THE HARMONIOUS GRID

The Northwest electric system and the embrace of customer-side resources

INTRODUCTION

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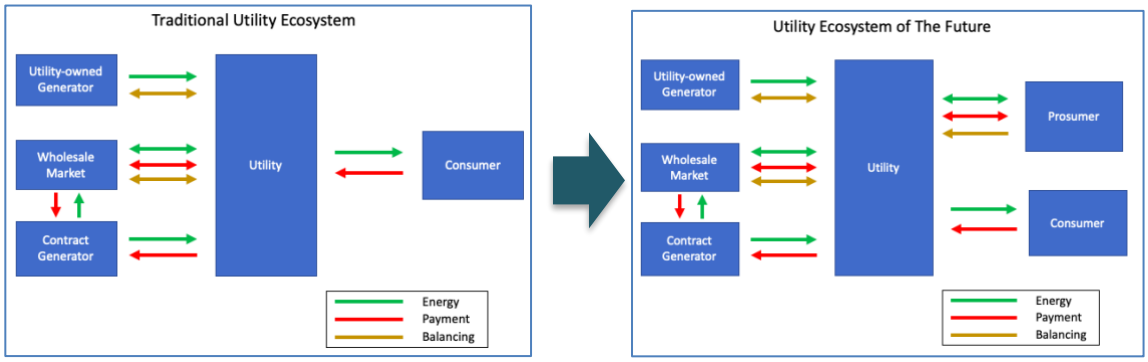
NW Energy Coalition
for a clean and affordable energy future

The Harmonious Grid

The Northwest electric system and the embrace of customer-side resources

Our present-day electric system, or "the grid" as we often refer to it, is a dynamic but generally one-way system that provides electricity in proportion to customers' constantly changing demand. Although that system has served us well, it is not well-suited or even adequate to meet future demand for electricity as we rapidly electrify our transportation and building sectors while simultaneously retiring fossil fuel resources. Meeting that challenge will require a new kind of electric system.

The good news is that recent technological innovations, many of them on the customer-side of the electric meter are beginning to transform the grid into a multi-directional, interactive system that will greatly reduce the need for new generating resources. In this new system, customers and their resources will be engaged by utilities to shape and manage demand as well as supply in order to achieve optimum efficiency and reliability. That's not just a change or an upgrade. It's a paradigm shift that changes the relationship between utilities and customers by requiring utilities to assimilate the new customer-side resources and understand how those resources can be integrated with supply-side resources to from a single controllable system.



This is all happening at an opportune moment for the Northwest where states are committed to building, by mid-century, an equitable and affordable electric system that is free or nearly free of greenhouse gas emissions. In addition to helping achieve that goal, reinventing the grid to take advantage of customer-side resources can yield important collateral benefits.

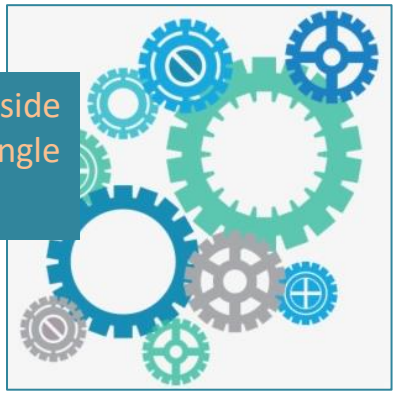
- Energy efficient homes and buildings are safer, more comfortable, and better for our health, which results in an improved quality of life and reduced absenteeism and improved performance by workers and students.
- The development of customer-side resources can create significant new business opportunities and large numbers of jobs that are geographically dispersed and that range from entry-level to highly technical positions.
- Good planning will make it possible for people, businesses, and communities that may be adversely affected by the transition to clean resources, particularly those that have historically shouldered a disproportionate share of the energy burden, to be identified and assisted.

