Feedback report and meeting summary

Emerging resources: Resource Alternatives for Energy Storage

Meeting details

- Tuesday, April 23, 2024, 1:00 p.m. - 2:30 p.m.
- Virtual webinar hosted by PSE and facilitated by Triangle Associates
- Links to:
    - Presentation
    - Meeting recording
- Participants: 25 via Zoom (plus 14 panelists), 29 YouTube views as of May 15, 2024.

Meeting summary

Agenda Topic	Summary

Engagement Roadmap and Public Feedback Questions
Kara Durbin, Director, Clean Energy Strategy, PSE
	• PSE shared an overview of previous engagements focused on emerging technologies.
	• In June 2023, PSE released a survey to ask members of the public to suggest emerging resources that PSE should study. In September 2023, PSE asked for feedback about which topics to focus on in future public webinars. These conversations informed the IRP work plan that PSE filed in September.
	• PSE has hosted a public webinar series focused on emerging resources between December 2023 and April 2024. These webinars focused on hydrogen, small modular nuclear, and energy storage.
	• Concurrently, PSE met with the Resource Planning Advisory Group (RPAG) to get feedback on the emerging resources assessment and share additional details about these emerging technologies.
	• PSE invited members of the public to provide feedback on the following questions in the Q&A box, during public comment, via the feedback form, or via email:
	  ○ What risks and rewards for energy storage should PSE keep in mind?
	  ○ Can you identify any examples of energy storage projects at other utilities that you think are good for PSE to consider?

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Energy Storage Overview Elizabeth Hossner, Manager, Resource Planning and Analysis, PSE	• PSE's current work in electric resource planning is focused on establishing its resource needs by forecasting future growth in demand and exploring how different resources can meet that forecast. • PSE uses generic resources as placeholder resources to help evaluate sizing, timing, and types of resources that could meet future needs. • This stage of planning is not an acquisition process. After the planning stage is complete, PSE will go through a full acquisition process and evaluate all resource options. • PSE defined energy storage as resources capable of storing excess energy that can be discharged later. • PSE previously received feedback on storage resources that will be explored for the 2025 IRP. This feedback includes requests to model different battery configurations and vehicle-to-grid technology. • PSE assesses each emerging technology based on its technology readiness level (TRL). PSE will focus on resources that are at a TRL rating of 7 or higher. This includes resources undergoing demonstration projects (TRL 7) through commercially available resources (TRL 9). • PSE organized energy storage technologies based on duration: short duration (2 – 8 hours), medium duration (8 – 24 hours), and long duration (multi-day). • PSE hired Black & Veatch to study emerging technologies that PSE has not yet studied in previous IRP cycles.

Energy Storage Technologies
Prantik Saha and Michael Eddington, Black & Veatch
	• Black & Veatch studied two types of short duration storage: lithium-ion batteries and sodium-sulfur batteries.
	    ○ Lithium-ion batteries have been widely deployed for various uses. The two types of lithium-ion batteries are nickel-manganese-cobalt oxide (NMC) and lithium ferrous phosphate (LFP).
	    ○ The biggest safety concern for lithium-ion batteries is a fire hazard due to thermal runaway. LFP batteries are less risky than NMC.
	    ○ The main safety concern for sodium-sulfur batteries is a fire caused by exposure to molten sulfur and sodium.
	• Black & Veatch studied three types of medium duration storage: compressed air energy storage (CAES), mechanical energy storage, and flow batteries.
	    ○ CAES technologies use energy from the grid to compress air or other gases. In the discharge phase, these compressed gases are released, heated, and expanded across turbines.
	    ○ There are three subcategories of CAES: adiabatic, diabatic, and isothermal. Adiabatic stores heat from the compression process and uses it to heat the air during discharge. Diabatic does not save heat from the compression process and instead heats air by burning natural gas or hydrogen fuel. Isothermal continuously removes heat during the compression process and reapplies it continuously during the expansion process.

