EXH. CAK-5 (Apdx. C)
DOCKETS UE-22___/UG-22___
2022 PSE GENERAL RATE CASE
WITNESS: CATHERINE A. KOCH

BEFORE THE
WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, Complainant, v. PUGET SOUND ENERGY, Respondent.	Docket UE-22____ Docket UG-22____

APPENDIX C (NONCONFIDENTIAL) TO THE FOURTH EXHIBIT TO THE PREFILED DIRECT TESTIMONY OF

CATHERINE A. KOCH

ON BEHALF OF PUGET SOUND ENERGY

JANUARY 31, 2022

GRID MODERNIZATION

Strategy

2021-2030

PSE PUGET SOUND ENERGY

December 2021

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1. Executive Summary

Many factors have led PSE to the need for a unified Grid Modernization Strategy. PSE's mission is the same across the company; to be our customers' clean energy partner of choice is our north star. Investments made to modernize the grid are uniquely positioned to support the realization of that mission. The technical and organizational complexity of planning for, building, and operating a modern grid that serves all customers equitably has required a new strategic approach that recognizes the interdependence of investments and prioritizes customer value. While rapidly evolving technologies help PSE advance the capabilities of the grid, we continue to invest in sustaining existing infrastructure and capabilities to maintain the service our customers have relied on for over 140 years.

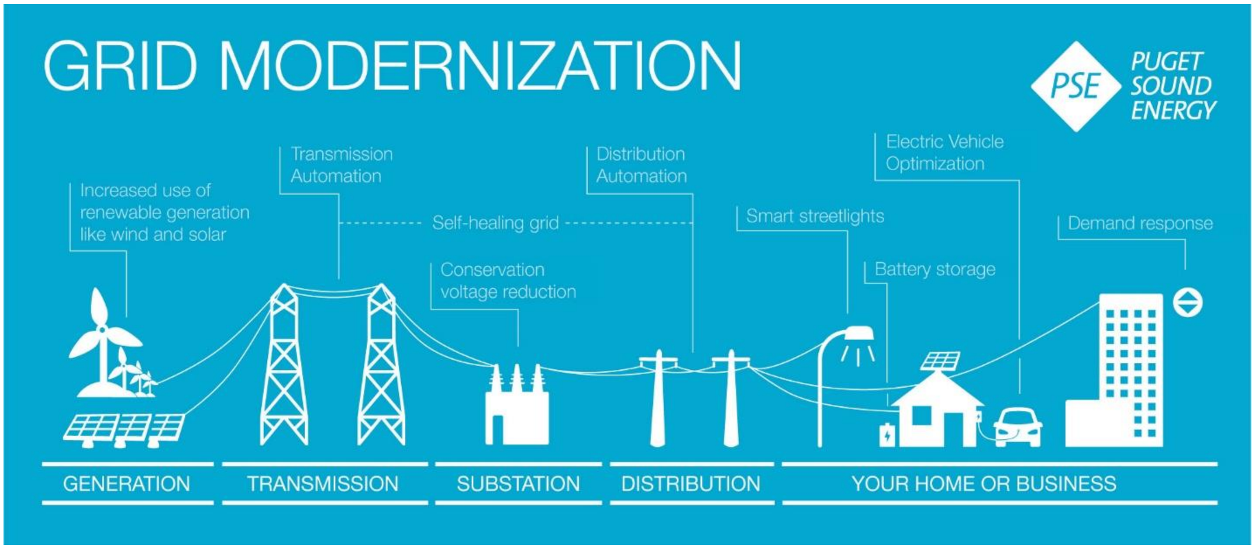
This document first encapsulates our vision and drivers, or the "why" behind the strategy. Then we move to the tangible objectives and value that grid modernization brings to our customers – the "what". Next, we discuss the development of people and processes and details around our advancing and sustaining programs tell us "how" the grid mod strategy relates to tactical actions planned over the next decade. Finally, we define success with metrics that will keep us on track to delivering results for customers.

As new technologies emerge, customer expectations change, and public policy and regulations evolve, the Grid Modernization Strategy will continue to develop. But, we will continue to invest in our infrastructure, tools, and processes to deliver on our mission. Grid Modernization brings value to customers by enabling the clean energy transformation while maintaining and improving grid reliability and resilience. We deliver this value through a comprehensive and holistic approach to advancing new grid capabilities while sustaining existing capabilities. This approach is dependent on other enterprise activities such as telecommunications and cybersecurity, and supports new customer programs like time-of-use rates and demand response. Guiding principles for action provide focus for programs today with forward-looking and proactive direction for the smart and flexible grid of the future. We define success and are accountable to others with tangible metrics including EVs enabled, and percent of the distribution system with SCADA.

PSE's Grid Modernization strategy begins a dialogue around how to deliver the business and technical capabilities to serve customers safely, reliably, and resiliently in a digital era. Our efforts enable the integration of clean energy resources, and support equitable access and accountability for customers to the benefits of a modern grid.

2. Our Customers' Clean Energy Partner of Choice

PSE's Grid Modernization Strategy informs an integrated and holistic approach to sustaining and advancing the electric system for the benefit of all PSE customers. PSE's mission is to be our customers' clean energy partner of choice. Grid modernization plays a key role in our mission by sustaining and advancing existing grid capabilities, while enabling new and emerging technologies such as distributed energy resources and electric vehicles. The Grid Modernization Strategy brings a focus to the building blocks necessary for the transition to the electric grid of the future.



PSE is committed to being the customer's clean energy provider of choice through proactive modernization of the grid. The modern grid is a reliable, resilient, smart, flexible and safe system that enables integration of clean technologies equitably and affordably. The energy industry is transforming, and grid modernization will be instrumental in building the system our customers need. This pathway to change requires technical competencies combined with diverse and committed collaboration. PSE strives to join forces with customers, communities, research institutions, peer utilities and others to clarify the needs and develop effective solutions. Therefore, PSE's Grid Modernization Strategy is a continuing dialogue to target objectives and investments that will build the grid of the future.

PSE has been on a path to modernize our electric system for decades, though more recent advances in technology have allowed faster movement in development compared to the recent past. Recognizing that the development of the electric system is built from the foundation of existing functionalities, PSE's grid modernization efforts consider two primary categories, 1) advancement and 2) sustainment.

ADVANCE

- Enhancement and increased functionality
- Transformative change
- Increasing or adding intelligence to the system

SUSTAIN

- Sustaining the existing capability
- Electric system maintenance
- Like for like replacement of aging assets

2.1 A Unified Mission

"To be our customers' clean energy provider of choice"

PSE's mission is to be our customers' clean energy partner of choice. The focus of the grid modernization mission being the same as the corporate mission brings a continuity of alignment between the Grid Modernization efforts and that of other departments. The Grid Modernization Strategy has been set to collaboratively move the company forward to its north star of a customer-focused, clean energy future enabled by a reliable, resilient, smart and flexible grid.

