Valuation of Transactive Energy Systems Technical Meeting Proceedings

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About this Document

The GridWise Architecture Council (GWAC) was formed by the U.S. Department of Energy to promote and enable ***interoperability*** among the many entities that interact with the electric power system. This balanced team of industry representatives proposes principles for the development of interoperability concepts and standards. The Council provides industry guidance and tools that make it an available resource for smart grid implementations. Readers of this document should possess a good understanding of interoperability, familiarity with the GWAC Interoperability Context-Setting Framework, and knowledge of energy markets and their business models. Those without this technical background should read the *Executive Summary* for a description of the purpose and contents of the document. Other documents, such as checklists, guides, and white papers, exist for targeted purposes and audiences. Please see the www.gridwiseac.org website for more products of the Council that may be of interest to you.

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INTRODUCTION

The United States Department of Energy (DOE) is conducting research on transactive systems as a key enabler for engaging distributed energy resources (DERs) in both the electric power system and in building energy management systems. The Pacific Northwest National Laboratory (PNNL) has been tasked with developing a valuation methodology for transactive energy systems, considering various stakeholders' perspectives and applying that methodology in preliminary test cases. PNNL seeks to leverage, connect, and compliment other efforts. DOE and PNNL also have an interest in strengthening the network of experts working on transactive or market-based coordination systems.

The technical meeting was held on July 7-8, 2015, at PNNL campus in Richland, WA. The purpose of this invitation-only meeting was to convene, under the auspices of the GridWise Architecture Council™ (GWAC), experts in various fields related to valuation of distributed energy resources, including demand side resources, to 1) exchange knowledge of related past and ongoing efforts, 2) provide feedback on PNNL's initial analysis framework, 3) identify existing potentially relevant methodologies, models and data sources that would support this effort, and 4) solidify a network of expert collaborators for this and future efforts.

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OVERVIEW AND OPENING REMARKS

Chris Irwin from U.S. Department of Energy (DOE) explained that an important element of transactive energy systems (TES) is the harmonization of economics and engineering. Traditionally the economics and engineering forces have been on their own frequency and they only correspond at the decade level. Transactive energy is a value access mechanism that allows us to better align and sync value in time and space. Through an understanding of value, we can synchronize economics and engineering through control, planning, etc.

PNNL Intro and Discussion

Rob Pratt from PNNL started the presentation and explained that TES goes beyond prices to devices. There is a set of issues that need to be solved simultaneously like a puzzle. It's hard to create a control system out of something you neither own nor control and that's what we are trying to do. We have to go after multiple value streams. It's not just peak. What can information do for EE?

Abhishek Somani presentation and discussion – It's all about distributed energy resource (DER) coordination. TE is overlaid on traditional constructs. It's not either/or. Is there a way to understand TES value from different time scales? Different locations/areas? Some benefits are very blanket, others are local. We need to accept that this is the case and deal with it. This is the United States and you have different areas – for example you have PJM and then 200 meters away you have a totally different construct. We need to recognize the autonomy of jurisdictions and markets and deal with it. What is the metric of environmental and social benefit? Carbon? Ambient air quality?

The regulator has to say "I am going to pay you for this." Regulators are struggling with how to value this kind of thing in a way that makes sense. A TES valuation framework coming from DOE could be very useful. What is the cost of adapting and hardening your coast line? That is part of the avoided cost and it's valuable to avoid having to do that.

The question was asked whether regulatory issues are the lynchpin. Some believed that right now they are. Some states are being required right now to write down on paper what their smart grid/grid modernization/distribution system implementation plan will be. The regulatory compact determines who will get paid and how and what the utility's obligation are. If utilities are obliged to do it, they should recover their costs.

Desired walk away from this project is a framework/methodology – a potential way to interpret stacks of scenarios. When a new valuation comes in, if the framework is coherent and well developed, a second framework can be evaluated through it. In the Quadrennial Energy Review (QER), a lot of priorities were developed. Valuation came down strongly as a priority and something where there's a lot we don't know.

PRESENTATIONS – DAY 1

The following are notes taken from the meeting and links to the presentations.

TRANSACTIVE ENERGY SYSTEMS VALUATION

SPEAKER: FARROKH RAHIMI, GRIDWISE ARCHITECTURE COUNCIL

Farrokh proposed answers to some questions posed by PNNL. #1) What are the key drivers for deployment of TES? Enhance reliability and reduce operation costs (bulk and distribution system), improve environmental impact, and provide investment signals for clean energy technologies, all with minimal imposition on power system operations (I.e., no or minimal interventions). It was suggested that answers to question #2) What are the most relevant future power grid composition scenarios that should be considered? Include: increased use of renewable energy (RE) and demand response. He said in Hawaii, they are worrying about the duck curve becoming the Nessie or Loch Ness curve.

There are different levels of potential DSOs. Capacity auction results in New York. Distribution substations upgrade deferment in New York. Ancillary services and capacity values.

Investment signals need long-term marginal costs. Value of reduced down time. Need to make sure you don't have unintended consequences to grandma in her house. Question was asked whether we could/should monetize externalities and include in the signal. Yes, but it would require intervention. If it's outside the market, someone needs to approve the investment. How might TES address that? Insurance companies can come in to guarantee this house reliability and engage in a transactive energy market based on economic signals. In that case, no regulatory signals are needed.

