance for seminar participants ensured a broader audience and wider range of perspectives, by enabling participation from states that may not have reached a point in energy storage policy development that would justify investment in such a training opportunity.

The perspective of participants, taken in aggregate, made two things clear: (1) Participants found the event to be valuable, and (2) participants had several ideas for how future seminars and program outreach efforts might be improved. Their feedback confirms the value of providing such training events and provides guidance from one of the program's key audiences that can strengthen the ability of future program efforts to better understand and meet state needs.

This report identifies four key lessons:

1 – Regulators are keenly interested in learning about the practical implications of energy storage on the work they do.

The only survey question that received a majority of "negative" responses was the one that asked participants if the seminar struck the right balance between research and practical information, to which six of 10 respondents said no. Each of those responses indicated that the seminar should have been heavier on the practical application side. A desire for more practical information was also a recurring theme in response to questions about what participants didn't like about the seminar, what topics were missing, and what the program's next steps should be.

Technological presentations should be streamlined and condensed in future seminars, with more of the information shifted into the take-home materials provided to seminar participants. Future seminars should be extended to a second day to allow for more discussion of energy storage valuation and emerging regulatory models, and specific case studies of how states are including energy storage in regulatory proceedings should be added to seminar content.

Research programs should invest resources into studying the policy and regulatory implications of technological advances, with an emphasis on identifying potential barriers in current regulations and options for addressing them. While the Energy Storage Program and other DoE programs do not provide policy recommendations to states, feedback strongly suggests that state representatives view DoE and the national labs as an objective source of information, tools, and ideas that can inform state policy development. Program research efforts should be designed to gather and disseminate objective and detailed policy research through reports and in-person seminars.

As the Energy Storage Program's research portfolio continues to grow, program managers should endeavor to present findings in the most practical terms possible.

2 – Participants want more content from the Energy Storage Program.

When asked directly what the next step of the Energy Storage Program should be, the most common response was that there should be additional seminars on a recurring basis. Half (five) of the responses expressed that opinion, and other responses requesting more detailed information on valuation and regulatory models also suggest an appetite for more program content. Commenters also suggested that additional/longer seminars would be helpful in response to other questions.

Six comments also stated that participants appreciated the opportunity to hear from experts at the DoE and laboratories. One commenter noted that hearing from objective experts who are not influenced by financial incentives was particularly helpful, and another suggested that future events should have an "Ask the Experts" component in which participants could ask questions of laboratory and DoE personnel.

Based on this feedback, the Energy Storage Program should repeat the seminar in other regions and plan a follow-up seminar in the west. Future seminars should be extended to at least 1.5 days, with the morning of the first day dedicated to state discussions and technology, the afternoon of the first day dedicated to valuation, and the morning of the second day dedicated to regulatory models. Additional details and case studies on the valuation and regulatory models sections may be added to extend the seminar to two full days.

Participant requests for more specific information about how energy storage can be effectively included in resource planning and procurement proceedings suggests that future work products should provide detailed case studies of the specific challenges entailed in accounting for energy storage in planning and procurement activities, and present emerging options for addressing those challenges. Providing energy storage cost benchmarking data would also be a useful effort.

3 – Regulators highly value the ability to network with counterparts in other states.

Regulators expressed enthusiastic support for the state discussion section of the seminar – no other single section received as many positive comments. It was the most highly rated section of the seminar (nine of 12 respondents said it had the right amount of information; no other section had more than six people say that about it). Additionally, seven respondents specifically mentioned it when asked what they liked about the seminar.

Some of the comments illuminate the reason why regulators found so much value in this section. As discussed below, regulators desire a more practical focus, and some commenters explained that the state discussion session was the best source of practical information in the seminar. Hearing the specific policies and approaches taken by colleagues in other states and being able to ask each other questions were particularly helpful activities, participants noted, and one participant requested a regular forum series for regulators to get together and share ideas for integrating energy storage.

Establishing networks of regulatory professionals who can collaborate and share information on energy storage policy development creates a valuable resource for state staff; one that can provide practical assistance that complements the research focus of the Energy Storage Program. Seminars such as this provide a catalyst for the formation of such networks.

