Harnessing Flexibility in an Evolving Electric Power System

Update from the 2016

Transactive Energy Systems

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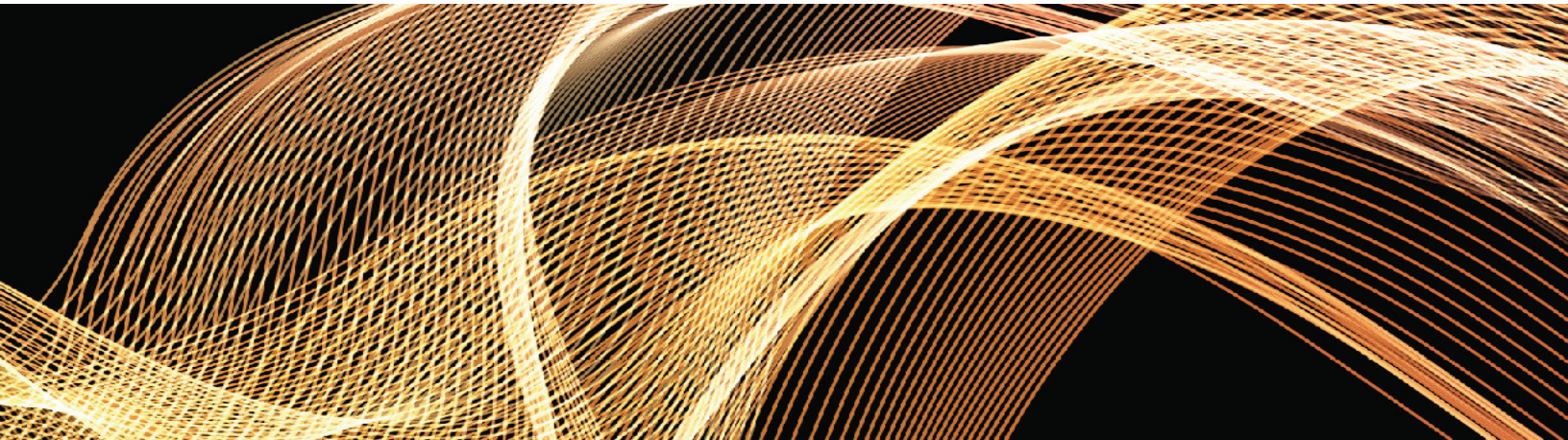

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EXECUTIVE SUMMARY

Major changes are afoot in how energy is generated, bought, and sold in the United States and globally. The GridWise Architecture Council, in partnership with Smart Grid Northwest, convened the third Transactive Energy System [TES] conference in Portland, Oregon in May, 2016 to address some of these changes. According to the GridWise Architecture Council, "Transactive energy" is the technique of managing the generation, consumption, or flow of electric power within an electric power system through the use of economic or market based constructs while considering grid reliability constraints. The term "transactive" comes from considering that decisions are made based on a value. These decisions may be analogous to or literally economic transactions. An example of an application of a transactive energy technique is the double auction market used to control responsive demand side assets in the GridWise Olympic Peninsula Project[1]. Another application of transactive techniques is embodied in the TeMix work of Ed Cazalet[2]. Transactive energy techniques may be localized to managing a specific part of the power system, for example, residential demand response. They may also be proposed for managing activity within the electric power system from end-to-end [generation to consumption] such as the transactive control techniques that were developed for the Pacific Northwest Smart Grid Demonstration project[3,4]. An extreme example would be a literal implementation of "prices-to-devices" in which appliances respond to a real-time price signal.

Speakers at the conference described Distributed Energy Resources [DER] issues and key challenges faced by utilities with increasing levels of distributed energy resources from solar, wind, electric vehicle [EV] charging, and a number of other sources. The conference included sessions on how utilities and regulators can be involved in the engineering and planning levels of transactive energy and play a part in its evolution. Speakers from around the world described new energy technologies and how a mix of traditional energy and renewable energy is being integrated in their countries. Questions discussed at the conference included:

- What is transactive energy?
- How do we measure or value the impact of transactive energy in support of distributed energy integration?
- What are the architectural concerns for an electric grid supporting more DER sources?
- How can we maintain and improve the reliability, resilience, and economic efficiency of the power grid?
- What are the roles of energy regulators and how will they change in the DER environment?

This paper summarizes a selection of discussions from the 2016 TES conference as well as provides information on the energy trends in the Pacific Northwest and what makes this region a unique leader in smart grid and transactive energy technologies and how it can benefit from such solutions.

Modernization of the Power Grid and Changing Solutions

In his keynote speech at the TES 2016 Conference, David Owen [Executive Vice President, Business Operations, Edison Electric Institute] described the modernization of the power grid and the changes the U.S. is facing. "The electric grid is being digitized and there is a much needed dialogue taking place on grid modernization. In most parts of the country there are flat or declining electric sales. Trends reshaping the utility industry include a slow economic recovery, aging infrastructure, regulatory issues, low natural gas prices, new competitors, emerging technologies, and changing customer preferences and behaviors. Approximately one third of the US energy fleet is based on nuclear or clean energy, yet we are shutting down 24 percent of coal capacity for energy production—this change is being driven by the customer. We will triple the non-hydro renewable sources between 2010 and 2020," stated Owen.

Changes in the Northwest [NW] track quite similarity to the trends in the country at large. Early retirement of coal facilities is underway, Oregon [OR] has passed a 50 percent renewable portfolio standard, and a variety of demand side resources are likely to make up a large portion of new resources. The newly released 7th Power Plan by the NW Power and Conservation Council headlines with the continued development of energy efficiency and new development of demand response in the face of mostly flat expected load. The Pacific Northwest Electric Power Planning and Conservation Act [Northwest Power Act] directs the Northwest Power and Conservation Council [Council] to develop a "regional conservation and electric power plan" and to review the plan not less than every five years. After nearly three years of extensive analysis and discussion of the challenges of maintaining a low-cost and reliable regional power system in light of the uncertainties facing the system over the next 20 years, the Council adopted the Seventh Power Plan in February 2016.

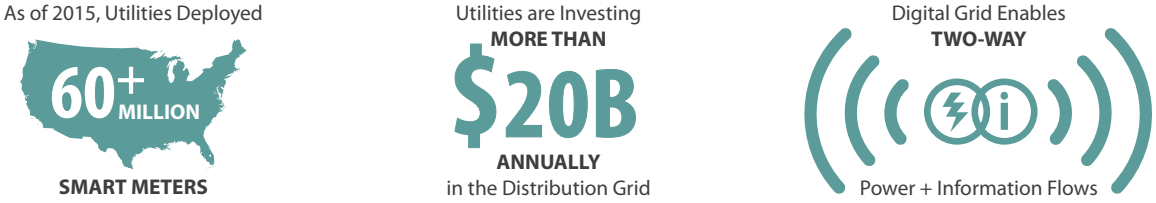


Figure 1 Electric Distribution System in Transition.[5]

Redefining the Energy Distribution System

In a modern grid with distributed resources, producing customers [called prosumers] generate a portion of their own power from sources like solar panels and smart energy efficiency solutions. This change from the norm is causing a global re-examination of how to regulate and price energy. According to Owens, "We need to define the energy distribution system and have a conversation with regulators to further define rules around the energy distribution system." In his speech Owen stressed the importance of a number of points:

- Considering how to identify, price, and distribute energy
- A uniform energy model for the future that involves individualized customer services
- Not all residential customers are the same and need different types of services.

Owens indicates that he believes there must be an improvement in pricing of services and that everyone who uses the grid must be charged. There are 43 states and D.C. implementing net metering, where if a customer provides a benefit by selling energy to the grid from a solar panel, wind, or electric vehicle, then the customer should get a discount and be able to use the generated energy at any time [not only when the energy was generated]. However, even customers with solar panels still need to be connected to the grid for the majority of their power as shown in Figure 2. "All power supply sources have some degree of subsidies and we are currently putting more subsidies into renewables. Subsidies distort market prices while transactive energy clarifies energy subsidies," stated Owens.

