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Valuation of Transactive Energy Systems Technical Meeting Proceedings

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About this Document

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INTRODUCTION

The United States Department of Energy (DOE) Offices of Electricity and Electricity Reliability and Building Technologies are 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. DOE has tasked Pacific Northwest National Laboratory (PNNL) with developing a valuation methodology for transactive energy systems (TESs), 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 September 29-30, 2015, at ERCOT in Taylor, Texas. 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 DERs, 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

These proceedings provide a summary of the technical meeting, including the presentations made, group discussions and the results of group work sessions. The following section contains a list of meeting attendees and their affiliations.

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WELCOME, RECAP OF PREVIOUS MEETING, SCOPE, AND DESIRED OUTCOMES

WELCOME

Chris Irwin from the DOE Office of Electricity and Energy Reliability explained that an important element of Transactive Energy Systems (TESs) is the harmonization of economics and engineering. At DOE, there is a lot of rigor in pursuit of valuation. Proper valuation of DERs and transmission and distribution systems is related to resilience. It is fitting that GWAC is hosting these valuation workshops.

Traditionally economics and engineering forces have been considered at different time scales and they only correspond at the decade level. Transactive energy (TE) is a mechanism that allows us to better align and synchronize value in time and space. Through an understanding of value, we can synchronize economics and engineering through control, planning, and other factors, but economic valuations lack interoperability; it is difficult to reconcile perspectives in valuations.

TRANSACTIVE ENERGY BACKGROUND

SPEAKER: RON MELTON, GWAC ADMINISTRATOR, PNNL

PRESENTATION: VALUATION OF TRANSACTIVE ENERGY SYSTEMS – TECHNICAL MEETING #2

Ron Melton kicked off the meeting with a presentation that provided a background on Transactive Energy (TE). The project is funded by the DOE Office of Electricity Delivery and Reliability, and the Building Technologies Office. DOE views transactive systems as a key enabler for engaging DERs in both the electric power systems and building energy management systems.

The goal of the project is to develop a valuation methodology for transactive systems that when applied, will yield cost and benefits of alternative scenarios that can be compared or ranked—costs and benefits that can be mapped to relevant stakeholders in order to understand the impacts from multiple perspectives.

It is important to note that TE is not an end unto itself, but facilitates coordination of DERs and other active elements of a modern power system. Devices will be making decisions whether we interact with them or not.

We need to be able to monetize operational objectives to be able to use them as a control signal. Economic time stamps are needed to help coordinate devices. TE allows us to harness flexibility that is available through distributed mechanisms to offset variability of increasing renewable resources. The value of a system needs to be assessed differently than the value of constituent components. One reason this study is important is because different studies come up with different values for the same systems. A common methodology is needed.

PREVIOUS TECHNICAL MEETING

SPEAKER: JULIET HOMER, PNNL

On July 7-8, 2015 GWAC convened an initial, smaller meeting on this project at PNNL in Richland, Washington. In addition to PNNL staff, presentations were made by Farrokh Rahimi (GWAC), James Newcomb (RMI), Michael Bendewald (RMI), Erin Erben (Eugene Water and Electric Board), Jeff Roark and Bernie Neenan (EPRI), Forrest Small (Bridge Energy Group), Eric Gilbert (Navigant), Lynne Kiesling (Northwestern University), Jeremy Hargraves (E3), Daniel Kirschen (University of Washington), and Kyri Baker (National Renewable Energy Laboratory). Proceedings from this meeting are available on the GWAC website, www.gridwiseac.org. Meeting participants agreed that a common valuation methodology could serve as a valuable decision-support tool for utilities, regulators and other policymakers in an increasingly complex energy ecosystem.

Some of the key takeaways from the first meeting included the following:

- Current valuation and resource planning methodologies don't consider temporal and locational value – this is important!
- Heterogeneity of systems and associated value is a reality – drivers/value vary by region and feeder; there is no one-size-fits-all value.
- Consistent, repeatable and transparent analytical processes are needed.
- Ability to compare studies on the same value basis is needed.
- Use of the same generally recognized methodology is needed.
- The value of resilience is important and difficult to quantify – the methodology should include resilience even if it is clumsy and inadequate at first.
- For investor-owned utilities (IOUs), regulators establish whether utilities can recover their costs.
- The case for transactive (or anything else) utilities want to do must be made to regulators.
- Regulators need to be part of the conversation.
- The important and hard-to-quantify value of increased customer choice and local control should be built into the methodology.
- Equity issues matter –impacts on non-early adopters and those on fixed incomes must be considered.
- Transactive systems are not the only answer.
- Ancillary services provided by smart inverters may be more readily achieved through equipment standards than transactive markets.
- Adoption needs to be part of the conversation; a methodology that will not be adopted has no value.
- Substantial value is derived through planning the time frame.
- Capital budgeting priorities are established through planning.
- Distribution system (planning) is changing.
- Current planning methods are limited.

- Vendors are approaching utilities with new products and services – the methodology could objectively show which are cost effective.
- Improved asset utilization and oversupply mitigation are valuable.
- Platform and markets can create new opportunities and value.
- Utilize tools that have already been developed – don't reinvent the wheel.
- Include more utilities in the conversation.

TRANSACTIVE ENERGY VALUATION METHODOLOGY – DAY 1

The following are notes taken from the meeting and links to the presentations. Notes represent presentations and ensuing questions and answers.

PROJECT CONTEXT

SPEAKER: JULIET HOMER, PNNL

PRESENTATION: VALUATION OF TRANSACTIVE ENERGY SYSTEMS – TECHNICAL MEETING #2

Juliet Homer described the overall approach and provided project context of PNNL's Transactive Energy Valuation project. In DOE's Quadrennial Energy Review (QER), energy priorities were developed. Valuation came down strongly as a priority. Many studies have attempted to determine the value of solar and other DERs. Existing valuation methodologies are not well suited for considering transactive/market-based resources. Representing impacts of transactive systems during valuations is challenging and valuation methodologies are not consistent, repeatable and transparent.

The goals of TESs are to

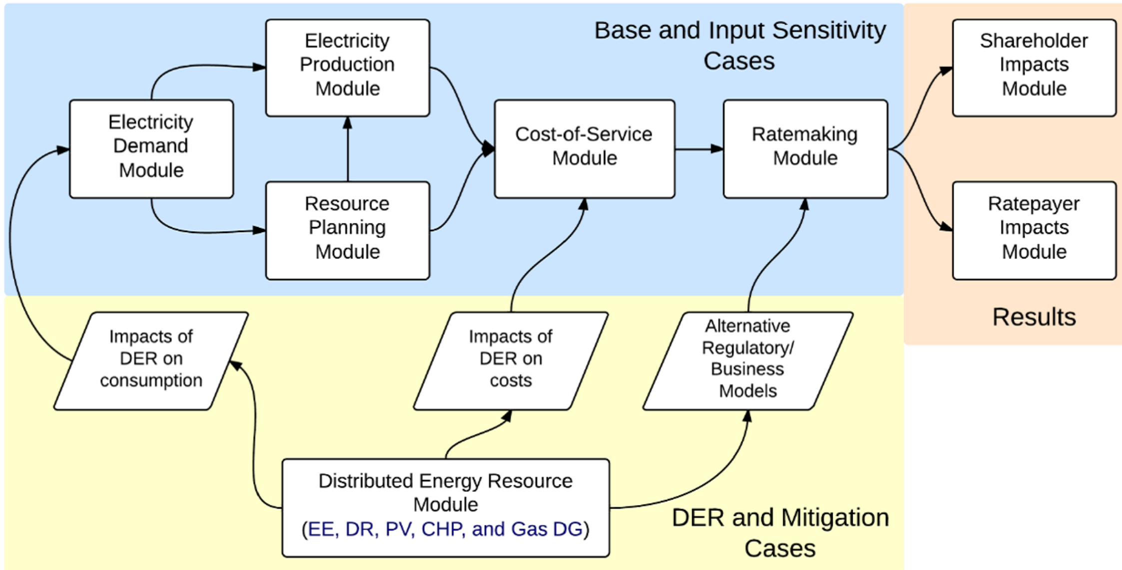
- provide a means for engaging and coordinating large populations of customer-owned, third-party, or utility-owned distributed assets
- use transparent, competitive means
- provide flexibility required by an adaptive, reliable, environmentally sensitive, and cost-effective future electric system.