Providing a structured opportunity for seminar participants to talk about current proceedings in their state and challenges they are facing facilitates discussion and networking, and should be given more time on the agenda in future seminars. Organizers should consider reaching out to participants in advance to identify common themes in current state proceedings.

Networking and discussion among program stakeholders provide opportunities for the practical learning that participants desire from the Energy Storage Program. It also provides an opportunity for program managers to identify emerging issues and research opportunities. Group discussions – through in-person seminars, webinars, or phone conferences – should be a regular component of program design.

4 – Involving participants in the planning process may improve participation and outcomes.

Three comments indicated that the agenda could be improved if organizers reached out to participants beforehand to find out what their specific interests are, and then tailored the agenda around identified needs. Furthermore, when the feedback is considered in aggregate, it is clear that future seminars can be refined to better meet the needs of regulators. Soliciting guidance from participating regulatory staff ahead of future events would strengthen the agenda and ensure that it better reflects the needs of the audience.

Given the clear interest in state discussion sessions at future events, it may also be useful to circulate recent storage policy developments from participating states among participants ahead of future events. Doing so may allow attendees to process the information beforehand and come to the seminar prepared with specific, thought-provoking questions that support a robust discussion.

When planning future seminars, organizers should consider circulating more in-depth information about the seminar agenda further in advance to facilitate more participant feedback. More targeted outreach to key staff in states with active regulatory proceedings involving energy storage may help identify topics that should be emphasized in the seminar.

From the program design perspective, involving stakeholders in the development of program objectives and research projects may facilitate participation and increase the applicability of research efforts. Program managers should consider conducting peer reviews of reports with external stakeholders to lend additional perspective.

Appendix A

List of Participants

Name	Title	Organization
Nick Liu	Engineer	Arizona Corporation Commission
Mimi Xavier	Engineer	Colorado Public Utilities Commission
Matt McDonnell	Commission Council	Hawaii Public Utilities Commission
Dave Parsons	Chief of Policy & Research	Hawaii Public Utilities Commission
Mike Louis	Engineering Supervisor	Idaho Public Utilities Commission
Mike Dalton	Rate Analyst	Montana Public Utilities Commission
John Reynolds	Utilities – Economics Bureau Chief	New Mexico Public Regulation Commission
Cydney Beadles	Division Director	New Mexico Public Regulation Commission
Elaine Prause	Senior Regulatory Advisor	Oregon Public Utility Commission
Jason Klotz	Senior Regulatory Analyst	Oregon Public Utility Commission
Kendall Mongird	Scientist	PNNL
Rebecca O'Neil	Manager	PNNL
Vince Sprenkle	Manager	PNNL
Patrick Balducci	Scientist	PNNL
Juliet Homer	Engineer	PNNL
Michael Kintner-Meyer	Engineer	PNNL

Name	Title	Organization
Carl Imhoff	Manager	PNNL
Michele Beck	Director	Utah Public Service Commission
Bela Vastag	Utility Analyst	Utah Office of Consumer Services
John Harvey	Economist, Technical Advisor	Utah Public Service Commission
Joseph Holland	Technical Staff	Utah Public Service Commission
Donald Lomoljo	Hearing Officer	Public Utilities Commission of Nevada
Ray Byrne	Technical Staff	SNL
Dan Borneo	Engineering Project Manager	SNL
Joe Paladino	Senior Advisor	U.S. Department of Energy
Katie Jereza	Deputy Assistant Secretary	U.S. Department of Energy
Imre Gyuk	Program Manager	U.S. Department of Energy
Bob Davis	Utility Analyst	Utah Division of Public Utilities
Joni Zenger	Utility Technical Consultant	Utah Division of Public Utilities
Jeremy Twitchell	Energy Policy Advisor	Washington Utilities & Transportation Commission
Kent Bolton	Staff Engineer	WECC
Stan Holland	Staff Engineer	WECC
Tyler Butikofer	Associate Staff Engineer	WECC
Nick Hatton	Associate Staff Engineer	WECC
Vijay Satyal	Senior Policy & Outreach Advisor	WECC
Branden Sudduth	Director, Reliability Planning	WECC