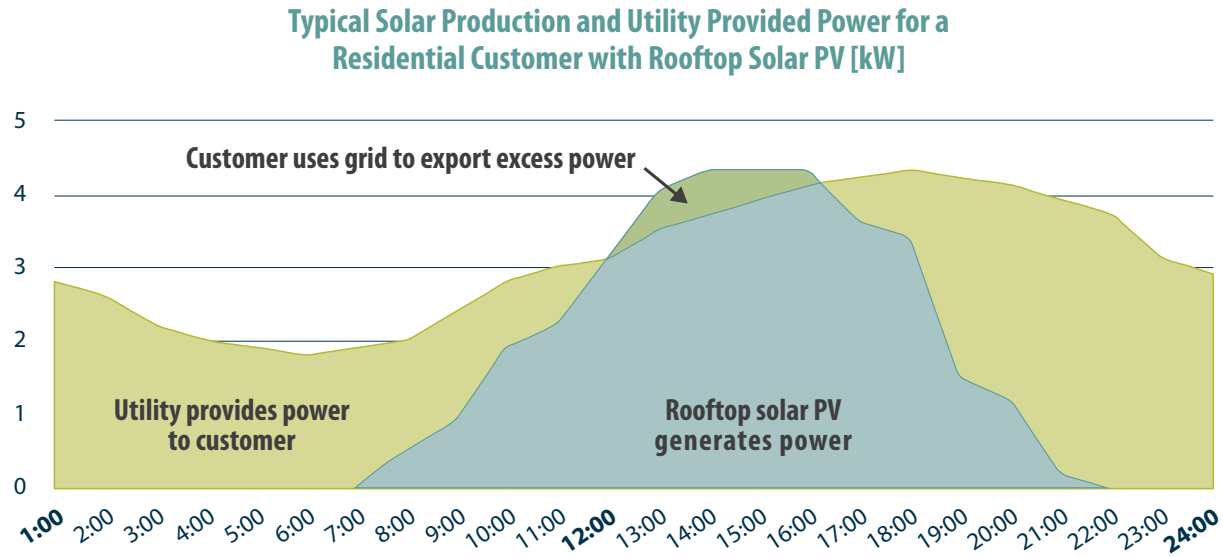


Figure 2 Solar production example with customer exporting energy back to the grid.

Finally, grid security is a top challenge for the industry. If grid control is no longer under control of the utility, then how do you ensure that the grid is secure? Owens stated that "As we think about transactive energy, we need to think about cyber and physical security and how to build it in."

Quadrennial Energy Review [QER]

Owens shared with the conference audience that the topics described in his speech are already under consideration by a number of organizations and leading thinkers. On January 9, 2014, President Obama issued a Presidential Memorandum directing the administration to conduct a Quadrennial Energy Review [QER]. On April 21, 2015, the QER Task Force released the first installment of the QER entitled, "Energy Transmission, Storage, and Distribution Infrastructure", which examined the Nation's infrastructure for transmission, storage, and distribution upgrade opportunities, including liquid and natural gas pipelines, the power grid, and shared transport such as rail, waterways, and ports. The QER document is designed to provide policy makers, industry, investors, and other stakeholders with unbiased data and analysis on energy challenges, needs, requirements, and barriers that will help inform a range of policy options, including legislation. Owens stated, "We are emphasizing that our industry is modernizing the power grid, providing clean energy, and focused on innovative customer solutions. We are reinforcing key QER 1.1 themes:

- The value of the grid should be properly recognized
- Reliability is mission number one for our industry
- Our industry plays a critical role in the future, and we are focused on proper integration of resources and investment

Another iteration of the QER is under development by the Department of Energy and is set to focus on "a set of findings and policy recommendations to help guide the modernization of the nation's electric grid and ensure its continued reliability, safety, security, affordability, and environmental performance through 2040."

States Implementing Energy Programs

There are a number of states implementing energy programs as part of the evolution of their energy systems:

- New York: "Reforming the Energy Vision"[REV]
- California: Distributed Resource Plans
- Minnesota: "e21 Initiative"
- Massachusetts: Grid Modernization Plan
- Hawaii: Power Supply Improvement Plan
- Illinois: Energy Infrastructure Modernization Act

New York State Implements NY REV Program

As of today 25 percent of New York State's energy consumption is comprised of renewable energy resources such as solar, wind and hydropower. The New York State Energy Plan established an aggressive goal [not yet set into policy] for New York to rely on 50 percent renewable energy for its total energy needs by 2030. This goal requires the state to double its consumption of renewable energy over the period from 2015-2030.

New York has one of the most closely watched energy programs in the nation, due to Governor Cuomo's announcement of the aggressive New York Reforming the Energy Vision [REV] energy policy. According to the NY REV website, "Reforming the Energy Vision [REV] is Governor Cuomo's comprehensive energy strategy for New York to help consumers make better and more informed energy choices, enable the development of new energy products and services, protect the environment and create new jobs and economic opportunity throughout New York State. In addition, the program is designed to protect consumers and ensure that no consumer class is left behind in accessing clean and affordable energy."

The REV program:

- Provides an Energy Affordability program to limit energy costs to six percent of income for low-income New York residents
- Creates a Clean Energy Fund programs and Utility Energy Efficiency Reforms to increase use of clean energy and enable utilities to establish energy-reduction targets for gas and electric use
- Conducts REV demonstration projects
- Enables low income customers to participate in community based solar installations, even if they live in an apartment or building that cannot support rooftop solar panels
- Encourages communities to develop microgrid projects with grids that can produce power independently of the main grid
- Promotes greater use of advanced energy management products to enhance demand elasticity and efficiencies

New York PSC Chair Describes Importance of NY REV Program at TES 2016

In her keynote speech at the TES 2016 Conference, Audrey Zibelman, Chair of the New York State Public Service Commission [PSC] described the NY REV project and its impacts on renewable energy, smart grids, and transactive energy. The NY REV program was developed to help provide weather event resiliency and to meet customer demand for solar, backup resources, provide power quality for data systems, and help lower energy prices.

The New York PSC is seeking to design a modern electric system that will integrate clean generation at the bulk level with distributed generation and dynamic load management at the customer level. Zibelman indicates that the NY Rev program is also designed to help New York utilities meet their energy distribution load while attracting Distributed Energy Resource [DER] suppliers. Currently, utilities in New York State have dynamic load tariffs. The goal of implementing the NY REV project is that utilities will be able to use more distributed energy and need to deploy less capital to build new facilities. One goal is "don't build big assets to meet energy peak demand—meet peak energy demands with DERs." As an example, Zibelman indicated is the Brooklyn-Queens substation upgrade which helped avoid a $1 billion dollar upgrade using this model. In 2014, the New York PSC issued an order approving Consolidated Edison Company of New York Inc.'s [Con Edison] Brooklyn/Queens Demand Management [BQDM] Program to address overload of sub-transmission feeders with a combination of traditional utility-side solutions and non-traditional customer- and utility-side solutions. The approval is a significant step towards a regulatory paradigm where utilities incorporate alternatives to traditional infrastructure to address planning and reliability. The PSC noted that Con Edison's proposal – involving deployment of distributed energy resources, increased clean energy solutions, and innovation through competition – is consistent with the Reforming the Energy Vision [REV] proceeding goals.

The cost of generating and delivering electricity varies throughout the day and in different times of the year, which adds a level of volatility to electricity prices. Electricity pricing is usually based on locational marginal pricing [LMP] which makes electricity costs different at various times based on user demand, transmission congestion, weather, and numerous other factors. According to Zibelman, "Education is a key to making REV work. With LMP, consumers do not understand energy costs. The NY REV program proposes educating customers about time-variant electricity pricing to help customers understand the difference in electricity pricing so they can modify their energy use patterns for times when there is less energy demand and prices are lower.

NY REV Platform Model—Promote Capital and Operating Efficiencies

In the traditional energy market, utilities price and distribute electricity. New York recently implemented the **REV Track 2** Order which provides new guidelines on how utilities and regulations will work. Under the Track 2 Order, "Utility revenue opportunities must be expanded to more closely align utilities' financial interests with the customer benefits from these elements of a modernized electric system."

The New York program proposes creating competitive markets with capital deployed by third parties, both on the wholesale grid and behind-the-meter. This will require making rate design changes as regulators determine how to price DER resources to the grid and set reliability and adequacy requirements for third-parties who want to be part of the new system. Regulator goals will be to enable energy efficiency, interconnection of resources, and provide outcome-based incentives and real time value for customers.

This proposal is currently under consideration with plans to develop a public Integrated Resource Plan [IRP] at the distribution utility level. New York PSC and regulators are working with the Department of Energy [DOE] and **Electric Power Research Institute** [EPRI] on elements of the design.

NY REV Demonstration Projects

The New York PSC directed the six large investor owned electric utilities in the state to develop, and file **demonstration projects** relating to REV. "The projects are intended to demonstrate new business models, such as new revenue stream opportunities for third parties and the electric utilities. In that regard, the projects will inform decision makers related to developing Distributed System Platform [DSP] functionalities, measure customer response to programs and prices associated with REV markets, and determine the most effective implementation of Distributed Energy Resources [DER]."

While there has been some recent added efforts around resiliency planning in the Northwest, these drivers have largely not impacted energy markets in the region. Additionally, tariffs in the NW are largely not variable like they are in New York. Finally, Bonneville Power Administration [BPA] has recently undertaken an examination of a non-wires solutions for a transmission project North of Portland but it is not yet clear if these solutions will have as large an impact as they have in New York already. It seems that the NW has a lot to learn [as many markets across the country do] while New York goes through its REV efforts.

The NY REV process is an important one with impacts far beyond the borders of the state. Markets across the U.S, and the world, are watching the New York REV project to see what features may be applicable to their systems and what worked in this ambitious effort.