The project desired outcomes are to

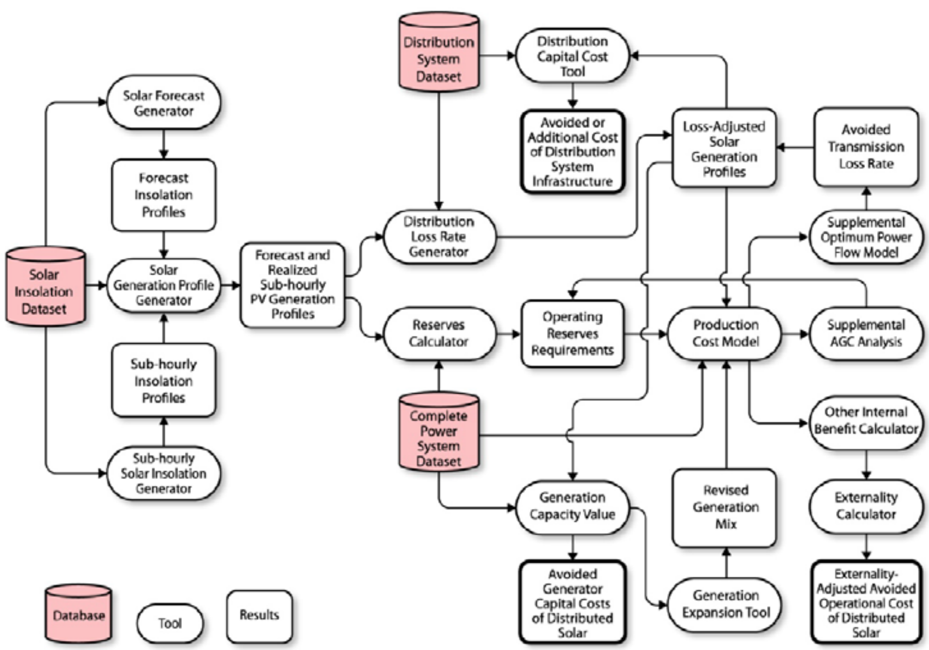
- create a foundational methodology that adequately considers transactive systems, from both the power grid and building perspectives
- consider all relevant stakeholder perspectives
- create a valuations methodology with a broad applicability for those designing and conducting comprehensive energy valuations and for those who want to compare studies and methods.

Valuation methodologies have been developed by others. The PNNL team reviewed different valuation methodologies. A few of the key ones are summarized below. Some are theoretical/concepts, others are actual executable models.

LBNL – Financial impacts of Distributed Energy Resources (FINDER) Model (Source: LBNL, http://emp.lbl.gov/finder-model)

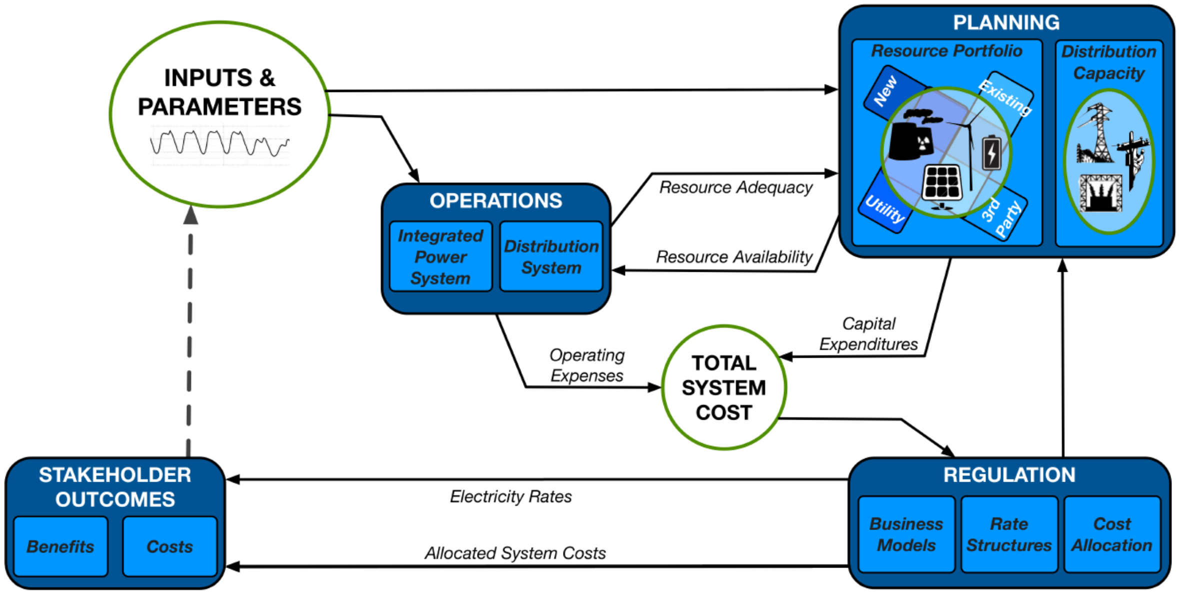


National Renewable Energy Laboratory (NREL) - Integrated Distributed-generation PV Value Study (DGPV). Process flow of an integrated DGPV study.

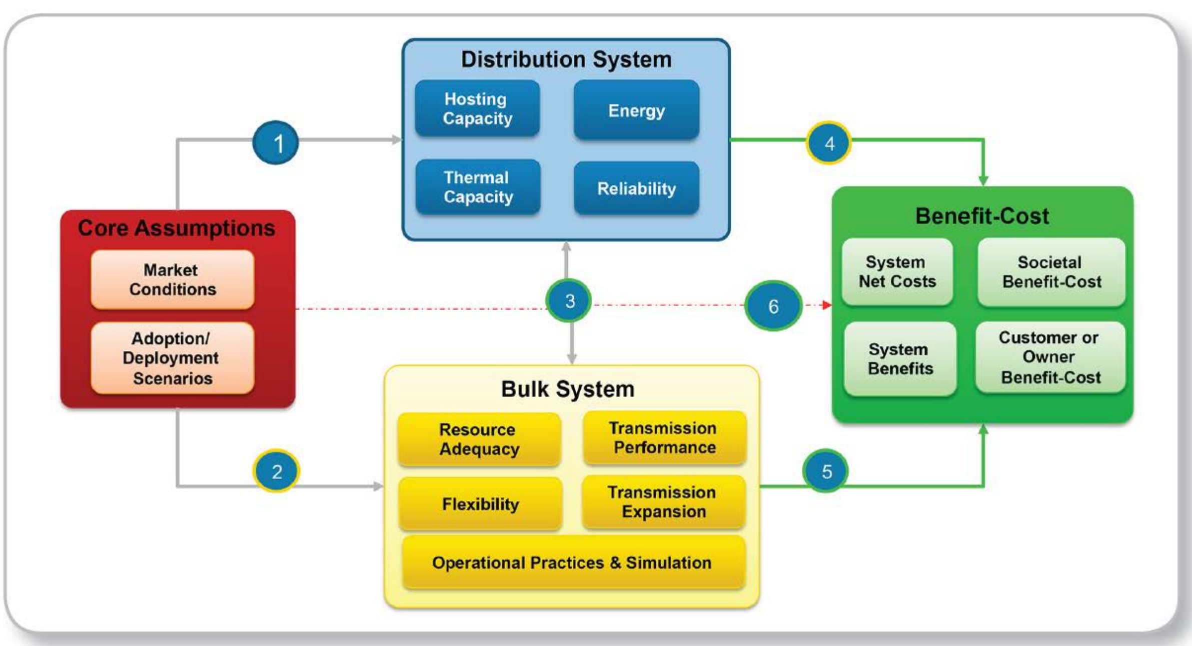


[Source: NREL "Methods for Analyzing the Benefits and Costs of Distributed Photovoltaic Generation to the U.S. Electric Utility System, September 2014]()

