Executive Summary

Smart Grid Technology Assessment and Recommendation
For the Northwest Power and Conservation Council and
Other Interested Parties

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Introduction

Over the period of the Northwest Power and Conservation Council’s (NPCC’s) Seventh Power Plan, the existing energy generation, transmission, and distribution system of the Northwest will face new pressures and needs that the grid was not designed to accommodate.

Two external drivers in particular will impact NPCC’s policy making in the Power Plan (twenty-year horizon) and the initiatives for implementation in the Action Plan (five-year horizon):

1. **Declining Electric Supply Flexibility**: Long-term constraints on flexibility in the electric supply result from changing ecological/social factors, climate disruption in the Pacific Northwest, water shortages, fish passage, navigation safety for maritime commerce, increased penetration of wind and solar, and evolving priorities of the Columbia River Treaty, among others; and

2. **Grid Resilience**: Increasing pressures for disaster preparation in light of the anticipated Cascadia Subduction Zone Magnitude 9.0 earthquake, and the lack of generation on the west side of the region, are raising demand for grid resilience.

Grid operators already juggle competing and complicating demands as they struggle to meet load and maintain grid reliability. Growing penetration of variable generation must be integrated. Historically, the hydro system has been an excellent tool for managing grid balance. Integrating additional variable generation will further tax the hydro system, and may require new policies and technologies. Complicating that effort are ecological constraints, such as court-mandated flow requirements and new Columbia River Treaty priorities, which will place further constraints on the hydro system.

Climate impacts will combine with growing variable generation and ecological constraints to further restrict system operators’ ability to use the Federal Columbia
River Power System to meet load reliably, maintain grid stability, and ensure power quality.

In the 2013 Oregon Resilience Plan\(^1\), and subsequent updates, the State of Oregon sought to better understand the potential impacts from the Cascadia Subduction Zone earthquake. That document reveals our significant regional inadequacies to cope with this serious threat. Estimates of three to six months of grid outages and disruption of other critical infrastructure, such as roads, emphasizes just how catastrophic this event can be.

**Problem Statement**

External drivers are affecting our regional energy system in ways that the existing grid was not designed to accommodate. The increasing penetration of variable renewable generation is changing the way the grid is operated. Increasing scrutiny of existing environmental regulations, coupled with new Ecosystem-based Management requirements pursuant to the Columbia River Treaty, for fish-passage and socio-political factors, will further reduce the flexibility of the hydro-electric system. Simultaneously, increasing awareness of regional earthquake threats creates a growing need for regional preparedness for the anticipated disruptions of critical infrastructure, and is causing increased demand for disaster resilience, including grid resilience.

**Solution**

To address these issues, the region’s historical reliance on adding centralized generation to meet customer peak load is expensive and, we believe, unnecessary. The solution is to “engage the load,” through the implementation of demand management, storage, and distributed generation. If we “engage the load,” new technologies, and the polices that support the implementation of those technologies, will help manage load peaks, maintain grid reliability, reduce environmental impacts, avoid new fossil fuel generation, and improve grid resilience.

**Business Analysis**

The current valuation methodology of incumbent energy resources neglects many hidden costs, including health, environmental, business uncertainty, and market distortions, resulting in inefficient allocation of resources. The current energy paradigm also suffers from over emphasis of least cost resources, neglecting other

important attributes and values. The old model, with its preoccupation with least cost supply, namely gas, neglects customer self-determination, clean energy, carbon, grid resilience, and emerging market opportunities. Smart grid technologies may appear to cost more when viewed through the lens of the old energy paradigm, where supply must meet load, but by engaging the load, demand becomes a manageable part of the equation, imparting value to the technologies and the positive externalities. Additionally, prices are declining quickly for new technologies, from photovoltaic panels to building energy management systems. The business case for smart grid systems, including demand management, storage, and distributed generation, makes sense today, and only grows stronger with each passing day.

Policy Analysis

Previous NPCC Regional Plans have identified the opportunity to explore the capabilities and potential improvements associated with the promise of the smart grid and have taken the first steps to implement smart grid technologies.

Many smart grid technologies are currently commercially available, and have been implemented in various programs both within the Pacific Northwest and in other parts of the country that typically employ the Integrated System Operator (ISO) model. Participation by Northwest-based parties in the development of these technologies is vital to ensure that the standards adopted will suit the needs and priorities of the region. Implementation and integration of these technologies today will help ensure that our region keeps pace with the industry in general and quickly ushers in significant improvements in the energy systems provided by these new technologies and programs.