Evolution of the Smart Grid and Impacts on Utilities, ISOs and RTOs

Utilities are facing challenging operating environments, with increasing levels of variable generation taxing bulk power and distribution systems, and the increased use of distributed energy resources [DER] threatening traditional utility business models. How can utilities adjust – and thrive – under a new paradigm? Discussions at TES 2016 focused on describing potential solutions, taking a look at programs and solutions used in various locations, and discussions of the regulatory changes that need to occur to enable these solutions.

A New Model of Energy Implementation

In the traditional model, electric utilities provide electricity generation and distribution of electricity for sale in a regulated market. Independent system operators [ISOs] coordinate, control and monitor the operation of the electrical power system, usually within a single U.S. state or across multiple states. Regional transmission organizations [RTOs] in the United States are responsible for moving electricity over large interstate areas and coordinate, control, and monitor an electricity transmission grid. All of these groups are controlled by regulations put forth by the U.S. Federal Energy Regulatory Commission [FERC].

The smart grid and increasing levels of variable generation from renewable energy resources are presenting challenges to the traditional bulk power and distribution system. The evolution of both the smart grid and transactive energy will change how utilities, RTOs, and ISOs work, and what they have the ability to control. In the past, utilities provided a flow of electricity to customers and customers paid the utility for this energy. In the traditional model, utilities monitor attributes of their energy system, such as current flows, voltages, and frequency, using this visibility to control the flow of electricity.

In a distributed energy system, utilities may have difficulty seeing or controlling many of these sources. However, utilities are still required to integrate these sources into their traditional power network, as well as providing security and guaranteed access to electricity.

The Northwest is currently not part of any organized ISO/RTO marketplace. However, change is percolating. A number of regional utilities including Pacific Power [and sister company NV Energy], Puget Sound Energy, Idaho Power, and Portland General Electric have expressed their plans to join into the California ISO [CalISO, maybe soon to become more of a WesternISO]. BPA and others have also been working toward what elements of an energy imbalance market [EIM] may look like for the region. Development of structured markets in the west would bring added opportunities for smart grid and transactive energy solutions.

A transactive grid is a physical grid where transactions coordinate parties' grid related investments and operations. Transactions are binding contracts for grid products. It is important to keep product definitions simple, as well as unbundle energy and transport products.

– Edward G. Cazalet, CEO TeMIX, Inc.

What is the Smart Grid and Transactive Energy?

According to the Smart Grid Dictionary 5th edition: The smart grid is a software-defined grid managed via market-based incentives to ensure grid reliability, resiliency, and economic efficiency. This is implemented with software applications that use economic signals and operational information to coordinate and manage devices' production and/or consumption of electricity in the grid. The smart grid is a digital grid that allows two-way communication, uses sensors, and provides features such as self-healing and self-monitoring.

Transactive energy [TE] adds another component to the smart grid, integrating pricing of electricity across the grid and two-way power flows. The transactive energy model also allows software and third-party agents or customers to conduct energy transactions rather than electricity and pricing flowing only from a utility.

Case Study Example: Transactive Distribution System Operator [DSO] Construct

In his presentation at TES 2016, Farrokh Rahimi, Senior Vice President, Smart Grid Projects, Open Access Technology International [OATI], described a view of a utility-managed Transactive Distribution System operation that includes pricing, payment, and cost recovery under a Transactive Distribution System Operator [DSO] Construct[6]. Figure 3 shows an example of how this system works.

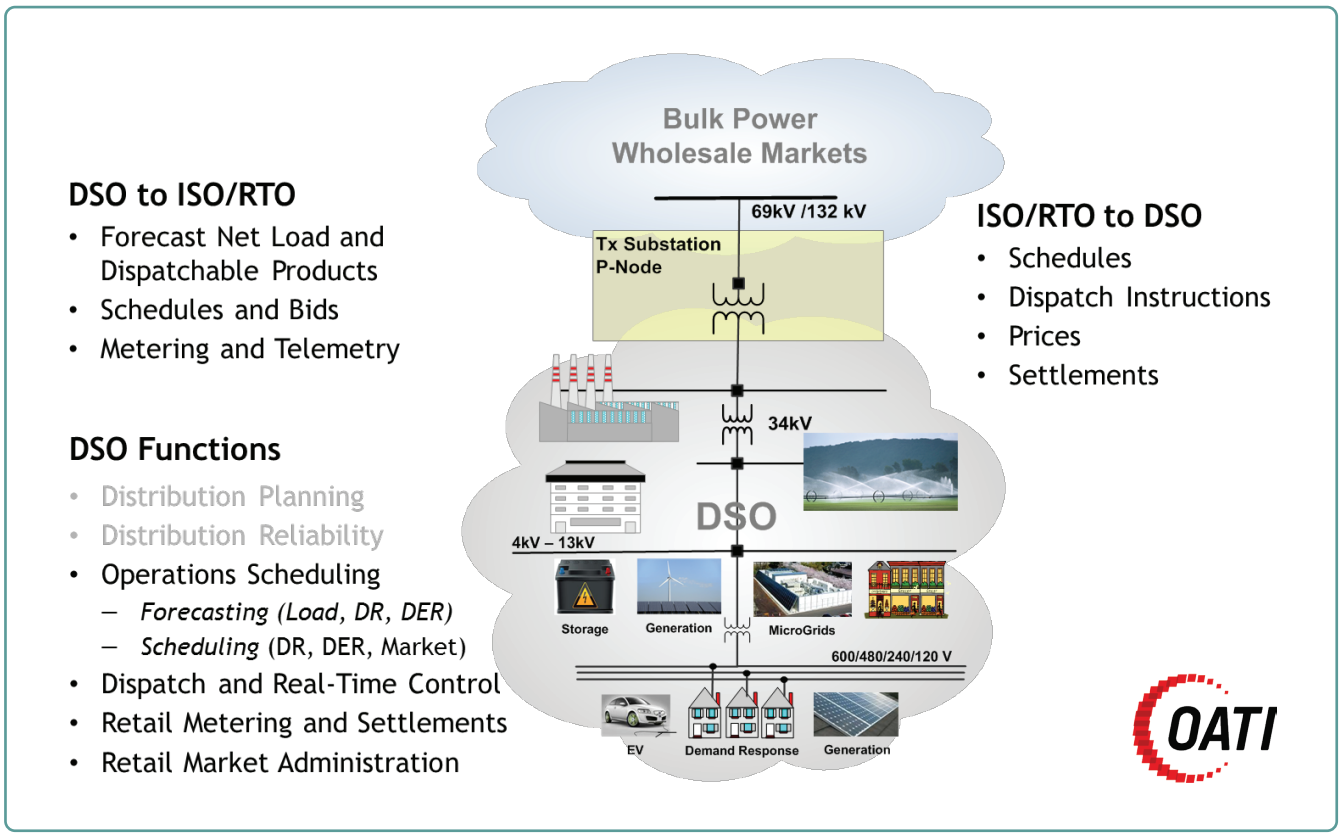


Figure 3 Distributed Transactive Distribution System Operator [DSO] system example. Farrokh Rahimi, Senior Vice President, OATI.

In this example, the lowest level of the grid hierarchy includes customers generating power from sources such as electric vehicles and solar panels over a two-way demand response system. The next level includes energy being generated by sources such as wind, power storage units, microgrids, and community solar systems installed in dense urban areas such as apartments and city cores.

The Distribution System Operator [DSO] is a new concept of how transactive energy might work across a smart grid, acting as an intermediary between ISOs and RTOs in the bulk power wholesale markets. In this scenario, the DSO performs operations scheduling, dispatch and real-time control, retail metering and settlements as well as retail market administration. The DSO passes information to ISO/RTOs about net loads and dispatchable products, schedules, bids, metering, and telemetry. The ISO/RTO passes information on schedules, dispatch instructions, prices and settlements back to the DSO.

This concept agrees with the theory proposed by the vision of transactive energy in 2014 by the California Public Utilities Commission[7] where Nilgun Atamturk, Senior Policy Analyst, California Policy and Planning Division stated, "The main idea of a TE construct is to integrate retail and wholesale markets and market signals into a single platform by utilizing forward and spot transactions, thereby guiding investment and operating decisions." Atamturk indicates that there will be three groups of players in the TE construct: energy services [customers, producers, prosumers, storage and owners]; transport services [transmission and distribution owners]; and intermediaries [exchanges, market makers and system operators]. "This is in contrast to the traditional model of customer types of residential, commercial and industrial. All parties will have sophisticated energy management systems and/or third party assistance that will help them optimize their energy use and production based on value and grid constraints."

DSO Interactions with Transactive Agents

The OATI DSO model also includes a variety of transactive interactions with agents and pricing signals as shown in Figure 4.