2.2 A Practical Vision

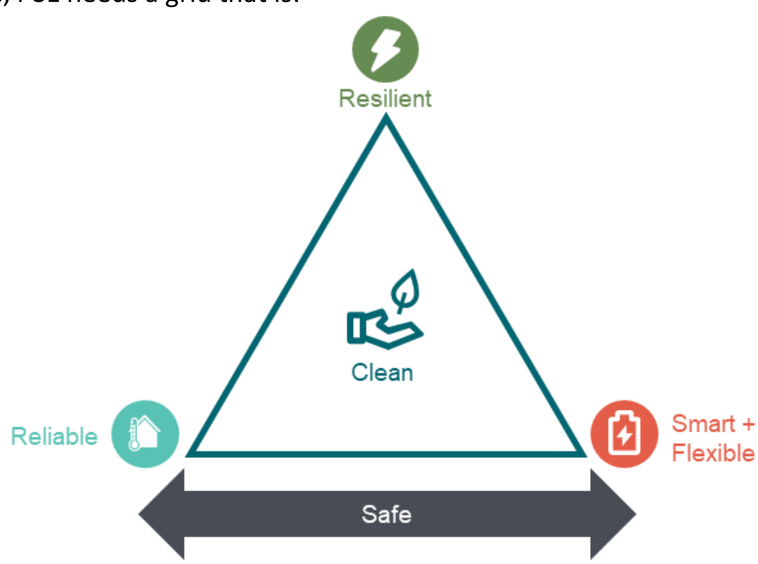
The vision for accomplishing this mission is built upon the "Grid Mod Triangle" which names five attributes of the future grid, and sets the direction toward our objectives and tactics. In almost all cases, grid advancement or sustainment solutions will support multiple attributes. The triangle allows us to represent the interrelatedness of our grid modernization objectives, and ultimately, the interdependence of our investments.

To be our customers' clean energy partner of choice, PSE needs a grid that is:

SAFE: Safety for the public, our workforce, and environment continues to be PSE's top priority.

RELIABLE: To decrease the amount and impact of power outages. This involves identifying asset health, proactively anticipating and mitigating failures/outages, and performing targeted maintenance.

RESILENT: So our region recovers more quickly from extreme weather events and other emergencies. This involves hardening the system to minimize damage and adding adaptive elements allowing for quick and localized recovery from disruptions.



SMART & FLEXIBLE: Adding intelligence to the electric system allows for more automation and technology to save energy and improve customer experience. This also increases the electric system and business flexibility which empowers customers to control their energy choices based on cost, carbon, or other preferences and enables advanced operational options.

CLEAN: Enabling the rapid and equitable integration of distributed energy resources and other green technologies.

As present opportunities are implemented and new solutions explored, it is important to be rooted in the core values and principles by which sustainable solutions are derived. The posture in approaching ambiguity and challenge helps to lay the foundations for desired customer focused outcomes. Therefore, the approach to grid modernization relies on Guiding Principles for Action.

2.3 Guiding Principles for Action

In the creation of the Grid Modernization strategy, a cross-functional group of PSE leaders developed 6 guiding principles for action. These statements steer decisions on where to focus efforts today to prepare for the future, and how customers and other stakeholders should be considered. Our guiding principles align with PSE's values: we all have a voice, we do what's right, and we have each other's back.

FORWARD THINKING	Anticipate and drive solutions that enable a future where new sources of energy are renewable and many are distributed.
CUSTOMER FOCUSED	Deliver flexible, segmented, and tailored value propositions that meet our customers' unique needs.
PROACTIVE	Proactively identify trends, and influence regulatory and legislative policy such as performance-based rate making.
FLEXIBLE	Be prepared for, and deliver service through a variety of operating models for behind-the-meter assets.
TRANSPARENT	Be transparent about decision-making and processes in collaborations with external stakeholders and customers.
EQUITABLE	Prioritize the principles of energy equity to enhance and align accessibility, affordability, and accountability in planning, design, decision-making and implementation.

3. The Need to Modernize the Grid is Clear

The timely alignment of need drivers has accelerated the rate of change in the electric power industry and within PSE. Customers are informed and looking for new experiences in how they interact with the electric system and PSE. In addition, society's dependence on the electric system is on a trajectory to substantially increase with clean energy transformation. The increased customer expectations have been coupled with technology advancements that unlock new capabilities.

Understanding and clarifying the needs helps set a solid foundation for imagining and envisioning the grid of the future.

Customer Expectations & Equity | Increasing Dependency | Advancing Technology | Policy & Regulation | Severe Natural Events | Safety & Security

CUSTOMER EXPECTATIONS & EQUITY

More than ever, customers are seeking out available options, expect greater reliability, desire the confidence of resiliency, want to clearly see the value and equity in resources acquired and energy delivered. This change in expectations has been guided by the access to information and the increased e-commerce developed in other industries, and critical conversations about equity in our society. Customers have become accustomed to being empowered with options. While reliable service remains a priority, more and more customers are installing their own renewable generation, and requesting support for new technologies such as battery storage and EV charging for their homes and businesses. At the same time, customers from highly impacted communities and vulnerable populations may be unaware of programs and experience barriers in accessing programs and services (e.g., language accessibility, renters, high cost of new technologies, etc.). With CETA, PSE has a responsibility to ensure that resources are distributed equitably and burden are reduced, with Customer Benefits Indicators helping embed equity in the clean electricity planning, decisions and transformation.

INCREASING DEPENDENCY

Electric power customers presently have significant dependence on the stability of the electric system and that dependence is increasing. Electricity is part of the critical infrastructure that fuels society. The criticality of the system is escalating with the transition to electric vehicles, greater adoption of electric appliances, and increased penetration of customer distributed energy resources. The resourcing of electricity, power quality, outages and resiliency present significant impact to customers financially, physically and mentally. This reality of growing dependency on the electric system increases the need for improving reliability & resiliency in a cost effective manner.

ACCELERATED TECHNOLOGY ADVANCEMENTS

The increased rate of technology development has introduced a greater need for systems integration and awareness to the complexities involved in system interrelationships. The presence of new technology has unlocked emerging potential and opportunity necessary to advance the electric system and meet the customer's expectations. The development of customer distributed energy resources, renewables, microprocessor relays, communication pathways, IT architecture, software, automation and optimization has presented opportunities to develop new capabilities on behalf of customers.

POLICY & REGULATORY

Dating as far back as 2010, WAC 480-100-505 focused on electric utility's preparation and progress towards a "smart grid" that enabled many elements outlined in future policies including the advancement of digital information relating to electricity use, costs, prices, time of use, nature of use, and storage and delivery signals to allow end use load device automation, controlling and managing electricity demand, congestion management, voltage control, operating reserves, and frequency regulation. It sought progress in the grids ability to sense local disruptions or changes in power flow, to use two-way communication to enable different customer contracts or programs, such as real time prices or demand response programs, to manage new end-use services to reduce operating or power costs, improve reliability, or improve energy efficiency, such as charging electric vehicles, to use real time measurement of power generated from customer-owned power facilities and overall to use digital information to improve the reliability or efficiency of generating equipment in an integrated manner to improve flexibility, functionality, interoperability, cyber-security, situational awareness, and operational efficiency of the transmission and distribution system. In 2019, the Washington State legislature passed the Clean Energy Transformation Act (CETA), one of the most comprehensive carbon laws in the nation that sets the pace for clean energy transformation. RCW 19.280.100 "Distributed Energy Resource Planning" under the Electric Utility Resource Plans Chapter establishes an expectation for DER Planning. At the federal level there has been FERC-2222 and other developments that will shift the policies & regulatory climate at an industry level which will give freedom for development in some areas and obligate development in others. Moving forward it will become more important to mindfully engage with the regulatory institutions in order to enable PSE's effort to steward the environment, empower communities and develop the business.

SEVERE NATURAL EVENTS

Global, national and local natural events has brought awareness to the need for an electric system able to withstand or recover from increasing environmental extremes. The recent electric system impacts from wildfires, heat waves, cold snaps, earthquakes, droughts, severe winds, and even pandemics has introduced a need to consider design parameters for increasing the system resiliency amidst such events.

SAFETY & SECURITY

Ensuring the safety and security of the physical electric system and cyber systems is an ever evolving challenge. The criticality of the infrastructure increases, range of communication networks expands, increase in interconnected IT/OT devices, development of interfacing between internal and external systems, and advancement of technologies presents a need to manage safety, security and cyber security & privacy.

