Transactive Energy Framework

Workshop Proceedings
September 10-11, 2014
Folsom, CA

Prepared by

(GWAC) The GridWise Architecture Council

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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

GWAC (The GridWise® Architecture Council) hosted a workshop on Transactive Energy hosted by California-ISO in Folsom, Calif., September 10–11, 2014. The Council is continuing to work on expanding the Transactive Energy Framework to include conceptual use cases, conceptual architectures, key interoperability requirements, and various cross-cutting elements. The workshop focused on the impact of transactive energy systems on the distribution side of the grid, including presentations and discussions on market flexibility, renewable resource integration and recent discussions on the role of Distribution System Operators (DSOs), and also a review of the Future of the Grid Summit hosted recently in Washington, D.C. by the GridWise Alliance. The plan for the upcoming 2nd International Conference and Workshop on Transactive Energy was reviewed and the Council discussed final assignments for GWAC led panels at the Conference and started work on planning the foundational session.

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OVERVIEW AND OPENING REMARKS

WORKSHOP LEADER: MARK KNIGHT, GRIDWISE ARCHITECTURE COUNCIL CHAIRMAN

The GridWise® Architecture Council (GWAC) recently published the Transactive Energy Framework (http://www.gridwiseac.org/pdfs/te_framework_report_pnnl-22946.pdf). This work will be revised during 2014 to reflect comments on the document and to possibly include additional material. Input from these workshop sessions will be used to help during this process.

A potential key element of the framework is an update to the definition of transactive energy and a revised set of associated attributes. The definition now being used by GWAC is, *"A set of economic and control mechanisms that allows the dynamic balance of supply and demand across the entire electrical infrastructure using value as a key operational parameter."* By adding a set of attributes, the council intended them to help the reader understand the boundaries of transactive energy, and to be used to discuss different approaches and implementations of transactive energy.

With that in mind these workshop sessions were intended to bring together experienced industry experts who have been doing work in areas considered to be transactive in nature, or who have plans in place for transactive energy systems. As more and more people start to use the term transactive energy, one of the council's goals in publishing the framework was to create common ground for all interested parties to discuss and advance this field. Since this was the aim of creating the transactive energy attributes, a key objective since workshop sessions of 2013 was to see how well the attributes worked in terms of providing common ground for comparing and contrasting different transactive initiatives.

Since the council wishes to update the framework in 2014 and also to hold another transactive energy conference in December 2014, it is important to get feedback on whether the attributes work for the purpose that was intended.

Each session is planned for 45 minutes, with 30 minutes for presentation and 15 minutes for discussion.

Background

What is transactive energy?
The meaning of the term "transactive energy" has been under discussion and refinement at the workshops on this topic hosted by the GWAC and through related work of others. An early definition referred to techniques for managing the generation, consumption or flow of electric power within an electric power system through the use of economic or market-based constructs, while factoring in grid reliability constraints. The term "transactive" came from the consideration that decisions are made based on a value. These decisions may be analogous to—or literally—economic transactions.

More recently, as the GWAC prepared the Transactive Energy Framework document[1], the definition was refined to, *"A set of economic and control mechanisms that allows the dynamic balance of supply and demand across the entire electrical infrastructure using value as a key operational parameter."* An associated set of attributes of transactive energy also were developed. These attributes define dimensions of transactive energy and are intended to enable rich descriptions of transactive energy methods or systems and allow for comparison of different approaches.

An example of an application of a transactive energy technique is the double auction market used to control responsive demand-side assets in the GridWise Olympic Peninsula Project[2]. Another would be the TeMix work of Ed Cazalet[3]. Transactive energy techniques may be localized to managing a specific part of the power system—for example, residential demand response. They may also be proposed for managing activity within the electric power system from end-to-end (generation to consumption), such as the transactive control technique being developed for the Pacific Northwest Smart Grid Demonstration Project[4,5]. An extreme example would be a literal implementation of "prices-to-devices," in which appliances respond to a real-time price signal.

The current situation is that dynamic pricing is widely used in the wholesale power markets. Balancing authorities and other operations such as hydro desks routinely trade on the spot market to buy or sell power for very near-term needs. In addition, dynamic pricing tariffs are being tried in a number of retail markets, for example, the PowerCentsDC dynamic pricing pilot[6].

[1] GridWise® Architecture Council, "GridWise Transactive Energy Framework, Draft Version", PNNL-22946, October 2013, Pacific Northwest National Laboratory, Richland, WA http://www.gridwiseac.org/pdfs/te_framework_report_pnnl-22946.pdf
[2] Hammerstrom, D.J., et al, "Pacific Northwest GridWise™ Testbed Demonstration Projects: Part I. Olympic Peninsula Project", PNNL-17167, October 2007, Pacific Northwest National Laboratory, Richland WA
[3] Cazalet, E.G., "TeMIX: A Foundation for Transactive Energy in a Smart Grid World", presented at Grid-Interop 2010, Chicago, IL http://www.pointview.com/data/files/2/1062/1878.pdf
[4] Hammerstrom, DJ, et al, "Standardization of a Hierarchical Transactive Control System", in the Proceedings of Grid-Interop 2009, November 2009, Denver, CO, pp 35 – 41. http://www.gridwiseac.org/pdfs/forum_papers09/don-business.pdf
[5] http://www.pnwsmartgrid.org
[6] http://www.powercentsdc.org

PRESENTATIONS – DAY 1

The following are the abstracts and links to the presentations.