Presentation Link: http://www.gridwiseac.org/pdfs/workshop_070715/oati_temp_20150707.pdf

PRESENTATION 2

SPEAKER: JAMES NEWCOMB, ROCKY MOUNTAIN INSTITUTE

In 2011 Rocky Mountain Institute (RMI) published *Reinventing Fire.* They used NREL's Region Energy Deployment System (ReEDS) model and some spreadsheets. In *Reinventing Fire* they developed a set of alternatives similar to NREL's 80% renewables alternatives. Coordination is key between RTO/ISO/customer. The piece of the framework that RMI brings is recognition of the institutional challenges, not just the technical ones. RMI's eLab is intended to improve institutional capacity across layers of the system. This is key to achieving the vision. Find ways to extend and support networks. RMI is also an advisor to New York's Reforming Energy Vision

(NY REV) looking at how the DSOs will ultimately shape up. Analyzing load defection and how actions might inadvertently encourage people to leave the grid or interact more intelligently with the grid.

Three key value drivers were discussed. First, and the most solvable problem, is to say we can aspire to create a value umbrella integrated across timeframes, locations, etc. The value umbrella includes things like energy, capacity, and ancillary services. The second set of value drivers has to do with resilience and reliability. Redefining reliability. Resilience – very difficult to value. What is the dependence of our economy on reliability? There are many things that could cause problems, including solar weather that could cause deep destruction. Resilience sits on the edge and shadows over our analysis. We need to push extra hard to build resilience into our methodology, even if it looks clumsy and inadequate in the early stages. It is important. It is tough to put a monetary value on resilience.

The third value driver discussed was the value of customer choice and local. Boulder has taken on the task to develop a municipal utility. Very difficult. A TES should build in the capacity to support those changes rather than thwart them. Build capacity and support for local choice. Make that an attribute from the beginning.

Implications to value design. A San Diego group is thinking about multi-dimensional solutions. San Diego Gas and Electric (SDG&E) is trying to figure out what rate designs will be needed. This is the type of process we need to build TE solutions. Vendors and aggregators are how the market will get there. Work with Tesla and Google.

Presentation Link:

PRESENTATION 3

SPEAKER: MICHAEL BENDEWALD, ROCKY MOUNTAIN INSTITUTE

Buildings to grid are an asset. EE and load flexibility. Megawatts and flexiwatts. Three things the buildings group at RMI are focused on: 1) Super efficiency – U.S. General Services Administration (GSA) push toward net zero building, 2) Commercial retrofit market – create technologies and business model to get low hanging fruit, and 3) Residential – single family homes are the #1 energy user in the U.S. Social behavior and energy transparency and key issues. They are also working in China. *Reinventing Fire* for China will be released later this month which proposes a plan for the next 5-years for China They are going to LBNL tomorrow to talk about implementation plans. Buildings as a grid asset.

Value proposition for energy efficiency and smart buildings and the commercial market for investor-owner and owner-occupant. Health and productivity. Well Building Standard certification for buildings. This will merge with LEEDS. A lot of overlap with energy efficiency and demand response (EE/DR). Owners can use equipment – lower maintenance costs, continuously commission buildings. There is added value owners can derive. For investors, there are the same values in these. Split incentives – green leases are emerging and taking care of a lot of these.

Second component of value – service from a power perspective. Johnson Controls Inc. (JCI) is layering demand response (DR) into performance contracts. This is a great opportunity for deploying transactive energy. Have EE providers start layering it into their projects. It can be costly to do that. It takes time and money to understand how it works. Can be different clients and contracts. We can address those costs and bring them down. This can create value. Who is engaged? Service providers/ESCO community, other service providers (AT&T, NEST, ABT Services), and trade associations.

Healthy buildings leads to reduced absenteeism, etc. LBNL has documented studies but there is a need for more data and research.

How can we value customer choice, where people want to go fast and are willing to pay more? How much more are they willing to pay? What is the choice value to them? Green districts/neighborhoods, universities, corporate campuses – value stream and willingness to pay for local distributed and green solutions. Keep them on the grid. There's a delta associated with not having a system with the capacity to be there to help solve the problems.

Presentation Link:

EPRI Integrated Grid Framework and Applications

Speaker: Erin Ebren, Eugene Water & Electricity Board

Erin presented on EPRI's Integrated Grid Benefit-Cost Framework. How to accommodate DERs and keep the rates low? Analytical process must be consistent, repeatable and transparent. Core assumptions are good – study timeframe, regulatory framework, resource mix, expected DER growth, environmental impact. Erin presented a value of solar study comparison slide that identified which studies looked at energy, capacity, customer savings, market development and other as values of solar.

Compared cost benefit analysis (CBA) framework to a simple "value of" approach. Should be looking at net-benefit, not just value. Someone pays the cost. You have to draw the bubble big enough to include everyone impacted. They are really interested in what the right time is and who pays the cost. Advantage if using a common framework is that you can compare different studies on the same value basis.

Equity issues – what happens for those who are not early adopters? Community value of resiliency. Eugene is looking at resiliency and the potential for the "big one" (Cascade subduction zone earthquake). Looking at the potential for microgrids where command centers would be and backbone generation and transmission system for hospitals, etc. When applying EPRI's framework, it doesn't have to be comprehensive every time. Look at the net benefits for society as a whole. Don't lose sight of how complex this is. A lot of customers won't adopt new shiny things and a lot of communities might not think they can afford this.

Is cost of carbon being considered? Can look at the social cost of carbon or the auction price. Human beings value proposition will be very subjective per person. We will never overcome that. Each person, region, etc. will be different. What's the value? Answer - "It depends".