A recent Brattle Group report titled "The National Potential for Load Flexibility"[1] quantified some of the potential benefits for the nation. It found:

- Nearly 200 GW of cost-effective load flexibility potential in the U.S. by 2030, which is equivalent to 20% of the projected 2030 U.S. peak.
- Economic benefits possibly in excess of $15 billion /year by 2030 as a result of avoided costs for added generation.

In the Northwest, where Oregon and Washington have enacted laws that will require a phasing out of many if not all fossil fuels, the need to seize the benefits of load flexibility is heightened by the fact that the region will have to replace nearly 17,000 megawatts of existing fossil fuel generation while also meeting new demand for electricity resulting from population growth and electrification in the transportation and building sectors.

The Harmonious Grid is a melding of supply-side and customer-side resources to form a single controllable system.



Reducing and shaping demand

Experts who study the challenge the Northwest faces are concluding that both supply-side and customer-side clean energy resources will be required to do the job. The Northwest Power and Conservation Council expects customer-side resources, including energy efficiency, demand response (DR), direct load control (DLC), distributed generation (DG), more sophisticated system management and control platforms, and storage, to meet nearly all of regional load growth over the next twenty years[2].

At present, energy efficiency is the only customer-side resource making a significant contribution. Distributed generation, primarily rooftop solar, is still fledgling. Demand response, direct load control, and storage technologies have never been needed in the Northwest until now and are nascent in their development. And so are the connectivity and grid management tools that will ultimately weave supply-side and customer-side resources into a single controllable system.

As these technologies are fully utilized, utilities will acquire the ability to reduce and shape demand with a flexibility they have not had before. Like the conductor of a symphony orchestra, utilities will be able to call upon and modulate an array of instruments to harmonize supply and demand. And customers will become orchestra members too, providing services to the grid. The result will be a more diversified and resilient grid that has a smaller, more environmentally friendly footprint.

1 The Brattle Group, "The National Potential for Load Flexibility", June 2019. https://brattlefiles.blob.core.windows.net/files/16639_national_potential_for_load_flexibility_-_final.pdf

2 Northwest Power and Conservation Council, February 2016. https://nwcouncil.org/news/northwest-path-lead-nation-in-maximizing-energy-efficiency-priority-energy-resource

It will be less costly to operate and maintain and will help us manage climate impacts, earthquakes, and the constant variability of loads.

To realize that promise, Northwest utilities will have to quickly test and deploy emerging customer-side resources not as mere add-ons to existing systems, but as fully integrated components in a new and reimagined system that we're calling the Harmonious Grid. This series of white papers explores the Harmonious Grid, the role and promise of customer-side resources, and policies that will be needed to accelerate their uptake.

The orchestra, the conductor, and the symphony

Since 1990, electricity demand in the Northwest has been nearly flat despite robust economic and population growth. While there have been some changes in the region's economy, the lack of growth in electricity demand is mostly due to more energy efficient buildings, appliances, and devices, which have caused the region's weather-normalized average household electricity consumption to decline by 15%[3] since 2005.

Had the Northwest's per capita energy intensity remained at its 1990 level, we would be consuming and paying for twice as much electricity as we use today[4]. And, as new technologies and management tools create new opportunities for improved efficiency, especially in existing buildings and housing stock, the cost to acquire additional efficiency remains low. A 2016 ACEEE analysis showed that since 2007, the levelized cost to acquire efficiency has been steady at just under $30/MWh[5]. By comparison, the Bonneville Power Administration's current average tier one rate for power is $35.57/MWh[6].

We can expect the proliferation of new customer-side resources will continue that trend while presenting new opportunities for continued and accelerated progress. The following is an overview of the areas of opportunity with approximations of potential contributions. A more detailed description of the customer side resources and the opportunities they provide, will be forthcoming in our 2nd white paper in this series.

