2024 PROJECT PEER REVIEW
U.S. DEPARTMENT OF ENERGY
BUILDING TECHNOLOGIES OFFICE

BTO Peer Review: UDERMS iCommunity

Utility Managed Distributed Energy Resources Intelligent Community

UDERMS iCommunity

PacifiCorp, Rocky Mountain Power (RMP), Electric Power Engineers (EPE), Utah State University (USU), University of Utah (UoU), Pacific Northwest National Laboratory (PNNL), Giv Group, OSI / AspenTech, National Association of State Energy Officials (NASEO),International Center for Appropriate and Sustainable Technology (iCast), Doglatin Media

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EERE Award No. DE-EE0009782.0000

Project Summary

OBJECTIVE: Develop a utility-managed, distributed energy resources (DER) control program that integrates various buildings and flexible energy loads to enhance grid efficiency and resilience.

OUTCOME: Effectively utilize grid interactive and efficient buildings (at least 30% energy efficiency savings) with DERs to deliver 8.26MW of demand flexibility.

IMPACT: The project will outline best practices for how building decarbonization and integration of DERs can be scaled and replicated nationally.

TEAM & PARTNERS

- PacifiCorp
- Pacific Northwest National Laboratories
- Utah State University
- University of Utah
- Electric Power Engineers
- iCast
- NASEO
- Giv Group
- OSI
- Doglatin Media

STATS

Performance Period: 6/1/2022 - 5/31/2028 (extended)

DOE Budget: $6,420k, **Cost Share:** $2,825k

Milestone 1.4.2: Initial communication pathway and control configuration 4/19/2024

Milestone 8.2.1: Hardware-in-the-Loop models of distribution grid and DERs 5/30/2025

Milestone 29.0.1: Complete best practices for the incorporation of DERs as a Business model 5/28/2028

Problem

- PacifiCorp is **experiencing massive growth** in load from a combination of population growth, electrification, and data centers driven by the AI advancements.
- PacifiCorp is being driven to **transition to decarbonized generation** to meet existing load as well as new load growth.
- Developing **optimized grid services** from DERs through demand response such as peak load management, frequency support, and contingency reserves is essential to meet the demand.
- **Customer experience and impact** needs to be integrated into the technical solutioning.

Alignment

Prioritize Equity

- Four participating facilities provide over 900 multifamily residential housing units, including over 300 **affordable housing** units.
- The UDERMS project integrates DER technologies across a **wide cross-section of customer types** spanning single family, multi-family, commercial, light industrial, transit, and research facilities.
- Electric transit bus applications are also a focus to support **equitable access** to clean transportation technologies.

Prioritize Affordability

- Achieve at least **30% energy efficiency** and productivity of buildings without sacrificing occupant comfort or product performance
- **Cost-effective technologies and building techniques** that enable high-performing, energy-efficient, and demand-flexible residential and commercial buildings in both the new and existing buildings.

Prioritize Resilience

- Implement efficient building design, operational strategies, and innovative building equipment coupled with smart technologies for building energy management to achieve at least **8.26 MW flexible load** and at least **two microgrid sites** capable of islanding.

Accelerate Onsite Emissions Reduction

- Supports all electric buildings and minimizes energy consumption through coordination of operations across all DERs
- The project is focused on decarbonization technologies including transportation and building electrification that have direct impacts on greenhouse gas reduction to **improve air quality for traditionally underserved populations** and the community at large.

Transform the Grid Edge

- Reducing electrical infrastructure cost and mitigating grid constraints by managing the supply and demand balance

Impact

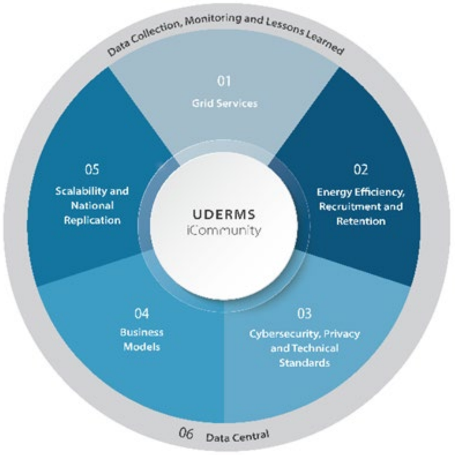
This demonstration will deliver at least 8.26 MW of grid services control and at least 30% energy efficiency savings. Additionally, **best practices** will be shared across the following domains:

Grid Services for DERs: Operational hand-offs at all project sites will provide the final inputs into best practices for high-performance grid services.
Efficiency, Recruitment, and Retention: Post project occupant surveys and focus groups will complement earlier participant outreach efforts to document best practices in efficient recruitment of participants into similar programs as well as how to maximize participant retention in those programs.
Cybersecurity: The final evaluation of cybersecurity measures and performance metrics culminates in documented best practices in cybersecurity as well as coordination with appropriate technical standards bodies regarding those best practices.
DERs as a Business Model: Key project findings will be presented to stakeholders that focus on operating the grid from an economic perspective (e.g., public utility commission and market operator.) Stakeholder feedback on these findings will help finalize the development of best practices on business models for DERs as a business resource.
Scalability and National Replication: The project has been designed with scalability and replicability in the forefront. After evaluating the successes and challenges identified through project execution, the best practices of scalability and replication will be documented.

Approach

Overview

Grid services	Includes frequency response, peak load management, ancillary services
Energy efficiency and customer experience	Starting with customer experience to implement advanced building practices and technologies to increase energy efficiency savings by at least 30%.
Technical standards, privacy and cybersecurity	Leverage open standards for DER integrations prioritizing customer privacy and cybersecurity.
Business models	Investigate business model impacts considering utility integration of DERs for grid services
Scalability and national replication	Clarity around the impact and barriers to scalability and national replication driven by program and implementation design
Data central	Develop processes and structures for collecting, managing, and analyzing various types and frequency of DER data

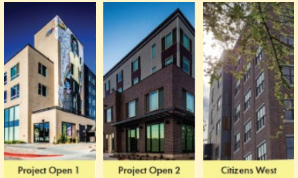


Approach

Customer-Centric Approach

- **Strategic Customer Recruitment and Engagement Strategies**
  - Customer outreach, recruitment, and agreements varied by customer segment
  - Incentive structure for pilot vs production programs
  - Different engagement strategies based on customer type (i.e., surveys, interviews, focus groups)
  - Varying engagement channels (email, working groups, physical materials, etc.)

- **Technology solutioning catered towards varying building types**
  - Network connectivity considering customer requirements and cybersecurity
  - Technology needs based on load types



Giv Group

All electric affordable housing buildings with over 300 units

Soleil Lofts

VPP: 600+ all electric luxury apartments with solar and batteries

USU ASPIRE Center

Research facility and microgrid with an electric vehicle testing track, office building, and DERs

Packsize

Light industrial manufacturing and office building with various DERs

UTA Bus Depot

80,000 sf bus and maintenance garage facility designed to house 132 electric buses