GRIDWISE ALLIANCE / DOE FUTURE GRID SUMMIT OUTCOMES

SPEAKER: BECKY HARRISON, GRIDWISE ALLIANCE

Over the past several years, the electricity industry has experienced fundamental changes on a scale not witnessed since the creation of the electric system more than 100 years ago. New technological advances are providing new grid capabilities, prices for clean energy sources are becoming more affordable, our digital economy is even more dependent on electricity, and consumers are demanding fewer outages and faster response times when outages do occur.

Our nation's grid - the electricity infrastructure between the generation sources and consumers - must evolve to respond to these developments and meet society's changing expectations and preferences. The evolution has already begun, and over the next 15 years and beyond, it will have significant implications for reliability, operations, security, resilience, consumer choice, and more. To successfully develop sustainable solutions to the challenging issues related to the evolution of the grid, it will be critical for all stakeholders to work together to understand each other's points of view and collaborate to develop the path forward.

With this in mind, the U.S. Department of Energy's (DOE's) Office of Electricity Delivery and Energy Reliability (OE) and the GridWise Alliance (GWA) partnered to facilitate a series of four Regional Workshops and a National Summit entitled the "Future of the Grid: Evolving to Meet America's Needs" to create an industry-driven vision of the electric grid in 2030 and, more importantly, to begin forging a path to realize that vision. This presentation covers the information glean from the Regional Workshops and the National Summit and reflects the participants' vision for the future electric grid, the associated changes in the utility business and regulatory models, and the recommendations for a path forward to achieve the future grid.

http://www.gridwiseac.org/pdfs/workshop_091014/harrison_091014_pres.pdf

Reference Materials

http://www.spiegel.de/international/germany/high-costs-and-errors-of-german-transition-to-renewable-energy-a-920288.html

Questions, Comments, and Discussion:

- People going off the grid: nobody (consumer advocates, regulators, etc., and not just the utilities) believes that grid will go away, and grid will continue to be the central nervous system.
  - Information grid that overlays the physical connectivity grid is all part of the definition of the grid in future
- The role of DSO in future would be more of a balancing authority, as well as, operator of a retail market, as answered by 70% people in the room.
  - The timing of when this vision manifests will depend on state to state.

- How is the distribution power exchange defined?
  - Retail market place, which allows for transacting energy and ancillary services
  - May be some third-party entity that may be entrusted with running the markets
- There may be economies of scale issues that would warrant the integration of these individual distribution systems, so in the end what will prevent the ISOs from becoming the ultimate administrators of the overall system/market place to?
  - FERC vs. state regulatory authority presents a considerable challenge in that kind of integration; customers are fundamentally under state jurisdiction which are not ready to give up control; state regulators may end up replicating each others' systems
  - Smart grid has really blurred that line, to an extent, between state and federal regulatory jurisdictions
- Huge regulatory and policy issues that need to be dealt with regardless of technology
  - At federal level, the issue will be how to deal with retail markets
  - Cybersecurity is an issue not just at the federal but also state level
- Utility business processes have to significantly change because the coming change is transformational for utilities.
- The reassuring message has been that there's still going to be a grid, but the grid may not be the grid of today; the reality is not that everything's coming to an end but that adaptability will be important.
- Not all public utitlies have the same regulatory processes but they still need to address their board and city councils etc.
- Grid modernization index: States that are doing better is because of the state-level policy, and not necessarily regulations.
- Customers who are protected most by the regulatory compact are not the ones that are most active or will respond the most to choices.
- There may be a range of different future grid visions that may be more appropriate, which will depend from region to region, but there may not be one national vision
  - A national roadmap may not be able to exist or just may not pass
  - A high level framework may still be needed, if not a roadmap
- What is the electricity divide, and what do have and have-nots mean?
  - Net-metering is a non-transparent subsidy, which is a means to get PV penetration going. The retail rates will keep going up as the PV penetration increases, putting more and more burden on the people who can't afford to put PV panels on roof-tops.
  - Global examples of have and have-nots:
    - Energy poverty in Germany and the role of renewables in causing it.
    - Cost of energy studies in UK and impact of renewables
    - Ontario: Increasing cost of energy in the subsidized houses leading to canceling of feed-in-tariff programs.
  - We don't do a good job of connecting a dots between policies and impacts on low income consumers
- Foundational investments: Do we have a good idea of the foundational investments by utilities? Some of the new investments are not backed up with cost-effectiveness studies, making it challenging to secure funding.
  - A lot of the investments do not involve cost benefits.
  - Sometimes the benefits are across domains, i.e., generation-side benefits due to investments by a wires-only company

  - Some of these are enabling investments without which DER deployment may not work, such as two-way power flow information etc.
    - Once the investments are made the benefits may follow
  - Sometimes the benefits may require changes in business processes, which can be a time consuming process.
- We are seeing consumer load growth declining but asking utitlies to make greater investments
  - It may be a question of doing things differently and investing differently
  - Peak demand records are being set year after year; peaks are growing but seen fewer number of times, which does raise the overall cost of peak capacity
    - Average consumption is decreasing and utility revenues are decreasing likewise. Peak capacity is supporting fewer peak periods.
- A common set of monetized metrics are missing, barring which the regulatory process may be a lot easier, especially as it relates to new investments.