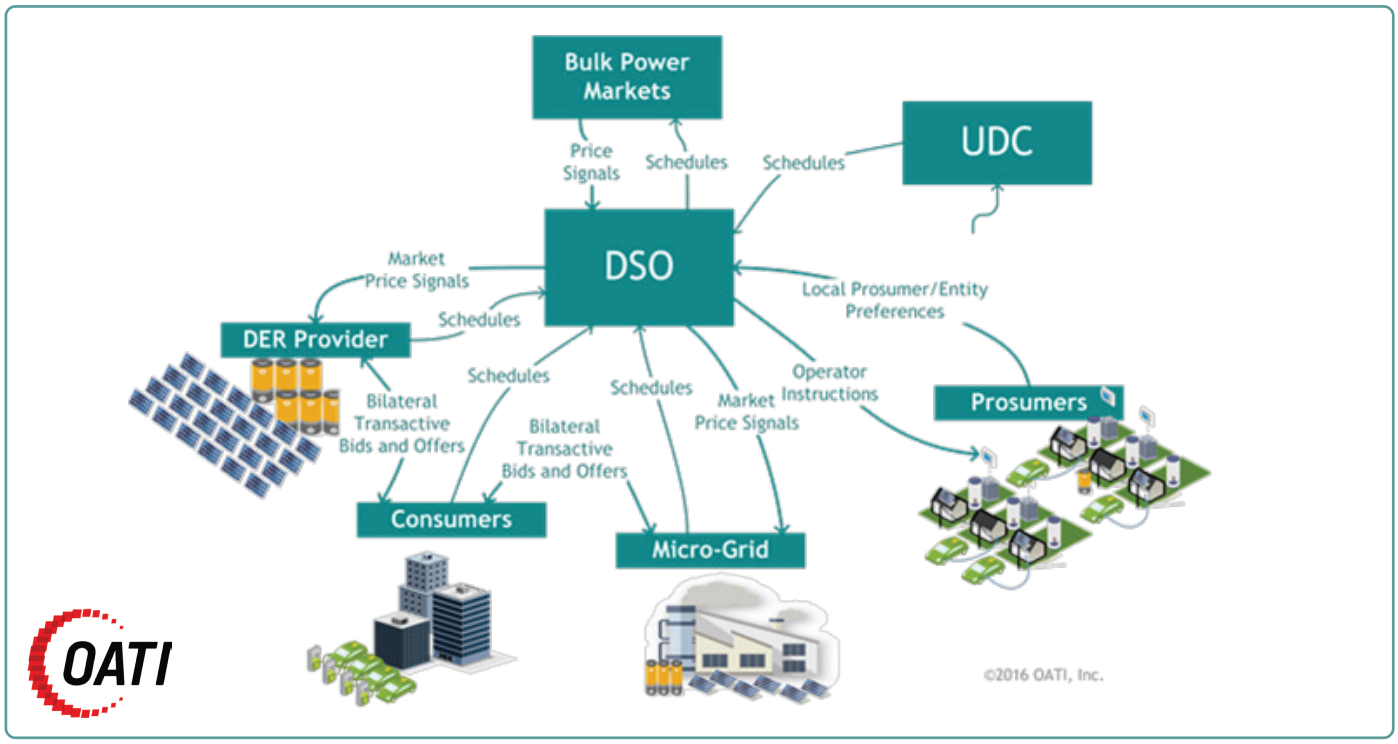


Figure 4 DSO interactions with transactive agents example. Farrokh Rahimi, Senior Vice President, OATI.

This model envisions bids and offers, schedules, market pricing signals and schedules being exchanged at all levels of the TE system. According to Fred Fletcher, Assistant General Manager, Burbank Water and Power [BWP], "The DSO model can help meet the needs faced by BWP in meeting the Renewable Portfolio Standards established by the State of California of using 33 percent renewable energy sources by 2020; 50 percent by 2030." The model can help:

- Meet or exceed the Renewable Portfolio Standards [RPS] established by states
- Manage imbalances inadvertently created via increased renewable energy
- Include in the plan Greenhouse Gas Reductions that may be economically reduced
- Quickly identify outages so that power to customers can be restored in a timely manner
- Improve communications between the utility and its customers so that customers have better information
- Maintain or improve customer privacy and security
- Maintain rates at or less than the rate of inflation as measured across retail electricity services sales

Pricing Models for Transactive Energy

Utilities currently purchase distribution grid services from third parties to defer grid capital investments or avoid operating expenses. There are extensive renewable energy programs in states such as New York, California, and Hawaii that offer net metering or incentives to install solar power systems. However, there is no approved national pricing model in the U.S. for renewable energy or transactive energy pricing. A presentation by John Caldwell, Lead, NIST TE Challenge Business and Regulatory Models Team, proposed that a fully functioning transactive energy market model would require:

- A method for DER services to be sold to the grid and/or traded "peer-to-peer"
- A mechanism[s] for pricing products and services
- A system for communicating price and other information
- An efficient means of allocating electricity and other services, consistent with grid constraints
- Appropriate incentives, controls and delegation of responsibilities to ensure that electricity service will continue to be delivered reliably, safely, and affordably to all customers

The NIST TE Challenge Business and Regulatory Models Team proposed a pricing methodology that would involve a two-way subscription tariff mechanism as shown in Figure 5. In this model, customers of DER accept long-term subscriptions for energy and distribution transport. A two-way transport tariff recovers more distribution costs when feeders are heavily loaded in either direction. While most energy transactions occur at a retail or wholesale interface, customers or DERs buy or sell incremental power at a spot price. Participants at TES 2016 discussed the need for an approved transactive energy pricing model to allow trading and selling by consumers, prosumers, and DSOs. General consensus at the conference was that these changes will not be accomplished without changes in energy regulations and legislation.

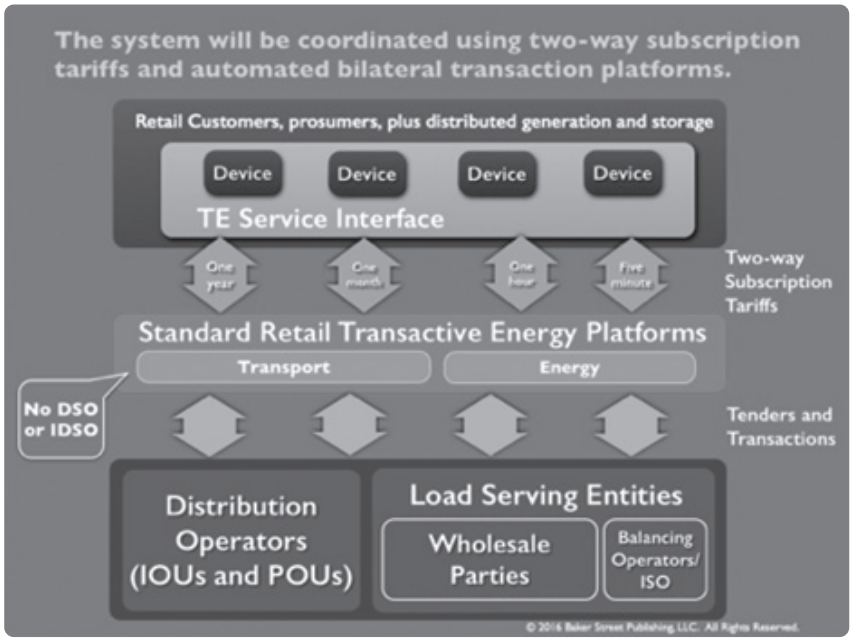


Figure 5 Two-Way Subscription Retail Tariff proposed by NIST TE Challenge Business and Regulatory Models Team

Examples of Utility and Smart Grid Work Across the Nation

Electric utilities are making major progress in addressing DER needs and increasing the percentage of renewable energy resources used in their states. A panel of experts at TES 2106 summarized the challenges they face and the programs they are implementing to meet these needs.

AVISTA Utilities, Washington State—Micro Transactive Grid [MTG]

Avista Utilities, headquartered in Spokane, Washington, provides electric and natural gas service to about 680,000 customers in a service territory of more than 30,000 square miles. Avista serves customers with a mix of hydro, natural gas, coal and biomass generation delivered over 2,200 miles of transmission line, 18,000 miles of distribution line and 7,600 miles of natural gas distribution mains. According to John Gibson, Manager DSO & ETS, Avista Utilities, "Avista has a bilateral transmission market and is not looking at the death spiral of our utility. Avista is looking at innovative methods to function as a utility and better meet customer needs. Our team wondered what would a shared economy look like for a utility? In light of evolving consumers' expectations, the team is creating the Micro Transactive Grid [MTG] or "grid within a grid" project in conjunction with Itron, Pacific Northwest National Laboratory [PNNL], McKinstry, and Schweitzer Engineering Labs [SEL]. MTG can become a platform to share in the investment and return of Distributed Energy Resources [DER] with a connected energy community. In addition to resiliency, the microgrid would facilitate economic value creation and exchange while operating in parallel with the distribution system [grid-connected]. In essence, the MTG facilitates the sharing of DERs through a controls platform which supervises, operates and optimizes utilization of DERs to improve building efficiency, renewable integration, DER utilization, grid coordination and transactive energy. Figure 6 shows an example of the MTG plans.