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	○ Diabatic and adiabatic CAES systems require caverns created by mining. ○ In mechanical energy storage, surplus energy from the grid is used to drive mechanical processes to store energy and then release it to convert it back to electricity. ○ Black & Veatch studied two sub-categories of mechanical energy storage: liquid air energy storage (LAES) and gravity-based rail. • PSE provided an overview of flow batteries. ○ Flow batteries store energy in electrolytes. Sub-categories include vanadium redox, iron, zinc bromide, and metal coordination complex. ○ Compared to traditional batteries, flow batteries require larger footprints of land. ○ Flow batteries have significantly lower safety concerns than lithium-ion and sodium-sulfur batteries. • Black & Veatch studied one type of long duration energy storage: iron-air batteries. ○ Iron-air batteries require a very large footprint. ○ Iron-air batteries are considered very safe because there is minimal fire risk, chemical spill risk, or gas emission risk.
Spotlight on Vehicle to Grid (V2G) and Vehicle to Everything (V2X) Malcolm McCulloch, Manager, New Products and Services, PSE	• PSE provided an overview of its vehicle-to-everything (V2X) explorations. • PSE is evaluating technical feasibility and operational requirements of two-way flows of energy that allow utilities and customers to collaborate and take advantage of electric vehicle batteries. • There are multiple V2X configurations: ○ Vehicle-to-load (V2L), which involves plugging power tools into electric truck batteries ○ Vehicle-to-home/building (V2H/V2B), which involves using an electric vehicle to provide supplementary power to a home or building ○ Vehicle-to-grid (V2G), which involves injecting electricity from an electric vehicle back into the grid. • Implementing V2X is challenging because of a lack of standardization from charging system producers and vehicle manufacturers. Also, customers' willingness to participate in unclear. • PSE is going through a process of technical demonstrations for V2H, V2B, and V2G with the goal of ensuring that PSE has the proper technology requirements, understanding customers' interest, and exploring how to integrate V2X with virtual power plants. The V2X project is currently in the design and development phases of PSE's standard development process. PSE intends to move through the development process to ensure integration capabilities are defined and tools and protocols for technology partners are understood. Then, PSE will move towards identifying potential demonstration sites and continuing enrollment.

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Next Steps and Public Comment Opportunity Sophie Glass, Facilitator, Triangle Associates	• Apr. 30, 2024: Feedback form closes • May 9, 2024: Local and regional delivery infrastructure needs public webinar • May 14, 2024: Western Resource Adequacy Program (WRAP) overview RPAG meeting

Feedback report

The following table records participant questions and PSE responses from the public comment opportunity and comments submitted via online feedback form or irp@pse.com. Meeting materials are available on the IRP website.

Note: PSE aims to provide clarity in responses but subsequent follow-up may be required at times. Please direct any follow-up clarifications to irp@pse.com.

No.	Date	Interested party	Submitted via	Question or comment	PSE response
1	4/23/2024	Don Marsh	Q&A	Want to acknowledge the INFORM level of public engagement. We appreciate it and would like to see an INFORM level of participation for nuclear at the RPAG.	Thank you for your feedback.
2	4/23/2024	Anonymous attendee	Q&A	Acronyms are used in places where there is no need to use them. For example, on Slide 37, a title slide, it would be much more understandable for someone scrolling through the slides to know what that section is about without acronyms. There was plenty of room on the slide to spell them out.	Thank you for your feedback; we continue to work to improve the readability and accessibility of these meetings.
3	4/23/2024	Don Marsh	Q&A	Both of the Li-ion and sulfer-sodium battery technologies will be useful. Just want to note that the safety concerns make these harder to site within a community. I don't know if/how PSE factors that into an IRP, but it might affect some cost and efficiency metrics. Can be useful tools in a portfolio of diverse resources.	*Answered live at 41:18:* We are just trying to get sizing of resources and are looking at very general, large areas in PSE's entire system. We need something to fit this type of resource. We're not necessarily going into the details of exactly where resources may go. That again will be going into an acquisition process. As part of the Integrated Resource Plan (IRP) process we're trying to identify the needs of resources and permitting; where specifically resources can go. The next step as we