Uncertainty will always be with us. We have to start somewhere. If unknowable things clump in one area, historically we have ignored the whole lot. When lack of "knowability" congeals, be really aware of it.

There was an eLab study – 15 solar PV benefit cost studies. Results showed: a) what a slow learning curve we are on, b) different states hire consultants to do different studies, and c) how can we learn from and cross pollinate all those to create methods? Not many have focused on security. Double counting is a real issue in many of the studies. Get the price right and be neutral about who provides the services.

Product redefinition – different approach to utility ratemaking. Cost allocation not aligned. Who pays is not always who benefits. Mutes all signals when costs are peanut buttered across everyone. Cost allocation is important.

Cost-based service has traditionally been impervious to valuation. Yes, that was true in the past. Where utilities are required to file grid modernization plans and then regulators approve them, are the regulators in essence, agreeing on or setting a price that reflects the value? A societally beneficial investment has no losers if the circle is drawn big enough.

Presentation Link: http://www.gridwiseac.org/pdfs/workshop_070715/epri_temp_20150707.pdf

EPRI Integrated Grid Framework and Applications

Speaker: Jeff Roark, Electric Power Research Institute

Assumption has always been that electricity flows one way. Distribution system (planning) is changing. Hosting capacity – the PV penetration level below which, you don't have to make any changes to the current system. Each feeder has its own hosting capacity. EPRI streamlined its hosting capacity method. It uses existing planning tools – CYME, Microsoft, Synergy. Hosting capacity is high near the substation. Impact areas: voltage, protection. Smart inverters are cheaper way to extend hosting capacity than reconductoring or adding voltage regulators, in terms of a 20-year leveled cost. A lot of value of smart inverter is avoided cost in the planning timeframe. CPUC- Rule 21 specifies all requirements for smart inverters. A standard may be the way to solve this kind of market.

EPRI has tried to develop a methodology that doesn't require a full-blown stochastic approach. Should utilities pick locations for DERs where there's the most hosting capacity? That's the way you would optimize by locations, but it's not really practical to do it that way. Customers and third parties are choosing locations. Utilities could host more if some capacity was curtailed through TESLA batteries. Hosting capacity can increase.

Through alternatives the need to replace a transformer can be deferred by a year or more. However, utility planning practices impact the potential to defer the transformer and conductor capacity. Another options is to opt for beefier designs now for increased flexibility down the road.

Presentation Link: http://www.gridwiseac.org/pdfs/workshop_070715/epri_temp_20150707.pdf

THE DISTRIBUTED SYSTEMS PLATFORM

SPEAKER: FORREST SMALL, BRIDGE ENERGY GROUP

Bridge Energy is providing ongoing support for the joint utilities as part of the NY REV process. The trick is to coordinate all the efforts going on. Regarding value, New York's stated policy objectives as listed in a white paper that led to the NY REV were:

- Customer knowledge and tools
- Market animation and leverage ratepayers contributions they have already made
- System-wide efficiency
- Fuel and resource diversity
- System reliability and resiliency
- Reduce CO2 emissions

Key capabilities needed to help achieve the policy objectives: customer empowerment, intelligent load management, DER integration, integrated planning, market enablement. Market needs to place a value on these. NY REV did just publish cost/benefit document with their rule for how to handle avoided costs. Massachusetts is doing the same kind of thing. Leaving it open how to value these things. In NY and MA, utilities are required to propose implementation plans. Utilities must make concrete decisions.

Information we need: voltage, current, consumption and production data throughout the distribution system, distribution hosting capacity, DER penetration forecasts, dynamic DER production forecasts, parametric values of DER by type and location (cost, characteristics, what it produces), and locational pricing. Big question to answer is how do we measure all this stuff? M&V in the systems with high DER penetration. What do you assume?

Value we want: lower energy costs for consumers, less wasted energy, better reliability and resilience, lower environmental impact, and better utilization of grid infrastructure.
The market is behind the platform.

Presentation
Link: http://www.gridwiseac.org/pdfs/workshop_070715/bridge_energy_group_temp_20150707.pdf

TRANSACTIVE ENERGY VALUATION ISSUES DISCUSSION

SPEAKER: ERIC GILBERT, NAVIGANT

Navigant prepared for BPA a regional business case to understand the potential for smart grid investments. They did a 30-year NPV type analysis. This is described in more detail on BPA's webpage. For the NW, the benefit of smart grid is $14.5 billion and the cost is $10.0 billion. This excludes traditional EE and other investments. To arrive at an overall value of TE, had to

break it down from a bottom up approach and then roll it all up. Constructing an investment baseline.

Structural issues. Advanced controls to solve problems. CPUC public tool – distribution deferral and RPS benefits. Model understands the asset sharing between them. It took 3 or 4 years to build the model. Built on Analytica platform. BPA has a copy of Navigant's model that was used to calculate the value of smart grid to the region.

Competition between EE and controllability from a total CO2 reduction perspective?
It is computationally intractable to look at each feeder in CA. Are the ISOs already operating TE markets?

Voltage control and reliability benefits to end users. Need a policy redress. PUC needs to say to the utilities: "We are going to give you money to do this." Need to carefully draw a box around what this/TES is for the purpose of valuation is critical.