CAL-ISO RENEWABLE ENERGY INTEGRATION

SPEAKER: MARK ROTHLEDER, CALIFORNIA ISO

The presentation provides an overview of the California ISO experiences integrating renewable capacity currently providing 20% of the energy in California and projects forward expectations in 33% and 40% scenarios per the CPUC long-term procurement planning (LTPP) proceeding.

http://www.gridwiseac.org/pdfs/workshop_091014/rothleder_091014_pres.pdf

Questions, Comments, and Discussion:

- How often is the solar generation smooth vs. highly variable?
  - When planning for the CA system daily operation, cannot rely on the average and one day may be very different from the next.
- The negative prices are only manifesting in real-time as opposed to day-ahead
  - Seen more often than previous years, but the number is still not very high
  - Energy imbalance markets may help mitigate to some extent because of possibilities to use excess capacity for regional balancing purposes
  - Are these seen persistently at particular nodes or across the region?
    - BOTH
  - Why can't these negative prices be offered to the retail customers?
    - Used only for wholesale markets and not retail rates
  - What about other markets that help take capacity off the system
    - Markets for dispatchable storage, pool pumps, etc., do exist now
- Any studies on whether long-term patterns of load and generation will change as result of interaction with the negative prices?
  - Studies being conducted that include demand participating in operations and using those in longer-term planning studies a well
  - Linkage between retail and wholesale will have to be made at some point and it is an ongoing challenge at the CPUC to allow wholesale prices be reflected in retail rates

- Is there any thought to reverse the pattern of imports into CA, which at present are in 3000-4000 MW in the morning, which is also when negative prices are observed?
    - Hurdles range from economic to operational; not enough capacity to absorb exports in neighboring regions because of need to keep long-start units for evening load pickup etc.
- One of the key business values of TE is that both surplus and shortfall can be addressed; if industries in CA can automate DR to use negative prices opportunistically then they cannot just stay in business but also prosper
    - DR is not just about reducing demand but also increasing demand as need be
- Historical load shape will not be the shape of the future; retail rate making in future will need to have a deeper understanding of the dynamics; for instance, the bottom of the duck curve happens at noon, while the new peak doesn't manifest until after 6pm, which is different from past
- Is there any consideration of advisory prices (expected real-time prices) after the RUC in day-ahead markets that would help participants plan better for real-time operations?
    - The results of RUC could be used to indicate expected over generation conditions and negative prices to market participants

A Framework for Flexible Contracts in Wholesale Markets

Speaker: Leigh Tesfatision, Iowa State University

The current design of electric power markets makes it difficult to ensure appropriate compensation for many important load-balancing services, such as flexibility in start-up times, ramp-rates, power dispatch levels, and duration. This talk will discuss the possibility of facilitating appropriate compensation through the introduction of standardized energy/reserve contracts with swing (flexibility) in their contractual terms. Concrete examples will be used to demonstrate how the trading of these standardized contracts can be supported by linked forward markets in a manner that permits efficient real-time load balancing subject to system constraints and reserve requirements.

Main References for Presentation:

[1] L.S. Tesfatsion, C.A. Silva-Monroy, V.W. Loose, J.F. Ellison, R.T. Elliott, R.H. Byrne, R.T. Guttromson, New Wholesale Power Market Design Using Linked Forward Markets, Sandia Report SAND2013-2789, Sandia National Laboratories, April 2013. http://www2.econ.iastate.edu/tesfatsi/MarketDesignSAND2013-2789.LTEtAl.pdf

[2] Deung-Yong Heo and Leigh Tesfatsion, Energy and Reserve Procurement through Standardized Contracts in Linked Electricity Markets: Illustrative Examples," Economics Department Working Paper No. 13018, Iowa State University, June 2014 http://www.econ.iastate.edu/tesfatsi/StandardizedContracts.HeoTesfatsion.WP13018.pdf

http://www.gridwiseac.org/pdfs/workshop_091014/tesfatsion_091014_pres.pdf

Questions, Comments, and Discussion:

- What's the ratio of ex-ante reservation payment to the ex-post performance payment? There may be some possibilities when the reservations payments may be consistently greater than the actual performance payments.
  - The generation portfolios cleared will depend on the reserve range required by the ISO, which will determine the reservation payments. For too large a reserve requirement the reservation payments would commensurately be large as well.
  - Hopefully, competition will ensure that bids and offers by market participants reflect true (or close to) costs.
- Is the contract structure being proposed extended to energy transactions, just like it's done for ancillary services products currently?
  - Swing contract intrinsically consists of provision of both energy and reserve; the resource is being provided as one integrated entity with each having its functional ability and bundle of services that can be provided.
  - Very similar to the current operational structure except for the contract structure
- Energy is different from ancillary services because ISO is the only one that buys reserves, while customers only buy energy and not reserves.
  - Load serving entity in the current formulation only bid to buy blocks of energy, while ISOs purchasing the reserves based on the reserve requirements.
- There may be issues with market liquidity because some of the products are not interchangeable (10 min vs 30 min etc.)

DISCUSSIONS – DAY 1

DISCUSSION 1 - HOW DOES TE FIT INTO PENDING STATE REGULATORY CHANGES?

PRESENTER: WARD CAMP, LANDIS + GYR & GWAC MEMBER

Suggested Read Ahead Materials
http://greentechleadership.org/wp-content/uploads/2014/08/More-Than-Smart-Report-by-GTLG-and-Caltech.pdf

http://www.gridwiseac.org/pdfs/workshop_091014/camp_091014_pres.pdf

Questions, Comments and Discussion:

- AMI and the increase in Time Varying Rates
  - Precursor to TE?
- The increasing role of Distributed Energy Resources
  - TE role in changing Net Metering Rules
- Microgrids
  - Is TE the enabling concepts for increased MGs?