Rocky Mountain Power

Commercial workplace with ~50 EVSEs

Approach

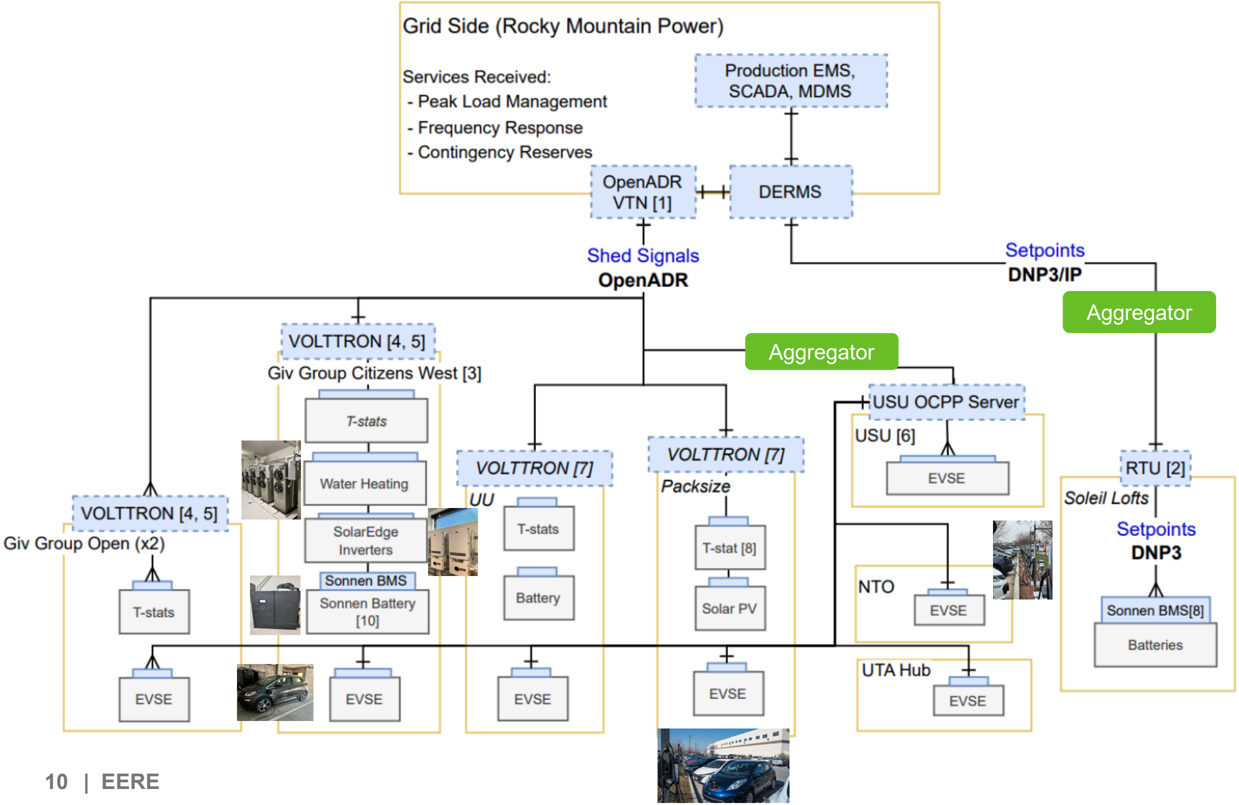
Energy Efficiency and Optimization

Alt-1 kWh Usage	Alt-2 kWh Usage	kWh Savings	% Savings
808,689.75	1,197,811.73	389,121.98	**32.49%**
Alt-1 kWh Usage	**Alt-2 kWh Usage**	**kWh Savings**	**% Savings**
566,809.11	828,449.00	261,639.89	**31.58%**
Alt-1 kWh Usage	**Alt-2 kWh Usage**	**kWh Savings**	**% Savings**
401,830.48	622,929.94	221,099.46	**35.49%**

- Strategy was to engage buildings for participation that **meet a minimum standard for energy efficiency** (>30%) as a foundational element prior to consideration of additional DERs.
- **Validate compliance** with this minimum standard **through building modeling and actual measurement** of energy efficiency savings achieved through building design and incorporation of energy efficient building technologies and design strategies.
- Focus on **fully electrified buildings** and coupling advanced distributed energy technologies like distributed solar and battery energy storage technologies to optimize energy and demand profiles.
- Identify any additional energy efficiency measures that should be considered for incorporation including the potential addition of sensors or other equipment, as needed.
- Implement ongoing monitoring for operational efficiency with building loads.

Approach

Hybrid Architype

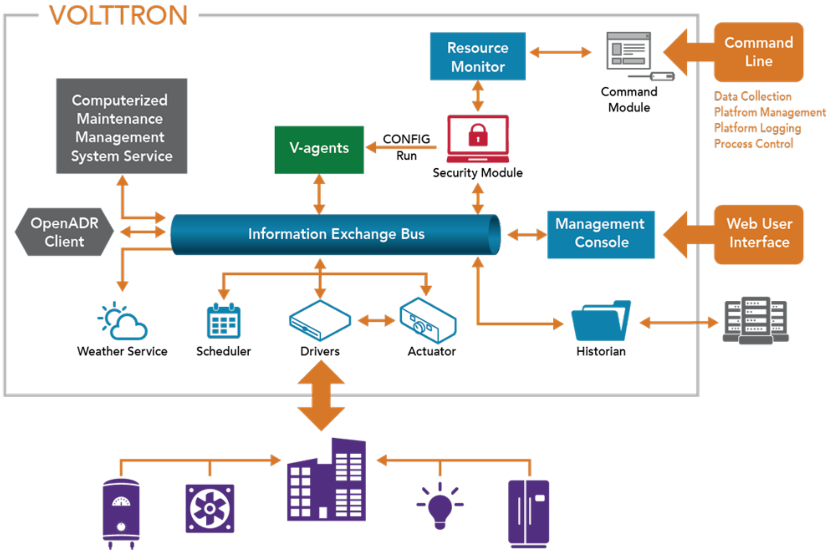


- Hybrid archetype leveraging controls to both an aggregator and direct to building.
- Bulk system grid services executed from utility operator / EMS system through the DERMS.
- Leveraging OpenADR 2.0b, DNP3, IEEE 2030.5, OCPP 1.6.
- Device solutioning based on existing equipment capabilities (i.e., no access to CTA-2045)
- DERs planned for integration:
  - Battery energy storage
  - Electric vehicles / EV supply equipment
  - Grid interactive buildings
  - Heat pump water heaters
  - Heat pump air conditioning
  - Smart inverters
  - Lighting