PSE faces a host of challenges, drivers of change, and opportunities. It is an exciting time for innovation and collaboration. In order to face these challenges and needs head on, the Grid Modernization Strategy must be supported by the effective collaboration and partnership between PSE, customers, government and tribal entities, and businesses in order to achieve our vision for the future grid.

4. Objectives of the Strategy

The grid of the future must anticipate, facilitate, and integrate new uses, structures and capabilities for how energy is produced, distributed, and utilized. The grid of the future will utilize multidirectional communication and power flow to maximize value for the benefit of all customers. The focus on grid modernization will help PSE maintain our commitments to safety and reliability, enhance system resiliency, and expand investment in smart and flexible technology to provide customers with the service and choices they want long into the future. By enabling the rapid and equitable integration of distributed energy resources, PSE will be our customers' clean energy partner or choice.

Successful implementation and continued commitment to the Grid Modernization strategy can provide desired results as described in the following:

ESTABLISH MEASUREABLE OUTCOMES

A key to this effort is defined and measureable results. Investments will have direct correlation to benefits that a modern grid provides such as operational efficiency and customer service improvements. Specific metrics of the Grid Modernization program are listed in section 10.

BUILD EQUITY IN INFRASTRUCTURE PROGRAM DELIVERY

As we build more value, efficiencies, and capabilities with a modernized grid, we must ensure that all customers and the community as a whole have a share in the benefits. Access to clean technologies and DER interconnection support equity as the grid transforms, including highly impacted communities and vulnerable populations. As we implement infrastructure and customer programs, we strive to keep rates affordable through the prioritization of projects that deliver the greatest benefits today and over time. All customers will enjoy the benefits of reduced electric demand and utility operational efficiencies that will keep rates from increasing as they may have otherwise.

ENABLE CUSTOMER CHOICES

The future grid enables customers and communities to leverage smart home technologies, transportation electrification, and lower cost distributed energy resources. Customers will have increased availability of their detailed daily usage data, making it easier to leverage smart technologies to use energy more efficiently and cost effectively aided by appropriate rate structuring (e.g. Time

Varying Rates). Proactive investments in grid modernization will enable customers to use market available tools on a more wide demographic basis through removing barriers and enhanced information.

READY THE BUSINESS AND TECHNICAL CAPABILITIES TO DELIVER RESULTS
We aim for aligned business practices and workforce competencies to leverage new technologies. Effective organizational change management will lead us to operating our business in a manner that maximizes anticipated benefits from our improved tools, processes, and technical skills. Our delivery system planning model identifies capabilities that we will build in order to deliver results.

FUTURE PROOF FOR EVOLVING TECHNOLOGIES, PREFERENCES, AND BUSINESS MODELS
While we endeavor to modernize the grid to accept and leverage the latest industry technologies and customer-accessible tools, we will carry over business lessons learned that will allow for grid integration of future technologies, customer preferences, and business models.

BRING VALUE TO OUR CUSTOMERS
PSE endeavors to keep our customers at the forefront of all the work we do. The aforementioned objectives to build a modern grid are inseparable from this principle. Achieving our goals will bring value to our customers as we continue to provide safe and affordable service while improving reliability and grid resilience. By sustaining the existing grid and investing in new technologies, we will bring shared benefits to all customers. Customers will be empowered through electric vehicle and DER enablement, smart home capabilities, and time varying rate structures.

5. Reimagined Processes

Grid Modernization requires the reevaluation and improvement of our work systems. PSE has initiated developing business capabilities that allow us to identify and integrate new technologies, stakeholder interests, and workforce advancements. These new approaches are further detailed as follows.

5.1 Integrating and expanding delivery system planning

With a renewed focus on comprehensive energy planning, PSE has developed a delivery system planning (DSP) framework that benefits customers by identifying the best options to proactively move PSE toward a reliable, resilient clean energy future through an optimized process. The cross departmental deliver system planning model and capabilities brings internal and external stakeholders of PSE together in a coordinated manner to achieve this. The operating model includes engagement of teams across PSE, addressing non-wired and hybrid solutions to meet system needs, and an eye towards continuous improvement.

The introduction of CETA affirmed, accelerated, and produced change to our processes and priorities in anticipation of the legislation. The delivery system planning process implemented changes to accelerate planned investments in alignment with CETA, including key equipment such as SCADA.

Additionally, industry trends driving PSE's changes to the planning process as a whole include:

- Cleaner, more decentralized and intermittent electric energy supply such as battery storage

- Rapidly evolving grid technologies which are more digital and enable greater visibility and automation, such as Advanced Distribution Management System
- Customers and stakeholders who are more engaged and want choices for how they solve their electricity needs
- Emerging new models and demand, such as Electric Vehicles

Specific processes are in place to identify and evaluate new technology solution alternatives to use to solve planning needs, and tools and templates have been created to help approach new technology evaluation and integration. An internal Grid Modernization Emerging Technology Council is testing these new tools and templates with ongoing pilot projects. Tasks include more thorough documentation during new technology development to facilitate integrating new technology into our routine business processes.

The DSP operating model and process changes are part of PSE's Grid Modernization vision and roadmap and they go hand in hand with load forecasting, Integrated Resource Planning (IRP), and new customer and product designs. Details of DSP Model are contained in Appendix A.

5.2 Broadening knowledge and input through a changed approach to stakeholder engagement

Grid Modernization allows us to revisit our approach to engage different stakeholder audiences. To solicit input and thought sharing, we can look to reaching beyond our regular stakeholder groups and generate engagement through focus groups, open community meetings, and targeted community organizations amongst other communication tools, learning about possibilities and approaches that we are less knowledgeable about.

Stakeholder engagement and participation throughout 2021 IRP cycle considered and integrated delivery system planning more intentionally than previous cycles. While Delivery System Planning has been a chapter in previous IRPs and has been a topic at least once in each stakeholder cycle, its connection to the larger outcome of the IRP was less clear. Current draft IRP rules, along with RCW 19.280.100 bring greater definition to how a robust delivery system can fulfill resource needs as delivered by distributed energy resources including technologies such as batteries and demand response. Connecting the various stakeholder engagement processes of the IRP and Clean Energy Action Plan, and DER planning will help stakeholders provide feedback with the greatest efficiency.

But we can do more. Diversity, equity, and inclusion is a major value in this process. Full consideration for a representative audience is a must, as well as seeking input in different ways that different audiences are comfortable with. Equity considerations in how new resources are designed, acquired and delivered are included in our implementation planning to ensure all customers benefit.

LEVERAGE INSIGHTS FROM THE EQUITY ADVISORY GROUP

The members of the community-based Equity Advisory Group (EAG) that will advise us on our Clean Energy Implementation Plan (CEIP) addressing the Washington Clean Energy Transformation Act (CETA), share perspectives from their experiences related to environmental justice, Tribal interests, highly impacted communities, vulnerable populations, social services and affordable housing which can inform thoughts on modernizing the grid.

DEVELOP CUSTOMER PARTNERSHIPS

PSE has focused on the customer and developing greater opportunities for customer partnerships. In 2020 PSE developed an intake process to help initiate collaborative opportunities. This process supports the evaluation of customer initiated partnership opportunities. The Tenino Microgrid project is an example of a customer partnership that increases the resilience needs of the Tenino community while allowing PSE to demonstrate new technical capabilities.

The Washington State 2021 Clean Energy Strategy provides additional context for partnership opportunities. The strategy recommends the development of resources for expanded outreach, technical assistance and education for community efforts. Potential partnership opportunities for PSE could include specific programs for Tribal energy projects, development of community resilience hubs and energy districts, and clean energy projects that benefit agricultural communities.

5.3 Identifying skills to transition to the future

In 2020, PSE evaluated workforce readiness to operate a modern grid. The evaluation consisted of three components -- Smart Grid Skill Sets, Develop Knowledge Transfer and Training Plans, and Define Organizational Responsibilities. We are future-proofing the skill sets of the workforce by identifying core skills to sustain critical functions as well as skills needed for future work growth supported by people planning processes and labor agreements.