DISCUSSION 2 – MANAGING THE HIGH PENETRATIONS OF DER

PRESENTER: DOUG HOUSEMAN, ENERNEX & GWAC MEMBER

Questions proposed to the participants to answer prior to the day-2 discussion:

- When it comes to DER what is it that "we/anyone" would like to control?
  - Example – Voltage availability
- At what level of DER penetrations, as a percentage of load is control necessary?
- For the percentage given for #2, what were your assumptions?

RECAP OF DAY 1

PRESENTER: RON MELTON

Key takeaway points:

- GWAC needs to identify a line of sight as to why utilities push for transactive energy
  - What is driving the change?
- Identify what is the balance between policy and regulatory
- We need to identify who is our audience and what are we trying to do
  - What are the next steps
  - Focus on planning
- Business and Policy is where the bulk of work needs to be focused
  - Utilities are not going to spend money ahead of policy and regulations
- Test beds for demonstration are vitally important to understand TE better
- High level of support for retail "exchanges"
  - Business and policy issues; standards and interoperability issues if there are multiple such exchanges around the country
- Identify the policy questions that need to be asked to drive to the next level
  - State level policies vs. Federal policies
- Change is inevitable, and the rate of grid adaption will vary by utility and jurisdiction
  - DER is driving change but it is different depending on location
- The energy industry is seeking clarity in the following 4 areas:
  - Changes in policy, business & technology
  - Indicators of when changes are needed
  - Time frames for implementation
  - Consequences of not changing
- GWAC should discuss the gap regarding business models that will help enable transition
  - Show me how the money fits into technology; allowed and enabled by policy
  - A pragmatic, workable, and profitable business model
- Rapid acceleration focus on DER and it is critical to provide guidance on this acceleration
- Look at the evolution of the least cost planning following the oil embargo and use the lessons learned to inform IRP in driving change forward

- It is difficult to pin down costs/benefits within the integrated TSO/DSO models
- Contained communities (e.g. islands) serve as natural tested environments
- Missing theme – change from prediction to intention
    - What should the energy system look like?
- Need to convey the bad news so they don't think they are being sold a "bill-of-goods".
    - Change is going to be costly and disruptive
    - How can change be managed to control costs?
    - The change can be good for the economy and society
- What can we do as a Council to be considered thought leaders?
    - From framework perspective, need to build artifacts equivalent to the GWAC Stack and Interoperability Constitution.
- Impacts on consumers – the social compact – impacts a broad swath of consumers
    - Long-term debt that is nowhere close to being retired which will be impacted; will impact the social compact because people's retirement funds tied to these investments with guaranteed rate of return
- Consumer equality
    - Availability of electricity
    - What is the political dimension
- Regulatory compacts is stressed. There is a ranging mix/dynamic between public infrastructure and commercial; for example Solar City)
    - Transparency of subsidies is necessary.
- For TEC foundation
    - Timeframe
    - TE as a toolbox

PRESENTATIONS – DAY 2

CALIFORNIA STORAGE ROADMAP

PRESENTER: HEATHER SANDERS, CALIFORNIA ISO & GWAC MEMBER

The California Energy Storage Roadmap is a partnership between the California ISO, California Energy Commission, and the California Public Utilities Commission. This presentation discussed the Roadmap's objective of understanding the needed policy and regulatory actions to facilitate the expansion of energy storage in California.

Questions, Comments and Discussion:

- Did the California mandate prescribe a path to implementation?
    - There is a requirement for about 600 MW in distribution and transmission, and 200 MW behind-the-meter;
    - There is no requirement for MW*h* but only MW in the mandate

- Interconnection, and interfacing of distribution level storage with wholesale is a significant issue confounding issues for C&I customers
- Assembly Bill 2514 determined that CPUC will set targets for energy storage;
  - Cost-effectiveness built into the language, i.e., utilities don't have to procure anything if not cost-effective
- Some states, like CA, are completely policy driven while markets and economics drive technology adoption in other states, such as Iowa
- A lot of ways to manage intermittency, including curtailing renewables (as mentioned by PUC) other than just storage
- What was the reason to arrive at 3 hour requirement for energy storage participation?
  - Look at ramping periods, based on duck curve, seasons, etc.; could be more nuanced in future
  - The requirement was based on ramp-up periods and not over-generation periods of the duck curve
  - The studies were not done based on location of storage in the system
- Is anybody looking at dynamic battery response to price signals etc.?
- All storage is not created equal; depends on battery chemistry;
  - Storage cube: response rate, chemistries etc., to differentiate the capabilities of different storage technologies;
  - We must be wary of using the term storage to describe all technologies
  - Systematic and proper modeling of all these devices is missing, which is essential to analyze the capabilities and usefulness of these devices
- Operational and engineering challenges with storage devices which present difficulties in incorporating those in the ISO network and operations models

http://www.gridwiseac.org/pdfs/workshop_091014/sanders_091014_pres.pdf

DSO MODELS

PRESENTER: FARROKH RAHIMI, OATI & GWAC ASSOCIATE

The electric industry is undergoing a paradigm shift due to a combination of factors including emphasis on increased use of renewable resources both at bulk power and distributed levels new technologies, increased demand-side participation, and increased emphasis on grid resiliency.

These changes while providing for opportunities for prosumers and transactive agents, give rise to new operational problems for operators of the distribution system.

Bulk power system and market operation are also impacted. The increasing levels of Variable Energy Resources put increased pressure on the system for increasing levels of flexible reserves and ancillary services. Much of the needed services and products can be supplied by assets located throughout the distribution systems including customer-side Distributed Energy Resources. However, the bulk power system operators (Balancing Authorities, ISOs/RTOs) have limited visibility and control over such distributed resources.