Approach

Site-Level DER Optimization

- An **opensource sensing and controls** Internet-of-Things reference platform to deliver energy efficiency and grid services
- Several built-in **cybersecurity** features; platform and application written in Python, can be deployed on small footprint computers like Raspberry Pi
- **Controls and coordinates behind-the-meter distributed energy resources**, such as, air-conditioners/heat pumps with smart thermostats, hot water heaters with and without CTA-2045 interface, connected lighting, etc.
- Supports **many standards-based protocols**, such as, BACnet, Modbus, CTA-2045, OpenADR, DNP3, etc.
- Can control proprietary devices using vendor provided **application programming interfaces**



Progress to Date

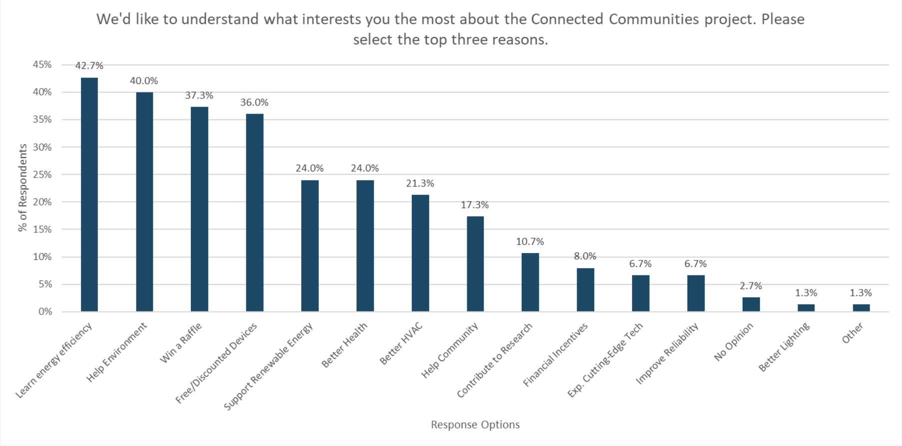
Major Accomplishments Include:

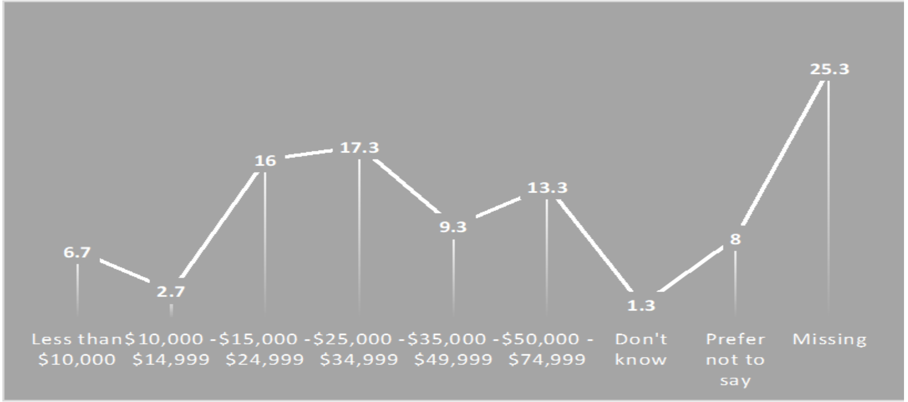
- **Inventory of participating DERs** and **AMI meters installed**
- The findings from the **initial control configuration** of the “testing sandbox”
- Initial **definition of grid services** including event execution parameters and notifications
- **Detailed system impact studies** for each of the participating buildings
- **Calculated energy efficiency savings** for each participating sites
- A report outlining the **findings from surveys and focus groups** for initial customer experience baseline
- **Cybersecurity Plan** updated to address all the comments for the Phase A Checklist requirements
- Completed initial draft of the **Plan for Business Model Development**
- An initial report was completed to address **baseline scalability and replicability** of project goals
- **Intellectual Property Management Plan** fully executed
- **Evaluation and Measurement & Verification (M&V) Assessment Plan** completed and updated