Using the Grid Modernization portfolio of work, PSE identified near-term skill sets and competencies required for deployment and support. From this we are presently developing knowledge transfer and training plans and defining organizational responsibilities.

Of concern are labor shortages in skilled craft occupations, particularly as we desire a diverse workforce representative of the communities we serve. Specific hiring challenges are line workers, technicians and electricians. PSE has built 2-Year college partnerships to address this through collaborative training programs and apprenticeships.

Apprenticeship participation retention is key as we look at the loss of knowledgeable staff in both technical and craft positons. Related to this is workforce succession planning. Expanding career development opportunities for technical and craft workers may help to reduce turnover, delay retirements, and control recruiting and training costs.

6. Grid Advancement: Developing Technologies

This section provides brief definitions/explanations of the technology advancement investments currently under development to drive grid modernization. These technologies enhance and increase functionality, add intelligence to the electric system, and drive transformative change.

Advanced Metering Infrastructure (AMI)	AMI is the current standard for metering technology for both gas and electric meters, replacing the end-of-life Automated Meter Reading (AMR) system. It uses two-way communication and on-board memory to send more detailed and accurate meter data through a secure wireless network. AMI is a foundational technology for Grid Modernization because it enables enhanced grid visibility and energy and operational data that supports system planning and advanced grid operations.
Advanced Distribution Management System (ADMS)	ADMS is a computer-based, integrated platform that provides the tools to monitor and control the distribution network in real time. ADMS is a foundational platform for Grid Modernization as it enables several advance operational tools such as VVO, FLISR, and DERMS.
Virtual Power Plant (VPP)	A VPP is a software platform that provides visibility and control of distributed energy sources to deliver system capacity. The VPP will enable monitoring, aggregation, forecasting, dispatch and management of DERs to meet resource capacity needs.
Distributed Energy Resource Management System (DERMS)	A DERMS is a platform by which DERs can be effectively monitored, managed, capabilities enabled, and optimized. When DERMS is integrated with ADMS, it will allow full visibility to the system operator and allow for safe and optimal dispatch coordinated with other operations activities.
Conservation Voltage Reduction (CVR) and Volt-VAR Optimization (VVO)	CVR is the adjustment to substation transformer and line regulator voltages such that customers operate in the lower end of the acceptable service voltage range. This increases the efficiency of equipment and saves energy. When combined with integrated reactive power management, referred to as Volt-VAR Optimization, it can provide more energy savings.
Distribution Automation	Distribution automation is the addition control schemes that operate digital sectionalizing devices to reduce a power outage as a result of a faulted portion of a distribution line to impact the least amount of customers, reconfiguring a circuit in milliseconds. Fault Location, Isolation, and Service Restoration (FLISR) is the advanced control algorithm that networks groups of switches on a feeder to vastly improve the reliability of utility delivered power by sectionalizing outages.

AMI Data Analytics	AMI Data Analytics is an intentional effort to develop ways to apply the additional and improved data from AMI into benefits for our customers such as • Aggregated Customer Data to provide more granular and timely usage data to empower customers to understand and manage their energy consumption • Load Disaggregation to better understand customers' energy use patterns • Improved outage location to aid restoration and improve reliability • Distribution Asset Health assessment
Data Lake and Analytics	Data Lake and Analytics is the collection of and the accessibility to disparate data such as DER asset information, near real-time metering data, customer program participation, and detailed electric system asset information to enable new system operations and business processes based in analytics. Advanced operational and planning capabilities require significant enhancements to data availability and granularity.
Microgrid Demonstrations	Microgrids are self-contained 'islands' of balanced generation and load that can operate independently at times when the larger electrical system is offline. They can provide high reliability & resiliency for essential services even during major outage events. PSE is conducting demonstration projects involving microgrids and DER integration to test how these strategies can improve reliability and resiliency in places such as highly impacted communities, transportation hubs, emergency shelters and areas at risk for isolation during significant weather events or wildfires.
Geospatial Load Forecasting	Geospatial and econometric load forecasting tools enable PSE to predict load and power changes, where these loads will occur, and how distributed generation affects the load shape. This will support the development of non-wires alternatives and DER optimization.
Hosting Capacity Analysis Tool, Map, and Enhanced Interconnection Portal	Hosting Capacity Analysis (HCA) and presentment enables customers, vendors, and planners to know where distributed energy resources are valuable additions to the operation and efficiency of the grid. When HCA results are made visible to customers and developers, it will result in a more transparent process and faster interconnection of DERs.
DER Optimization and Locational Valuation	DER optimization and locational valuation tools enhance the business case for DERs through economic dispatch optimization and development of location-specific value streams. PSE is investing in planning tools that will provide guidance to the most cost effective siting and operational approach for the growing portfolio of DERs.

Circuit Enablement – Transportation Electrification	Circuit enablement in anticipating more EV's on circuits will avoid reactive upgrades due to power quality. This aligns with PSE's Transportation Electrification Plan and includes distribution transformer upgrades for impacted circuits, and updating standards to address future increased loads.
Circuit Enablement – DERs and Microgrids	Circuit enablement to advance DERs and microgrids proactively improves electric infrastructure to increase hosting capacity equitably. As the DER portfolio scales, the peak capacity output for DERs on a circuit will be constrained by existing grid infrastructure due to high amounts of reverse power flow. This is a prevalent condition in 56% of distribution circuits (or 179 distribution substations) where low transformer loading conditions exist. Moreover, primary and/or secondary conductors on distribution feeders pose chokeholds to DER capacity in both aggregated/non-aggregated instances. Voltage imbalances caused by DER production onto the grid impacts reliability, which in turn limits available hosting capacity.

7. Grid Sustainment: Continuing Investments

In addition to developing new technologies, PSE is committed to supporting and maintaining our existing infrastructure to drive reliability and resiliency goals. Investment in monitoring, assessing, and maintaining our existing equipment is a low-cost way to extend the life of the electrical grid and drive reliability and resiliency goals.

Substation SCADA	Substation Supervisory Control and Data Acquisition (SCADA) will bring capabilities that enable data collection and communication between equipment in order to function automatically or to be controlled remotely if needed. SCADA implementation includes upgrades typically to the substation breakers on the 12.5kV distribution system and the installation of controllers, relays, sensors, software and IT (Information Technology) upgrades for communication. and
Worst Performing Circuits (WPC)	WPC are circuits that have historically had poor reliability performance year after year with high customer minutes interruptions (CMI) and high circuit SAIDI and SAIFI, typically in more rural areas with lower number of customers. PSE is focused on 135 circuits presently in a multi-year effort to make targeted investments to improve the performance of these circuits. Different reliability strategies are applied to the WPC circuits, including tree wire, underground conversions, overhead rebuilds, adding new feeder ties and distribution automation and more recently considering non-wire alternatives, i.e., energy storage solutions until the circuit improves by 50%.