Appendix B

Seminar Agenda

Energy Storage Seminar
Western State Regulatory Commission Staff

November 6, 2017
Western Electricity Coordinating Council offices
155 North 400 West, Suite 200, Salt Lake City, Utah

AGENDA

TOPIC	TIME
Welcome and Introductions • Dr. Imre Gyuk, Energy Storage Program Manager, US DOE • Branden Sudduth, Director of Reliability Planning, WECC • Vijay Satyal, Senior Policy and Outreach Advisor, WECC	8:30-9:00
Seminar Overview (O'Neil)	9:00-9:15
State by State Review (All) *Material*: Memo on State Energy Storage Dockets □ Activities within Western regulatory dockets	9:15-10:30
BREAK	10:30-10:45
Energy Storage Program Overview (Gyuk)	10:45-11:15
Energy Storage Program Technology (Sprenkle) • Performance • Market adoption • Costs and Learning Curves • Emerging Chemistries • *Discussion*	11:15-1:00
(INCLUDES WORKING LUNCH	12:00-1:00)

Energy Storage Seminar

Western State Regulatory Commission Staff

November 6, 2017
Western Electricity Coordinating Council offices
155 North 400 West, Suite 200, Salt Lake City, Utah

TOPIC TIME

Energy Storage Program 1:00-2:45
Valuation (Balducci/Kintner-Meyer)

- Valuation Principles and Models
- Operational Uses and Capabilities
- Case Studies
- Trends
- Model Integration
- *Discussion*

BREAK 2:45-3:00

Energy Storage Program 3:00-4:30
Regulatory Models (O'Neil/Homer)

- Legislatively-Required Procurement Target
- Resource Planning
- Grid Modernization
- Distribution System Planning
- Tariff Design
- Avoided Cost
- *Discussion*

Wrap Up and Next Steps 4:30-5:00

Appendix C

Responses to Qualitative Survey Questions

A short time after the seminar, PNNL circulated an online survey to participants to provide more structured feedback. The survey consisted of 10 questions; four of them with multiple-choice responses and six of them with open-ended responses. Twelve of the 18 state-level seminar participants responded. Appendix C presents the responses to the quantitative questions and summarizes the feedback from the qualitative questions.