Progress and Future Work

Customer Engagement

- Multiple methods utilized to gather survey responses
  - Physical flyers
  - Emails
  - Information posted on community board
- Strategic survey incentive and deployment to maximize participation
- Customers satisfied with their existing facility services
- Customers interested in:
  - Energy efficiency
  - Helping the environment
  - Access to discounted equipment
  - Incentives
- Over 50% of survey respondents have an income less than $50,000
- **Customer recruitment for smart thermostat control in tenant units is planned for future budget periods.**

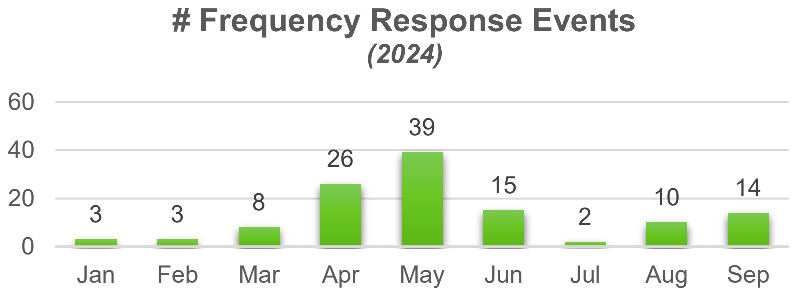


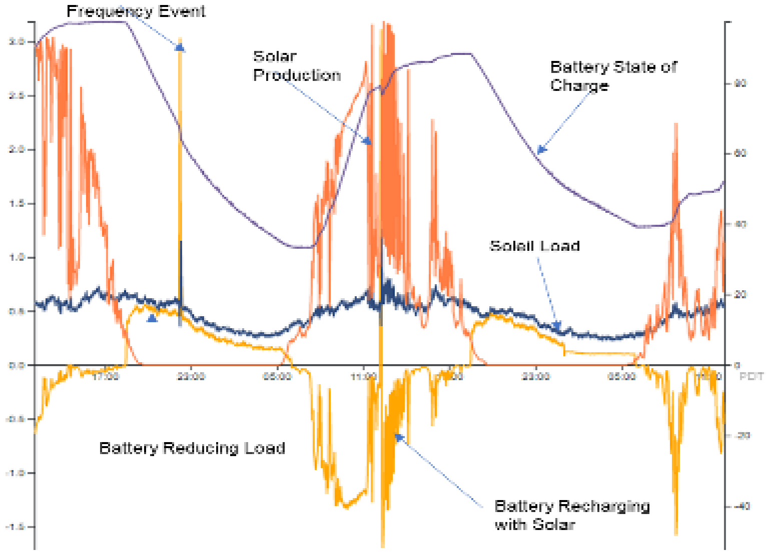


Progress and Future Work

Grid Services – Frequency Response

- Need for frequency events is driven by the transition to inverter-based resources (IBRs)
- High volume of frequency events being executed
    - 120 events in 2024 to date
- Frequency response events last 5 minutes or less
- ~20-25 MW of control per event
- Combination of residential single family and multifamily battery energy storage systems
- Frequency events can happen multiple times per day
    - i.e., 10 events on 5/11/2024
- Event timeframes happen at all hours of the day
- **Working to incorporate other DERs into frequency response event execution**