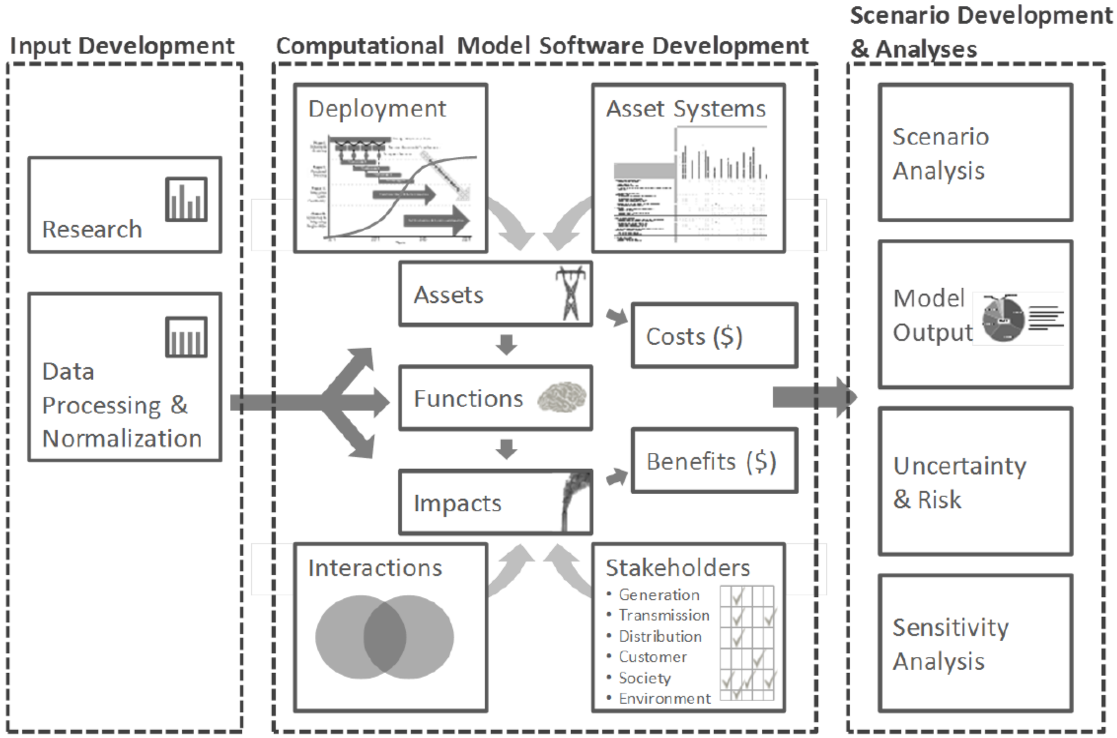
RMI - Electricity Distribution Grid Evaluator (EDGE) Model (Source: RMI, EDGE Model Progress Update, Spring 2014)



EPRI - Integrated Grid Framework (Source: EPRI, The Integrated Grid: A Benefit-Cost Framework, Executive Summary, Feb 2015)



Navigant - Smart Grid Regional Business Case for the Pacific Northwest – Overview of Model Structure (Source: http://www.bpa.gov/Projects/Initiatives/SmartGrid/DocumentsSmartGrid/Navigant-BPA-PNW-Smart-Grid-Regional-Business-Case-2013-White-Paper.pdf)



Of the models listed above, EPRI's and NREL's are conceptual models. The others are all executable models.

After analyzing these other valuation methodologies the following list was developed that identifies what we felt was missing:

- ability to value technologies or programs based on services provided in time and space
- standardized way to represent valuation methods
- transparent visibility of assumptions
- harmonization of terminology among practitioners
- extensibility to new situations and to introductions of new value streams
- systems view that will be needed to evaluate transactive systems
- clear baseline comparisons
- clear mapping to an extensible set of stakeholders
- organized repository for best valuation practices.

INTRODUCTION AND OVERVIEW OF METHODOLOGY

SPEAKER: DON HAMMERSTROM, PNNL

PRESENTATION: VALUATION METHODOLOGY FOR TRANSACTIVE SYSTEMS

Don Hammerstrom described PNNL's valuation methodology and provided a summary of the initial insights and results that were detailed in the "Transactive Valuation Methodology Insights" primer that was circulated to the meeting participants prior to the workshop.

Twelve Key Insights discussed in Dr. Hammerstrom's presentation included

1. Harmonize terms.
2. Adopt a systems approach to valuate transactive systems.
3. Separate methods' growth and operations processes.
4. Create clear baseline comparisons.
5. Allow for extensibility for new cases and value streams.
6. Make assumptions visible.
7. Track valuations using defined signal pathways.
8. Handle both abstracted and specific valuations cases.
9. Separate stakeholders' business and hardware.
10. Map benefits to an extensible set of stakeholders.
11. Adopt a standard way to represent valuations.
12. Establish an organized repository for best valuation practices and tools.

Methodology (see above linked presentation and paper for further details)

- In a succession of feasible operational scenarios, the set of feasible operations may be trimmed to single pathways based on the "optimality" of the series of scenarios.
- If operations meet requirements, the scenario is "viable."
- If the operations don't meet operational requirements, the scenario must be revised according to the actions allowed by the planning model.
- This eventually results in at least one feasible scenario.
- The new candidate scenario introduces new costs in Year n+1 if new assets were installed.
- Benefits should be stated with respect to specific stakeholders.
- Interplay between the defined connections is the key to defining operational engineering models and their requirements.
- PNNL's approach was heavily influenced by object-oriented methods.
- Unified Modeling Language (UML) was originally intended to standardize the design of software, but has also been used to design non-software systems and even business practices.
- UML is free and widely available.
- There is a need for a conceptual repository for documenting proven methods for evaluations; this may be a worthy recommendation to the DOE.

LUNCH PRESENTATION – DISTRIBUTED ENERGY RESOURCES IN THE ERCOT

SPEAKER: SAI MOORTY, PRINCIPAL, MARKET DESIGN & ANALYSIS, ERCOT

PRESENTATION: DISTRIBUTED ENERGY RESOURCES: FUTURE MARKET OPTIONS

Sai Moorty's presentation was on the impact of increased penetration of DERs throughout various regions, ERCOT's focus on DERs, and their creation of a concept paper titled: "ERCOT Concept Paper on Distributed Energy Resources in the ERCOT Region" about integrating DERs into the ERCOT, which was published in August 2015. The development of the concept paper involved discussions with various market participants, transmission and distribution entities, load servicing entities, generation companies, and power marketers. The intent was for the concept paper to serve as a catalyst for discussions among the ERCOT stakeholders and it describes the following topics:

- potential market options for DERs
- data requirements
- registration/interconnection requirements
- metering issues
- settlement mechanisms
- forecasting tools
- compliance metrics.

In addition to the concept paper, the Technical Advisory Committee (TAC) of ERCOT has set up a task force called Distributed Resource Energy & Ancillary Markets (DREAM). DREAM will continue to further refine and modify the ideals presented in the above mentioned concept paper, develop possible stakeholder consensus, report back to the TAC on issues that require clarification/guidance from the Public Utility Commission of Texas or a voting stakeholder body, and develop market rule changes.

Discussion continued on the content of the concept paper and on ERCOT's approach to integrating DERs into ERCOT operations. The following are notes taken from Dr. Moorty's presentation and the interactive discussion. For further details, please refer to the linked presentation.

Background

- ERCOT is an island connected to the rest of the United States through DC supplies, and also to Mexico.
- ERCOT has 25,000 MW of additional transmission interconnection requests for utility scale wind and solar; this does not include DERs.

ERCOT and DERs

- What does ERCOT ISO need relative to DERs?
  - awareness
  - knowledge of where DERs are and how much they produce
  - to perform DER mapping and map into ERCOT common information model
  - real-time or near-real-time operational data.

- Different potential metering types for DERs are being evaluated: unidirectional, bi-directional, dual, and traditional net metering. They are leaning toward dual metering, in which the load measurement is separated from generation measurement.
- Today DERs are settled on the applicable load zone (LZ) settlement point price (SPP) and are "passive" participants in prices.
- A case study is being considered where a local price would be provided to motivate DERs to start generating.
- In order to obtain a location price, need real-time information is needed.
- Currently there is less than 100 MW of DERs across Texas, but they anticipate future increase.
- Transmission planners need tighter information about the existing and future DERs, including for capacity demand reserve study.
- Stakeholders need to convene to address these issues.

Market Options

- Three market options are being considered:
  1) <u>Minimum/Status Quo</u>
     a. Price would settle at the SPP for the applicable LZ.
     b. DERs would self-respond to energy markets.
  2) <u>DER Light</u>
     a. Price would be that at local electrical bus(es).
     b. DERs would self-respond to energy markets.
     c. DERs would not be eligible for ancillary services market.
     d. Aggregating would be allowed.
     e. Metering would be separate (dual) for generation and native load.
     f. Telemetry and real-time or near-real-time information would be used.
  3) <u>DER Heavy</u>
     a. DERs would be treated the way a generator is currently treated.
     b. Price would be that at local electric bus(es).
     c. DERs would be dispatched based on security constrained economic dispatch (SCED) .
     d. DERs would be eligible to participate in ancillary service markets.
     e. Aggregation would be allowed.
     f. Telemetry to and from ERCOT would be real-time and near-real-time.
     g. Outage scheduling would be required.

Key Considerations

- ERCOT may consider a pricing run to keep all DERs from going on and off at the same time. NOTE: PNNL has successfully addressed this issue in pilots.
- DERs in ancillary services markets would require market rules for registration, qualification, validation, and aggregation issues.
- Common interconnection requirements would be necessary based on experience from areas with high penetration of DERs.