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					move into the acquisition process is to actually start evaluating the resources.
4	4/23/2024	Joel Nightingale	Q&A	have any of the existing installations of "diabatic" CAES that Black and Veatch studied use fuels other than natural gas as a fuel source? If so, what fuel sources?	*Answered live at 45:38:* There are really only two large compressed air energy storage (CAES) units in service, and they both rely on natural gas as the source of heating. There's a lot of interest in trying to use cleaner fuels so hydrogen is important to consider so that you don't release carbon dioxide into the atmosphere. When we burn natural gas we create carbon dioxide so that's in the interest of decarbonization. Right now there is no hydrogen-fired or "green" fuel fired but it would be something to definitely consider. There's a process called CAES 2 which has a gas turbine and that gas turbine could burn hydrogen, for example.
5	4/23/2024	Don Marsh	Q&A	Has PSE considered any of the thermal storage batteries (hot bricks or sand, ice, etc.) for customers who are looking for reliable heat or cooling? These are specialized applications, probably mostly for high density or industrial applications, but seem like they are feasible for certain applications.	*Answered live at 53:39:* Electric thermal energy storage is another area of great interest and development. What you do is have electric heaters that are heating sand, concrete, graphite or other storage medium, and then you can take the stored heat and perhaps make steam from it to reconvert it back into electricity when demand is high. Those are systems that have high energy storage efficiency. The harder part is to have an efficient conversion of that thermal energy back into electricity. It does reduce the overall round-trip efficiency of that process but if you are looking at heating and cooling and the use of processed steam, something like that is a very efficient way to store electricity when it's available and use that to offset other fuel needs.
6	4/23/2024	Joel Nightingale	Q&A	It looks like many of the deployments for these medium duration storage options align better with the "short" duration (2-8 hours) category. Can Black and Veatch describe how these technologies were chosen as medium duration technologies? Is there reason to	*Answered live at 1:00:58:* The short duration and medium duration storage actually overlap around the 8-hour mark. So, we have short duration around 2 to 8 hours, but it could be more like 2 to 6 hours, whereas the medium duration is 8 to 24 hours. These technologies do hit that eight-hour mark,

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				believe they are likely to have longer-duration applications in the future?	which we've identified as the medium duration. For example, a lithium-ion battery we have categorized as short duration. It could be 2, 4 or even 8 hours depending on what the needs and costs are. This is all weighed with the needs, cost curves, and how these technologies can best fit. We're trying to categorize these, but some of these can span both short and medium duration depending on how we size them. Whenever we consider any energy storage technology we usually get a range of storage duration, and when we classify the medium duration or short duration, it's based on what duration the levelized cost of energy comes out to be. Lithium-ion batteries can be deployed for 2 hours and 8 hours as well, but in the shorter durations the levelized cost of energy is lower so you will see some overlaps.
7	4/23/2024	Anonymous attendee	Q&A	I agree that PSE should be considering thermal storage. It is a proven technology that has been in use for many, many years.	Thank you for your feedback.
8	4/23/2024	Matt Larson	Q&A	Can you speak to the comparative efficiencies of these various battery systems/technologies? 100% energy goes in and ___% comes out. Which have the highest losses, or best returns?	*Answered live at 1:06:30:* Lithium-ion batteries have the highest efficiency above 85%. In fact, in some cases we have also seen close to 92% efficiency. So, if you put in 100 MWh of energy into the battery you'll get about 90 MWh. The flow batteries we have seen have an efficiency in the range of 70-75%. Vanadium flow batteries have a higher round trip efficiency. The iron and zinc bromide flow batteries have lower round trip efficiency. With metal coordination complex we are not so sure; we don't have much data. The iron air battery suffers from a very low round trip efficiency caused by the fact that there is an iron-to-rust and rust-to-iron chemical (electrochemical) cycle that goes on. To the best of our knowledge the round-trip efficiency

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					for iron-air battery is around 43%, which is the range for electrochemical systems. With sodium sulfur it's a little bit tricky if you don't have any source of external heat to raise the temperature to 300 degrees; we have seen the efficiency be close to 70%. However, if there is waste heat that can be used to raise up the temperature then we have seen close to 80% efficiency. For compressed air energy storage (CAES) an adiabatic type could be 55% efficient, or a range of 45-70%. If there's additional waste heat it's going to be 60-70%. When you look at some of the gravity energy storage systems they're going to be maybe in the 85%+ efficiency.
9	4/23/2024	Thomas Kraemer	Q&A	Why is only one long duration technology considered? Consideration should also be given to hydrogen by electrolysis and tank storage, discharging back to grid using fuels cells. A study released in February by Mark Jacobson's group at Stanford University showed that this technology is cost-effective for long duration storage. (50 hours and greater)	*Answered live at 1:10:05:* We are looking at hydrogen as a fuel source through electrolysis or other forms, and what we are doing is pairing it with a thermal peaking unit. It can be used as storage. There are fuel cells we haven't looked at. We are mostly looking at a thermal peaking unit for this IRP process. With this long duration storage we're trying to get sizing. There are multiple different technologies out there. Iron air is a technology we're looking at for long duration but we're just trying to get sizing and seeing how the long-duration storage can fit into the resource portfolio and how it may work.
10	4/23/2024	Markus Virta	Q&A	Has PSE considered the aggregate capacity of behind the meter BESS/VPP to serve some of the short, medium, and even long duration storage functions?	PSE is only considering the aggregate capacity of behind-the-meter BESS within the VPP to support short-duration functions. The technology (lithium-ion) of behind-the-meter (BTM) residential batteries does not support medium or long-term functions. There is, however, potential to limit the immediate dispatch of our VPP aggregated BTM BESS so that