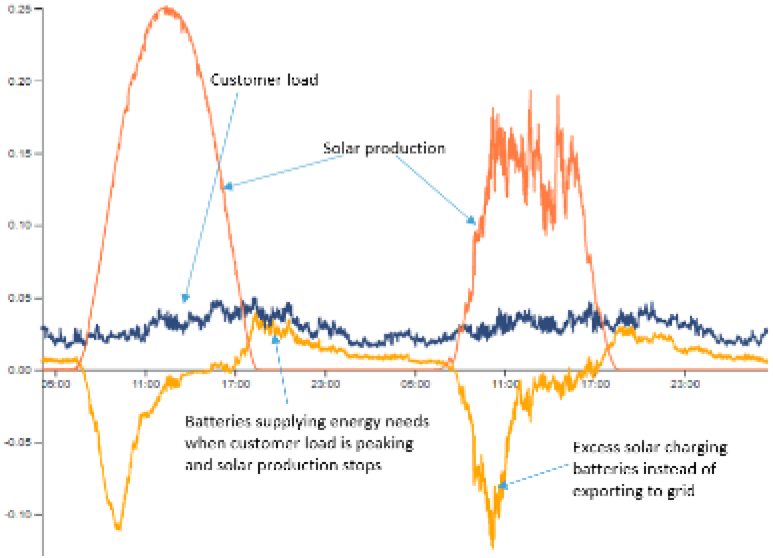


Frequency Response

Progress and Future Work

Grid Services – Peak Management

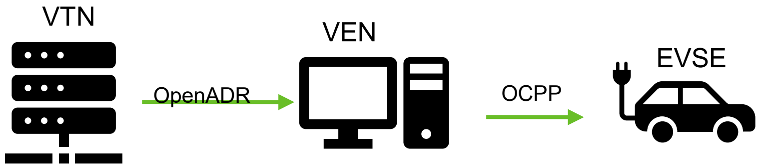
- Solar plus batteries operating in self-consumption mode for maximum peak load reduction.
- Excess solar is used to charge the batteries.
- Batteries supply the energy needs of the load if solar generation is not sufficient or present.
- **Working to incorporate networked EVSEs, water heater, and HVAC controls for grid services**



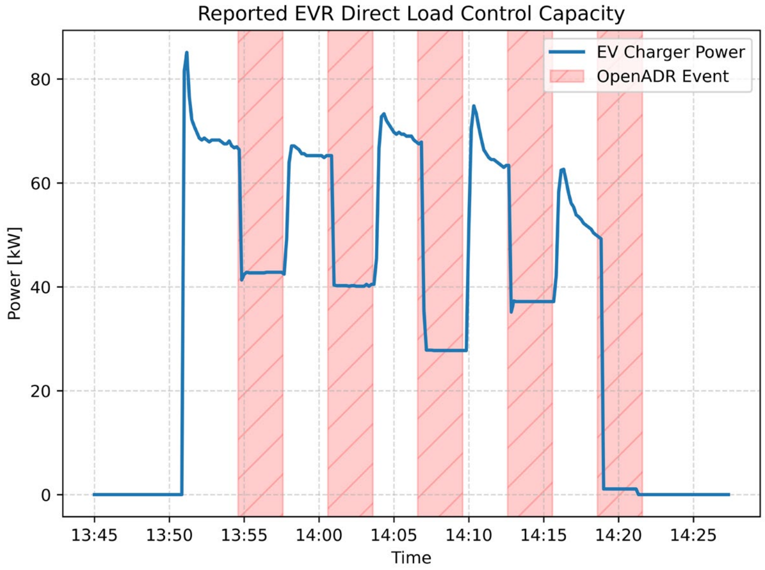
Peak Load Management
(48-hour Timeframe)

Progress and Future Work

OADR Testing



- The project is testing the ability to remotely curtail EV charging
- Curtailment events are designed to be fast enough to provide
    - Frequency regulation
    - Contingency reserve
    - Peak shaving
- Latency needs to be small and there are two sources of latency:
    - OpenADR from VTN to VEN
    - OCPP from VEN to EVSE
- Actual data shows sub-second latency over OpenADR
- Nearly all latency is between the VEN and EVSE
- **Improvements in latency will mostly come from faster a OCPP implementation**



Latency Test Results (4 Events)

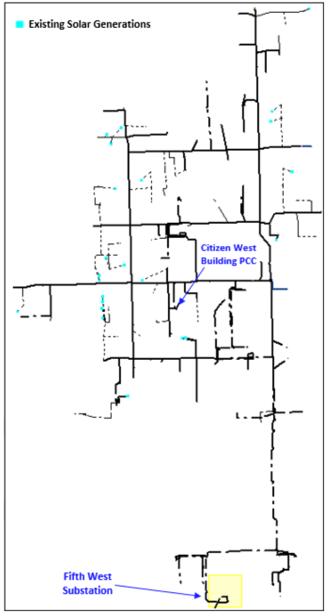
VEN->VTN (ms)	VEN->EVSE (ms)	Total VTN->EVSE (ms)
628.4	15,856.82	16,485.22
567.7	6,698.90	7,266.60
859.0	16,542.27	17,401.23
4.7	13,055.68	13,060.39

Progress and Future Work

Grid Modelling

Scenario	Description	Distribution System Load Model	Building Load Status	BESS Status	Solar Generation Status	Switched Devices
Scenario 1	PV Offline, Battery Offline, and Building Load Offline	Peak Load	Minimum Load	OFF	OFF	Unlocked
Scenario 2	Maximum Building Loading and Minimum Generation	Peak Load	Maximum Load	Charging at Maximum Rate	OFF	Unlocked
Scenario 3	Maximum Building Loading and Maximum Generation	Peak Load	Maximum Load	Discharging at Maximum Rate	Full Output	Unlocked
Scenario 4	PV Offline, Battery Offline, and Building Load Offline	Minimum Load	Minimum Load	OFF	OFF	Unlocked
Scenario 5	Maximum Generation and Minimum Loading	Minimum Load	Minimum Load	Discharging at Maximum Rate	Full Output	Unlocked