A new Distribution System Operator (DSO) construct presented here is intended to take on the responsibility for balancing supply and demand variations at the distribution level and linking the wholesale and retail market agents, while maintaining the traditional role of the operator This presentation will provide a classification of DSP functions, and identify new operations tools and infrastructure needed to assist the DSO to support the emerging Transactive Energy paradigm. The presentation will also address some regulatory issues that must be addressed to achieve a fully transactive DSO construct.

http://www.gridwiseac.org/pdfs/workshop_091014/rahimi_091114_pres.pdf

Questions, Comments and Discussion:

- Utility perspective:
  - The utility can use demand-side resources (DERs) to provide services back into the bulk-power markets
  - The utility (DSO) will need to take some actions to allow trade and exchange of power/energy between microgrids, customers, etc.,
    - The utility in future may be allowed to charge customers for facilitation of such trades
- Sophisticated products are being developed and deployed that will optimize the system after a DR event to avoid unwanted second and third-order consequences
  - Precisely why the DSO is needed to deal with and take care of the local challenges
  - ISO doesn't have jurisdiction and visibility below distribution substation and hence, cannot take effective control actions
- One of the hurdles, from a technical perspective, may be coming up with shift factors and other distribution system parameters
- The presentation focuses on framing the nature of the problem and not a solution. Presenter's response: Definition if the DSO functions provided in this presentation is the starting point for development of functional specifications.
- What is OATI patenting around the DSO concept?

DSO MODELS

PRESENTER: LORENZO KRISTOV, CALIFORNIA ISO

Focusing on the transmission-distribution interface provides a useful approach for defining roles and responsibilities of the distribution company and the transmission system operator. This presentation uses this approach to describe a spectrum of possible ways to structure these complementary roles for the highly distributed electric power system of the future.

http://www.gridwiseac.org/pdfs/workshop_091014/kristov_091114_pres.pdf

Questions, Comments, and Discussion:

- Interoperability and standards are implied within the models but it would be nice to have explicit mention of those
- In model C is the aggregator different from the DSO in that the operations are explicitly a function of the DSO, while scheduling and interfacing with the ISO are functions performed by the aggregator?

    - The models are general enough to accommodate all these architectures
    - This may be quite a fundamental issue relating to reliability of system operations
        - Concepts such as no tier by-passed (in case the aggregator has direct access to the transmission system) becomes important from architecture perspective to ensure reliability
- Any business requirements or architecture have been prepared for the four models?
- No assumption of a virtual power plant is being made in regards to the new type of resource that is being offered by the DSO?
    - A VPP model potentially hides a lot of the flexibility of the DERs in order to be offered as a resource within the current context of an ISO

DISCUSSIONS – DAY 2

DISCUSSION 3 – THE EMERGING ROLE OF DSO

PRESENTER: FARROKH RAHIMI, OPEN ACCESS TECHNOLOGY INTERNATIONAL, INC. (OATI)

Discussion Questions:

- Why the need to think differently about distribution systems?
- What functions are needed in the DSO construct? What is the minimum necessary and sufficient set of functions?
- What are the architecture considerations? Business, economic, process, control, etc.? How is value alignment achieved?

Questions, Comments, and Discussion:

- Is model D proposed as the best option for future power system?
    - Like the idea of the layering; not just the question of retail and wholesale markets, but regulatory structure is also more clear cut because the boundaries are well defined
- In the conceptual model do you need regulatory changes first or do you need a threshold of DERs in the distribution system first?
    - Seems worthwhile to construct some future version of the world, and analyze how the operational issues of such a system.
    - Let's pursue the architecture a little more, and then see what kinds of regulatory and business models we need to make those work.
- All the models seem to be variants of hierarchical control paradigms;
    - Decentralized markets may be an alternative approach
- Is the only distinction between C and D is that in C there are multiple resources aggregated under a substation and in D there is a single resource?
    - There is a spectrum of different operational models for the DSO
- The DSO construct does not disallow bilateral and multilateral transactions, much like the ISO in the wholesale markets.
    - No approaches must be precluded in the future constructs so as to allow maximum participation from customers, as well as, spur creativity in the kinds of business models that emerge.
- Must offer obligations are only instituted to maintain resource adequacy during peak-load conditions

- New arrangement might fit better with the regulatory structure?
    - Every distribution system is different and it may not be possible to get the level of participation and liquidity that we believe
- Distinction between distribution and transmission:
    - Distribution is almost entirely single phased. The load grows based on the desire of the customer and does not require any approvals, etc. There are significant issues with allowing everyone to do whatever they want to do. As soon as aggregate load profiles begin to be affected, that's when problems happen.
- What characteristics and issues are needed to be addressed within a distribution system is what the discussion should be rather than jumping to decisions.
- The problem of 60% losses in Ontario's distribution grid is not a control problem but one of policies and tariffs.
    - If the high power losses are not reflected in prices then customers have no incentives to participate and optimize.
- This discussion would greatly benefit from building a series of use-cases.
    - Distribution utilities are all of different shapes and sizes, and their issues are vastly different.
- On distribution side we are dealing with end-use customers, who are not power engineers.
- Maturity of the network models will be a crucial issue in distribution systems;
    - Smaller cities and municipalities tend to have better grasps over their issues. Rates are also lower with such municipalities etc. Is the landscape full of smaller utilities better for system operations in the future?
- Introducing some structure into analysis and discussion based on what utilities do today compared to what utilities might do in the future is really important.
- A net-zero house has 5-7 times the impact on the distribution grid than the neighbor without the net-zero.
    - Policies fail to account for the banking operations that the utilities provide in case of over-generation.
    - DSO will have to provide different tariffs for different services they provide.
    - 2-paragraph/page narrative description of use-cases that would comprehensively describe the set of functions that the DSO does is critically important.
- When we talk about the distribution system, we are talking about the state regulations; changes in regulatory models needs to include this consideration; important to figure out where the federal-state interconnections will be when thinking about regulatory changes.
- There are a lot of localized problems in the distribution system which make it very different from the transmission system.
    - Distribution system is not as static as the transmission system
- During the AEP demo we didn't realize up front on how many customers switch feeders. These kinds of details are important to any implementation of TC or even DLC, and future DMS concepts.
- Companies making business decisions in the distribution system with no correlation to the value being realized from actual operations may be an issue.
- Is the fundamental difference between the utility systems of today and the DSO concept that we are introducing economic interactions through markets down into the distribution system?
    - Not simply an addition of economic interactions to distribution system operations.
    - Fundamental nature of distribution systems is changing because of the new moving parts making their operations more complicated.