Presentation Link: http://www.gridwiseac.org/pdfs/workshop_070715/navigant_temp_20150707.pdf

VALUATION OF TRANSACTIVE SYSTEMS

SPEAKER: PAUL DE MARTINI, NEWPORT CONSULTING

Value is directly related to time and location. Energy is not a distribution value. Value of distribution losses can be estimated today using historical data. Some values are mutually exclusive – one function may preclude another if assets are shared. Potentially diminished net value in terms of time and location with increasing granularity. TE is a composition of people, process & technology, implemented incrementally over time based on discrete value realization. Paul presented a table of value components. NY PSC released a white paper last week that contained a range of value components. What is incremental need relative to these values?

Avoided cost and benefit has two parts. Integration cost as the delta between gross value and net locational value. Energy is a bulk power system value. Distribution capacity deferral. Short-term DERs being installed are load-modifying, not supply side resources.

Sandia did a study on value in relation to time. Discharge duration. What time dimension do you need to capture value a component? Diminishing returns after a certain level of granularity in time and location. One of the best places to start in getting value is the distribution substation: breakers, poles, wires, transformers and apparatus. Potential value (in California) lies in the distribution system (deferred system upgrades).

Spectrum of TE systems/techniques. Stage 1: wholesale capacity reserve balancing. Stage 2: Ramping services. Stage 3: Full Market – T&D grid services
TE valuation system five step process:

1. Identify value components

2. Determine value based on requisite location and timing

3. Determine functionality necessary to realize the value
4. Identify diminishing value curve
5. Select a point on the curve that yields the desired net value

Then A) Identify the implementation sequence for each value component and B) Develop a transactive energy system functionality implementation roadmap – by utility or state.
What product would be most useful to current efforts in CA, NY, MN, and HI?

Presentation Link: http://www.gridwiseac.org/pdfs/workshop_070715/newport_temp_20150707.pdf

AN 'AIRBNB FOR ELECTRICITY': INSTITUTIONAL THEORY AND PRACTICE FOR A REGULATED INDUSTRY IN A TECHNOLOGICALLY DYNAMIC ENVIRONMENT

SPEAKER: LYNNE KIESLING, NORTHWESTERN UNIVERSITY

Transactive Energy, an "Airbnb for electricity" - phrase borrowed from an RMI blog. Institutional design and institutional framework and what emerges out of that. Organic ways individuals will be able to interact. From reliability toward broader concept of resilience. Think about economic experiments, not just field experiments.
4 muses:

1) Creative destruction is the essential fact about capitalism – Joseph Schumpeter. Utility death spiral.
2) Transaction cost reducing characteristics and the boundary of the firm – Ronald Coase. Digital innovation reduces transaction costs. Changes in transaction costs change the boundary of the firm. Falling transaction costs reduce the economic impetus for vertical integration.
3) Permission less innovation, focus on value rather than cost – Vint Cerf. How do you achieve a cleaner and more prosperous future? Lower barriers to innovation and experimentation – in a distributed and small scale way. Decentralized experimentation - what market processes really are is a process for trial and error learning. No innovation without experimentation. Decentralized market processes are innovation platforms. An Uber or Airbnb for electricity – a platform business model. Technology platform. Economic platform – heterogeneous agents with distributed knowledge and intelligence at the edge of the platform. "Bring together heterogeneous agents who only know their own needs, in a way that provides a mutually beneficial connection and you will profit."
4) Regulator as gardener not engineer - F.A. Hayek. Current system – persistent regulatory entry (and exit) barriers to experimentation and implementation. Old regulatory systems may now be getting in the way and creating exit (and entry) barriers. Low barriers to entry and exit are good and important concepts. Think about this when considering different regulatory constructs. Regulators cannot see the end from the beginning and should not attempt to know all details up front. Rather they should create the conditions, like a gardener, where the system can thrive. Compatible and enabling regulatory institutions competing around the distribution edge. Open interoperability standards – open and transparent rules.

Verge of transforming regulatory and organizational models. Regulatory barriers to innovation. What does it mean to be resilient in a broadly distributed system?

Presentation Link: http://www.gridwiseac.org/pdfs/workshop_070715/northwestern_temp_20150707.pdf

MOVING TOWARDS TRANSACTIVE ENERGY: E3'S EXPERIENCE

SPEAKER: JEREMY HARGRAVES, E3

E3 is working in NY, CA and HI. E3 is designing a technology agnostic tariff. One tariff to rule all tariffs – based on service provided, not the technology (DR, EV specific). Value-based tariff. Attribute-based pricing. Missing money – delta between the cost and value. Some bootstrapping consideration to enable the cost effective adoption by others. Menu of successor tariffs in New York – looking a lot at net energy metering (NEM), which is a problem tariff. They are looking to replace. Missing money – cross subsidization through rates. Need to include non-participant impact. There will be a transition period – implications for valuation over a timeframe.

Crux issue:

1. Collect embedded costs
2. Deciding on an end state
3. Deciding on a transition path

Integrated DSM model. E3 avoided cost framework. CA goal is to create a plug and play grid. CPUC Net Energy Metering Reform – alternatives to NEM tariff. Google is a perspective customer – result in bill savings and societal value. How do customers and the grid benefit? Hawaii – proposed transitional tariff. E3 is looking at limits to DG PV interconnection on the current HECO systems. In Hawaii, they need beyond basic smart inverter, they need control too. Storage may be better and more effective than retrofitting inverters even though it/storage is more expensive. Grid-scale storage may be the best choice.
E3 worked with Google on a home energy optimization study.