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					we can have sustained capacity over a longer period of time. Additionally, PSE is exploring long-duration storage options such as iron air BESS.
11	4/23/2024	Shruti Misra	Q&A	1. Wouldn't some thermal storage fit under the long duration storage? 2. What are some technical and cost parameters along which iron-air batteries need to still prove themselves for PSE to consider their large scale deployment?"	*Answered live at 1:12:05:* Thermal energy storage can be sized and appropriate for long duration energy storage, so it could fit. For our modeling process, the resources will be inputted and we will do a full capacity expansion. This is an optimization model that will consider the operating characteristics of the resources, the cost of the resources, and how it best fits into the portfolio. We go through an optimization of resources based on these cost characteristics and create a least reasonable cost portfolio looking at all these different categories. What goes in may not come out as results, we're just evaluating different options. This is not necessarily saying we're going to be using these resources, we're just trying to evaluate the options.
12	4/23/2024	Bill Westre	Q&A	NASA studied flywheel batteries in the 1980 to 1990 time period. What data do you have on that work?	*Answered live at 1:13:56:* There are a lot of other companies developing flywheel technologies now. Some are looking at 4-hour discharge periods so there is definitely development happening.
13	4/23/2024	Joel Nightingale	Q&A	It's my understanding that the projects in CO and MN are 100-hour batteries, not 10-hours (as it states on slide 35). Can PSE confirm that they plan to model a 100-hour iron-air battery, not a 10-hour battery?	*Answered live at 1:14:42:* Yes, we will model a 100-hour battery; the 10-hour battery was a typo in the meeting slides.
14	4/23/2024	Don Marsh	Q&A	We are very interested in these iron-air batteries. Drawbacks are that they are big, heavy, and not very efficient. However, after Form Energy's presentation to the Northwest Power and Conservation Council, we realized these are useful for SEASONAL storage. That is really interesting, especially in years when we have low hydro in the late summer or an arctic winter	Thank you for your feedback.

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				event. Form says they can help reduce electricity prices by 6%. We would like to see if PSE's analysis produces a similar result in its service territory.	
15	4/23/2024	Quinn Weber	Q&A	Would the interconnection agreement be between PSE and each customer participating in V2G, or something else?	*Answered live at 1:25:09:* That interconnection agreement is basically our way to ensure that the energy that the inverter involved in that technology mitigates the backflow of energy onto our system without that direct control. We will go through an interconnection process very similar to what we do with other renewable systems that come onto our system. That's part of what we would be working through with this technology demonstration.
16	4/23/2024	Don Marsh	Q&A	The willingness of customers to participate in V2G will be a function of how much they can earn. If they can reduce their electric bills by $100/month or more, you will have a lot of people who are interested at that level. Do you have any idea of the range of compensation at this point? Many customers will be interested in V2H just to avoid power outages, of course.	*Answered live at 1:25:58:* We have not aligned to what that compensation looks like and that's part of that demonstration process and engagement with customers to really find out a couple things in this process. 1. What state of charge are they willing to reduce their vehicle battery to 2. What point of compensation are they really interested in That demonstration will be part of that market research along with looking at best practices from some of our peers who are also doing some demonstrations.
17	4/23/2024	Quinn Weber	Q&A	Is PSE concerned about a bottleneck of EV make/model compatibility with V2X equipment?	*Answered live at 1:26:45:* There are a lot of different approaches that are being assessed today and there are original equipment manufacturers (OEM) vehicle producers that are creating their own consortium of energy companies. That's part of what we need to understand and how to integrate those within our virtual power plant. That's why we believe that this is a still fairly nascent market because it's evolving. One example you can look at is there are several different charging adapter standards that have been in place for many years for electric vehicles. Tesla has now moved into