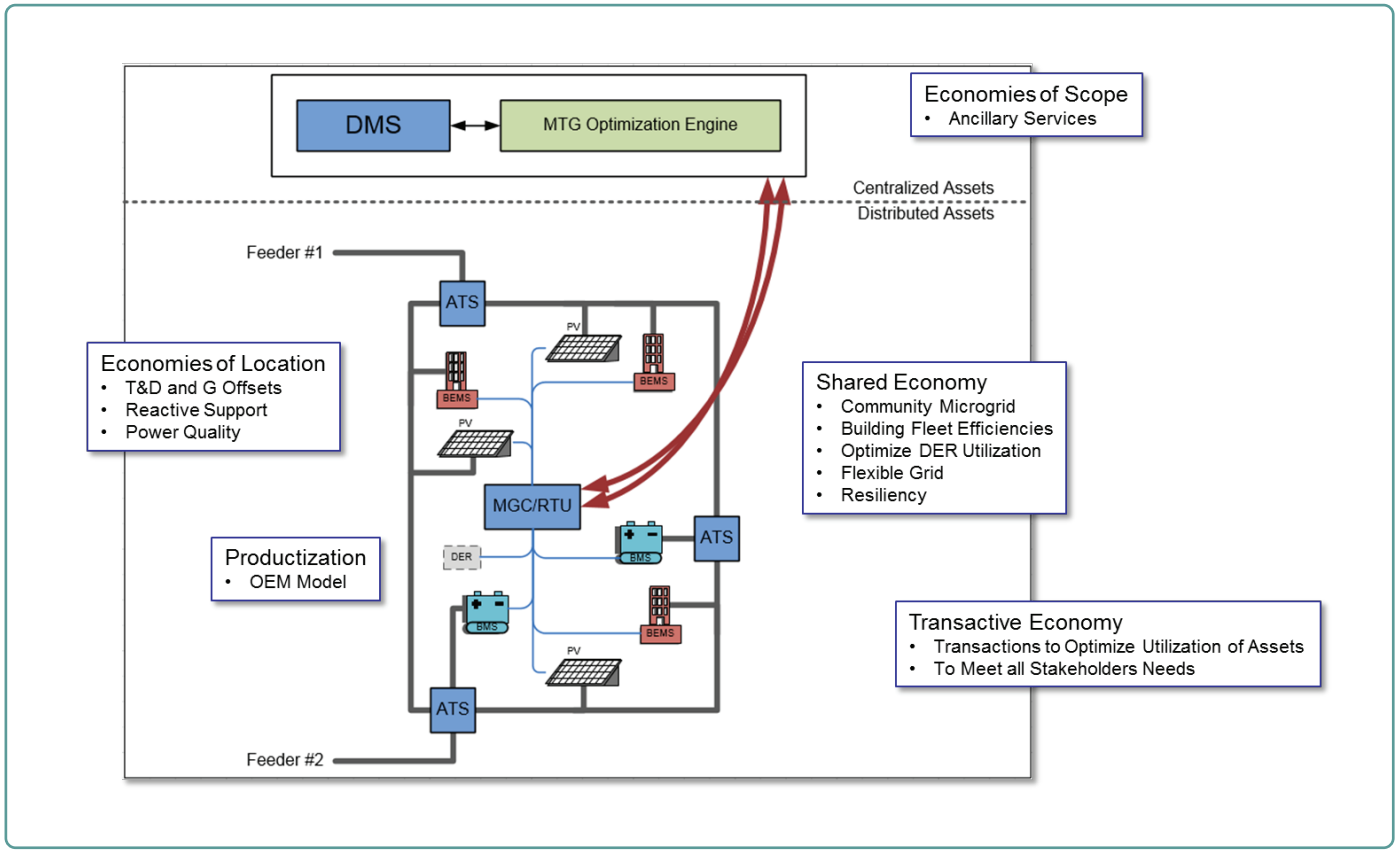


Figure 6 Avista Utilities Micro Transactive Grid [MTG]

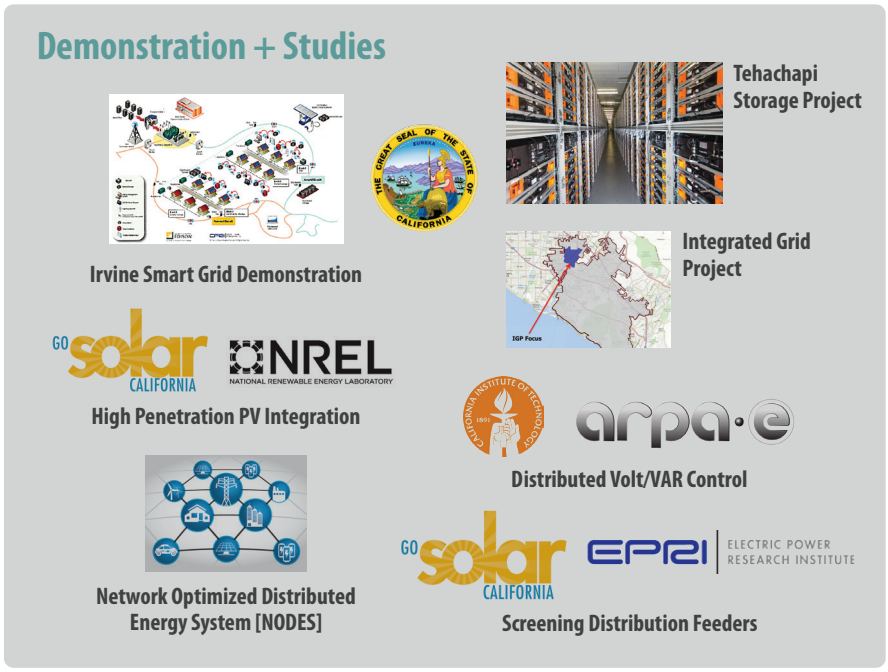
In "grid within a grid" mode, MTG provides provisioning of local loads from local resources in competition with bulk power resources. In "islanding" mode, the microgrid optimizes the balance of supply and demand within the MTG. In "building mode", the connected buildings will be expected to either respond to an incentive signal by providing a forward forecast of energy or submit a price. Avista and partners are also looking at how to implement the project with software to help make it plug and play for fault detection, energy management and other energy-related systems.

Southern California Edison [SCE]—Innovation and Renewable Resources

Edison International is the parent company of Southern California Edison [SCE], which is a regulated utility. Southern California Edison is one of the largest electric utilities in the nation and the nation's single largest purchaser of renewable power. The SCE motto is "The electricity marketplace is changing rapidly, and we're well positioned to capitalize on it."

Robert Sherick, Principal Manager, Renewable Integration, Southern California Edison describes work being done in California to meet the state's aggressive clean energy goals. "California is ramping up on solar PV with a beneficial rate structure and huge incentives to get solar installed. Our utility will probably need a different rate structure for something like a smart inverter with compensation for the customer."

SCE is also looking at how to try to find a way to balance distributed energy resources. The utility is finding ways to innovate and are involved in a number of projects including: the Irvine Smart Grid demonstration project, Tehachapi storage project, NREL High Penetration PV integration project, distributed Volt/VAR control, integrated grid project, EPRI screening distribution feeders, and Network Optimized Distributed Energy System [NODES] project. Figure 7 shows various DER projects and studies being worked on in California.



Hawaii is the first state in the United States to set a renewable energy goal of 100 percent renewable energy for electricity by 2045. To reach this goal, Hawaii will continue to modernize the grid so that it can accept many different forms of renewable energy, including solar, wind, geothermal, biomass, biofuels, waste-to-energy, and hydro power.

– *Duke T. Oishi, Hawaiian Electric, Senior Associate General Counsel*

Figure 7 Projects in California to meet aggressive renewable energy goals

Hawaii Utilities—Most Aggressive Renewable Energy Goal in the Nation

There are three electric utilities using five unconnected grids that provide electricity to more than 95 percent of Hawaii's population of 1.4 million. These include Hawaii Electric, Maui Electric and Hawaii Electric Light.

Solar Energy Growth: In Hawaii, the growth of solar PV systems in homes and communities is one of the largest in the nation. As of 2015, 29 percent of single family homes have solar rooftop PV systems installed with 17 percent of all customers using solar systems. Net Energy Metering [NEM] has been the largest driver of Hawaii's exponential solar growth. NEM exported generation is credited at a retail rate and the statute prohibits placing additional charges or controls on NEM customers. There is also a Renewable Energy Income Tax Credit [REITC] that provides a 35 percent income tax credit, or $5,000 per system, whichever is less.

The NEM program was closed to new customers in October 2015. New energy incentive programs include:

- Customer Grid-Supply [CGS]: The credit rate is fixed for two years [15.07 cents/kWh on O'ahu] with a $25 minimum bill [residential] and monthly true up.
- Customer Self-Supply [CSS]: Customer uses all generation of solar power [no export], energy storage not required but advanced inverters are required. There is a faster approval process for this program.