Presentation Link: http://www.gridwiseac.org/pdfs/workshop_070715/eee_temp_20150707.pdf

OPTIMAL COORDINATION AND SCHEDULING OF DEMAND RESPONSE VIA ECONOMIC INCENTIVES

SPEAKER: DANIEL KIRSCHEN, UNIVERSITY OF WASHINGTON

Presented a case study research project on Optimal Coordination and Scheduling of Demand Response via Economic Incentives. Predictive load optimization based on real time pricing (RTP). Consumer demand increase due to EVs will stress distribution system. Aggregator transacts on a sub-hourly basis with its consumers to: a) incentivize demand response, b)

maintain the grid within its limits, and c) determine offers and bids into the wholesale energy/regulation market. Combination of price-based and incentive-based DR yields the most benefits.

Aggregator can provide value to all entities:

- Utilities and/or distribution system operators - Aggregator provides significant investment deferral benefits by managing consumer loads, e.g. EVs
- RTOs/ISOs - Aggregator brings the retail demand-side into wholesale. More participation leads to more efficient markets
- Consumers - Aggregator compensate consumers for participation. Aggregator provides other value-added services

Conclusions: Consumer response depends on the value of monetary incentive offered. If some consumers do not participate, aggregator can still maintain grid limits. Interactions between a consumer and the aggregator is a contractual agreement.
It was suggested that you don't need full participation by all customers. 4-5% participation is all you need to get the value you are looking for.

Presentation Link: http://www.gridwiseac.org/pdfs/workshop_070715/u_of_w_temp_20150707.pdf

PRESENTATION 13

SPEAKER: KYRI BAKER, NATIONAL RENEWABLE ENERGY LABORATORY

NREL's Integrated Energy System Model (IESM) Discrete event simulation coordinator. IESM is a simulation tool with physics-based performance of technologies and buildings. Includes multiple retail markets and tariff structures. Provides market layer input to device HIL testing. HEMS minimize costs for air conditioning. Time of use pricing. HEMS minimize cost by precooling houses. Average residence saves 5% on electric bill. Market/tariffs need to evolve and supporting equipment is necessary.

Integrated Grid Modeling System (IGMS) – ISO-to-appliance scale electric power grid simulation. Analyzes system level interactions of distributed resources. Distributed PV, storage and demand response can be monitored at the grid scale. Future work is distributed control and optimization.

Presentation Link:

VALUATION OF TRANSACTIVE SYSTEMS

SPEAKER: ABHISHEK SOMANI, PACIFIC NORTHWEST NATIONAL LABORATORY

TES and the overarching concept of the value of DERs. Is performance of TE system embedded in its value and cost? I.e., is how well it works being considered in terms of defining

the value? Risk should be taken into consideration. From utilities POV, vendors are trying to sell a lot of different things. Demonstrate there is a new approach, architecture, and way to use data that is more cost effective and less risky than the monolithic old ways. The real value in this project is to show what new systems are cost effective.

Help inform utilities about what value is there. Is it true that only 4-5% of customers need to be engaged to solve the problem? Is that true even in a future with high DERs?
What system are you designing it for? Solve the immediate problem of cost effectiveness and then make it modular. A modular approach that builds over time. Be sure to include the social and environmental value.

Regulatory aspects need to be taken into be taken into consideration
In terms of scenarios, it was asked how many will be developed. Need diversity in scenarios. Need to model each scenario differently in each region. Australia looked at four. Should also look at WECC Advanced Scenario work. Four different futures. This work was funded by DOE. NIST is also putting together some scenarios.

TES will have the most value when there is the most variability. What assumptions will be made about the baseline in terms of institutional and market assumptions? Every area is different. 2 or 3 times more benefit from demand response when the technology is automated.
What about an approach of starting with location marginal pricing in the bulk system and going from there?

Once a finalized methodology is developed, can other value of solar studies be dropped into it and evaluated through it?

People who come are going to come with something. QER says value streams are not being digested by electric system. Minnesota comes in with a value of solar study. Don't get anywhere until everyone is looking at the same generally recognized methodology. Individual locations/utilities will just change the parameter value, but the framework is consistent. We should haggle over numbers not over methodology.

Wholesale market needs to understand what the distribution system is doing so there are no scheduling mistakes. Open question as to how we would accomplish this technically.
Would like framework to allow for a focus on shifting toward resilience in those susceptible environments that require high resilience. Two ends – power quality and resilience.

Presentation
Link: http://www.gridwiseac.org/pdfs/workshop_070715/pnnl_somani_temp_20150707.pdf

DISCUSSIONS – DAY 2

RECAP OF DAY 1

PRESENTER: ABHISHEK SOMANI

Key takeaway points:

- Basis of comparisons between different valuation methodologies need to be identified
- Temporal and locational value components associated with DERs and transactive systems need to be identified and reconciled
- Current cost of service model needs to be reconciled against "value of" model
- Distribution system (planning) is changing
- Different regions will have different parameters
- Regulatory and institutional uncertainty
- Scale and scope of studies: WECC/CA/NY/TX?
- Customer choice and other societal benefit streams need to be explicitly considered
- Value of resilience v/s reliability?

BREAKOUT SESSIONS – DAY 2

Meeting participants were subdivided into three groups to brainstorm answers to the following six questions that were sent out in advance of the meeting:

1. What are the most relevant future power grid composition scenarios that should be considered?
2. What are the operational and control objectives for an integrated grid in a high DER scenario?
3. How can the value associated with those objectives be quantified and monetized?
4. What is the relationship between the value of a transactive energy system from an operational perspective and a long-term planning perspective?
5. What are the value drivers for deployment of transactive energy systems?