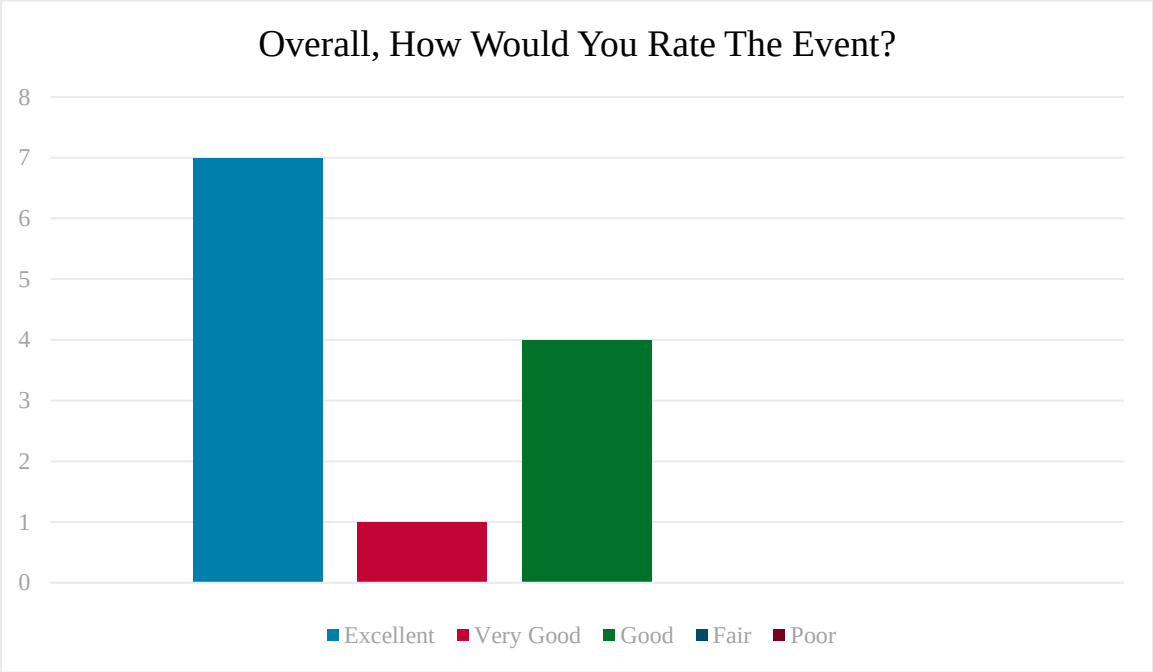

Figure 5: Responses to Survey Question 1.