- Requirements for DER installations include two-way communication, anti-islanding protection, low- and high-voltage ride-through, low- and high-frequency ride-through, dynamic volt/VAR operation, ramp rates, fixed power factor, and soft start requirements.
- The potential biggest advantage is that if a DER market is adopted, there could be a lot of participation; this is very exciting.
- The potential biggest disadvantage is that zero marginal cost resources lead to suppression of prices and no more build-out of conventional resources to deal with intermittency.
- The ideal is true reflective prices that keep the right incentives.

Mixed Panel Discussion – Insights from Practitioners

Moderator: Steve Widergren, PNNL

Panelists: Gordon Matthews, BPA; Jeff Roark, EPRI; Cynthia Wilson, U.S. DOE/EPSA

Steve Widergren moderated a mixed panel discussion designed to gain insights on valuation from practitioners. The panelists briefly introduced themselves, shared their background and experience relating to TE and valuation methodology, and then were asked three questions on valuation. Below are the notes taken from the panel session and interactive audience discussion.

Panelists Introduction and Background

- Gordon Matthews, BPA
  - Started with Georgia Power Research Center and came to BPA in 1992
  - Manages the laboratory at BPA and coordinates all R&D spending for the agency
  - BPA has been heavily involved in TE demo projects
  - Gordon is interested in making this a functioning business model
- Jeff Roark, EPRI
  - Formerly with Southern Company in transmission and generation planning and in strategic planning at the Tennessee Valley Authority
  - Trained as a power engineer and worked in regulated and unregulated sides of the business
  - Has experience with cost–benefit analysis of smart grid technologies
- Cynthia (Cyndy) Wilson, DOE / Energy Policy and Systems Analysis
  - Background in public policy
  - The QER motivated a valuation of stability, reliability and flexibility of energy resources
  - Distributed photovoltaics (PV) and the utility industry asked DOE to help with valuation of DERs, particularly what should be done about net metering; this is still evolving
  - Partnerships needed to support efforts going forward
- Ron Bernstein, RBCG
  - Focused on the consumption side rather than generation or distribution

- Buildings and smart cities consultant; was previously in industry for 30 years in automation, interoperability, and integration
- Background in mechanical engineering, psychology, and philosophy

General Comments

There is a distinction between cost–benefit analysis and the cost minimization that planners have done:

- Cost minimization is a simplified form of cost–benefit analysis.
- Planners have constraints and have to minimize the costs of meeting those constraints.
- It gets more complex when you go beyond cost minimization and have to evaluate the benefit of devices—benefits are a new part of the analysis.

Question 1: What is the problem and what do valuations not provide?

"Tell me this is going to be as reliable as hanging aluminum on steel."

- New power lines are very expensive and often needed just to meet peak load.
- With utility planners, demand response (DR) and TE don't factor into the question.
- <u>The distinction between probabilistic (DR and TE) and deterministic (steel in the ground) solutions is significant from planner and regulatory perspectives.</u>
- Traditionally, DR was a way to get around a system failure of some kind.
- A price-based signal was provided to people asking them to defer doing clothes drying or water heater operation; DR is now seen as a crutch.
- What is a good way to convey that a transactive method is a sustainable way of doing business the majority of the time?

Regulatory implications of valuation are huge.

- If a regulator doesn't understand the technology, they don't have a lot of impetus to accept the technology; they need to trust it.
- How should transactive technology be brought from the bottom up and also help those who are making decisions from the top down?

Distribution planning discipline is just about to change—a lot.

- Utilities typically haven't thought about valuation and planning from the distribution side.
- Currently utility distribution planning is district-by-district.
- Distribution planning folks are often out in district offices; plans are usually short term and reflect the personality of field office planners.
- Planning standards are all very different.
- A lot of transmission people don't think down into the distribution system.
- Distribution system planning is about to become much more high profile and complex due to increasing DERs.
- EPRI is doing a 20-year-long distribution planning study looking at DERs and the technical issues that need to be solved; they are putting everything in terms of customer costs.

A system doesn't benefit a customer in and of itself; customers benefit from reduced cost.

- For a regulated utility, benefits mean minimizing customer costs.
- Some things reduce costs, such as deferring or eliminating a project.

- In some cases, DERs can actually increase costs.

From a buildings perspective, two-way communication and integration are missing.

- Buildings/facilities cannot affect change by themselves.
- What is the model that allows the buildings to engage and see the value of helping the grid?
- Now it is a push down instead of two-way.
- There would be more value streams if there were more resources interacting with each other that are aggregated to provide solutions to the grid.
- Energy audits that address more than energy efficiency would be helpful.
- Technology is there, but programs and incentives aren't.

Question 2: What's the main thing you are looking for from valuations? What do you expect to get out of it?

Adaptability and complexity

- Things change; we need to learn how the system will adapt over time.
- Changes include adding a building, removing a building, or adding a new piece of equipment.
- Valuations can't be fixed, they have to have flexibility, e.g., a software application that can adapt to changing circumstances in real time.
- Most models are not adaptability or complexity models.

Limitations of models and San Diego 24-hour blackout in September 2015

- It's important to gain insights and understand sensitivities rather than just rely on models. To have one single answer from a model really cheapens the complexity and elegance of the whole thing.
- Things don't always go the way you think they will.
- The valuation needs to account for unexpected events.
- Every few years, something comes around and changes everything; models can't predict that.
- The week of September 21, 2015 was hot in San Diego.
    - San Diego Gas & Electric (SDG&E) called a *Flex Your Power* DR event for three days in a row.
    - The fourth day they didn't call an event, and that resulted in a blackout almost 24 hours long.
    - This was a modeling issue.
- There is a valuation proposition of when you call a DR event.
- Who is going to be responsible when the model doesn't work that day?
- Planners would say, "If I had built steel in the ground, I wouldn't have to worry about this happening."
- A 24-hour blackout is a huge cost and negates savings of avoided construction costs.
- Planners often believe a deterministic solution is superior to one based on probability.
- TE is not a tool in a planner's tool kit.
- No one wants to be the one held responsible in San Diego when the lights go out.

Planning and day-to-day operations

- Systems need to be interoperable, but because of future uncertainty there can't be perfect decision making on capital investments.

- We need to ask whether we are really displacing something, and what is the value?
- In New York, Consolidated Edison avoided needing a big substation because they implemented instead a microgrid and transactive system.
- EPSA wants to see enough information at the table so that issues that are not issues will disappear; they want to bring the "noise" level down on technologies and whether they are accepted or not.
- In many cases, analyses are not being fairly conducted; people cherry pick.
- Political noise is not good for implementation of clean technologies.
- It would be helpful to help regulators and policymakers sort through the noise.

Question 3: Is there a way there could be more transparency to how things are being conducted?

Widely understandable principles are needed.

- When valuations are conducted top down, principles and value are easy to identify
- When valuation is considered bottom up, (i.e., where resources are located, what would DERs displace, how are they operated) it becomes much more difficult.

What you get is based on who it comes from.

- Sometimes technical people don't understand the economics.
- If we can have nontechnical people looking over the shoulders of technical people, this can help to make jargon more transparent and understandable for regulators.

Collaboration and clear common language are needed.

- It is not going to be one group figuring out transactive and another figuring out renewables; it needs to be integrated.
- If we can start to drive transparency and common terminology, then we will be able to make a difference.
- Transparency, terminology, and language at the level a grade-school person can handle are needed.

Group Discussion

- Does anyone really check valuations that have been done?
  - Not really, public utility commissions (PUCs) could use support.
  - There is a lot of "gaming" of numbers.
  - Many PUCs are understaffed.
- We have a very fractious industry; with deregulation, it's hard to get all the participants in the room.
- The public understands more and more that we need to do something different in the next 100 years.
- How can we improve trust in the models?
  - We can always get an answer from models, but trusting them is another thing.
- Transmission and distribution service providers, energy service companies (ESCOs), and other third-party service providers have different financial agendas and pictures.
  - If utilities are planning around ESCOs and third-party providers, they are no longer planning based on their own profit motive.

- Uncertainty grows a great deal when you put others in your plan.
- People will participate when they see an advantage; we need to know what will bring them to the table.
- Describing alternatives from the technology point of view may be conflated with companies having their business model disrupted.
- There are two different kinds of entities (load-serving entities vs. ESCOs, etc.) with different financial and business objectives; how do you incorporate those within a common planning horizon?

- Does the regulatory model need to change?
    - There are societal interests at play here that are bigger than just regulators.
    - It may no longer be appropriate to have least-cost options drive the process.
- EPRI is working on the value of resilience and reliability along with power quality
    - Entities that are spending money on resilience are basing decisions on proxy impacts because resilience impacts are not easy to quantify.