Group answers to these questions are summarized below:

1. What are the most relevant future power grid composition scenarios that should be considered?

- UN Carbonization effort scenarios – paths to future state, trends, yearly look, avoid pitfalls, least cost transition to end state
- RMI – *Reinventing Fire* scenarios
- CSIRO scenarios and process
- E3 2050 report
- High resilience scenarios
- David Holmberg/NIST has list of use cases

- Key scenario drivers – regulatory, climate, adoption rate, economy
- Water starvation option
- Make the duration clear
- GHG scenarios – application/approaches may vary but GHG goal/requirement could be common
- Consider transmission system, distribution system, load, generation in scenarios
- Different typologies
- Interconnections
- Hypothetical scenarios based on current targets (CA RPS, etc.)
- Also look at oddball scenarios (huge drop in cost of storage, natural gas price peak, etc.)
- Look at 4 quadrants - low to high DER penetration on the horizontal axis and low to high DER aggregation through microgrids on the vertical axis
- Dimensions of scenarios - % wind, solar, storage (bulk and distributed), DR, EV, EE, Net zero building, load growth
- Consider seasonal variations – oversupply mitigation, hottest summer day, coldest winter day

2. What are the operational and control objectives for an integrated grid in a high DER scenario?

- Phase balancing/phase control below the substation
- Resiliency – can change the operation and control objectives
- Revised interpretation of reliability at the distribution level – need reliability criteria for distribution systems
- No regrets investments and standards (i.e., smart inverters - spatial and temporal considerations)
- Smart Inverter Working Group of California – good source of operation and control objectives
- Economically efficient (i.e., cheap), reliable, clean and transparent to end users
- IRPs or market forces
- Transactive energy is a way to trade – find proper scale. Will grow over time
- Need good forecasting - need day ahead distribution level predictions
- Look at Smart Grid Interoperability Panel (SGIP) TE use case work
- Renewable ramping
- Oversupply mitigation – desalination as an optional load
- Manage voltage/loading constraints

- Non-wires solutions
- Contingency avoidance

3. How can the value associated with those objectives be quantified and monetized?

- Refer to presentations from Day 1 - Distill literature and look for commonality
- Time, frequency, and location as critical dimensions – build into quantification of values
- Forward commitment, duration/latency
- Frequency
- Look at the right baseline - Counterfactual establishes potential value
- What value streams are accessible through the current paradigm? Regulatory, CBA, or other?
- Some things is makes sense to socialize
- Unbundle services to reveal value
- Southern California Edison set tranches of value for different sets of services based on needs of substations after San Onofre Nuclear Generating Station shut down.
- Does architectural analysis exist that can be built upon?
- Address adoption as well as availability
- Be vigilant in maintaining transparency issues
- Need for integration planning between distribution and resource planning
- Ability of non-wires solutions to meet distribution needs
- Quantifying risk/uncertainty
- If you build it, will they come?
- What adoption rate do you need to hit?
- Non-monetized value
- Declared prices
- Bids and offers
- External influences
- Policy drivers
- Stakeholder POV
- What services are required – can TES be used to provide? Products: VAR support, ancillary services and reserves (value for being offline)
- Flattening/locking the peak has high value as does being able to grow low utilization times

- At any point in time, which is greater? The cost of the asset or value of the asset? Look temporally
- Value of information that is available – new information available to distribution and bulk power operators. Real time telemetry and situational awareness. There is value. How to characterize?
- Continuous real time ELCAP
- BPA is finding big value of synchrophasers is in power plant characterization/tuning

4. What is the relationship between the value of a transactive energy system from an operational perspective and a long-term planning perspective?

- Trust
- Frequency, how often it is called upon?
- Platform to consider non-wires alternatives to expansion – look at avoided cost
- Local capacity signal – transparency and risk
- Confidence and predictability
- Real-time telemetry
- TES as part of core operating structure – how you do business
- Address in planning: load following, supply following, customer following
- Distribution planning – capital budgeting priority
- Bidirectional planning relationships. No longer just from BPA to utilities to customers – now utilities can plan and generate and shape and sell to BPA, and customers can sell to utilities
- Negotiated outcomes
- Regulatory business models
- Cost recovery and pricing are in conflict and need to be in balance
- Cost allocation and value streams need to be aligned

5. What are the value drivers for deployment of transactive energy systems?

- See presentations from yesterday
- Increase asset utilization
- Innovation/access to market
- Climate
- Choice in reliability levels

- Location based pricing and avoided cost by feeder. (See EPRI hosting capacity model) Where need it and where not – capacity, etc.?
- Importance of open communication standards to facilitate easier access to value streams
- DER penetration
- Beyond standard conservation
- Non-wires solutions
- Pricing to optimize siting
- Distinction in reliability levels
- Address uncertainty
- Opportunities for prosumers
- Managing variability
- Climate is of interest at multiple levels – even local/city
- Increasing/improve reliability through flexibility
- Extend transactive from bulk to distribution system
- Platform, opportunity to create value
- Drivers vary by region
- Marginal capacity
- Increase asset utilization
- Consumer choice
- New markets create opportunities for new economic activity (like Uber!)
- Being clear on energy and non-energy value streams. Transactions that provide a range of value – more clearly quantified and attempt to quantify the less certain categories such as resiliency.
- Leverage DER for one purpose (reliability) to capture additional value streams (i.e., price spikes). Aggregator likely to enhance penetration substantially
- Energy-water nexus and impact of drought on value, i.e., solar for desalination