  - Don't fundamentally redefine DSO the entity, but the functions.
    - Look at the public policy objectives, how those might manifest – maybe in the form of more distributed resources – and then figure out what needs to be done to operate that system properly.
  - DSO responsibilities will include recognition of cost-causation, and cost allocation.
- We may want to think of a DSO as a platform for information exchange, maybe through markets or otherwise, and all the associated issues that come along.

DISCUSSION 4 – CONTROL ASPECTS OF TRANSACTIVE ENERGY

PRESENTER: DOUG HOUSEMAN, ENERNEX & GWAC MEMBERS

http://www.gridwiseac.org/pdfs/workshop_091014/houseman_091114_pres.pdf

Questions, Comments and Discussion:

- Everyone has a different internalized definitions of DERs
  - Wide range for penetration levels of DERs which warrant control actions
- Need to come to a consensus on
  - what assumptions we are using to build the TE framework, and
  - what definitions we are using
- What does control mean in the context of TE?
  - Device-level control:
    - On/off decisions etc.
    - Automation
  - System-level control:
    - Stability
    - Unplanned events,
    - Aggregation such as within microgrids, etc.
    - Balance
    - Reliability
    - Constraints:
      - Institutional structures, such as market rules, etc.
  - Deterministic and verifiable, either open/closed loop
  - Direct: ON/Off signals
  - Indirect/Implicit: Price-like signals based on knowledge of preferences
  - Dispatchable/non-dispatchable
- Coordination vs. control
  - Trying to elicit useful behavior from device/system through a signal
  - Two-way flow of information between system operator and device operator
- Controls in place in wireless telecommunications to manage capacity:
  - Busy signal
  - Dropped calls

- The most popular DR program in the US is direct load control program, which is mostly used for peak load reduction application
    - Demand response has other applications than just peak-load reduction;
    - Turning demand on during over-generation scenarios is also becoming important

WORKSHOP REVIEW

PRESENTER: RON MELTON, GWAC ADMINISTRATOR & MARK KNIGHT, GWAC CHAIRMAN

FUTURE TRANSACTIVE ENERGY WORKSHOPS AND 2014 TRANSACTIVE ENERGY CONFERENCE

The group generally agreed that future workshops should be held with the intent to continue to expand the number of participants.

Workshops have been planned for February and at the fall 2015 GWAC meeting.

TRANSACTIVE ENERGY WORKSHOP CLOSING COMMENTS & SPECIAL THANKS

Ron Melton
GWAC Administrator, PNNL

On behalf of the GridWise Architecture Council I want to thank the participants in this year's workshop for the time they spent preparing for and participating in the workshop. The discussions were lively, thoughtful and thought provoking.

This workshop continued the efforts of the Council to build a community of interested regulators, policymakers, researchers and practitioners around the topic of transactive energy. This effort has come a long way from the handful of participants in the 2011 workshop to where we find ourselves today with broad recognition of this topic across the industry. The Council invites all interested parties to join the further discussions,

Finally, the Council would like to specially thank California ISO for hosting this meeting. The willingness of organizations such as California-ISO to support the work of the council is greatly appreciated.

GWAC Transactive Energy Framework
Proceedings of past transactive energy workshops and conferences.
http://www.gridwiseac.org/historical/tew2011/tew2011.aspx
http://www.gridwiseac.org/historical/tew2012/tew2012.aspx
http://www.gridwiseac.org/historical/tec2013/tec2013.aspx
To learn more, please visit
http://www.gridwiseac.org/about/transactive_energy.aspx

REFERENCE MATERIAL

Important Links

During the course of the workshop participants brought up related material that may be of interest to the broader community. Links to that material are included here.