Hawaii Electric has found that energy from utility-scale solar PV costs much less for customers compared to roof-top solar PV. Duke T. Oishi, Hawaiian Electric, Senior Associate General Counsel states, "We'll continue to add distributed solar, including rooftop PV and grid-scale solar farms, in a way that's sustainable and fair for everyone."

In early 2016, Stem, Inc., a leader in intelligent energy storage, announced a partnership with the Hawaiian Electric companies in a federally funded research program as part of the "Sustainable and Holistic Integration of Energy Storage and Solar PV" [SHINES] program. As part of the three-year project, Stem plans to deploy its intelligent storage systems at local businesses on O'ahu, Maui, and Hawaii Island. "By providing increased visibility and control of customer-sited resources, Stem is adding a new arrow to utilities' quivers and turning a challenge into a solution," said Tad Glauthier, Vice President of Hawaii Operations at Stem. "This project not only supports Hawaii's goal of 100-percent renewable energy by 2045, but also serves as a replicable model for global energy companies of how today's distributed resources can truly compete with traditional, fossil fuel-based alternatives."

From a regulatory perspective, changes were needed as solar power grew in Hawaii, "In looking at Hawaii's net metering policy, it was evident that it was not designed to operate at that scale, and with price signals that Hawaii was seeing with so much solar power. In 2015, the Net program was set as fully subscribed and the CSG and CSS programs were implemented instead," states Matthew McDonnell, Commission Counsel, Hawaii PUC.

Oregon and Portland General Electric [PGE]—Growing Distributed Energy Resources

The State of Oregon recently established a Renewable Portfolio Standards goal of using 25 percent renewable energy sources by 2025 and 50 percent by 2040 [for the State's IOUs]. Portland General Electric [PGE] is a major utility in Oregon that provides electricity to customers in the northern Willamette Valley, serving over 1.7 million customers, which is 45 percent of the state's population within a 4,000-square mile service area, including 52 Oregon cities. PGE serves 75 percent of Oregon's commercial and industrial activity, including companies such as Intel, Boeing, Precision Cast Parts, Nike, and data centers.

The penetration of distributed energy in Oregon is not as great as California and Hawaii, but it is growing. The energy mix for the PGE area is made up of:

- Distributed standby generation: 100 MW on-line and available
- Photovoltaic solar: 75 MW connected [17th among states]
- Energy storage: A 5 MW/1.25 MWh battery in Salem
- Electric vehicles: Customers own about 4,000 EVs
- Energy efficiency: High adoption rate, about 30 MW/yr
- Hydroelectric power: 22 percent from various dams on Columbia River
- Wind power: 15 percent
- Purchased power: 18 percent
- Natural gas: 28 percent
- Coal: 17 percent [the coal plant is slated to close in 2020 and research is being done on biomass or other renewable energy sources to replace coal]

Oregon currently has one large energy storage battery, and Oregon House Bill 2193 provides a mandate for the Oregon Public Utilities Commission to put at least another 5 MWh on the energy storage system in Salem. "Oregon and PGE are looking at what we can we do now to set up the policies, procedures, and infrastructure to integrate the various resources need to meet the RPS renewal energy goals. We are in the process of evaluating how much renewable energy is available and how we can effectively integrate it. We are also looking at pricing fundamental to determine how to value the resource so it provides more value to the customer," states Darren Murtaugh, Electrical Engineer, Portland General Electric.

As PGE and Pacific Power grapple with the new 50 percent RPS and regional energy stakeholders determine the impacts of California's 50 percent RPS as well, energy markets in the west are certainly in the midst of change.

U.S. Regulators Call for Changes in Energy Regulation

A number of regulators spoke at TES 2016, representing small and large states in the U.S. and the District of Columbia, as well as regulators from MISO, whose area covers a number of Midwest states in the U.S. and parts of Canada. A common theme in their comments was that the process for energy planning and regulation is more challenging as more unregulated energy from renewable sources, demand-side sources, and batteries comes online. Speakers indicated that central energy generation will continue to be used in the future, but that new rules and regulations need to be created that set up guidelines for incorporating DERs and establishing a transactive energy market. While not all markets are shifting their landscape as dramatically as New York [described previously] each of them have a number of dynamic elements.

Energy Marketplace is in a State of Flux

Each state is different with varying regulatory constructs, types of utilities, and statutory guidance. However, each regulatory body subscribes to a similar set of principles on rate design, including affordability, reliability, resilience and availability of the electric supply. In his keynote address, Travis Kavulla – President and Chairman of the Board of Directors of the National Association of Regulatory Utility Commissions [NARUC] and Commissioner, Montana Public Service Commission, stated, "The energy marketplace is in a state of flux. As we look at new regulations, the value of DERs should reflect the real value - imagine there are factories creating a similar product and have the capacity to create the next unit of a product. The cost of the product will equalize around the marginal value of demand. Currently, we have cost-of-service based regulations in a command and control energy environment. We don't know the real cost of the energy product in a market if there is open competition. We need to be conscious that things with an unrealized social cost, if they don't command prices in general, then it is not a good idea to set a price for it."

"Regulators need to create a platform that doesn't go into blind alleys. You should be willing to pay more cost now to not lock in prices in the long term. Even if it is more expensive to get a capacity contract, it is better to avoid making a 30-year investment. I assume there will be more regulations in the near political future."

"Similar to telecomm, competitiveness has made old and new regulatory burdens. While rate regulation has gone away, they still must have the old underlying pipe providers. I don't know if you can ever get away from utility transmission and distribution provider supply obligations. If there is a scarcity of the energy commodity, then what happens? Regulators need to think about the underlying legal obligations of energy scarcity."

"With variable generation, the cost/rate of allocation must change. With market participators – such as battery storage and ancillary services – you are seeing a shift of revenue that is not paid through the energy market but rather through the ancillary market. The Federal Energy Regulatory Commission [FERC] continues to do pricing based on peak demand just because there is a peak demand. You need to be able to set a rate that is simple enough to respond to the price signal or the regulars can simply set a cost."

Setting up Regulation Guidelines

Kavulla indicated that he would like to see some regulation discussions that involve RTOs as a test. He also mentioned that there is a need for regulators to be able to innovate as business changes, and would like to see NARUC involved in determining guidelines. Some of the issues the Commissioner would like to see addressed include:

1] DERs and the role of utility regulators: The need for regulation has increased as distributed energy has increased. Consider the high page count of regulations for the MISO transmission tariff. RTO tariffs are more complex than simply describing a product and guidelines need to be determined around the purpose and role of utility regulators.

2] Diversity of service territory: There are many state regulators and regulations may need to change depending on the place. For example: The population density for the Con-Edison New York utility is 5463 customers per square mile versus Montana's 1.62. New York requires more redundancy and capacity for a mesh communications system than a rural state. Service territories also have different reliability issues which need to be considered in the creation of regulations.

What we should do, I believe, is focus on making sure that whatever future is the most affordable and reliable will ultimately prevail in the regulatory setting we create. That system of regulation should be durable enough to accommodate either future.

– Travis Kavulla, President & Chairman of the Board of Directors of the National Association of Regulatory Utility Commissions [NARUC] and Commissioner, Montana Public Service Commission

District of Columbia Controlled by a Single Utility

Jorge Camacho, Chief Infrastructure and System Planning, Public Service Commission [PSC] of the District of Columbia indicates that the District is unique because of its size and high the density of buildings [especially federal facilities]. Since January 2001, the PSC has allowed all residential and commercial electricity customers to choose their supplier of generation and transmission [G&T] services. All electricity suppliers must meet certain minimum renewable energy requirements in order to comply with the District's renewable energy portfolio standard. The minimum requirement was 5 percent for 2009 with the minimum requirement increasing to 20 percent by the year 2020.

Camacho stated, "Within the District of Columbia, the PSC is concerned about how we can move energy more efficiently for solar, geothermal, and other renewable energy sources. Because many residents live in apartment buildings or condos rather than single family homes, the PSC has approved solar community renewable energy facilities so that residents can subscribe to a shared PV solar system. We want to meet the policy goals of the city with lower cost, less waste, higher clean energy, and for the user to have more control of how they use energy services."

An area of concern for the PSC is how regulators can work effectively with third-party aggregators who say they can provide a service such as installing solar panel smart converters. Camacho stated, "Utilities are required to provide a level of reliability and accountability for quality of service to the customer. As regulators, we need to determine how to qualify and treat third-party aggregators in relation to pricing and providing reliability as we bring on more DER sources. Perhaps a utility should not be dealing with this but we need a group to handle the aggregators."

MISO—Issues in Running a Multi-State ISO

Unlike the single utility in the District of Columbia the Midcontinent Independent System Operator [MISO] operates in multiple states in the U.S. as well as part of Canada and faces some different issues. The Midcontinent Independent System Operator, Inc., is an Independent System Operator [ISO] and the Regional Transmission Organization [RTO] that provides open-access transmission service and monitors the high voltage transmission system throughout the Midwest United States, and Manitoba, Canada, and more recently integrated a southern region which includes much of Arkansas, Mississippi, and Louisiana. MISO operates one of the world's largest real-time energy markets.