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					being the standard that most folks are adopting. That evolution will happen normally as the market evolved but it is something we're going to be keeping an eye on.
18	4/23/2024	Joel Nightingale	Q&A	Does the "operate" phase of this roadmap indicate that PSE expects to open these V2X programs system-wide in 2025, or is that the pilot/demonstrations?	*Answered live at 1:27:51:* We will be demonstrating in 2025. That will provide us with the capability to really understand how we get these systems interconnected and then we will move forward with broader deployment as we feel more confident about that technology or capability.
19	4/23/2024	Matt Larson	Q&A	Any indication that Tesla will get on the bi-directional bandwagon anytime soon?	We are not able to speak to what Tesla is planning.
20	4/23/2024	Joel Nightingale	Q&A	When will the next IRP Public webinar be?	The next public webinar is May 9, 2024.
21	4/23/2024	Don Marsh	Q&A	How many people were here today?	Please see the first page of this document for a count of attendees and participants.
22	4/24/2024	Thomas Kraemer	irp@pse.com	*PSE asks, on Slide 10 of today's presentation: Can you identify some examples of energy storage projects at other utilities that you think are good ones for PSE to consider?* Pacific Gas and Electric has been ramping up a vehicle-to-grid pilot program for over a year. See report from California PUC. *Slide 12 says, and Elizabeth Hossner reminded us today that "Separate acquisition and evaluation process are used to select and acquire specific resources to meet capacity and energy needs, and CETA requirements."* It would be helpful to see a timeline for completing evaluations, selecting, and acquiring generation and storage capacity. We see the engagement roadmap at the start of each presentation. It would be beneficial	Thank you for your feedback. Resource acquisition is indeed a separate process that falls outside of the resource planning purview. You can read more about how PSE acquires resources and our Request For Proposal (RFP) process on our RFP website. *Answered live at 1:10:12* PSE is looking at hydrogen as a fuel source or hydrogen through electrolysis or other forms paired with a thermal peaking unit. It can also be used as storage. For this IRP process we are looking at a thermal peaking unit. For long-duration storage we're trying to focus on sizing and seeing how long-duration storage can fit into the portfolio.

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				to see a roadmap for selecting and acquiring the needed resources as well. The presentations so far have provided good technical information on various clean energy technologies, but not how PSE will evaluate and select them. In particular, the storage technologies presented today should be evaluated for their ability to match the variability of planned renewable resources (short duration storage) and serve as backup power during outages (long duration storage). They also need to be evaluated in the context of the likely supply curve and other demand side initiatives. In other words, plans and schedule for acquiring various resources must be carefully coordinated, both with regard to what technologies to use and when to acquire them. Where is PSE in this process? On slides 34 and 35, why was only one long duration storage technology, Iron-Air battery, studied? Consideration should also be given to hydrogen by electrolysis and tank storage, discharging back to grid using fuels cells (among others). A study released in February by Mark Jacobson's group at Stanford University showed that this technology is cost-effective for long duration storage. (50 hours and greater) when combined with short duration batteries. See Jacobson, iScience 27, 108988, February 16, 2024, https://doi.org/10.1016/j.isci.2024.108988.	
23	4/25/2024	Don Marsh on behalf of Washington Clean Energy Coalition	irp@pse.com	During the April 23 Public Webinar on Resource Alternatives for Energy Storage, I was surprised that there was no mention of thermal energy storage technologies such as the Rondo Heat Battery (https://rondo.com/products) for storing heat. Smaller systems like the Ice Bear (https://www.thuleenergystorage.com/products/) can store cold for refrigeration or air conditioning.	Thank you for your feedback. We can add this emerging technology to the list of resources to consider in the future. Please note, the IRP process is designed to use generic resources to estimate the scale and timing of resource needs. Neither generic resources nor the preferred portfolio represent a "shopping list" for future acquisitions.

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				When asked, a consultant from Black and Veatch responded that thermal energy storage could qualify as “long duration storage,” for which PSE had listed only one technology, an Iron-Air battery from Form Energy. While we remain very interested in the Form battery for long-duration or even seasonal storage, thermal energy storage was not adequately considered. Black and Veatch said a heat battery offers high efficiency by converting electricity into heat, and then converting the heat into steam which can run a turbine generator to produce electricity when it is needed. However, if that electricity is subsequently used to produce heat for the consumer, the conversion of heat to steam to electricity and then back to heat is not ideally efficient. There are customers who could use the heat directly in industrial processes or to heat large buildings. In fact, a recent pilot program approved by our legislature would make district heating more feasible as a replacement for individual gas furnaces in a neighborhood. A central source of heat could provide heating in the winter and hot water year-round. Such systems are commonly used in European cities like Copenhagen, Denmark. The Rondo battery offers some compelling features. According to the company, it provides up to 300 MWh of emissions-free heat (if charged with renewable electricity) at 98% efficiency with 20% lower costs than natural gas. Obviously, it isn’t a general solution like a big chemical battery might be, but it has its own strengths. It actually needs to be located close to loads, where safety concerns limit the siting of big chemical batteries near where people live and work. If PSE works with customers, this could be a good	