Targeted Reliability Upgrades	Targeted Reliability Upgrades focuses on circuits that have the greatest benefit-cost ratios which typically have a high number of customers. Improvements include Overhead (OH) or Underground (UG) Rebuilds, Tree Wire Upgrades, UG Conversion, Feeder Ties and other Reliability improvements.
Distribution Reclosers	Distribution Reclosers are specialized protective devices that sectionalize and reduce the number of customers impacted by a permanent fault on the main line feeder and reduce the frequency of sustained power interruptions by quickly tripping to clear temporary faults and restore power following a momentary outage. Distribution Automation leverages reclosers extensively.
Cable Remediation (CRP)	CRP is focused on remediating primarily direct buried bare concentric neutral cables that have a trended probability of failure, of which high-molecular weight (HMW) cable type is the worst offender.
Pole Replacement	Pole Replacement is focused on the structural integrity of the overhead electric system in order to optimize equipment lifecycle and effectively mitigate system risks in alignment with industry best practice, the NESC, USDA Rural Utilities Service.
Substation Reliability	Substation Reliability is focused on the proactive replacement of major substation assets that are in poor condition to reduce the risk and cost of unplanned outages due to equipment failure.
Resilience Enhancement	Resilience efforts are focused on low probability, high consequence risks that take significant efforts to understand and mitigate along with ongoing system-wide asset health issues that make the electrical system more susceptible to destabilization. Included in these programs are wildfire mitigation, earthquake preparedness, drone based LiDAR and IR scanning, and microgrid systems that can serve customers during widespread interruptions.
Fusesavers	Fusesavers is a technology focused on replacement of existing fuses (100T) on the electric distribution system with specialized protection devices that trip quickly to reduce the frequency of sustained power interruptions by quickly tripping to clear temporary faults and restore power following a momentary outage. – Strategic deployment of Fusesavers will reduce CMI, SAIDI, SAIFI, and CEMI by shortening some outages from sustained outages that require serviceman deployment to momentary outages with no personnel dispatch required.
Vegetation Management	Vegetation Management is focused on trimming trees along PSE's overhead infrastructure in to ensure clearances are maintained and safety for the public. The prevention of vegetation contact helps to deliver reliable power as well. Additionally, danger trees off right-of-way that risk falling into transmission lines are identified and removed as possible.

Transmission Automation	Transmission Automation is the enhancement of control schemes that operate digital sectionalizing devices to reduce a power outage as a result of a faulted portion of a transmission line to impact the least amount of customers, reconfiguring a circuit in milliseconds. This improves resiliency following transmission line faults.
Root Cause Analysis	Root Cause Analysis is a process that brings a holistic approach to improving PSE's reliability indices through robust outage investigation, strategic culture assessment, and application of comprehensive solutions.
Wildfire Resilience	Wildfire Resilience is focused on preventing and mitigating wildfire impact relative to size, frequency, and destructive effect. PSE's wildfire mitigation plan improves situational awareness, assessment of the wildfire risk, implementation of mitigation solutions, and development of operational processes to ensure communication and safety.

8. Organizational Intersections

Grid Modernization coordinates strategies and programs in other organizations within PSE. This approach creates an enterprise view of the cross-functional activities that all support PSE's vision to be our customers' clean energy partner of choice.

8.1 Key Supporting Activities

Cybersecurity and Privacy, Data governance, and telecommunications are key ongoing programs that are deeply embedded in the success of much of the Grid Modernization strategy. Along with delivery system planning and workforce development, these efforts create physical, digital, and institutional infrastructure that support grid modernization objectives.

CYBERSECURITY AND PRIVACY: While pursuing our grid modernization strategy, PSE places a strong focus on cybersecurity and privacy. PSE applies the same level of due diligence across the enterprise to ensure risks are consistently addressed and mitigated in alignment with the rapidly changing security landscape and privacy requirements. PSE utilizes a variety of industry standards and policies to measure maturity as each standard approaches security and privacy from a different perspective. As critical infrastructure technology becomes more complex, it is even more crucial for PSE to adapt and mature cyber-security practices and programs allowing the business to take advantage of new technical opportunities such as Internet of Things (IoT) devices. In addition, we continue to foster strong working relationships with technology vendors to ensure their approach to cyber-security matches PSE's expectations and needs.

As we look at cybersecurity for Distributed Energy Resources (DER) we aim to develop cyber security best practices, practical management approaches, and reference architectures to protect critical OT systems from risks related to integration of multi-party systems. We seek to understand and develop tools and guidelines for DER device security from large scale connected environments to component level. We continue to investigate potential cyber security concerns and solutions for automated demand response and end-use technologies.

We also realize the importance of Cloud Security for Real-Time Systems – As cloud applications mature in IT environments and have clear value propositions, questions about security risks, security architectures, and regulatory requirements are now being asked. We are reinforcing changes in cloud security to support this strategic shift in the use of the cloud.

DATA GOVERNANCE: PSE's Data Governance team manages decision rights over data in order to derive the most value from this corporate asset. It includes managing the integrity, quality, and usage of data during its lifecycle. Business and technology groups are involved in the decisions that affect data in order to ensure it is reliable, consistent, and complete. Data governance supports Grid Modernization by creating access and consistency across many data sources.

TELECOMMUNICATIONS: PSE's telecommunications infrastructure supports business and grid mod capabilities with a validated, flexible, and high security environment. PSE is upgrading wireless and fiber infrastructure and leveraging the AMI network to support current operational technologies, as well as new technologies such as microgrids.

8.2 Adapting the Grid to Reshaped Energy Use

Transportation electrification, smart street lighting, DERs, and time-varying rates are expected to shift the way our customers use energy over time. Programs and plans that advance these energy use changes require close alignment to adjust strategy and planning activities and prevent reactive or unnecessary investments.

TRANSPORTATION ELECTRIFICATION: Transportation electrification is set to dramatically shift the energy use and the concentration of loads within PSE's service territory. PSE filed a Transportation Electrification (TE) Plan with the WUTC in 2021. Grid Modernization supports the TE plan through targeted infrastructure improvements and revisions to standards to enable future charging infrastructure.

SMART STREET LIGHTING: PSE began installing Smart street lights for municipal customers in 2021. The technology adds controls and software to LED streetlights to enable two-way communication. Smart street lights can be instantly turned on and off or dimmed for benefits like energy conservation or reducing light pollution at night. Because smart street lights can operate more efficiently, customers will be able to optimize their energy use, lower costs and reduce carbon in our environment. Smart street lighting is PSE's first step towards enabling smart cities and grid interactive building capabilities.

DER: PSE is developing Distributed Energy Resource (DER) programs as part as part of our Clean Energy Implementation Plan (CEIP). Grid Modernization enables DER programs through infrastructure enhancements, and delivery of planning and operational tools.