- Conducted **grid modelling analysis** to evaluate multiple DER scenarios on the distribution network for each participating facility.
  - **Load Flow Analysis**
    - To evaluate the impact of the DER project on the power flow within RMP's distribution system.
    - To determine the project's impact on thermal loading, voltage profiles, voltage drop, and power factor were evaluated for peak and minimum load conditions.
  - **Voltage Flicker Analysis**
    - To evaluate the impact of the DER project on the voltage regulation of RMP's distribution system.
    - The analysis assesses voltage fluctuations at the PCC, the farthest three-phase point, feeder CB, and substation transformer caused by changes in power demand, generation of the DER project.
  - **Short Circuit Analysis**
    - To evaluate the impact of the DER project on the fault current levels on RMP's distribution system.
    - To determine the project's impact on change in available fault current at the PCC, circuit farthest three-phase point, feeder CB, and substation transformer.
- **Conduct <u>time-series analysis</u> and <u>hardware-in-the-loop modelling</u> to investigate transient impacts and effects of <u>various grid services operations</u>.**



Citizens West

Future Work

Next Steps

Grid Services for DERs

- Evaluate DER control strategy and compliance with PacifiCorp operational performance criteria
- Conduct hardware-in-the-loop modelling and run demonstrations at the microgrid facility
- Iterate control algorithms demonstrating that the updated algorithms and communications showing performance to meet system requirements
- Conduct grid services control with production systems
- Collect data on DER control and performance
- Perform continuous improvement evaluation of grid services control system based on previous year's operation and make necessary improvements or modifications
- Compile and report on grid services best practices

Efficiency and Customer Engagement

- Determine any new energy efficiency measures and associate incentive levels to support adoption and implementation
- Implement energy efficiency improvements at relevant properties
- Measure actual energy efficiency performance for new measures
- Monitor effectiveness of efficiency measures and achieve energy savings greater than modelled estimates
- Evaluate occupant comfort and impact
- Perform continuous improvement based on previous year's operation
- Complete best practices for energy efficiency measures

Cybersecurity Plan

- Outline detailed cybersecurity roles and responsibilities and deploy cybersecurity plan and
- Complete threat detection and response solution addressing any identified risks
- Outline evaluation criteria for cybersecurity framework and tools at the microgrid facility
- Demonstrate cyber security solutions in testing environment
- Evaluation potential threat detection and response solutions across partner sites
- Implement potential recovery solutions
- Report on implementation and improvement of cybersecurity solutions
- Complete best practices for cybersecurity

Business Model

- Develop wholesale market strategies to meet identified requirements
- Evaluate potential application of DERs to wholesale markets based on "real world" operational conditions
- Update business plan based on actual performance of DERs
- Determine viability and structure of including DER management in utility planning
- Complete best practices for incorporation of DERs into the utility business model

Scalability and National Replication

- Evaluate scalability and national replication potential
- Identify barriers to scalability and replication of the implementation model
- Complete benchmarking review with the project achieving similar or better results compared with programs from across the country
- Modify evaluation of barriers to scalability and replication
- Complete best practices for scalability and national replication

Data Coordination

- Update and implement evaluation plan with data collection initiated from partner sites
- Conduct data monitoring, collection, and quality control processes
- Complete data analysis plan and IT requirements for data aggregation
- Conduct data analysis to determine insights for DERs, sites, and the system
- Share data findings and interesting insights with the national coordinator and the wider connected communities cohort

Thank you

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EERE Award No. DE-EE0009782.0000

Reference Slides

Project Execution

	Budget Period 1				Budget Period 2				Budget Period 3			
Planned budget	$ 1,740,722.00				$ 1,688,602.00				$ 1,355,272.00			
Spent budget	$ 1,685,564.93				-				-			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Past Work												
Compile inventory for participating DERs												
Develop schedule for installing AMI for customers with participating DERs												
Complete a distribution model and analysis												
Calculate the design efficiency savings and achieve 30% energy savings												
Evaluate consumer preferences based on pre-deployment surveys and focus groups												
Complete cybersecurity plan												
Complete plan for Business Model development												
Develop baseline for scalability study												
Current/Future Work												
DERMS hardware meets performance criteria for operation within PacifiCorp's EMS												
Hardware demonstration of validated HIL grid distribution and DER models												
DER control algorithms and communications to meet system requirements												
DER control system is deployed in PacifiCorp's grid operations center												
Evaluate application of DERs to wholesale markets based on "real world" operational conditions												
Post deployment focus groups and occupant surveys at the partner building sites												

Go/No-Go Decision Points:

- DER control system, architecture and communication pathway in operation at testing facility and able to control 100% of DERs at microgrid facility
- DER control system in production environment and able to control 8 MW of flexible loads
- Achieve operating savings of 15% for the grid within the connected communities as a result of the program thru cost reductions and market transactions; and reduce greenhouse gas emissions 15% as a result of the program.