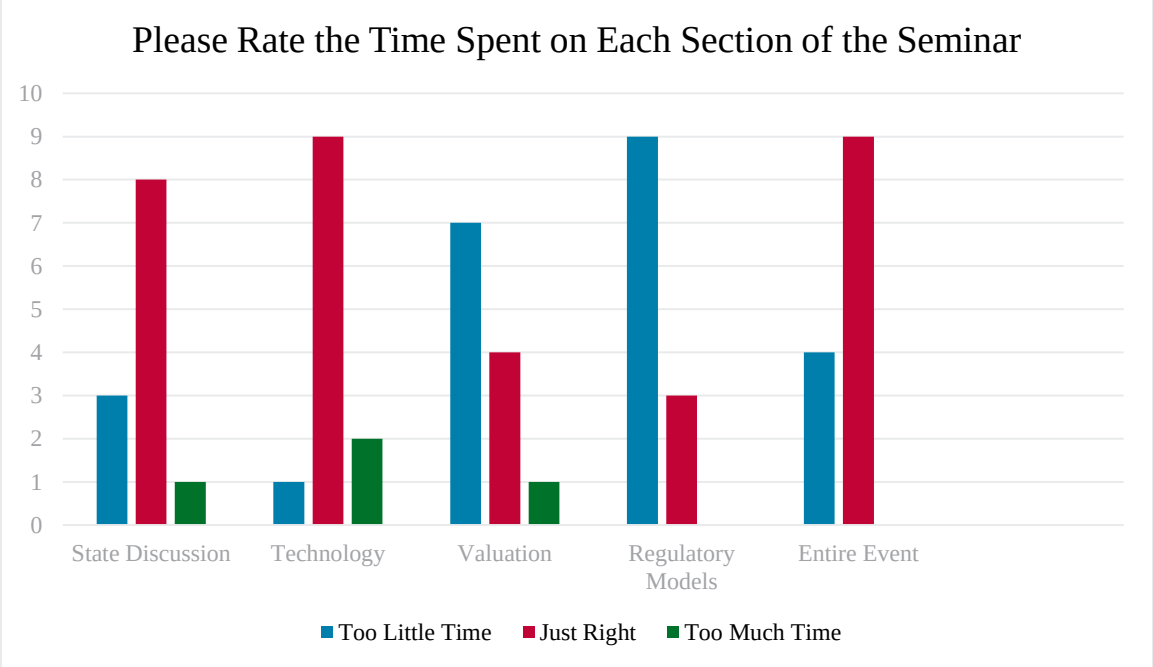

Figure 6: Responses to Survey Question 2

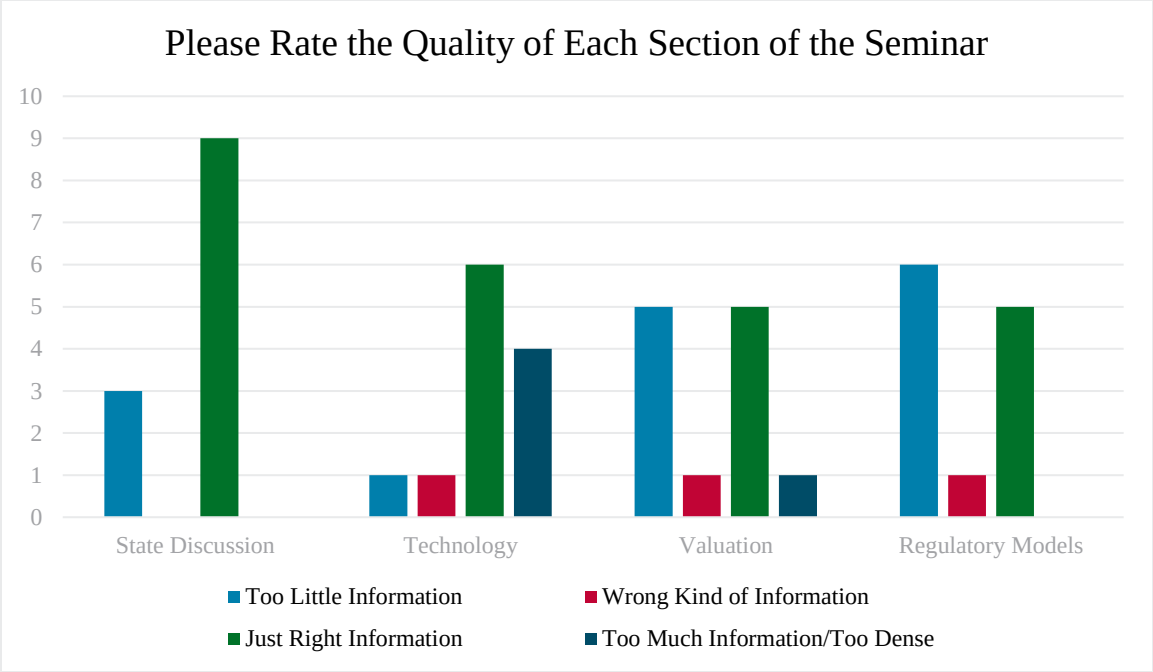

Figure 7: Responses to Survey Question 3

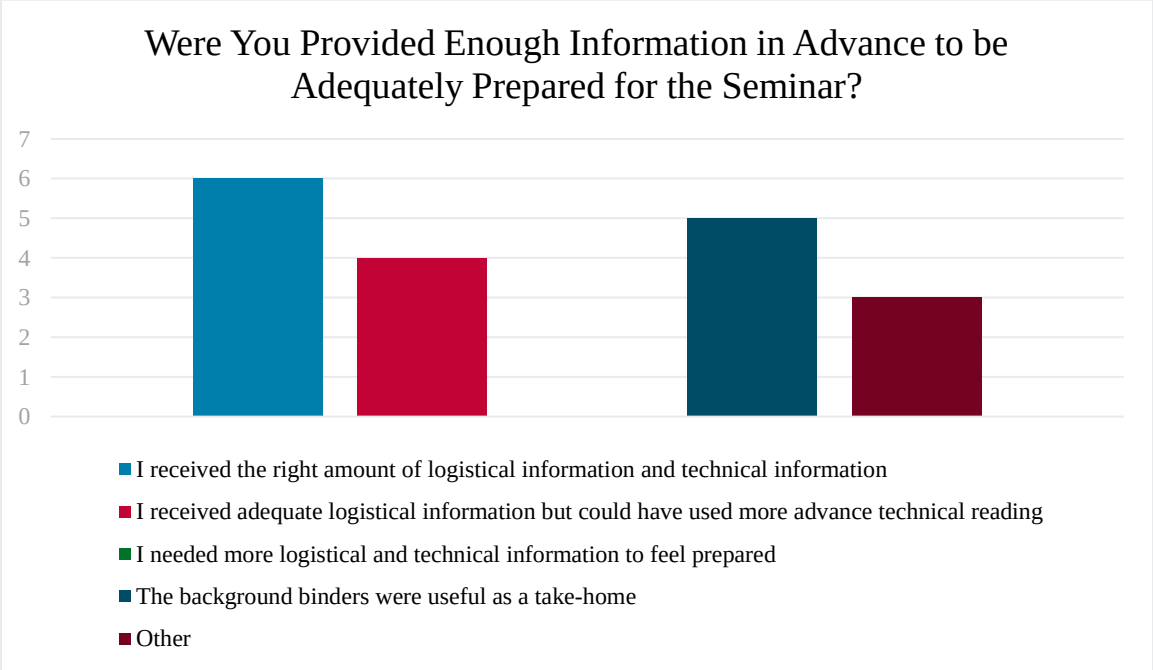

Figure 8: Responses to Survey Question 6

Two points are worth noting about Question 6. First, the wording of the answers was not mutually exclusive, and seems to have confused respondents as a result – 12 respondents provided 15 answers to the question.

Second, the three "other" responses stated that (1) it would have been good to have printouts of the PowerPoint presentations on hand during the seminar for taking notes, (2) more of the deep technological

information could have been provided in the background binder instead of during the seminar, and (3) the background binder is a great resource.

The first of the qualitative questions asked participants what they liked about the seminar. All 12 responders answered the question, with a handful of common themes emerging in their comments (numbers in parentheses indicate how many people commented on that theme; total is greater than 12 because some participants commented on multiple topics):

1. The opportunity to hear from and interact with their counterparts in other states was highly valuable (seven);

2. Good speakers/useful presentations (six);

3. The event was organized well (two); and

4. It was helpful to hear from objective, nationally recognized lab personnel (two).

One participant also indicated that "everything" worked well, and suggested that the event should be two days.

The next question asked what participants didn't like about the seminar; ten people responded. Only one common theme emerged in comments, as seven individuals made comments relating to the schedule. Comments generally indicated that not enough time was devoted to the valuation and regulatory model sections, or conversely, that too much time was spent on the technology section. No other theme was mentioned by more than one respondent, but they bear mentioning:

1. The seminar should have been longer;

2. It would be helpful to have recurring events on a quarterly or semi-annual basis, with the opportunity for attendees to suggest topics; and

3. It would have been helpful to have more practical examples of how these principles are being incorporated into real-world planning processes.