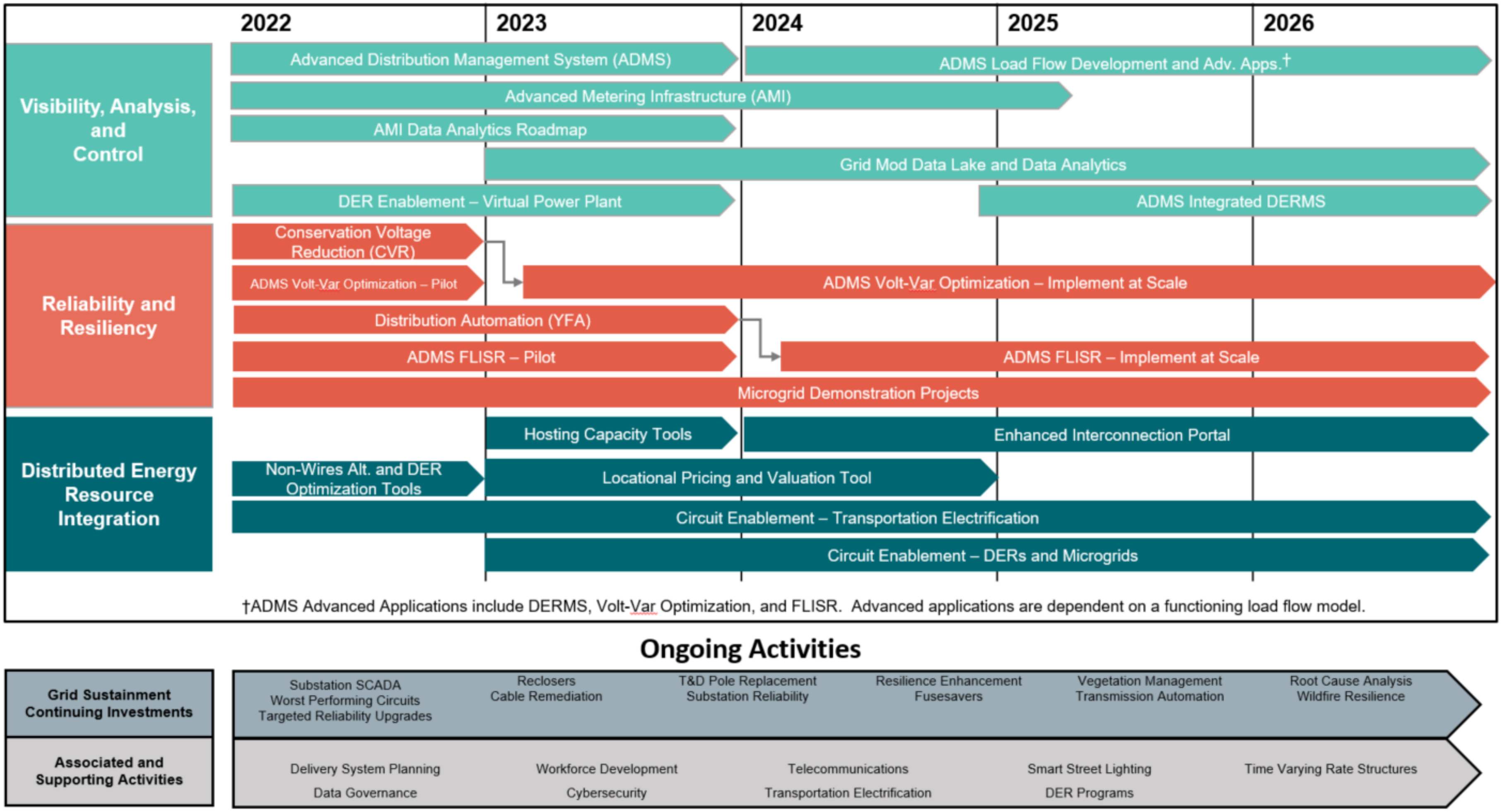
TIME VARYING RATES: PSE is developing several time varying rates (TVR) to be filed with WUTC in 2022. PSE fully supports exploring time-varying and other outcome based pricing for its customers in the residential and small commercial classes. They can be helpful in managing system and local peak, mitigating customer costs, and/or integrating variable renewable generation, among other use cases.

9. Roadmap

The Grid Modernization roadmap shows the programmatic approach to advancing grid technologies in three categories: Visibility, Analysis, and Control; Reliability and Resiliency; and Distributed Energy Resource Integration.

Sustaining investments, and associated and supporting activities are shown below the roadmap, as they continue on an ongoing basis through coordinated planning across the enterprise.

GRID MODERNIZATION ROADMAP
5 YEAR OUTLOOK



10. Measureable Outcomes

PSE has established 7 primary metrics to measure the progress of the grid modernization strategy for each of the key grid characteristics, and continues to explore appropriate targets for each that reflect a future state of the electric grid that meets ongoing and emerging needs.

Table 1. Summary of grid mod metrics

Metric	Description	Grid Characteristic(s) Measured			
		Resilient	Reliable	Smart & Flexible	Clean
1	Percent of customers with automatic backup Service	●	●		
2	Percent of distribution system having SCADA	●	●	●	
3	System Average Interruption Duration Index (SAIDI)		●		
4	System Average Interruption Frequency Index (SAIFI)		●		
5	Distributed Energy Resource (DER) integration			●	●
6	Conservation Voltage Reduction (CVR) energy savings				●
7	Electric Vehicles (EVs) enabled				●

PERCENT OF CUSTOMERS WITH AUTOMATIC BACKUP SERVICE: This metric counts the percent of PSE customers that benefit from automated distribution FLISR capabilities as well as automated islanding from DERs. A higher percentage means more customers will experience reliable service from a resilient grid.

PERCENT OF DISTRIBUTION SYSTEM HAVING SCADA: This metric counts the % of distribution protective devices serving customer load that are visible and remotely controllable via SCADA. A higher percentage indicates a greater portion of the system can be monitored and controlled to adjust to changing circumstances resulting in greater reliability, resiliency and flexibility. A device must have real time remotely visible information from field sensors available in DMS and show status (open/closed) and include remote control capability (open/close). Devices include all PSE owned in-service distribution breakers and distribution line reclosers. This excludes spares, bus ties and other devices not directly serving customers. Most transmission and generation breakers and circuit switchers already have SCADA and are excluded from this metric.

SYSTEM AVERAGE INTERRUPTION DURATION INDEX (SAIDI): SAIDI measures the average customer experience with respect to interruption duration per year. It is measured in minutes with a higher number of minutes reflecting a greater average total duration of interruptions and therefore a lower level of reliability. This measure excludes Major Event Days (MEDs) which prevents extreme events from skewing the data such that progress is obscured.

SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX (SAIFI): SAIFI measures the average customer experience with respect to interruption frequency per year. It is measured as number of interruptions with a higher number reflecting a greater average number of interruptions and therefore a lower level of reliability. This measure excludes Major Event Days (MEDs) which prevents extreme events from skewing the data such that progress is obscured.

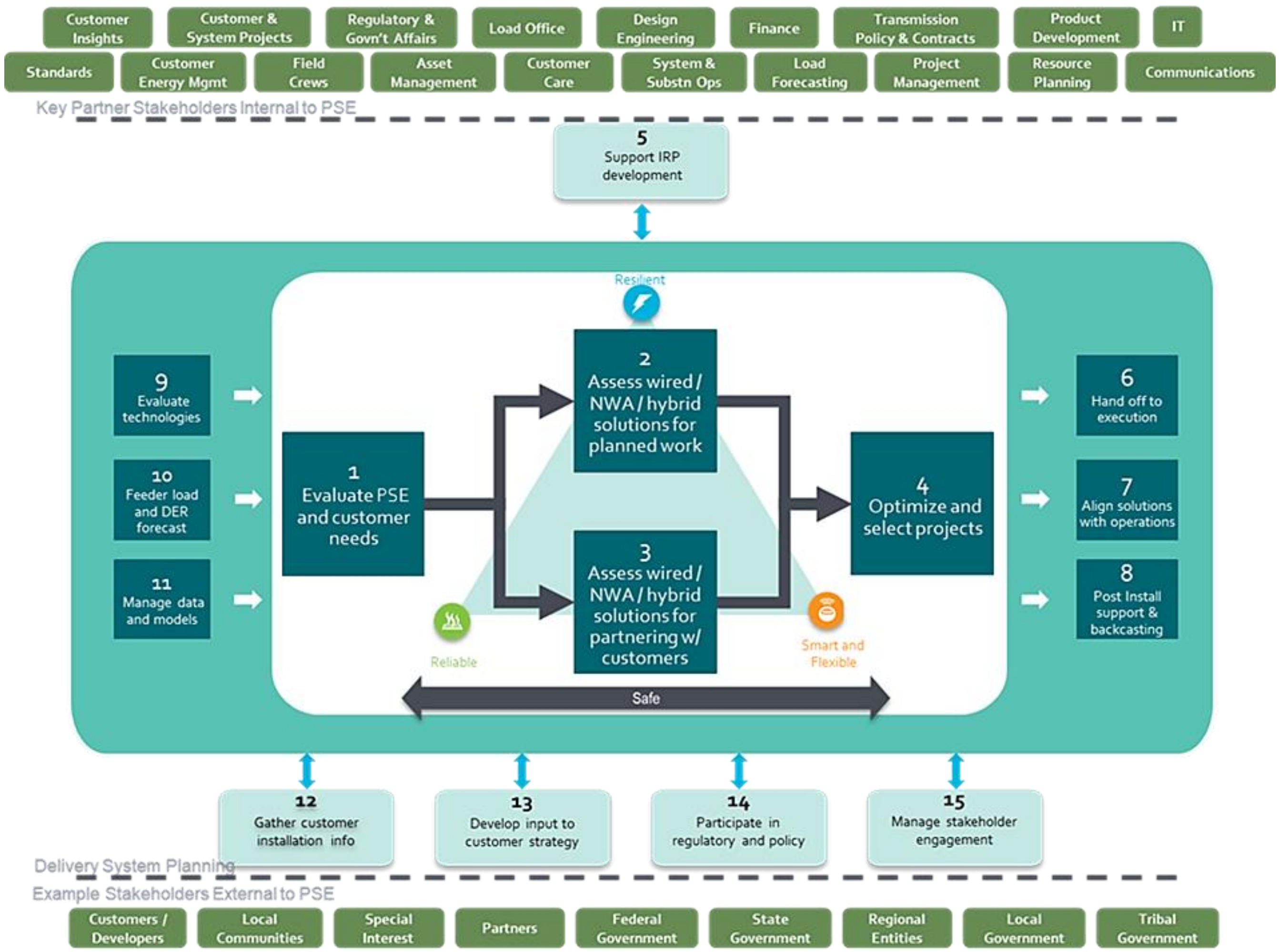
DISTRIBUTED ENERGY RESOURCE (DER) INTEGRATION: This metric calculates the total DER nameplate power connected to the system as well as the total contracted reduction in demand (demand response) connected to the system. It is measured in MW, with a higher number associated with a cleaner and more flexible grid. For this metric, DERs can include small generation sources such as solar as well as energy storage technologies and demand response.

