First International Transactive Energy Conference and Workshop Proceedings 2013

Implementing the Future of the Electrical System

Prepared by

The GridWise Architecture Council

May 23 – 24, 2013

PNNL-SA-96361

About this Document

The GridWise Architecture Council 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. In the spirit of advancing interoperability of an ecosystem of smart grid devices and systems, this document presents a model for evaluating the maturity of the artifacts and processes that specify the agreement of parties to collaborate across an information exchange interface. You are expected to have a solid understanding of large, complex system integration concepts and experience in dealing with software component interoperation. 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 whitepapers, 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.

ACKNOWLEDGMENTS

This material is based upon work supported by the U.S. Department of Energy's (DOE's) Office of Electricity Delivery and Energy Reliability, and the Building Technologies Office within the DOE's Office of Energy Efficiency and Renewable Energy.

TABLE OF CONTENTS

INTRODUCTION

The GridWise® Architecture Council (GWAC or Council), with support from Pacific Northwest National Laboratory (PNNL), the Bonneville Power Administration (BPA) and Smart Grid Oregon and Portland General Electric, convened the First International Conference and Workshop on Transactive Energy in Portland, Oregon, on May 23−24, 2013.

The Transactive Energy Conference and Workshop 2013 were organized by the GWAC as part of its mission to further the advanced thinking about the guiding principles, or architecture, of a highly intelligent and interactive electric system.

The goal of the conference and workshop was to bring together organizations, researchers and practitioners that have been researching, developing and deploying transactive energy techniques and business models.

The conference was part of the continuing work of the GWAC in defining Transactive Energy and developing an overarching framework to support development of this technical area within the electric power and building technologies industries. The GWAC believes that these results will enable accelerated adoption of transactive energy policy and technologies policy worldwide.

This first of its kind conference offered industry participants an opportunity to demonstrate leadership, both in products and in industry evolution. Organizations were given an opportunity to help offset the cost of the conference through sponsorships and 25 of them did so. The Architecture Council and Smart Grid Oregon are thankful to them for their support.

The conference structure was an adaptation of the "GWAC Stack" (a layered model of electric power system interoperability) to lay out theory (Architecture) and practice (Implementation) tracks for transactive energy. Within each track the layers of the GWAC Stack formed the scope of discussion. This started at the upper layers (Business and Policy) and moved through the middle layer (Control Architecture) to the lower layers of the GWAC Stack (Technical or Cyber-Physical). Two domain-specific workshops were included focused on building technologies from the perspective of grid integration and then looking at applying transactive approaches within buildings and facilities.

Each of the four topical areas included two serial sessions to engage the experts and interested stakeholders and in combination spanned a total of three hours of discussion of the topic with attention to both theory and practice.

These proceedings start with a summary of opening remarks and some background material on the topic of transactive energy and the previous GWAC workshops on this subject. The conference program is then presented with short summaries of each session and links to the presentations. The main body of the proceedings concludes with a framework progress summary, basically an overall recap of the conference, and discussion of next steps. Four appendices are included. Appendix A provides links to the read ahead and other reference material for the conference and workshops. Appendix B has the agenda for the

meeting. Appendix C presents the summarized discussion notes and take always for each of the workshop sessions. Finally, Appendix D has profiles for each of the conference or workshop speakers.

About the GridWise Architecture Council

The GWAC was convened in 2004 by the U.S. Department of Energy (DOE) with PNNL providing administrative and technical support with DOE funding. As a volunteer council, the GWAC includes practitioners and leaders with broad-based knowledge and expertise in power, information technology, telecommunications, financial systems and other fields who are working together toward a coordinated GridWise vision—the transformation of the nation's energy system into a rich, collaborative network filled with decision-making information exchange and market-based opportunities.

About Smart Grid Oregon

The mission of Smart Grid Oregon is to enable, promote and grow the smart grid industry and infrastructure in Oregon and the Pacific Northwest. Organized as a trade association, Smart Grid Oregon has two major goals:

- Advocacy/public policy: Smart Grid Oregon will work with smart grid stakeholders to craft and advocate for effective public policies that promote and grow Oregon’s smart grid industry and infrastructure.
- Business promotion/networking: Through informational events, conferences and other forums, Smart Grid Oregon will be a catalyst for smart grid entrepreneurs and leaders to meet, interact, compare notes and work together to grow and promote the industry in Oregon and the Pacific Northwest.

OVERVIEW AND OPENING REMARKS

CONFERENCE LEADER: RON MELTON, PACIFIC NORTHWEST NATIONAL LABORATORY

This conference built on the previous workshops on the topic of transactive energy organized by the GWAC in 2011 and 2012. The first workshop was held at Open Access Technology International, Inc. (OATI) in May 2011. The objective of the first workshop was to bring together a small number of people engaged in research and development (R&D) of transactive energy techniques to share their approaches, discuss the nature of these approaches, identify opportunities for collaboration and identify R&D needs. Participant described their work through presentations to the group. Proceedings of the workshop have been published by the GWAC through PNNL on www.gridwiseac.org.