Value of Transaction Building Energy Systems

Speaker: Chad Corbin, PNNL

Presentation: Value of Transactions Building Energy Systems

Chad Corbin presented on the value of transactions in building energy systems. Building energy systems, including space conditioning and ventilation, hot water, refrigeration, and lighting systems, dominate electricity consumption nationally and therefore represent the largest opportunity for transactive systems to provide grid services. Transactions expose potential opportunities, which are defined by their impacts. Transactions occurring between these systems may be broadly classified by the transacting entities. Dr. Corbin continued to discuss different types of building energy transactions, mapping impacts and relationships, modeling impacts, quantifying the benefits—both economic and non-monetary—and the value of comfort. Following are the notes taken during the presentation and interactive audience discussion.

Building energy systems link grid and building benefits.

- McKinsey & Co. estimate a value of $59 B/year in grid-ready appliances in residential and commercial buildings.
- The purpose of many proposed transactions may be to help the grid, but non-energy benefits must be favorable to the building.
- No transaction will endure if it is net unfavorable to any of its stakeholders.
- Transactions expose these benefits to both stakeholders.

For buildings, non-energy costs dominate, yet buildings consume the majority of electricity nationally.

- Getting these relationships right is critical.
- Grid benefits are relatively well understood.
- Evaluating non-energy benefits is a greater challenge.

- A methodology requires that impacts and relevant stakeholders be mapped in order to assign benefits. The relationships are complex.
- Feedback loops exist.
- Direct impacts to buildings have impacts on other stakeholders.
- Expected impacts inform model choices.
- Quantifying building impacts may be appropriate in some cases.

Models and assumptions should capture change.

- change in occupant behavior
- change in equipment performance
- retrofit due to failure
- change in building usage
- change in building codes.

Quantification of benefits exposes new opportunities to transact.

- How do we determine general value to uncover opportunities?
- Benefits represent potential, possibly new value streams.

Detailed modeling highlights what can be done concurrently.

- Concurrency is a function of the scenario and the system design.
- The time and the location of an asset determines its availability.
- Buildings are not as “simple” as batteries; they have operational constraints that must be considered.

Transactions

- We are looking to address impacts of co-management of energy and non-energy benefits and cost efficiencies available when we address both energy and non-energy benefits with the same asset systems.
- By tracing the transactions down to impacts and their relationships, we can see where potential exists.

Buildings Discussion

- In terms of planning and operations issues for buildings, a lot of work has already been done.
- Good non-energy benefits work has been done by LBNL and RMI.
- Building owners will ask: “What’s in it for me? What would you pay me to do that?” Incentives drive behavior.
- Someone may elect to shut their building down for two hours rather than operate it if the cost of lost productivity is less than the cost to operate.
    - Revenue mechanisms would need to be in place.
    - How does that lost opportunity fit into a building operations system?
    - How much load in commercial building is flexible/dispatchable?

HANDS-ON EXERCISE #1 – ENERGY AND BUILDING SERVICES THAT ARE / ARE NOT SUITABLE FOR TRANSACTIVE SYSTEMS

FACILITATOR: JULIET HOMER, PNNL

In hands-on exercise #1, the group was divided into five subgroups. Each subgroup was provided a series of tables to fill out. They were asked to identify grid services and building services that lend themselves well to a transactive approach and grid and building services that did not lend themselves to a transactive approach. The summary table below is a synopsis of the results of the working group discussions.

Table 1: Energy and Grid Services that Lend Themselves Well to a Transactive Approach

Energy or Grid Service	Technology that Provides the Service	Participants in Transaction	Measurement or Signal that is the Basis of Transaction	Basis for Monetization
Energy (hour ahead or longer)	Generation (including DERs), storage, DR	Generators, utility, load aggregator, distribution system operator (DSO), ISO	kW, price, control signal, or event notice	Gross output, clearing price, auction, bilateral price negotiation, swap
Energy (real-time/ imbalance)	Controllable load (a subset of generation)	Subset of generators, utility, aggregators, ISO, DSO	kW, price, control signal, or event notice	Gross output, clearing price, auction, bilateral price negotiation, swap
Reducing transmission and distribution congestion – Peak and off-peak demand reduction	DERs, DR, loads	Customer or flexible load, DSO, ISO	kW, price, control signal, or event notice	Avoided cost, negotiated price discovery mechanism, bilateral swaps
Feeder balancing and substation reliability	Customer loads, other DERs	Customer, DSO	Phase, kWh/time	
Spinning and contingency reserves	Customer loads, other DERs	Customer, DSO, ISO	kWh	

Frequency support	Fast acting DER, devices with flexible load	Customer or device owner, DSO, ISO	AC frequency, price, kW/kWh	Auction – not real-time, cost reduction
Black start	On-site generation, storage	Customer, DSO	kW/kWh	
Deferral of construction	Flexible load and generation	Customer, utility	Power monitoring and control	Cost reduction
Voltage and VAR support / reactive power	PV with inverter, DR	Customer, DSO (+ISO?)	Volt/VAR imbalance on feeder	Avoided cost of mitigating imbalance
Ramping	Loads, DERs (microturbines, variable speed drives)	Customer, DSO, ISO	kWh/time	
Communica-tions, connectivity and data	Customer or third-party communica-tions	Customer, DSO	Mb/sec and quality	
Islanding	Customer resources and distribution system equipment (e.g., IntelliRuptors)	Customer, DSO, ISO	kW or event signal	Portion of avoided lost revenue

Additional Input

- Almost anything can be transacted as long as there is location visibility, two-way communication, and good instrumentation for measurement and verification.
- The more firm energy consumption commitments are, the more valuable they are for planning and reliability.

Table 2: Services for which TESs are Not Well Suited

Energy or Grid Service	Why TES is Not the Best Approach	Preferred Alternative Method for Providing the Service	Comments
Bucket truck services	Require intensive up-front investment	Standard service – built into rates; utilities contract to meet industry and government requirements	
Safety	Not negotiable / must have		
Security – cyber/physical	Not negotiable / must have		
Resource planning	Too complex, multiple interests and captive jurisdictions with human value system involved	Multi-stakeholder processes that address reliability, resilience, flexibility, sustainability, affordability, and security	
Transmission planning			
Physical infrastructure – poles and wires			
Business as usual • **reactive support** • **voltage support** • **frequency support**	Local phenomenon and rapid/automatic response required. Can be provided easily and efficiently with standard equipment	Batteries and smart inverters can be designed to perform these functions by default, without the need for individual transactions	During unusual/non-business-as-usual conditions, transactive system could provide more than day-to-day reliability support

Additional Input

- Services that don't lend themselves to locational visibility and two-way communication are not ideal for TES.
- Alternatives are superior where policy and regulatory mandates make TES untenable.
- TES is not ideal where good measurement and verification instrumentation is not available.
- TESs are not suited for situations where transaction costs and setting up and configuring the transactive mechanism are prohibitively time consuming and expensive relative to payoff.

Table 3. Building Services that Lend Themselves Well to a Transactive Approach

Building Service	Technology/Action that would Provide the Service	Participants in Transactions	Measurement or Signal that Serves as Basis for Transaction	Basis for Monetization
Regulation services – load balancing	Building automation systems (BASs), energy contracting system	Energy engineer, procurement staff, ESCO, utility	kWh	Energy costs
Demand response	BAS	Building manager, energy manager and ESCO, utility	kWh, kW	Energy costs
Comfort	BAS, heating, ventilating, and air conditioning (HVAC), human resources (HR)	HR, building manager, energy engineer	Sick days, work hours	hrs./worker
Productivity – commercial and industrial	HR & process/Industrial control systems	HR, building manager, energy engineer	Sick days, work hours	hrs./worker
Operational efficiency systems	Energy management system, enterprise energy management system, energy information management system	Building manager	Alarms	operating expense (OPEX), equipment
Diagnostics and fault detection	Analytics system	Building engineer, scheduler, truck rolls	BAS data from systems	Cost savings, $ OPEX
Reliability, microgrid, resilience	Building management system	Energy manager, building manager	Uptime, alarms, status	OPEX, production
Carbon footprint, green, sustainability	Energy and sustainability systems	Sustainability officers	CO_2, kWh/x	CO_2 offset, $/kW

Table 4. Building Services for which TESs are Not Well Suited

Building Services	Why TES is Not the Best Approach	Preferred Alternative Method for Providing the Service	Comments
Security – physical/cyber	No optimization – acceptable risk policy implications	Business as usual/policy	
Safety	Not negotiable	Business as usual/policy	
Environmental – water, gas, sewage	Health concerns	Business as usual/policy	
Flexible building design and usage	Unpredictable scenarios	Policy	Future use may bear no relation to current use or current alternatives. Might use TE with "must run" option. Human decision approval required (not predefined by value preference)
Human resource & locational event services	Human-in-the-loop required	Policy	

Day 1 Wrap-Up

Speaker: Ron Melton, PNNL

- Transactions can go beyond energy and money.
  - In Carlsbad, California, there are customers that want to tie their home PV systems to a local seawater desalination plant.
  - They want to put extra PV on their roof to supply the diesel plant and then get credit on their water bill.
  - This would be a three-way transaction.
- A revelation from today is the planners' mentality with respect to models; we will need to understand and tackle that.
- Probabilistic control, not deterministic control, is the rule and probably will be the rule going forward.
  - There is a need to start to figuring out what the defects are.
  - Aircraft today are moving toward probabilistic controls, not deterministic controls.
- This gets to the heart of the people issues we are going to need to think about.