MISO members include 51 transmission owners with more than 65,800 miles of transmission lines. Members include investor-owned utilities, public power utilities, and cooperatives, such as: Entergy, Indianapolis Power & Light, International Transmission Company, Great River Energy, Xcel Energy, and City Water Light and Power.

Rao Konidena, Principal Advisor, Policy Studies, Midcontinent Ind. System Operator [MISO] indicates that most of the MISO area is regulated. Due to its vast territory, MISO holds a planning resource auction to show that they have adequate resources to meet electricity demand for the coming year. Because wholesale electric costs change throughout the day and night, MISO creates a real-time Locational Marginal Price [LMP] map which show electricity prices and are color-coded to show a constraint that may limit the flow of electricity across the area. The MISO map, shown in Figure 8, is updated every five minutes.

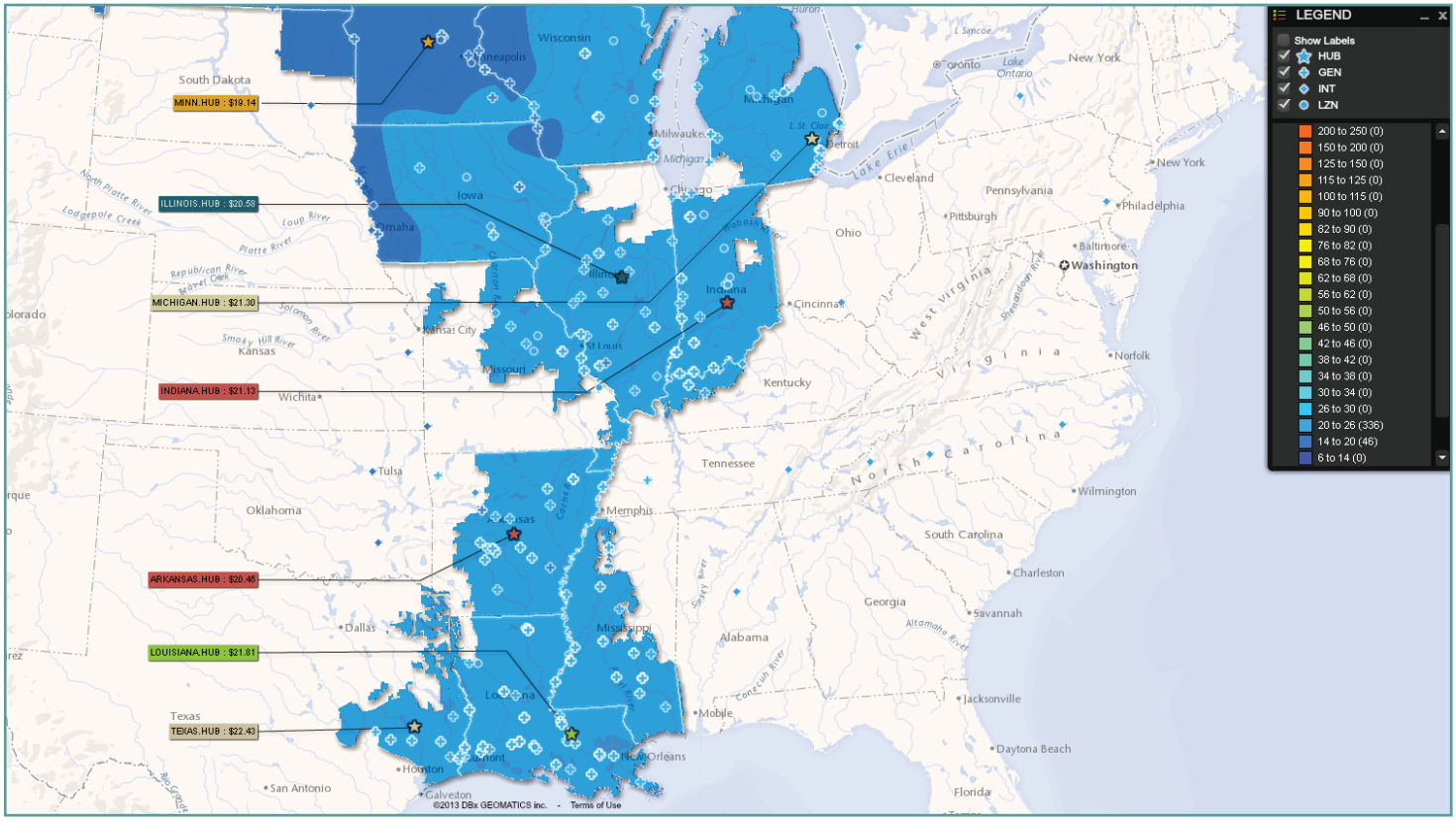


Figure 8 MISO LMP map showing electricity pricing across the region

MISO evaluated the following types of energy sources across its region: natural and other gases, hydro, nuclear, solar, biomass, wind, coal, and other. Some other resources, such as wind, are considered a dispatchable intermittent resource. The levels of these resources are projected through 2020. Konidena indicates that MISO is researching energy battery storage providers and planning for wind, solar, and other DER sources as well as moving away from some coal plants.

"As regulators, we need to get together and do energy transmission and generation planning to determine how to integrate DERs and talk about other areas such as third-party aggregators and transactive energy. Perhaps using the OMS MISO survey would be a good basis for this discussion," states Konidena.

Oregon Public Utilities Commission—DER Planning for the Future

The state of Oregon has relatively steady electricity rates which are lower than most parts of the U.S. due to the number of dams on the Columbia River generating hydro-electric power. The State of Oregon established a Renewable Portfolio Standards goal of using 25 percent renewable energy sources by 2025. Oregon Senate Bill 1547 requires an RPS goal of 50 percent by 2040 and also requires that coal power be phased out.

According to Jason Salmi Klotz, Oregon PUC, "We are currently considering Net Metering and are looking at the **resource value of solar** to identify the business and individual benefit that solar brings to the grid and how it helps rate design." Klotz is in charge of looking at climate change and electric vehicles and stated, "We are considering how utilities can invest in EV infrastructure and rules for time-of-use rates for EVs and whether it requires sub-metering. EVs are a big battery on wheels—so what will the rate structure look like and how does a utility transfer costs to the public that doesn't have EVs?"

The Northwest Utility Region—What Makes It Unique?

The **Northwest utility region** consists of the states of Alaska, Idaho, Montana, Oregon, Washington and Wyoming. In the Pacific Northwest portion of the region, almost half of the region's people live in western Washington and Oregon, where the region's two largest cities—Seattle and Portland—are located. In the Pacific Northwest, about 70 percent of generated power comes from hydroelectric dams in the Columbia River system, which have provided low-cost energy for the region for a number of decades.

The region is unique from an electricity sector perspective, with a large installed wind capacity across multiple states, as well as other growing distributed energy resources, including solar, geothermal, electric vehicle batteries, and demand response assets. Many states in the region are looking to increase their use of renewable energy sources to meet Renewable Portfolio Standard goals. The Pacific Northwest region is also unique in a number of other ways:

- The region experiences winter energy use peaking rather than summer peaking [most other balancing authorities and utilities design for summer peaking loads]. Winter loading currently peaks in the northwest, due to cold winters and mild summers with the use of electrical heaters causing winter peaking load profiles.
- There are a number of smaller utilities located all over the Northwest region, with independent utilities often working together in co-operatives.
- The region has a long history of conservation and have reached deep levels of efficiency, many in leading levels to any part of the country
- The regulatory environment here is different from other utility regions in a number of ways:
    - There is a high proliferation of Public Utility Districts [PUDs] who are not required to follow the dictates of regulators, but who often take leads from their decisions.
    - There are progressive populations in Washington and Oregon and more conservative ones in the other states in the Northwest region.
    - Due to low cost energy from the hydro-electric dam systems, it's harder for the commissions to push upgrades and changes in policy that could have long term benefits but increase prices in the short term.

Bonneville Power Administration—Perspective on Energy Needs in the Pacific Northwest

The Bonneville Power Administration [BPA] is a federal nonprofit power marketing administration based in the Pacific Northwest which operates and maintains about three-fourths of the high-voltage transmission in its service territory which includes Idaho, Oregon, Washington, western Montana and parts of eastern Montana, California, Nevada, Utah and Wyoming. Elliot Mainzer, Administrator & CEO of the BPA, spoke about BPA's perspective on transactive energy, alternative energy, and goals for the future during his keynote speech at the 2016 Transactive Energy Conference. "This is an interesting and transformative time. There are now limits on resources, and we as a Federal agency need to be smart about technology. Power loads in Portland, Oregon and Vancouver, Washington are really spiking and we need new tools. We need to look at every last solution for power congestion before building new lines," stated Mainzer.