CONSERVATION VOLTAGE REDUCTION (CVR) ENERGY SAVINGS: This metric determines the amount of energy savings from the CVR program and future Volt-Var Optimization (VVO) program. It is measured in MWh with a higher number being associated with a reduction in generation and a cleaner grid. This metric does not distinguish between various methods of control or devices used to manage voltage. Any intentional reduction in voltage for the purpose of saving energy can be included in the calculation.

ELECTRIC VEHICLES (EVs) ENABLED: This metric determines the number of electric vehicles registered in PSE's service territory. A greater number of electric vehicles corresponds to a greater amount of energy transitioning from fossil fuels to cleaner sources. Grid modernization investments support this effort by identifying where EVs are likely to be connected to the grid and pro-actively upgrading the system to accommodate the additional load and complexity that comes with increasing numbers of EVs.

Appendix A – Delivery System Planning Model

The Delivery System Planning process is comprised of 15 capabilities. The process segments and details are explained more clearly here:



1	Evaluate and prioritize system planning needs	The traditional planning process that analyzes and prioritizes reliability and capacity needs. This capability includes establishing criteria for the solution based on Transmission and Distribution Planning Guidelines.
2	Assess wired/NWA solutions for inclusion into planned work	Use the results of the alternative (NWA, DER, OT, etc.) technologies capability and prioritized planning needs to develop traditional wired solutions, NWA solutions, and/or hybrid solutions combining of both and identify the best alternative(s).
3	Assess Wired/NWA solutions for partnering with customer planned work	Use the results of the alternative (NWA, DER, OT, etc.) technologies capability to work with some or all customers to both influence their NWA decisions but also to find ways to collaborate with them to incorporate solutions beneficial to both
4	Optimize investment decisions & select projects	The process of determining the best investment decisions considering costs and benefits of all alternatives and finalizing the set of projects within the budget. The current process and tools may be used in different ways such as project alternative comparison.
5	Support IRP Development	The integration and monitoring of the planning process with the IRP process with inputs and outputs associated with ensuring that (1) non wires alternatives are considered (2) DER implementations by customers are considered and (3) changes to the grid required to handle 2-way power flow when DER penetration requires it.
6	Hand off to execution team for implementation	The capability to define the package of information required by the execution team to implement the project. Planning will also stay involved during the construction phase to ensure that the implementation is as planned.
7	Align solution with operations	The capability to interact with operations in the front-end and the back-end of the planning effort. In the front-end, Operations will provide key requirements that need to be addressed during planning. On the back-end, planning will provide the operating scenarios under which the planned changes can be operationalized.
8	Post installation management and support	This capability is the ongoing process of supporting a project after go-live to ensure that the benefits are realized. Feedback loop should be established to incorporate lessons learned. This capability assumes that root cause analysis is performed when major incidents occur.
9	Evaluate and incorporate alternative technologies	Assess different alternative (NWA, DER, OT, etc.) technologies available in the industry including automation, software systems, DER technologies and other NWA solutions to confirm their applicability (cost, performance, and suitability) to solve one or more problems identified during the planning process.
10	Feeder/zip code level load and DER forecast	Forecasting load and DER/NWA kW, kWh and hourly load profile at the feeder level, including variability and information on end uses. This capability is also about tracking the roadmap for changes to DER penetration and defining mechanisms on how to track it over time.
11	Manage data and data models	This is a foundational requirement for all grid modernization efforts. Manage and track data and models associated with forecasting and other related planning tasks. Tasks involve identifying data required, their sources, their maintenance, and their stewardship. PSE Standards are incorporated in planning input data.
12	Gather customer installation information	Customer installation of DERs, NWA and wired solutions require PSE coordination. However, this information is not always available to the planning team. This is a new capability to define a system that will collect customer installation information (including C&I and residential) and disseminate to all.
13	Develop inputs to customer strategy	Identify potential DER/NWA and even wired product options for consideration by customers.

14	Monitor, evaluate and incorporate regulatory and policy developments	The capability to monitor and track regulatory and policy developments and understand the impact of these changes to planning, both directly and indirectly through other areas of the utility.
15	Manage stakeholder engagement	Defining the need to engage with stakeholders, to listen and factor in their input, and to increase transparency through a combination of meetings, dissemination of the information and regulatory interactions.

Acronyms

ADMS	Advanced Distribution Management Systems
AMI	Advanced Metering Infrastructure
BESS	Battery energy storage system
BTM	Behind-the-meter
DOC	Department of Commerce (Washington State)
DER	Distributed Energy Resources
CVR	Conservation Voltage Reduction
DERMS	Distributed Energy Resource Management System
DG	Distributed generation
DMS	Distribution Management System
DOE	Department of Energy (U.S.)
DOT	Department of Transportation
DR	Demand Response
DRMS	Demand Response Management System
DSM	Demand-side management
DSCADA	Distribution Supervisory Control and Data Acquisition
EE	Energy efficiency
EMS	Energy Management System
EPRI	Electric Power Research Institute
ESS	Energy storage system
EV	Electric Vehicle
FAN	Field Area Network
FERC	Federal Energy Regulatory Commission
FLISR	Fault location, isolation, and service restoration
IEEE	Institute of Electrical and Electronics Engineers
GIS	Geographic information system
IT	Information Technology
kW	Kilowatt
MW	Megawatt
NERC	North American Electric Reliability Corporation
NIST	The National Institute of Standards and Technology
NREL	National Renewable Energy Laboratory
NWA	Non-wires alternative(s)
NWS	Non-wires solution
OMS	Outage Management System
OT	Operational Technology
PV	Photovoltaic (solar power)
PNNL	Pacific Northwest National Lab
RF	Radio Frequency
RFI	Request for Information
RFP	Request for Proposals
R&D	Research and development
RPS	Renewable Portfolio Standard

RTU	Remote terminal units
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SME	Subject matter expert
TE	Transportation Electrification
T&D	Transmission and Distribution
TOU	Time of Use rates
V2G	Vehicle-to-grid
VVO	Volt/VAR optimization
VPP	Virtual power plant
WAN	Wide Area Network

Glossary

A

Advanced Distribution Management System (ADMS): The software platform that supports the full suite of distribution management and optimization. An ADMS includes functions that automate outage restoration and optimize the performance of the distribution grid. ADMS functions being developed for electric utilities include fault location, isolation and restoration; volt/volt-ampere reactive optimization; conservation through voltage reduction; peak demand management; and support for microgrids and electric vehicles.