- Change can be messy.

Discussions – Day 2

Recap of Day 1

Presenter: Juliet Homer, PNNL

Presentation: Day1 – Key Takeaways

Day 1 - Key takeaways

- Key takeaways from Day 1 are detailed in the linked presentation above.
- Meeting participants offered the following additional comments:
  - Clarifications regarding modeling
    - It's not that modeling shouldn't be done.
    - Modeling can help determine how systems work and provide insights on a system.
    - With folks who have been around awhile, there is some disenchantment with top-down models.
    - Don't take the results of models too literally—things always change.
  - Least cost is a subset of cost–benefit; least cost should not be used alone.
  - Regulatory commissions currently look at least cost in the short term.
    - Long-term life cycle costs and look at social factors need to be examined.
    - This is the change in the regulatory model that is needed.
  - Instead of dispatchable buildings, the issue should be at what price a building is willing to be dispatchable.
    - How much flexibility is in commercial buildings?
    - Could that be changed with use of a transactive system?
    - A rolling brown-out could be considered a case of flexibility.
    - Maybe at the right price, everyone is flexible.
  - What are the *characteristics* of loads that can be negotiable?
    - Load characteristics might be a good starting point.
    - Characteristics are functions of time and circumstance; e.g., water. heaters and air conditioners have different characteristics.
    - Maybe the characteristics are what is transacted.

CONTINUED DISCUSSION ON VALUATION METHODOLOGY

SPEAKER: DON HAMMERSTROM, PNNL

Connectivity Diagrams

- Does the connectivity diagram show where transactions occur?
    - The connectivity diagram shown previously only shows connections by copper.
    - Connectivity diagrams allow for specifying entities at some level of abstraction.
    - Connectivity diagrams are the basis for all the things to do with balance in the system.
- Not all generation is tied to the transmission or distribution system; DERs exist now where you have generation tied right to a customer.
- Default TE that currently exists is our customer bill.

Connectivity and Management

- There are functional relationships between connections on the connectivity diagram and hierarchical management relationships.
    - There is a functional relationship between the power connectivity diagram and the connectivity diagram for building domains.
    - Functional relationships between the arrows are the basis for the operational models.
    - Hierarchical management relationships also exist and are important.
    - In terms of operational models, there's the copper conductivity model and then orthogonal management hierarchy that needs to be understood.
    - Financial connections are also layers of connectivity.
- Microgrids could be managed using transactive systems.
    - Vendors don't want anyone touching their systems, but the microgrids could be interfaced with other systems transactively.

Time, Space and Scale

- If you can't expose and document the value stream in terms of time and locations, you can't access it. Will the framework property expose the value and where and when it exists?
- There is a scale where transactions make economic sense. What is the sweet spot?
- Management systems inside buildings are often siloed, but when you get to the smart grid or a microgrid within buildings, they need to be interactive. Transactive systems can be the energy glue between silos.
- Vendors don't want others touching their systems. Vendors today offer solutions, but they don't know how to manage cogeneration and HVAC. People operating cogeneration and HVAC are siloed as well. These present a good opportunity for education and integration.

- If you can't document value streams in proper resolution, then you can't access them. TE is a value access mechanism for this.
- Looking at methodology at an abstract level makes it hard to make a judgment on whether it is correct or not; a specific example would help the discussion a lot.

Worked Example of Methodology

Speaker: Don Hammerstrom, PNNL

UML Activity Diagram

- An activity diagram of the Olympic Peninsula Project was shown in UML format.
    - The diagram shows the places transactions exist and how you formulate those transactions.
    - Lines are pieces of information.
    - Detail in each box shows how functions are being used.
    - Inputs are override status, outdoor temperature, and thermal properties of residents. People's choices are very difficult to model.
    - Other inputs include the residential thermostat set point.
    - In the Olympic Peninsula Project, an agent made the change, not the customer, based on pre-established customer settings.
    - Value is dynamically changing. The TES managed their comfort. The agent did the transaction.
- This is a start point to an end point.
    - At some stage there is a decision point and if certain criteria aren't met, you bring it back to the start and adapt.
    - You could go back to your agent or transactive system and adjust the comfort setting to adjust your bill.
    - It is a relational system that adapts over time with feedback loops that goes all the way through.

Mixed Panel Discussion – Predicting and Measuring Value

Moderator: Steve Widergren, PNNL

Panelists: Al Galiunas, Navigant Consulting, Inc., Stephen Knapp, Energy Alternatives Solutions, Inc., James Sherwood, RMI

Steve Widergren moderated a the second panel designed to facilitate dialogue on predicting and measuring value. The panelists briefly introduced themselves, shared their background and experience relating to TE and valuation methodology, and then were asked two questions on valuation:

1. Does the valuation work you are engaged in fit within the methodology that has been presented?
2. What needs to change in the way you do your valuations today to handle a transactive approach?

Below are the notes taken from the panel session and interactive audience discussion.

Panelists

- Al Galiunas, Navigant Consulting, Inc.
    - There is a long history of describing methods for cost–benefit analysis.
    - When everyone agrees to the method, there is less pushback from regulators.
- Stephen Knapp, Energy Alternatives Solutions, Inc.
    - Energy Alternatives Solutions are building two optimization models:
        - One is the power system.
        - The second is a communications array needed at the utility substation so the DSO knows what's happening in real time and how to dispatch.
- James Sherwood, RMI
    - RMI has been focusing on valuation since its inception.
    - They are starting to look at buildings as DERs themselves.
    - RMI is working on New York's Reforming the Energy Vision (REV) - to answer what is the value of REV, they must understand the value of resources playing in the market and the baseline.
    - To understand the impact of rate design, they must understand the benefits and costs of resources at their disposal.

Question 1. Does the valuation work you are engaged in fit within the methodology that has been presented?

- The framework aligns with how RMI is approaching it in terms of interconnections between different modules.
- Overall the methodology has some nice concepts, flows, and processes; the devil is in the details:
    - 1) power system design 2) modeling 3) optimization of software
    - Communication infrastructure is key.
    - Look at alternative loads and generation alternatives that mitigate regulatory and environmental risks.
- We are interested in how to communicate through the substation to the prosumer.
- An important issue is how you make decisions about what to cut out, because you can't look at everything:
    - how to make decisions on prioritization
    - how to make it very clear when you have cut things out.
- Important items include common language, a consistent baseline, and getting clarity on the characteristics of the grid that is currently in place.
- Watch out for double counting, particularly when services and benefits are shared across different entities.
- Clarity on a common language and a consistent set of inputs would be helpful.

Question 2: What needs to change in how you do your valuations today to handle a transactive approach?

- It is not a challenge to adapt results to transactive systems, rather it's about taking results and applying them to transactive systems:
    - More specificity in what the model looks like will be needed.
    - The valuation methodology would not need to be adopted; it is the models that need to be adapted.
    - The value is the same value; it is just that it would be operated differently.
- Frequency of performing valuations would need to change when considering transactive
- The TE market is heading to where the commodities market went - building a market that has transparency of discovery:
    - Typically, it has been fixed infrastructure and boundary and you can control it.
    - It is moving to a more flexible system and creating a market in energy based on commercial situations, not physical infrastructure.
    - How much a counterparty is willing to pay points to value.
- Difference between modeling today and the future is that models will be more probabilistic:
    - Today you are modeling physics but with TE you are modeling more agents and interactions.
    - What about learning systems? How do you capture the value of a learning system when you don't know what it is going to learn and how it is going to interact?
    - Behavior is a key aspect and tricky to model.
- If models can be built and validated effectively, the probabilistic models can have more certainty.
- We have not previously considered the planning and modeling people at the utilities as people we need to talk to.
    - They are the ones who make decisions about the checkbook.
    - They make things move.
    - They need to know, in their modeling study, what the loads will be and how they will be utilized.
    - Need to think about the decision-makers' process – who are going to be the participators in evaluating that and doing validation?
    - Evaluators need to reach out to practitioners who are going to implement this.
- Now most valuations are mainly internal
    - Panelists agree with involving stakeholders, including vendors and customers.
    - It is important to get stakeholders involved to understand where the technology is heading?
- Consumer behavior is changing now
    - How should that be put into the models and how should the reliability there be valued?
    - Value is how much someone is willing to pay: add that into the methodology.
    - How to model volition is a challenge.