Transactive Energy Framework Draft
http://www.gridwiseac.org/pdfs/te_framework_report_pnnl-22946.pdf

Transactive Energy 2013 Conference
http://www.gridwiseac.org/historical/tec2013/tec2013.aspx

Transactive Energy Workshops
http://www.gridwiseac.org/historical/tew2011/tew2011.aspx
http://www.gridwiseac.org/historical/tew2012/tew2012.aspx
http://www.gridwiseac.org/pdfs/gwac_tec_052313/tec_2013_proceedings_pnnl_sa_96361.pdf

GridWise Architecture Council
http://www.gridwiseac.org/

National Institute of Standards and Technology
http://www.nist.gov/smartgrid/

Pacific Northwest National Laboratory/Energy and Environment Directorate
http://energyenvironment.pnl.gov/

Pacific Northwest Smart Grid Demonstration
http://www.pnwsmartgrid.org

APPENDIX A - AGENDA

Wednesday, September 10, 2014

7:30 – 8:00 am	**Arrival / Continental Breakfast**
Administrative Agenda	
8:00 – 8:15 am	**CA-ISO Welcome and Opening Remarks** *Petar Ristanovic, VP of Technology, California ISO*
8:15 – 9:00 am	**GWAC Business** *Ron Melton, GWAC Administrator, Mark Knight, CGI & GWAC Chairman*
Conference/Event/Meeting Planning	
9:00 – 10:00 am	**Transactive Conference Planning** *Ron Melton, GWAC Administrator*
Transactive Energy Workshop Presentations	
10:00 – 11:00 am	**Presentation 1 – GridWise Alliance / DOE Future Grid Summit Outcomes** *Becky Harrison, GridWise Alliance*
11:00 – 12:00 pm	**Presentation 2 A Framework for Flexible Contracts in Wholesale Markets** *Leigh Tesfatsion, Iowa State University*
12:00 – 1:30 pm	**Presentation 3 – Cal-ISO Renewable Energy Integration – Working Lunch** *Mark Rothleder, California ISO*
Discussions	
1:30 – 3:00 pm	**Discussion 1 – How does TE fit into pending state regulatory changes?** *Facilitating – Ward Camp, Landis + Gyr & GWAC Member*
3:00 – 4:30 pm	**Discussion 2 – Managing the High Penetrations of DER** *Facilitating – Doug Houseman, EnerNex & GWAC Member*
Review	
4:30 – 5:00 pm	**Recap of the Day** *Ron Melton, GWAC Administrator*
5:00 pm	**Adjourn**

Thursday, September 11, 2014

7:30 – 8:00 am	**Arrival / Continental Breakfast**
8:00 – 8:05 am	**Welcome back for Day 2** *Ron Melton, GWAC Administrator, Mark Knight, CGI & GWAC Chairman*
Presentations	
8:05 – 9:00 am	**Presentation 4 – California Storage Roadmap** *Heather Sanders, California ISO & GWAC Member*
9:00 – 9:45 am	**Presentation 5 – DSO Models** *Farrokh Rahimi, OATI*
9:45 – 10:30 am	**Presentation 6 – DSO Models** *Lorenzo Kristov, California ISO*
Discussions	
10:30 – 12:00 pm	**Discussion 3 – The Emerging Role of DSO** *Facilitating – Farrokh Rahimi, OATI, Lorenzo Kristov, California ISO*
12:00 – 1:30 pm	**Lunch**
1:30 – 2:30 pm	**Discussion 4 – Control Aspects of Transactive Energy** *Facilitating – Doug Houseman, EnerNex & GWAC Member*
2:30 – 3:30 pm	**Integrated Next Steps** *Facilitating – Ron Melton, GWAC Administrator, Mark Knight, CGI & GWAC Chairman*
Review	
3:30 – 4:00 pm	**Workshop Review** *Ron Melton, GWAC Administrator, Mark Knight, CGI & GWAC Chairman*
4:00 – 4:30 pm	**Action Items** *Ron Melton, GWAC Administrator, Mark Knight, CGI & GWAC Chairman*
4:30 pm	**Adjourn**

APPENDIX B – SPEAKERS' PROFILES

Petar Ristanovic

Vice President of Technology, California ISO

Petar Ristanovic is Vice President, Technology. He joined the ISO in 2010 with more than 25 years of experience in the electric utility industry. Besides overseeing all technology functions for the ISO, Mr. Ristanovic also leads the Program Management Office, Physical and Information Security.

Mr. Ristanovic's career includes developing strategies for technology use, introducing new technologies and power system applications, developing and deploying advanced IT solutions and system architectures, and implementing large-scale complex utility control centers.

Mr. Ristanovic came to the ISO from Siemens Energy Automation. During his tenure with Siemens, he held numerous key positions within the development, sales, product marketing and delivery organizations. Most recently, he has served as Siemens EA Solutions Global Innovation Manager responsible for control center products and technologies. Prior to Siemens, Mr. Ristanovic worked at the Electric Institute Nikola Tesla, Belgrade, developing and implementing advanced power system applications.

He holds a Master of Science degree in Electrical Engineering from the University of Belgrade, Serbia, where he also earned his Bachelor of Science degree in Electrical Engineering.

Becky Harrison

CEO, GridWise Alliance

Biography of Becky Harrison

Becky Harrison is currently the acting CEO for the GridWise Alliance based here in Washington, DC. The GridWise Alliance is focused on advocating for policy and regulatory changes needed to advance the modernization of the nation's electrical grid.

Ms. Harrison was previously the Director, Smart Grid Technology and Outreach for Progress Energy. Harrison was responsible for establishing the Progress Energy's Smart Grid Program for both its Carolina and Florida service territories. Under Harrison's leadership, Progress Energy was awarded a $200M ARRA Smart Grid Investment Grant.

Progress Energy is a leader in the industry in deploying technologies on the grid to enhance operations and improve efficiencies. Its innovative Distribution System Demand Response program has been approved as a DSM/EE program by the North Carolina and South Carolina utilities commissions, and when fully deployed will deliver 310 megawatts of demand response capabilities by leveraging advanced volt/VAR control across the distribution grid. With the ARRA grant dollars and company matching funds combined, Progress is expected to spend $520M in during the three years grant period on Smart Grid projects across the Carolinas and Florida.