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				solution for specific applications, thereby reducing demand on the rest of the grid. If a few large heat batteries were located in PSE's service territory, they could help reduce peak demand in challenging winter scenarios. At least, the feasibility of this idea should be evaluated in PSE's Resource Adequacy modeling to see if it might be a cost-effective solution to assist in the clean energy transformation.	
	4/30/2024	Joel Nightingale (RPAG member) on behalf of Washington Utilities and Transportation Commission	irp@pse.com	Storage: 1. Slide 16 indicates that PSE plans to use Compressed Air Energy Storage (CAES) as its medium-duration generic resource for the 2025 IRP. Which type of CAES (adiabatic, diabatic, or isothermal) does PSE plan to use for modeling purposes? Vehicle to Everything (V2X): 2. Has PSE developed any equity guidelines or framework around potential V2X/V2G programs? Given the equity concerns Staff has raised in connection with net metering, what has PSE done to connect the implementation of V2X/V2G to the tenets of Energy Justice and CETA's requirement for equitable distribution of benefits? 3. How and when does PSE intend to incorporate equity considerations into – and include named communities in – the development process of emergent Transportation Electrification technologies (like V2X) and the new programs they enable?	1. PSE is modeling adiabatic CAES. 2. While the presentation on V2X was meant to be informational only and does not directly relate to the current IRP process, please see the below regarding PSE's approach to incorporating equity into future V2X technology demonstrations. PSE is promoting procedural equity in its product design by giving Named Communities and their service providers a seat at the design table. For example, from September 2022 through May 2023, PSE conducted community engagement on future DER products. By engaging with over 250 low-income residents and over 40 agencies, municipalities, organizations, and tribal entities who serve those aforementioned residents in 1:1 interviews, focus groups, workshops, and surveys, PSE was able to hear from them directly about the benefits and barriers customers may face when it comes to DER products, and how future product design can alleviate these barriers and maximize the desired benefits. PSE is committed to using these and additional community engagement outcomes to shape the V2X technology demonstration designs and planned operations for named communities and their service providers, where possible.

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					3. As an example, within PSE's service area there are school districts that serve students at the intersection of medium and high vulnerability and residing in a highly impacted community. Expediting the transition from diesel school buses to electric buses can reduce localized emissions while unlocking grid benefits by allowing the batteries to act as portable power banks during the time they aren't in use by implementing vehicle-to-building or vehicle-to-grid capabilities, which in turn can provide resiliency and/or an additional revenue stream for school districts. PSE will engage with identified school districts with V2X electric school buses to gather further insights and incorporate the associated equity considerations as part of the demonstrations to validate the realization of benefits.

Attendees (alphabetical by first name)

1. Bill Drumheller
2. Bill Westre
3. Bill Will
4. Chris Goelz
5. Don Marsh
6. Grace Bouziden
7. Jay-Paul Lenker
8. Jim Schretter
9. Joel Nightingale
10. Kate Brouns
11. Katie Chamberlain
12. Markus Virta
13. Matt Larson
14. Meghan Anderson
15. Pete Stoppani
16. Quinn Beckham
17. Quinn Weber
18. Robert Twa
19. Seth Baker
20. Shruti Misra
21. Stephanie Chase
22. Taylor Nickel
23. Thomas Kraemer
24. Virginia Lohr
25. Wesley Franks

PSE staff

1. Brett Rendina, PSE
2. Elizabeth Hossner, PSE
3. Kara Durbin, PSE
4. Malcolm McCulloch, PSE
5. Meredith Mathis, PSE
6. Phillip Popoff, PSE
7. Ray Outlaw, PSE

Guest presenters

1. Gina Holland, Black and Veatch
2. Mike Eddington, Black and Veatch
3. Prantik Saha, Black and Veatch

Facilitation staff

1. Emilie Pilchowski, Triangle Associates
2. Jack Donahue, Maul Foster & Alongi (MFA)
3. Pauline Mogilevsky, Triangle Associates
4. Sophie Glass, Triangle Associates