- How should the flexibility in a building be modeled? This is a gap in many approaches.
- How do we include the cost of communication/engagement infrastructure?
- New technologies need to be better accounted for and we need to properly value the new resources.
    - Where in the framework would you better account for new technologies?
    - Navigant research group looks at what is happening in the market place; they have to model each new technology separately.
    - It is important to establish a baseline.
    - Technology has grown very quickly, and consumer behavior too; those variables need to be accounted for.
- Panelists support an object-oriented approach that is adaptable to new approaches.
- Batteries and PV are fundamentally the same, we just need to define the constraints around them.

What are the top three priorities PNNL and DOE should work on in this project?

- Have a standard model or foundational component that different modeling components can be plugged into.
- Compare the basic assumptions that underlie everyone's models; right now they are hidden, they need to be brought out and expressed in a standardized way.
- An inventory is needed that shows key inputs in a typical model and what typical outputs come out of it.
    - Practitioners don't need to use all of them, but if they don't use some, they should explain why.
    - Create an inventory of all inputs, outputs and assumptions.
- It will be best if it's based on real data: people tend to not trust something not based on actual data.
    - Look at underlying theoretical assumptions.
    - Look at those that have gone through vetting and pilots, or research labs with data behind them.
    - The model should be informed by models built on actual pilots.

Is there a role for PNNL or DOE that brings the convergence we are talking about and supports spreading knowledge across regions?

- Yes, there is a role for DOE and PNNL and other labs to play in determining and defining a standard model.
- Yes, either creating a new model or pulling in an existing model to make the de facto standard model and then performing outreach to get that to regulatory commissions
- Putting a framework together with some structure in it will be useful, and better than a specific model; a model would be saying you want everyone to use it.
    - People will want to use their own model.
    - A framework with guidelines of various inputs and types of analyses you could do and output you should have would be very helpful.
    - Let individual organizations do the models to drive the results.

What are the most important questions those models need to answer and what about validating models?

- The purpose depends on who is going to use it: a utility? a person who deals with a lot of solar energy? It is project dependent.
- How you validate the models is very significant; there could be benchmarking variations.
- With validation, there's no single good answer
- Good to benchmark model results against other models
- If performing power flow or distribution system analysis, benchmark against other distribution analysis; make the assumptions visible.
- People working on TE are still looking at a lot of conceptual models. There is some valuable data in the United States and some overseas.
- To build confidence, we need more data on prosumers, etc.

Would it be helpful to develop a repository of benchmarks?

- Yes!
- It would be great if there were collaboration between different companies and regulatory entities in the government.
    - There is a common value where everyone participates.
    - The need is to share, not compete; we should find a way to share but maintain confidentiality when needed.
- With TESs, there are new perspectives that need to be valued:
    - Although not necessarily new, the customer perspective becomes increasingly important.
    - There's a huge social perspective we have to add as well as low income perspective.
    - The social aspect is key: there are smart devices at all levels of society.
        - What about a StubHub like entity that manages storage capacity?
    - What's the role of a regulated entity?
        - Bilateral contracts are not always managed today.
        - Maybe commodities are not regulated.
        - Different states will do it differently.
    - Need to be transparent across the board.

Hands-On Exercise #2 - How Do Valuation Methods Differ

FACILITATOR: Ron Melton, PNNL

In hands-on exercise #2, the group was again divided into five subgroups. Each subgroup was asked to discuss and develop answers to the following three questions:

1. How do valuation methods differ, and why do similar valuations come to different conclusions?
2. In what way(s) is/are the valuation of a transactive system different from other valuations?
3. What information must be captured with a (transactive) valuation methodology?

SUMMARIZED COMBINED FEEDBACK

How do valuation methods differ, and why do similar valuations come to different conclusions?

- **Customers and purposes** – Valuations differ according to "for whom" and "for what." Design and outcome depend on the end-user and purpose of the valuation. Valuations can be biased toward a certain outcome. There is implicit and inherent bias. Valuations performed for utility planning have different methods and requirements than those for setting rates (example: the regulatory "used and useful" mandate applies for setting rates, not planning). Valuations can appear to have the same objective (question), but the specific question is different.

- **Assumptions –** Different valuations use different forecasts and assumptions for foundational parameters. Examples include future penetration levels of DERs, cost and performance of resources, assumed return on investment, intertemporal changes and assumptions, stranded cost considerations, and baselines. Price assumptions also vary. Price can be location dependent.

- **Data** – Valuations utilize different data sources. Key considerations for data are source reliability, repeatability, uncertainties, cleaning process/data sorting, subjective choices of data components, and subjective simplification or aggregation.

- **Methodologies –** Different valuations employ different methodologies, including physical and behavioral representations. Some methodologies are top down and others are bottom up.

- **Model rigor and type** – There are differences in the quality and rigor of models and tools and in the skill of those using the tools. There are differences between economic (not necessarily measurable in dollars) and financial models.

- **Constraints** – Different valuations use different constraints.

- **Attributes** – Different systems have different attributes that lead to different results.

- **Level of detail** – Valuations vary in level of detail. This can be based on how much money and time one has to do the valuation and on subjective simplification or aggregation. Valuations differ by whether location, location detail, and time are accommodated. Valuations differ based on whether feedback loops between variables are included.

- **Time horizons –** Valuations consider different time horizons and deployment periods (decadal, hourly, minutes).

- **Stakeholders considered** – Some valuations are blind to perspectives other than the utility perspectives, while others consider multiple perspectives (customers, regulators, ISOs/RTOs, and legislative).

- **Transparency** – Valuations have varying degrees of transparency. Some valuations performed internally for business reasons are not transparent by design. In some instances, there is transparency around certain aspects of a valuation but not others. When assumptions are not clearly documented, it is difficult to communicate results in a way that others can understand.

- **Different definitions of "value"** – People don't agree on what the definition of "valuation" is. Different studies focus on different parts or value components. Valuation methods are not well defined or categorized.

- **Jurisdictional and regulatory environment** – Valuations consider different jurisdictional and regulatory environments. Some valuations assume or anticipate market redesign or changes while others assume status quo.

In what way(s) is/are the valuation of a transactive system different from other valuations?

- **Platform –** A TES is a platform that facilitates behaviors that may have value. Open access is allowed to many players for many purposes. A TES valuation needs to look at the cost and value of putting a TES in place and substituting plug-and-play across industry functions to maximize optimizations. A TES platform applies to interfaces where decisions about energy parameters are made. Value streams pass through a TES.

- **Multiple objectives** – Transactive systems achieve many objectives concurrently—for example, wind integration, frequency control, etc.—and can include multi-objective optimizations. Sometimes the goal will be more than energy (for example, a greenhouse gas [GHG] trading app where a customer or group of customers can optimize to minimize GHGs and share results with friends). Impacts can occur at multiple levels. Multi-objectives analysis is needed that finds "good" solutions given multiple objectives.

- **Model granularity** – Increased granularity of models is required to project price signals, TES response, and feedback loops. Modelers need to know how a resource is actually used, not just how much flexibility it can provide. More detailed modeling is needed to accomplish this. Temporal aspects of feedback loops need to be considered; for example, the distribution system impacts from PV systems. A TES represents a broader and more complex valuation problem.

- **Different perspectives** – Need to look at many different perspectives, each with different interests. Players who are not anticipated need to be accommodated.

- **Multiple relationships** – There are many relationships and potential relationships in a TES that need to be considered. There are new rules and different interactions.

- **Feedback** – Feedback must be considered: for example, equilibrium models with feedback. There is not one base case. The value of preserving optionality should be included.

- **Control mechanism – distributed rather than central** – The control mechanism in a TES is fundamentally different and includes distributed decision making and semi-autonomy as compared to single/deterministic decision making. For planning purposes, different operating characteristics of TES resources need to be considered. We need methods to shift from a single point of failure to multi-dependencies. This will impact security and resilience outcomes. Different mechanisms for assessments are needed.

- **Risk and uncertainty –** There are different levels of risk and uncertainty when we are not dealing with steel in the ground. Consider uncertainty, dispatchability, and level of firmness with TES. Shift of risks and rewards.