Any of these technologies, taken individually, can benefit grid flexibility and resilience. Integration of the multiple technologies listed below is required for a long-term solution. Further, evolving technologies can present serious challenges when implemented at full-scale. New technologies can require fundamental changes in policies and procedures, lest they impact the region’s access to affordable and reliable power, and cause significant economic and social impacts.

Smart Grid and Related Technologies to Engage the Load

- Demand Response
  - Smart Thermostats (e.g., NEST)
  - Residential Batteries (e.g., Tesla’s Powerwall)
  - Residential Hot Water Heaters
  - Commercial-Scale Batteries
  - Integrated Electric Vehicle Charging
Home Energy Management Systems (HEMS)  
Building Energy Management Systems (BEMS)  
Factory Process Control  

- Advanced Metering Infrastructure  
- Storage  
  - Residential Batteries (e.g., Tesla’s Powerwall)  
  - Residential Hot Water Heaters  
  - Commercial-Scale batteries Integrated Electric Vehicle Charging  
  - Thermal Energy Storage  
- Distributed Generation  
  - Dispatchable Standby Generation  
  - Wind  
  - Solar Photovoltaic  
  - Biomass  
  - Wave  
  - Tidal  
  - River In-stream Current  
  - Geothermal  
- Smart Homes and Buildings  
  - Smart Appliances  
  - Distributed Sensors  
- Smart Inverters  
- Related Technologies  
  - Disaster-Resilient Solar PV  
  - Decision Support for Fish Passage (The Salmon Highway)  

Focus on Specific Smart Grid Technologies

**Demand Response** technologies can enhance grid flexibility. Modifications in electric usage by end-use customers is already causing changes in normal consumption patterns. In some markets, this is in response to the dynamic pricing of electricity over time, which can cause significant changes in demand patterns. Customer incentives, designed to induce lower electricity use at times of high wholesale market prices, can improve system reliability. Factory process control is an existing example of Demand Response. The
technologies required to implement Demand Response already exist, and are implemented successfully across the country.

**Advanced Metering Infrastructure (Smart Meters)** with two-way communications, control devices, and appliances with smart features that can be controlled, constitute the core technologies. Whether provided by energy service companies, implemented individually, or aggregated by third parties, these technologies will significantly reduce the need for new peaking supplies and reduce required capacity overall.

**Storage** technologies continue to evolve; the much-heralded Tesla battery is just the latest iteration. Recently, Mercedes has also released a competing battery design for home use. Many options will emerge, as the price for a kilowatt hour of storage continues to fall to estimates in the $150 to $200 range by the mid 2020’s. Other storage technologies, such as thermal storage in the form of hot water heaters, ice, and thermal mass are already being implemented throughout the world.

**Distributed Generation** continues its advance, as prices plummet and ratepayers express their preference for clean power and self-determination/reliance. **Solar Photovoltaic** power is exploding in the southwest, but even locations like Oregon and Washington have solar insolation equal to or better than Germany, where solar already provides about seven percent of the total load.

**Smart Homes and Building Energy Management Systems**, from such companies as Apple (HomeKit), ADT, and Honeywell, provide modern commercialized technologies able to manage demand at the building level. These technologies run the gamut from simple, customer-oriented products to highly sophisticated industry-based systems. Home depot and Lowes already sell these systems.

**Distributed Generation** from such diverse sources as biogas from landfills and wastewater treatment, small wind, solar thermal, and wave energy continues its growth and development, as the technologies improve and the costs plummet. These new sources of widely distributed generation sources offer tremendous opportunities for clean energy, energy diversity, and economic development opportunities.

Collectively, smart grid and related technologies operationalize demand response, storage, and distributed generation, and represent a likely future for the Pacific Northwest and beyond. Reduced reliance on fossil fuel, lower greenhouse gas emissions, less fuel price volatility, increased reliability, reduced costs, and
ratepayer empowerment are all reasons why the Council should continue to focus on the opportunities these technologies offer, as well as the barriers to a better energy future.

**Summary and Challenges**

**Summary:** This report assesses Smart Grid technologies. Several of the available technologies can improve the flexibility and resilience of the existing and future regional power system.

**The Challenge:** Technologies alone are not a solution. Technologies, integrated with thoughtful policies that are implemented with stakeholder support, can develop into practical solutions.

**Solutions:** Smart Grid technologies, particularly technologies that are integrated with supportive policies and good stakeholder engagement, can create outcomes and benefits that are beneficial to the utilities, the regulators, and the customers. These integrated solutions can progress into a level of acceptance that brings implementation costs into a practical range.