Team

ROCKY MOUNTAIN POWER Utility / Principal Investigator	EPE ELECTRIC POWER ENGINEERS Technical Project Management / Implementation Support	giv DEVELOPMENT Participating Location / Tenant Engagement	ICAST Multifamily Energy Efficiency
NASEO National Association of State Energy Officials National Replication / Scalability	OSI An AspenTech® Business DERMS	PNNL VOLTTRON Building Integration / EM&V / Grid Services	THE UNIVERSITY OF UTAH Cybersecurity / Participating Location
STATE UtahState University Participating Location / Grid Modelling / R&D / Surveys	UTA UTAH TRANSIT AUTHORITY Participating Location	sonnen Key Technology	kW ENGINEERING Commercial Energy Efficiency

Grid Modeling and Network Analysis Results

Load Flow Analysis: Evaluated against the following criteria to identify violations:

- Thermal: No equipment (line, transformer, capacitor, regulator, breaker, etc.) over 100% of its manufacturer's recommended rating
- Voltage: 117-126 V on a 120 V scale

Criteria	Citizens West	Project Open 1	Project Open 2	Packsize	UTA	USU
Peak Load Scenarios						
Equipment over 100% of its manufacturer's recommended rating	No	No	No	No	No	No
Voltage between 117 V and 126 V on a 120 V scale	Yes	Yes	Yes	Yes	Yes	Yes
Power factor above 90% at Substation	Yes	Yes	Yes	Yes	No	No
Minimum Load Scenarios						
Equipment (line, transformer, capacitor, regulator, breaker, etc.) over 100% of its manufacturer's recommended rating	No	No	No	No	No	No
Voltage between 117 V and 126 V on a 120 V scale	Yes	Yes	Yes	Yes	Yes	Yes
Power factor above 90% at Substation	No	Yes	Yes	No	No	No
Conclusions						
Required RMP system upgrades, modifications and/or change in operating conditions.	None	None	None	None	None	None

Grid Modeling and Network Analysis Results

Voltage Flicker Analysis: Evaluated against the following criteria to identify violations:

- Aggregate Voltage Fluctuation at Substation:
- Aggregate Voltage Fluctuation at PCC and Circuit's Farthest Point

Criteria	Citizens West	Project Open 1	Project Open 2	Packsize	UTA	USU
Peak Load Scenarios						
Maximum average flicker magnitude at substation (%)	-0.01	0	0	0	0.17	0.11
Maximum average flicker magnitude at PCC (%)	0.26	0.41	0.27	0.33	0.66	0.52
Maximum average flicker magnitude at on the furthest peak load point on the circuit (%)	0.14	0.17	0.14	0.20	0.17	0.40
Minimum Load Scenarios						
Maximum average flicker magnitude at substation (%)	0	0	0	0	-0.08	0.08
Maximum average flicker magnitude at PCC (%)	-0.25	0.4	0.27	0.33	0.57	0.43
Maximum average flicker magnitude on the furthest minimum load point on the circuit (%)	0.14	0.17	0.13	0.2	0.17	0.33
Conclusions						
Worst-case swing in primary circuit voltage (%)	0.26	0.4	0.27	0.33	0.66	0.52
Required RMP system upgrades, modifications and/or change in operating conditions.	None	None	None	None	None	None

Grid Modeling and Network Analysis Results

Short Circuit Analysis: Evaluated against the following criteria to identify violations:

- Change in available fault current at the PCC
- No protection device either over-sensitized or desensitized

Criteria	Citizens West	Project Open 1 - 2	Packsize	UTA	USU
Change in available fault current at the PCC less than 10%	No	N/A	No	N/A	No
Protection device either over-sensitized or desensitized by more than 10%	None	N/A	None	N/A	None
Protection device over 100% of its duty rating	None	N/A	None	N/A	None
Conclusions					
Required system upgrades, modifications and/or change in operating conditions	None	N/A	None	N/A	None