ADDITIONAL INPUT – DAY 2

Group members were asked to offer their suggestions, using sticky notes, to questions posed to the group and printed on large pieces of paper that were hung around the room. Below is a summary of the questions and responses:

1. Who else should we be including in this discussion?

- Policy makers in reforming states (CA PUC, NY PSC and DPS, HI PUC)
- Utility regulators and state regulatory staff
- Utility representatives, particularly distribution utilities
- Innovative legislators
- FERC
- ESCOs (especially with economics experience)
- Environmental concerns
- DOE (EPSA, EE/RE)
- Other national labs – LBNL, Grid Mod Lab Consortium Valuation Team
- Edison Electrical Institute
- National Rural Electric Cooperative Association (NRECA)
- Canadians
- Aggregators, SW providers
- Big disruptive customers (e.g., Microsoft, Walmart and other large retailers)
- 3rd party developers (storage, PV, etc.) and 3rd party providers of EE and DR
- System operators and planners (ISOs, RTOs, WECC, PeakRCO, NERC etc.)
- For some parts of the conversation it may be useful to engage people from Tesla, Google, Enernoc, Advanced Microgrid Solutions, Spirae, etc.
- End use representatives
- Council of State Governments, National Conference of State Legislators
- Consumer advocates
- Vendors
- NARUC

2. What developments in national and state policy, business, technology, and research should inform this conversation?

- NY REV, CPUC proceedings on DER and DSOs, HI reforms
- TE interfaces and simulation/co-simulation interoperability (connection to NIST TE Challenge)
- State DSO activities
- Dynamic rates / ratemaking activities at the state level
- Regulation markets, 111(d), microgrids, changing utility business model, new product development for grid services, cost of solar

- NW Smart Grid Demo, AEP Smart Grid Demo, ARPA IE Network Optimized Distributed Energy Systems (NODES), DOE grid architecture work.
- Interdependencies – 1) natural gas and electricity, 2) electricity and ICT, and 3) water-energy nexus
- U.S. response to UN Climate Change Initiative
- Need regulators to contribute their thoughts (NARUC)
- Transactive energy research and demos
- EPRI Integrated Grid demo projects
- Need more clarity on end state we are driving to and how to stop. Milestones and signposts along the way to one of several possible future scenarios. Can be many drivers so don't draw your circle too small.
- Net energy metering proceedings in states (CA, AZ, MN, CO, etc.), other valuation efforts (CA More Than Smart, MA GridMod, etc.)
- Individual state goals, policies and regulations should be researched further and taken into account in these discussions
- ARPA-E Network Optimized Distributed Energy Systems (NODES) Funding Opportunity Announcement (FOA)

3. How can we best be contributing to others' efforts and how can they best be contributing to ours?

- Identify who is making contributions to this area and talk to them. More academic participants (identified through publications, white papers, etc.)
- Tie seminars to areas (regions/utilities) that are going to be looking at options. For example: Hawaii and their transition over the next five years is critical and they are looking for options, or CA RPS target dates
- Interface with DSO/DSP effort
- Communicate about how transactive energy can help address grid challenges
- Solicit utility feedback on the value of services to the system
- As you ID topics that require broad stakeholder engagement, feed this to SGIP
- Tie the future scenario simulation model development into the Transactive Energy Challenge
- GWAC transactive energy engagement and DOE ESPA Valuation
- Webinars to: NCSG, NCSL, IEEE, SGIP, etc.
- DOE efforts – need to get their attention, Grid Architecture, NY, CA, TX, MA, HI leaders/staff, simulation and modeling community
- Do literature search on prior work – create bibliography (no need to re-invent) list other key, related efforts (CA AB 327, NY REV, etc.), show how this work relates to this prior work

- Coordinate with other doing similar work. Can't you jointly publish or at least endorse the framework? (i.e., EPRI, Navigant, E3 and PNNL)
- Would be great value for someone to estimate the value of TE for NY State
- Conference calls or webinars with groups engaged in similar efforts
- GridWise Alliance
- Collaborative on scenarios, collaborative on elemental costs and benefits and cost-benefit calculations
- What does TE do for states with aggressive RE policy? Crystalize thoughts to bring them to broader audience
- Use DOE's unique position as a credible convener to bring together the people who are solving the grid modernization challenges in California, Hawaii, Massachusetts and New York. Keep it small, and try to facilitate information exchange while creating some critical mass.

4. How can this effort be meaningful to utilities, regulators, ISOs, etc.?

- Dialog – business case development, demo with simulation and modeling, input from them on our test cases
- Create a tool they can put their numbers in
- Point to opportunity to use valuation with stakeholder POVs to identify business model and regulatory disconnects
- Have more representatives from these places attend and report back
- Discuss market designs already in use and their relevance to Transactive Energy and the distribution system – lessons learned
- Solicit opinions on how regulatory system should evolve to include transactive energy
- Show values in concert with valid business models
- Treat it as an extension of transactive systems from wholesale/bulk power to retail/distribution
- Needs to be machine readable/automatable, has to have a computer face, not a paper face
- Creating a general framework (and worked examples if possible) for regulators to be able to assess the societal benefit of TE
- Robust numbers
- DER integration, social equity
- Create value streams and certainty for and about the future
- Understanding of utilities that transactive energy doesn't mean death
- Framing of benefits for utility and regulator buy in