3 Northwest Power and Conservation Council, https://www.nwcouncil.org/sites/default/files/final_comparisonofresidentialuse_rates_bills_2016-12_1.pdf

4 Northwest Power and Conservation Council, https://www.nwcouncil.org/sites/default/files/2018_0612_p1.pdf

5 Baatz, B., Gilleo, A., and Barigye, T., "Big Savers: Experiences and Recent History of Program Administrators Achieving High Levels of Electric Savings", April 2016. https://aceee.org/sites/default/files/publications/researchreports/u1601.pdf

6 Bonneville Power Administration "Current Power Rates". September 2019 https://www.bpa.gov/Finance/RateInformation/Pages/Current-Power-Rates.aspx

Energy Efficiency

In 2016, the Northwest Power and Conservation Council projected that increasingly energy efficient buildings, appliances, devices, and equipment can save enough electricity to meet nearly all of the region's new energy needs (3,000 aMW) through 2025 and 80% of the need (5,500 aMW) by 2035[7].

Demand Response

Demand Response (DR) encompasses the use of pricing strategies as well as the direct management of customer-side resources to lower and redistribute demand.

Rate structures and direct incentives can be designed to send price signals that motivate customers to shift some of their energy consumption to different times of day and away from peak-use periods. Doing so reduces the amount of infrastructure and resources required to meet peak needs. Rate design tools include time-varying rates sometimes referred to as time-of-use (TOU) rates, critical peak pricing (CPP, sometimes referred to as "demand charges"), and real-time pricing (RTP).

Direct load control enables utilities to control various customer-side assets including heating systems, water heaters, electric vehicles, and potentially other appliances and devices in both homes and businesses. In a 2018 analysis commissioned by the Bonneville Power Administration, the Cadmus Group[8] found that demand response and direct load control alone should be able to meet 10% to 21% of peak load requirements in 2036. The following table lists the demand response tools Cadmus considered in its analysis.

Table 5. DR Products

Sector	DR Product	Deployment Mechanism	Seasonality
Residential	DLC—Water Heating	DLC	Summer and winter
	DLC—Space Heating	DLC	Winter only
	DLC—Central Air Conditioning (CAC)	DLC	Summer only
	DLC—Smart Thermostats	DLC	Summer and winter
	Critical Peak Pricing (CPP)*	Tariff-Based	Summer and winter
	Behavioral DR	Direct Communication (e.g., event notifications)	Summer and winter
Commercial**	DLC—CAC	DLC	Summer only
	Lighting Controls	Automated Response	Summer and winter
	Thermal Storage	Cooling Storage	Summer only
Industrial***	Real Time Pricing (RTP)*	Tariff-Based	Summer and winter
Commercial and Industrial	Demand Curtailment and DLC	Contract (Automated or Manual Response)	Summer and winter
	Interruptible Tariff	Tariff-Based	Summer and winter
Agricultural	Irrigation DLC	DLC	Summer
Utility System	Demand Voltage Reduction	SCADA	Summer and winter

*Cadmus assumed that TOU rates were already in place.
**In this assessment, Cadmus included public buildings in the commercial sector.
***In this assessment, Cadmus included public process loads such as municipal water treatment plants in the industrial sector.

Distributed Generation

In 2018, the consulting firm Navigant projected that customer-side solar generation by Portland General Electric customers would provide nearly 300 average megawatts of power by 2035 and over 500 megawatts by 2045[9]. Portland General Electric customers constitute about 12% of the

7 Northwest Power and Conservation Council, 7th Plan, February 2016.
https://www.nwcouncil.org/sites/default/files/7thplanfinal_allchapters.pdf, page 1-2.

8 Cadmus Group, "Demand Response Potential in Bonneville Power Administration's Public Utility Service Area", March 2018.
https://www.bpa.gov/EE/Technology/demand-response/Documents/180319_BPA_DR_Potential_Assessment.pdf

9 Portland General Electric, "Integrated Resource Planning, Roundtable 18-4", September 2018.

Northwest energy market so the regional figure should be much higher. In addition, small community-scale solar and wind projects are expected to grow and be a part of the customer-side portfolio.