Mainzer agreed with comments and concerns expressed at the conference and would like regulators and utility representatives to answer these questions:

- How do you build a reliable DER supply?
- What are various pricing algorithms for short term distributed energy?
- How do you aggregate the technology?
- What are the best controls and pricing structures for distributed energy resources?

Pacific Northwest DER and Smart Grid Projects

BPA is active in smart grid projects throughout its territory—ranging from large, dense cities to remote and sparsely populated rural areas. BPA Administrator Elliot Mainzer visited the Pacific Northwest National Laboratory [PNNL] and saw a demonstration of the Pacific Northwest Smart Grid Demonstration Project [PNW-SGDP]. The project is a unique demonstration of unprecedented geographic breadth across five Pacific Northwest states: Idaho, Montana, Oregon, Washington, and Wyoming. It involves about 60,000 metered customers, and contains many key functions of the future smart grid. Mainzer realized the power of distributed energy when he saw a demonstration of a clothes dryer that used an electronic chip that could sense the system frequencies of the grid supply. If the grid was running under frequency—meaning more demand exists than available energy— the chip on the dryer would shut off usage and drop its load from the grid. This is an example of what a "distributed grid" is all about. Mainzer indicates that "We need to be ready for a world where control varies without an on and off switch.

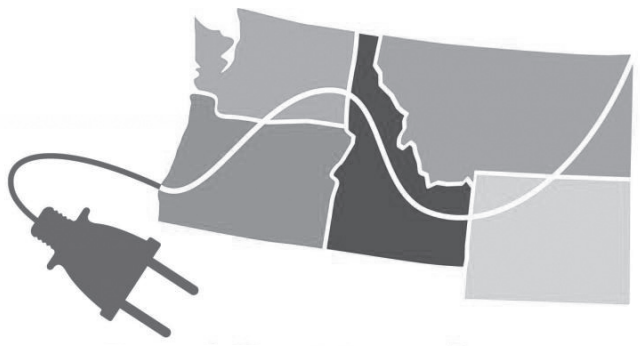


Figure 9 Pacific Northwest – the Smart Grid Demonstration Project is active across five states

There are a number of other recent smart grid projects across the BPA region including:

- Idaho Falls Power: Idaho—Small Idaho city grid gets smarter with automation
- NorthWestern Energy: Butte, Montana—Small steps to a smarter grid
- Flathead Electric Co-op: Kalispell, Montana—Building a smart grid the cooperative way
- NorthWestern Energy: Butte, Montana—Small steps to a smarter grid
- Milton-Freewater: Oregon—A frontier for new technology
- Portland General Electric: Portland, Oregon—Smart power in store for the future
- City of Ellensburg: Ellensburg, Washington—Renewable expansion for a historic utility
- Peninsula Light Company: Gig Harbor, Washington—Smart grid provides power bridge to Fox Island
- Benton PUD: Kennewick, Washington—Stepping into smart grid
- Avista Corporation: Spokane, Washington—Creating a smart city by focusing on grid efficiencies
- University of Washington: Seattle, Washington—Electric grid gets smart with living laboratory
- Lower Valley Energy: Afton, Wyoming—Cold-climate co-op heats up with smart grid

Grid Modernization Proposal, Can Congress Contribute Meaningfully?

The Energy Policy Modernization Act presented by the Chair of the Senate Energy and Natural Resources Committee from Alaska Lisa Murkowski and by ranking member from Washington State Maria Cantwell strongly passed the Senate in April of 2016 and as of the publication of this paper awaits the chance to get conferenced with a House Energy Bill. The bill has a multi-prong focus on grid storage, resilient microgrids, standards, and various grid modernization planning and development tools for states. United States Senator Maria Cantwell from Washington State has been a staunch supporter of smart grid solutions and an advocate for the economic benefit that tech investments bring to the region and across the country. And other members of the NW Senator delegation, including Ron Wyden from Oregon, are supporters of demonstration funding so developing energy solutions can better be deployed in real-world situations. As of July 13, 2016 Senate and House members were going to work on conferencing the energy Bills proposed by each side of Congress. A signal from the federal government on important grid modernization issues will be very important as the energy marketplace moves forward.

Communication—Delivering Clean Energy Message to Customers

An overall theme heard during the conference was the need to communicate and train customers about the smart grid, renewable resources and transactive energy.

Our research reinforces that positive customer-centric messaging is most effective. We need to establish and demonstrate that our industry is value-focused. Here are messages to provide to customers:

– Reliability is mission number one for our industry.

– Our industry plays a critical role in the future, and we are focused on proper integration of resources and Investment.

– Our industry is modernizing the power grid, providing clean energy, and focused on innovative customer solutions.

David Owens, Executive Vice President, Business Operations, Edison Electric Institute

What's Next for the Pacific Northwest?

Our region of the U.S. grid continues to be well positioned to transition into a highly intelligent power infrastructure. As the multitude of smart grid and transactive energy focused projects over the last decade have shown, the region has the brain trust and the necessary grid assets to not only continue evolving our local grids, but to also play a critical role in the global drive towards smarter energy management and delivery.

While factors stand to make the transition a difficult one, from the low cost of the region's energy, the lack of organized balancing and trading markets, to the diversity of perspectives from varying customer and utility types, one thing brings the grid architects of the Pacific Northwest together – we are pioneers and we are collaborators. Stakeholders in the Northwest have always been better about coming together and effectively solving challenges than most other regions of the country. We have led on efficiency and green buildings and we can position ourselves as leaders as energy markets move toward a more transactive grid. From the open planning process of the Power and Conservation Council to the numerous trade organizations working on advanced energy solutions, we are positioned to tackle the opportunities that the changing energy landscape provides.

We would like to offer the following key takeaways from the TES 2016 conference for the Northwest. We believe that those in the region who have the willpower and capabilities can help continue to evolve our power grid towards increased levels of intelligence and efficiency.

- Work to influence the 8th Power Plan to incorporate TE technologies and techniques as they evolve towards 2021 and beyond
- Fund additional TE projects focused on DER integration [solar, storage, EV charging, demand side management, etc.]. An important area around these projects will be standardizing TE methods and communications protocols.
- Engage with the US Department of Energy TE activities to bring more funding and visibility to Washington State and the Region. This should be ongoing effort which leverages the brainpower of PNNL + the influence of Senator Cantwell among other key stakeholders.
- Consider some of the ideas developed by Smart Grid Northwest and Oregon BEST for the creation of a Transactive Energy Center of Excellence located in the Region.
- Monitor and report on the projects happening elsewhere that are pioneering TE methods, especially in California, New York, Australia, and Europe. Identify specific implications, learnings, and technologies that can be deployed in the Region.
- Start a TE investigation under the WA UTC to develop a regulatory model for TE implementations.
- Consider initiatives and projects that leverage the deep bench of regional experts in the green building arena to bring forward next level efforts on smart and responsive buildings

Keywords

Article Keywords:

- Electric Grid
- Utilities
- Energy
- Transactive Energy
- Smart Grid
- Renewable Energy
- Distributed Energy

[1] Hammerstrom, D.J., et al, "Pacific Northwest GridWise™ Testbed Demonstration Projects: Part I. Olympic Peninsula Project", PNNL-17167, October 2007, Pacific Northwest National Laboratory, Richland WA

[2] Cazalet, E.G., "TeMIX: A Foundation for Transactive Energy in a Smart Grid World", presented at Grid-Interop 2010, Chicago, IL http://www.pointview.com/data/files/2/1062/1878.pdf

[3] Hammerstrom, DJ, et al, "Standardization of a Hierarchical Transactive Control System", in the Proceedings of Grid-Interop 2009, November 2009, Denver, CO, pp 35 – 41. http://www.gridwiseac.org/pdfs/forum_papers09/don-business.pdf

[4] http://www.pnwsmartgrid.org

[5] The Edison Foundation Institute for Electric Innovation, Thought Leaders Speak Out: Key Trends Driving Change in the Electric Power Industry, December 2015.

[6] Farrokh Rahimi and Sasan Mokhtari, "From ISO to DSO", Public Utilities Fortnightly, June 2014, pages 42-50.

[7] Nilgun Atamturk and Marzia Zafar, "Transactive Energy: A Surreal Vision or a Necessary and Feasible Solution to Grid Problems? California Public Utilities Commission Policy & Planning Division, October 2014.

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Smart Grid Northwest Founded in 2009 as Smart Grid Oregon, Smart Grid Northwest expanded its regional focus in 2014. The organization's mission is to promote, grow, and enable the smart grid industry and infrastructure in the Pacific Northwest. SGNW has 70 member companies and growing, representing regional utilities, smart grid industry companies, higher education, government agencies, non-profits, and other grid development stakeholders. Smart Grid Northwest's efforts to promote a cluster of smart grid related companies, while also working to accelerate deployment of smart grid solutions, are focused in three priority areas: education, public policy, and regional planning. Learn more at: ***www.SmartGridNW.org.***