- Talk in terms utilities and regulators are used to hearing
- Regional focus – similar issues in electric system
- Stakeholder engagement – make regulator, utility staff, ISO, part of the process
- Ask them how to make it meaningful
- Actual simulations that demonstrate feasibility and cost/benefits
- Draft PUC policies or docket questions
- Draft utility RFPs
- Vendor consortium bringing producers to market
- Propose a method that can contribute to regulatory discussions – something that can be used to compare approaches

5. What should we focus on next time?

- Details of the methodology **-** flesh out the model with a) simulations, b) trials, c) competitive architectures
- Business models/concepts that will drive
- Participant Clos Categorize grid services by value to system in varying conditions
- Refine the scenarios – no more than 4
- Use cases for TE system evaluation
- Being clear with definitions
- Tools for regulators, innovation development, comparisons of existing demo projects
- Valuation methodologies within the framework - CBA methodology**,** list value drivers, list metrics, prepare calculation methods
- Necessary regulatory and price barriers to overcome for technology adoptions
- Enabling technologies and policies
- Preliminary framework discussion
- How do we make the current distribution system transparent enough to expose values to a transactive system?
- How do we manage a transition? TE impact on utility business model - transition for utilities and regulatory process to get there
- Scenarios, modeling and simulation requirements, feedback on draft methodology
- Suggest bringing stronger focus to adoption and behavior on the customer and service provider side, otherwise it is an empty exercise
- Itemized list of elemental costs and benefits, mapping these among valuation schemes
- Establishing an “open alliance” on valuation and modeling framework

- Transparency of distribution system (utility engagement and buy in)
- Non-monetized values: list them, metrics, potential proxies for monetization
- Consideration of uncertainty in distribution planning
- Specific TE vs. non-TE comparison framework
- How TE practically fits in to utility planning
- The fundamentals – whatever the topics, trace back to our atomic, foundational elements

PARTICIPANT CLOSING COMMENTS

Each participant offered closing comments. Closing comments are summarized below:

- TE should be thought of not as a solution looking for a problem
- Need representation from other regions – PNW is so different. Need to think about business models so that regulators don't see this as a way for us to make a lot of money off of consumers
- We are trying to create a platform, but instead of competing, we need to get buy-in on the framework and worry about making money later
- Regulators and policy makers, legislators need to be involved because that is where the change begins
- Looking forward to seeing a draft of the valuation methodology
- We need a bigger tent. Utilities want new ideas – we need to get them on board. Be mindful of the industry, region. Need utilities in this discussion. Need regulators too.
- Move closer to building on what was done in the demonstration project and have a real system for people to see how it works. Need FERC involvement.
- TE is a platform. Assessing value (realized) is based on adoption. That conversation needs to be central to this process. At the household, TE might not be the reality. Will be driven by the Tesla and Nest.
- Bottom line is how this gets put to use. More approaches need to be on the table. Policy makers need to be here. Changes are rapid and require an innovative response. TE is part of the solution, but not all of it. Could be marginalized greatly if we can't show use/value, if we don't do it correctly. Scared of unnecessary complexity that we could create tools they already have. There is no need to reinvent the wheel – there are a ton of valuations out there we can use, just need to pull together the pieces. Need utilities.
- TE is a nebulous term. Similar to "big data" three years ago. Need to crystalize what TE is, and make it concrete for utilities, policy makers and get this understood by broader audience. Need to really define TE.
- Surprised by the amount of work already done on valuation studies. Challenge is to take it all into a framework and not reinvent the wheel, use what has been done.
- Might benefit from an open alliance for a valuation framework.

- This now seems more complex. How do we make the appropriate assumptions and simplifications and still reflect the complexities and give them a place in the framework? Perhaps we have a roadmap for expanding the framework and complexity.
- Have regulators in the conversation. Need to have this in a form they can digest.
- Want to see what is developed be usable by utilities.

Next Steps:

Another meeting will be held on this topic, with a larger group, in September of this year. The tentative dates for the follow-up workshop are **September 29-30th** and it will be hosted by ERCOT in Taylor, TX.

APPENDIX A - AGENDA

Day 1 – Tuesday, July 07, 2015

8:00 – 8:15	**Welcome and Introductions** *Ron Melton, PNNL* *Chris Irwin, DOE*
8:15 – 8:45 am	**Project Background** *Rob Pratt, PNNL*
8:45 – 12:00pm	**Presentations by Participants** • *Farrokh Rahimi, OATI* • *James Newcomb/Michael Bendewald, RMI* • *Erin Erben, Eugene Water and Energy Board* • *Jeff Roark, EPRI* • *Forrest Small, Bridge Energy Group* • *Erik Gilbert, Navigant*
12:00 – 1:00 pm	**Working Lunch: Presentation – "A Day in the Life of Transactive Grid"** *Ron Melton, GridWise Architecture Council Administrator, PNNL*
1:00 – 3:45 pm	**Presentations by Participants** • *Paul DeMartini, Newport Consulting Group* • *Jeremy Hargreaves, E3* • *Lynne Kiesling, Northwestern University* • *Kyri Baker, NREL* • *Daniel Kirschen, University of Washington*
3:45 – 5:00 pm	**PNNL Presentation and Discussion** *Abhishek Somani, PNNL*

Day 2 - Wednesday, July 8, 2015

8:00– 8:15 am	**Day 1 Summary** *PNNL*
8:15 – 11:15 am	**Group Discussion on Valuation of Transactive Systems** *PNNL*
11:15 – 11:45 am	**Summary and Next Steps** *PNNL*
11:45 – 12:00 pm	**Closing comments** *Ron Melton, GridWise Architecture Council Administrator, PNNL* *Chris Irwin, DOE*