Storage

Storage capabilities of batteries, electric vehicles, water heaters, and other appliances can redistribute both supply and demand in order to minimize load variation and the severity of peak load events. The result will be less overall need for generating resources and more effective utilization of renewable resources when they are contributing to the grid. The result should be less overall investment in generating resources, lower bills for consumers, and a more stable, resilient, and responsive system.

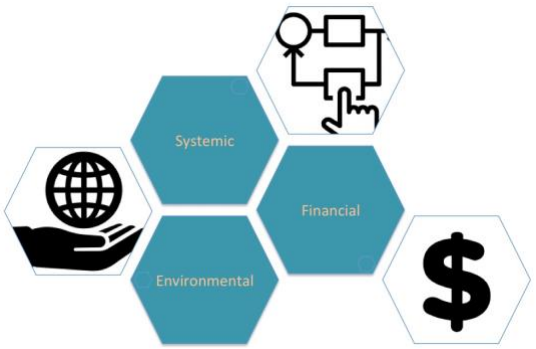
Digital System Management

At present, there are no quantitative standards or goals for peak load reduction, but we're becoming equipped with tools, aided by digital telecommunication technology and the internet, that allow peaks to be managed. These will make it possible and worthwhile for the region and individual utilities to develop relevant performance metrics.

According to the just-released "Meeting the Challenge of Our Time"[10] study by the Clean Energy Transition Institute, these customer-side resources should be able to reduce per-capita energy consumption in Oregon and Washington by more than half and cost-effectively meet upwards of three-quarters of the region's new capacity needs.

The Harmonious Grid's Meta-benefits

The Harmonious Grid will provide added systemic, financial, and environmental benefits to those already cited.



System benefits: Flexibility, reliability, & resilience

By reducing peaks and total load and actively managing the load that remains, the Harmonious Grid will make it easier to integrate variable renewable resources. The Harmonious Grid will also inoculate the system against interruptions in fossil fuel supplies and large outages that may result. And, because it will give system operators more levers to pull, the Harmonious Grid will be more responsive in the event of system stress.

Financial benefits: Less cost volatility, reduced capital requirements

By taking volatile commodity prices and exposure to carbon pricing out of the equation, the costs to maintain and operate the Harmonious Grid will be more stable and predictable, making it easier for utilities to recover costs. Meanwhile, participation in the grid will be distributed as customers and governments invest directly in customer-side resources.

10 Clean Energy Transition Institute, "Pathways to a Clean Energy Future for the Northwest", June 2019.

A smaller footprint leads to big social and environmental benefits

As the region ramps up direct investments in job-rich categories such as energy efficiency, load control, and distributed generation in rural, urban, and suburban communities we will be creating a multiplier effect from which all parts of the region will benefit. And, by relying more heavily on the full portfolio of customer-side resources, the Harmonious Grid will reduce pressure on our infrastructure and the need to build more.

Making the Harmonious Grid a reality

For the Harmonious Grid to be realized as a fully integrated controllable system rather than as a version of the existing grid with a few more resources tacked on, we will need to advance quickly and simultaneously on three fronts.

First, development and refinement of existing and new customer-side technologies and their associated products and supply chains will have to be completed. That's also true of new grid management software and tools upon which utilities will depend to conduct their newly expanded orchestras.

Second, public policies and markets will have to be developed to adapt and refine business models and incentive systems so that all players in the energy ecosystem, from utilities and their customers to equipment manufacturers and energy efficiency service providers, will be motivated to play their respective roles in developing the Harmonious Grid.

Third, utilities and the regulatory bodies that govern them must embrace the vision of the Harmonious Grid, translate that vision into specific plans for the transformation of their operating systems and business models, and then implement those plans.

Coming installments in this series will discuss how the Northwest can perform those three tasks.

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