Asked if anything was missing from the event, eight people responded, five of which answered "no" or "uncertain." Of the three who provided substantive responses, one indicated that there needs to be more discussion about implementation and operational challenges for energy storage projects, one indicated that it would be useful to learn about how to incent utilities to identify and develop storage opportunities, and one indicated a desire to learn about what other countries are doing on energy storage technology and policy.

The next question asked participants if the seminar struck the right balance between research and practical information. Ten people responded; six said no (all of which indicated that there was not enough practical information), and four said yes. Some of the more detailed comments suggested that it would be helpful if the participants had been polled beforehand so that the agenda could be more tailored to specific needs, and that it would be helpful if the training was more focused on the regulatory implications of the research. Others said that the state discussion provided a good base of practical knowledge, and that as the number of projects grows, the amount of practical information to be shared will also grow.

Building on that question, the next question asked what additional information, tools, or next steps the Energy Storage Program could provide to regulators. Several themes emerged across the 10 responses received:

1. Additional/recurring seminars requested (five);

2. More practical guidance for applying the information into regulatory processes, including planning, RFPs, and pilot program design (four);

3. A deeper dive into valuation and regulatory models (four); and

4. An update of new demonstration projects and their analyses (two).

One participant also requested regular updates on energy storage system costs and forecasted cost declines.

The final question gave participants the opportunity to provide any remaining feedback or suggestions. Four people responded. Two of them expressed their gratitude for the event, one suggested a more focused presentation of the specific applications of energy storage at the different functional levels of the grid (generation, transmission, distribution, and behind the meter). The final respondent suggested that future events solicit questions from participants in advance and then shape the agenda around those needs.

Pacific Northwest
NATIONAL LABORATORY

www.pnnl.gov

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99352
1-888-375-PNNL (7665)

U.S. DEPARTMENT OF
ENERGY