Advanced Metering Infrastructure (AMI): Refers to the full measurement and collection system that includes meters at the customer site, communication networks between the customer and a service provider, and head-end data reception and management systems that make the information available to the service provider.

Advanced inverter: A power electronics device that transforms variable direct current to alternating current and that provides functions such as reactive power control and voltage and frequency ride-through responses to improve the stability, reliability, and efficiency of the distribution system.

B

Base load: The minimum amount of electric power delivered or required over a given period at a constant rate.

C

Capacity: The maximum output (generation) of a power plant. Capacity is typically measured in a kilowatt (kW), megawatt (MW), or gigawatt (GW) rating. Rated capacity may also be referred to as "nameplate capacity" or "peak capacity." This may be further distinguished as the "net capacity" of the plant after plant parasitic loads have been considered, which are subtracted from "gross capacity."

Conservation Voltage Reduction (CVR): An operating strategy of the equipment and control system used for VVO that reduces energy and peak demand by managing voltage at the lower part of the required range.

Curtailment: A reduction in the output of a generator from what it could otherwise produce given available resources.

D

Demand response: Voluntary (and compensated) load reduction used as a system reliability resource. Demand response allows utilities to cycle certain loads on and off in exchange for financial incentives.

Demand-side management (DSM): The modification of consumer demand for energy through methods such as financial incentives and behavioral change. The goal of DSM is to encourage the consumer to use less energy during peak hours, or to move the time of energy use to off-peak times such as nighttime and weekends. Peak demand management does not necessarily decrease total energy consumption, but could be expected to reduce the need for investments in networks and/or power plants for meeting peak demands.

Distributed Energy Resources (DER): A source or pool of power that is located on the distribution system, any subsystem thereof, or behind a customer meter. These resources may include, but are not limited to, electric storage resources, distributed generation, thermal storage, and electric vehicles and their supply equipment.

Distributed Energy Resources Management System (DERMS): A software platform that is used to organize the operation of the aggregated DER within a power grid.

E

Energy storage system (ESS) Technologies: capable of storing electricity generated at one time and for use at a later time. Storage technologies include batteries, pumped hydroelectric power, compressed air storage, thermal storage, and others. Also *Storage*

F

Fault: An event occurring on an electric system such as a short circuit, a broken wire, or an intermittent connection.

Fault Location Isolation and Service Restoration (FLISR): Distribution automation system which detects and responds to faults in order to minimize the number of customers affected by a distribution system outage.

Flexibility (operational): The ability of a power system to respond to changes in electricity demand and supply.

Flexible generation: The ability of the generation fleet to change its output (ramp) rapidly, start and stop with short notice, and achieve a low minimum turn-down level.

Frequency response: The ability of generation (and responsive demand) to increase output (or reduce consumption) in response to a decline in system frequency and decrease output (or increase consumption) in response to an increase in system frequency. Primary frequency response takes place within the first few seconds following a change in frequency. Secondary frequency response (also known as regulating reserve) takes place on a timescale of minutes (or faster) following a disturbance.

G

Grid Architecture: A discipline with roots in system architecture, network theory, control engineering, and software architecture, all of which we apply to the electric power grid. An architectural description is a structural representation of a system that helps people think about the overall shape of the system, its attributes, and how the parts interact.

Grid congestion: The event that occurs when actual or scheduled flows of electricity over a line or piece of equipment are constrained below desired levels.

Grid integration of renewable energy: The practice of power system planning, interconnection, and operation that enables efficient and cost-effective use of renewable energy while maintaining the stability and reliability of electricity delivery.

I

Interconnection: An independent electricity system network that operates at a particular frequency. An interconnection consists of one or more balancing area authorities that balance demand and generation within certain geographic areas of the interconnection.

L

Line capacities: The maximum and minimum voltage, current, frequency, real and reactive power flows on individual equipment under steady state, short-circuit and transient conditions, as permitted or assigned by the equipment owner.

Load: An end-use device or customer that receives power from the electric system.

Load forecast: A prediction of future demand. For normal operations, daily and weekly forecasts of hour-by-hour demand are used to develop generation schedules that ensure sufficient quantities and types of generation are available when needed.

Load shedding: The reduction of system demands by systematically and in a predetermined sequence interrupting the load flow to major customers and/or distribution circuits, normally in response to system or area capacity shortages or voltage control considerations.

M

Microgrid: A microgrid is a self-sufficient energy system that serves a discrete geographic footprint, such as a college campus, hospital, business center, or neighborhood. Within microgrids are one or more kinds of distributed energy (solar panels, wind turbines, combined heat & power, generators) that produce its power.

N

Net load (net demand): Demand that must be met by other generation sources if all wind and solar power is consumed.

O

Operational flexibility: *See Flexibility (Operational)*

Operational Technology: Hardware and software that detects or causes a change, through the direct monitoring and/or control of industrial equipment, assets, processes and events." 11 The term has become established to demonstrate the technological and functional differences between traditional IT systems and Industrial Control Systems environment, the so-called "IT in the non-carpeted areas"

P

Peak load: 1. The highest hourly demand within a Balancing Area occurring within a given period (e.g., day, month, season, or year). 2. The highest instantaneous demand within the Balancing Area.

Photovoltaic: Solar cells, also called photovoltaic cells, convert sunlight directly into electricity. Photovoltaics (often shortened as PV) gets its name from the process of converting light (photons) to electricity (voltage), which is called the photovoltaic effect.

R

Rated capacity: The maximum capacity of a generating unit.

Reactive power: The portion of electricity that establishes and sustains the electric and magnetic fields of alternating-current equipment. Reactive power must be supplied to most types of magnetic equipment, such as motors and transformers. It also must supply the reactive losses on transmission facilities.

S

Storage: See *Electric energy storage*

Supervisory Control and Data Acquisition (SCADA): A system of remote control and telemetry used to monitor and control the transmission and distribution system including substations, transformers and other electrical assets.

System: A combination of generation, transmission, and distribution components.

System Average Interruption Duration Index (SAIDI): A description of the length of time all customers would have been out of power if the total number of hours out of service in a year's time were to be shared, and it is typically measured in minutes.

System Average Interruption Frequency Index (SAIFI): A measurement of the average frequency or number of times customers experience a sustained interruption of service during a predefined period of time.

T

Transmission constraint: A limitation on one or more transmission elements that may be reached during normal or contingency system operations.

V

Variable renewable energy (RE): Electricity generation technologies whose primary energy source varies over time and cannot easily be stored. Variable generation sources include solar, wind, ocean, and some hydro generation technologies.

Virtual Power Plant (VPP): A Virtual Power Plant (VPP) is a software platform that provides visibility and control of distributed energy sources to deliver system capacity. A VPP enables monitoring, aggregation, forecasting, dispatch and management of DERs to meet resource capacity needs.

Volt/VAR optimization (VVO): A process of optimally managing voltage levels and reactive power to achieve more efficient gird operation by reducing system losses, peak demand or energy consumption or a combination of the three. The efficiency gains are realized primarily from a reduction in the system voltage

Voltage: The difference in electrical potential between any two conductors or between a conductor and ground. Voltage is a measure of the electric energy per electron that electrons can acquire and/or give up as they move between the two conductors.

Voltage regulator: A device designed to maintain voltage levels within acceptable limits.