- **Dynamic valuation** – The system is dynamic and responsive rather than static.

- **Bottom up** – A TES is inherently bottom up and the valuation methodology must accommodate that.

What information must be captured with a (transactive) valuation methodology?

- **Statement of objectives to be achieved by the TES (operational, business, other)**
  - Key the operational variables to all stakeholders being considered in the market.
  - Incorporate the ability to compare performance vs. objectives.
- **Assumptions around "firmness" or dispatchability of TES**
  - consistency of performance
  - transparency of performance
  - How persistent is the use of the TES?
- **Asset utilization and equipment performance**
  - rate of deployment, rate of adoption
  - how expansion and growth are managed
- **Time frame**
  - Time frames into the future are being considered.
  - The longer the time horizon, the harder it is to model.
- **Actors/participants**
  - number of actors
  - capabilities of the participants
  - price elasticity of participants and dynamics of elasticity
- **Services and performance of the TES**
  - limitations on technologies/capabilities - among other things may affect price elasticity
  - uncertainty factors in information needed by the TES
  - human factors (to the extent that humans are in the loop)
  - the decision making process for interacting in a transaction

  - the signals exchanged to execute a "transaction"
  - the level of participation/penetration of the TES that is required to provide measurable benefit (value)
  - location impacts and dependency
  - time dependency
  - time dynamics (seconds, minutes, hours, etc.)
  - temporal impacts, including timing of constraints
  - stability driven limitations
  - the degree to which the system responds to market segment drivers and what the drivers are
  - links to other infrastructures and services (e.g., home security, water, natural gas, etc.)
  - the degree to which the TES supports differentiated supply such as "green power"
  - locational and geographic impacts
  - qualification of unknowns
  - sensitivity to assumptions
- **Costs and avoided costs**
  - how the TES adapts to existing technology vs. requiring investment in new technology
  - cost of technology to enable the TES (hardware and software)
  - cost impacts on all participants – estimating investments distribution
  - avoided costs of physical infrastructure
  - service life and replacement cost of technologies and capabilities
- **Stakeholders**
  - means to identify stakeholders and mapping of values and costs among stakeholders (e.g., savings or other performance parameters)
  - priorities of operational variables based on stakeholders
  - exposure of participants to results
  - ability to link to outcomes, such as climate/environmental impacts
- **Feedback loops**
  - whether the system is able to learn and adapt responses over time (for example, adjusting the translation of comfort into elasticity)
  - a means to both account for feedback loops and use actual performance data to refine a valuation model
- **Market conditions**
  - standards, climate/environmental constraints, regulatory constraints, economic assumptions, inflation, interest rate, rate of return, commodities (natural gas, oil) market segments, level of maturity, risk, futures market, swaps, fixed prices
- **Cyber/physical security**
- **Risk monetization**
- **Similarities to energy efficiency (EE)**
  - Learn from EE deployment and valuation.

  - Cost effectiveness tests may be similar – both utility and customer costs are included in total resource cost test (TRC) for EE.
  - There is a potential for decoupling utility revenue from sales.

Participant Closing Comments

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

Transactive Energy Platform

- Value of a platform
  - iPhones migrate into all other different applications.
  - Once a platform is in place, negotiating all other values can happen.
  - There are primary values and secondary values.
  - A platform is a necessary condition for realizing value, not an end unto itself.
  - We need to think beyond cost: think of cell phones; people pay more because they want to and they get more.
- In a TES, value is the result of behaviors by devices and people setting them up.
  - What we describe here is a top-down analysis that includes everything as if you know what is going to happen.
  - With platforms, you don't always know what is going to happen.
  - The platform isn't doing anything specific beforehand.
  - Valuing platforms is difficult if they enable transactions, but don't "do the thing" itself.
  - Value passes through the platform; this puts TES into a different category.

Collaboration

- We need more participation by the Federal Energy Regulatory Commission, utilities, regulators and customers in these discussions.
- How can we collaborate?
  - Collaboration occurs where there is mutual opportunity to benefit.
  - With valuation, one must ask who the pushers for harmonization are.
  - There is not a lot of openness for third parties to share proprietary information proprietary third parties.
  - It's up to the regulators to request transparency and openness.
  - Collaboration in a highly competitive environment is not likely.
  - If trying to build a shared body of knowledge, try to reduce variability between definitions.
- Is there a professional organization valuators go to?
  - Yes, there are conferences.
- There are 50 or 51 different regulatory bodies in the United States – it's a challenge.

Closing

- We are setting the stage for an interesting period of convergence and trying to get on the same page in valuation space.
- Equity issues are important. What about the person who just wants a standard service, like a landline rather than a smart phone? They should not be forced to participate.

- Regarding reliability and resilience of data, the trusting of data impacts outcome; you sway the result by how you use data.
- Hopefully this effort is the start of a multi-year program.

APPENDIX A - AGENDA

Day 1 – Tuesday, September 29, 2015	
Administrative Agenda	
8:00 – 8:30 am 8:30 – 8:45 am 8:45 – 9:00 am	• **Sign in** • **Welcome and Introductions (Forfia, Melton, Irwin)** • **Calendar, Minutes Approval, Action Items Review (Melton and Forfia)**
Conference and Event Planning	
9:00 – 9:30 am 9:30 – 9:45 am	• **#TES2016 Planning Update (Melton)** • **GWAC Meeting at Smart Grid Interoperability Panel (SGIP) Conference Update (Forfia and Melton)**
Technical and Policy Activities Agenda	
9:45 – 10:30 am	• **Transactive Energy Decision Maker's Checklist (Melton and Knight)**
10:30 – 11:00 am	**Transactive Energy Valuation Meeting – Welcome, Recap of Previous Meeting, Scope and Desired Outcomes** • *Chris Irwin, DOE* • *Ron Melton, PNNL* • *Juliet Homer, PNNL*
11:00 – 12:00 pm	**Transactive Energy Valuation Methodology – Introduction and Overview of Methodology** *Don Hammerstrom, PNNL*
12:00 – 1:00 pm	**Lunch and Presentation: Distributed Energy Resources in the ERCOT** *Kenneth Ragsdale, Principal, Market Design & Analysis, ERCOT*
1:00 – 2:00 pm	***Mixed Panel Discussion - Insights From Practitioners*** *Moderated by Steve Widergren, PNNL* • *Gordon Matthews, BPA* • *Jeff Roark, EPRI* • *Cynthia Wilson, U.S. DOE / EPSA* • *Ron Bernstein, RBCG LLC*
2:00 – 2:30 pm	**Group Discussion** *Steve Widergren, PNNL*
2:30 – 3:00 pm	**Value of Transactional Building Energy Systems** *Chad Corbin, PNNL*
3:00 – 3:15 pm	**Introduce Hands-On Exercise #1: Energy and Building Services That are/are not Suitable for Transactive Systems** *Juliet Homer, PNNL*
3:15 – 4:00 pm	**Hands-On Exercise #1: Energy and Building Services that are/are not Suitable for Transactive Systems**
4:00 – 4:45 pm	**Working Group Report Out and Group Discussion** *Juliet Homer, PNNL*
4:45 – 5:00 pm	**Day 1 Summary and Wrap-Up** *Ron Melton, PNNL*

Day 2 – Wednesday, September 30, 2015	
8:30– 9:00 am	**Day 1 Summary** *Juliet Homer, PNNL*
9:00 – 9:30 am	**Worked Example of Methodology** *Don Hammerstrom, PNNL*
9:30 – 10:30 am	**Mixed Panel Discussion – Predicting and Measuring Value** *Moderated by Steve Widergren, PNNL* • *Al Galiunas, Navigant* • *Stephen Knapp, Energy Alternatives Solutions* • *James Sherwood, Rocky Mountain Institute*
10:30 – 11:00 am	**Group Discussion** *Steve Widergren, PNNL*
11:00 – 11:15 pm	**Introduce Hands-On Exercise #2: Insights About the Ideal Transactive System Valuation** *Ron Melton, PNNL*
11:15 – 12:00 pm	**Hands-On Exercise #2: Insights About the Ideal Transactive System Valuation**
12:00 – 1:00 pm	**Lunch and Continue Hands-On Exercise**
1:00 – 2:30 pm	**Report Out from Working Groups and Discussion** *Ron Melton, PNNL*
2:30 – 3:30 pm	**Summary and Next Steps** • *Ron Melton, PNNL* • *Don Hammerstrom, PNNL* • *Chris Irwin, DOE*
3:30 pm	**Adjourn Workshop**
3:30 – 4:30 pm	**GWAC Members - Working Discussions**