Harrison has a BS in Electrical Engineering from the University of South Carolina and an MBA from Wake Forest University. She is a registered professional engineer in North Carolina and South Carolina with over 20 years experience in the electric utility business in distribution and information technology. Harrison has managed several successful business transformation efforts that leverage new technologies to drive business value which positioned her well to lead Progress Energy's Smart Grid efforts. Harrison is active in the industry's efforts to advance Smart Grid and serves on the board of directors for the GridWise Alliance and the Smart Grid Consumer Collaborative.

Heather Sanders

Director of Regulatory Affairs, California ISO

Heather Sanders is the Director of Regulatory Affairs at the California Independent System Operator in Folsom, CA. Her focus is on advancing policy that enables the incorporation of distributed energy resources that include distributed generation, demand response, energy storage, electric vehicles, and microgrids. Formerly, she was the Director of Smart Grid Technologies and Strategy responsible for demonstration, research and promotion of smart grid and other technologies supporting ISO reliability, market efficiency, and transmission utilization objectives. She also leads an internal ISO corporate initiative titled "Grid Evolution Readiness" that studies the impact of renewable integration, evolving operational needs and resource requirements, smart grid technology integration and pilots, and renewable forecasting.

Ms. Sanders has worked in the wholesale side of electricity for over 15 years in consulting and software. She holds a BS in Electrical Engineering from South Dakota School of Mines & Technology an MBA from the University of Utah.

Leigh Tesfatsion

Professor of Economics, Iowa State University

Leigh Tesfatsion received her Ph.D. degree in economics from the University of Minnesota in 1975. She is Professor of Economics, Mathematics, and Electrical and Computer Engineering at Iowa State University. Her principal research area is agent-based test bed development, with a particular focus on electric power market design. She is an active participant in IEEE Power and Energy Society working groups and task forces focusing on power economics issues. She serves on the editorial boards of a number of journals, including the *Journal of Energy Markets* and *Foundations and Trends in Energy Markets and Policy*.

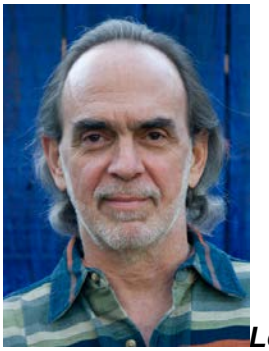
Mark Rothleder

Vice President, Market Quality and Renewable Integration, California ISO

Mark Rothleder is Vice President, Market Quality and Renewable Integration at the California Independent System Operator Corporation and is leading of the ISO's renewable integration work. Mr. Rothleder has held several critical positions at the ISO after joining the grid operator as one of its first employees in 1997. He is now the longest serving ISO employee. Before being named vice president, he was Executive Director of Market Analysis and Development. His previous positions included Principal Market Developer and Director of Market Operations.

In spring 2009, Mr. Rothleder led a multifunctional team in designing and implementing market rules and software modifications related to the ISO's Market Redesign and Technology Upgrade (MRTU). Since joining the ISO over fifteen years ago, Mark has worked extensively on implementing and integrating the approved market rules for California's competitive wholesale energy and reserves markets.

Mr. Rothleder is a registered Professional Electrical Engineer in the state of California and holds a B.S. degree in Electrical Engineering from the California State University, Sacramento. He has taken post-graduate coursework in Power System Engineering from Santa Clara University and earned an M.S. in Information Systems from the University of Phoenix. Prior to joining the ISO, Mr. Rothleder worked for eight years in the electric transmission department of Pacific Gas and Electric Company, where his responsibilities included operations engineering, transmission planning and substation design.



Lorenzo Kristov

Market and Infrastructure Policy Principal, California ISO

Lorenzo Kristov is Principal, Market and Infrastructure Policy at California Independent System Operator (ISO). He develops ISO policy in the areas of market design, transmission planning, new generator interconnection, and integration of distributed energy resources. In recent years he was instrumental in designing the ISO's new market system based on locational marginal pricing, and in the redesign of the transmission planning and new generator interconnection procedures.

During the industry restructuring of the 1990s he worked at the California Energy Commission developing the rules for retail direct access. Before that he was a Fulbright Scholar in Indonesia working on a commercial and regulatory framework for direct foreign investment in power generation.

Farrokh Rahimi

Vice President of Market Design and Consulting, Open Access Technology International, Inc. (OATI)

Farrokh Rahimi is Vice President of Market Design and Consulting at Open Access Technology International, Inc. (OATI), where he is currently involved in analysis and design of power and energy markets and Smart Grid solutions. He has a Ph.D. in Electrical Engineering from MIT, along with over 40 years of experience in electric power systems analysis, planning, operations, and control, with the most recent five years in the Smart Grid area.

Before joining OATI in 2006, he collaborated with California ISO, Folsom, CA for eight years, where he was engaged in market monitoring and design. His prior experience included eight years with Macro Corporation (subsequently KEMA Consulting), five years with Systems-Europe, Brussels, Belgium; one year with Brown Boveri (now ABB), Baden, Switzerland; ten years, as a university professor, researcher, and consultant in power and industrial control systems, and two years with Systems Control, Inc. (now ABB Systems Control, Santa Clara, CA), where he started his professional career.

Dr. Rahimi is a Senior Member of IEEE, and a number of Smart Grid task forces and committees, including NERC Smart Grid Task Force, NAESB Smart Grid Task Force, WECC Variable Generation Subcommittee, and Open Smart Grid Users Group