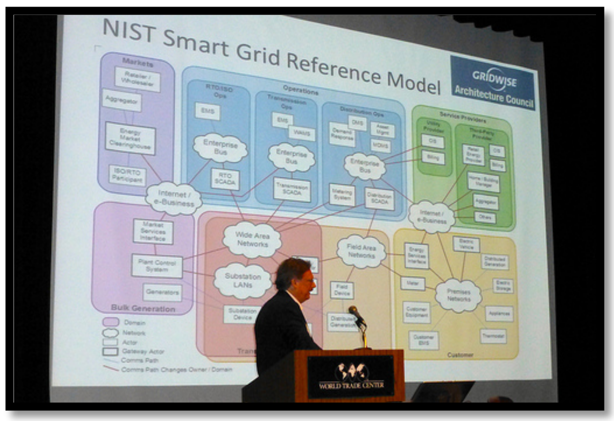
The Council hosted its second workshop on transactive energy at IBM's T.J. Watson Research Center on March 28 – 29, 2012. The 2012 Transactive Energy Workshop (TEW) engaged a broader group including researchers and others in the electric power industry with an interest in the topic. The first day of the workshop consisted of presentations from 2011 workshop participants updating their ongoing work and presentations from new participants describing their work related to this topic. The second day consisted of working sessions to discuss a proposed transactive energy white paper, discuss tutorial material on transactive energy to be presented at upcoming meetings, and to coordinate transactive energy panel sessions and tracks at meetings including Grid-Interop 2012 and the 2013 IEEE Innovative Smart Grid Technologies Conference.

After these workshops, the focus of the GWAC shifted from working with National Institute of Standards and Technology (NIST) in forming the Smart Grid Interoperability Panel to the topic of transactive energy. The GWAC embedded one-day workshops on transactive energy in its October 2012 and February 2013 face-to-face meetings. During the embedded workshops, the Council identified a need to develop an overarching document, a framework, to provide a point of reference for promoting discussion among those actively working on transactive energy technologies and applications and to introduce area newcomers to the topic.

The Council's approach in developing this Transactive Energy Framework is to build on its previous work on electric power system interoperability, in particular on the "Interoperability Context Setting Framework."[1] This document is the source of the eight-layer model of interoperability commonly referred to as the "GWAC Stack." The eight layer model may be summarized into three broad layers: business and policy, information interoperability, and cyber-physical. The Transactive Energy Framework document envisioned by the Council will be organized by these three layers and include consideration of why transactive energy approaches are needed, what the basic elements of transactive energy approaches are, and how they can be applied to meet evolving challenges to the industry.

This conference and workshop was structured to both educate the community about the topic of transactive energy and associated needs and challenges (in the plenary sessions) and to engage participants in providing input to the Council as it begins work on the framework document (in the workshop sessions). Professional facilitators assisted workshop session leaders in engaging the audience in responding to key questions identified in advance by each session leader. Session panelists were asked to give short presentations focused on providing background for the discussion of the questions.

[1] http://www.gridwiseac.org/pdfs/interopframework_v1_1.pdf



BACKGROUND

From the second workshop on transactive energy we have an answer to the question, "What is transactive energy?" The following is taken from the results of that workshop.

The term "transactive energy" is used here to refer 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 considering grid reliability constraints. The term "transactive" comes from considering that decisions are made based on a value. These decisions may be analogous to or literally economic transactions. An example of an application of a transactive energy technique is the double auction market used to control responsive demand side assets in the GridWise Olympic Peninsula Project.[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

[2] Hammerstrom, D.J. et al. 2007. *Pacific Northwest GridWise™ Testbed Demonstration Projects: Part I. Olympic Peninsula Project*, PNNL-17167, October 2007, Pacific Northwest National Laboratory, Richland, Washington.
[3] Cazalet, E.G. 2010. "TeMIX: A Foundation for Transactive Energy in a Smart Grid World", presented at Grid-Interop 2010, Chicago, Illinois. http://www.pointview.com/data/files/2/1062/1878.pdf.

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.

Currently, dynamic pricing is widely used in the wholesale power markets. Balancing authorities and others 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 have been or are being tried in a number of retail markets, for example, the PowerCentsDC dynamic pricing pilot[6] and the AEP GridSmart® experimental real-time price tariff[7].

In addition to these practical applications, research is taking place on more sophisticated techniques such as the previously cited work on transactive control. The community of people performing this research had not had a focused opportunity to discuss their work – hence the need for the workshops previously convened by the GWAC. The mini-workshops, held as a part of the October 2013 and February 2014 GWAC meetings, provided additional opportunity for interested parties to join the discussion. During these workshops an important realization was that a key driver for change in the grid is the increasing use of distributed energy resources (DER). The growth in DER presents new challenges for control of the electric power system, in particular the need to introduce more distributed control. The discussion of transactive energy in these workshops has grown to include a convergence of engineering needs, for example distributed control, with the economic aspects. The GWAC sees this as an important element of the transactive energy discussion going forward.

---

[4] Hammerstrom, D.J., et al, “Standardization of a Hierarchical Transactive Control System.” In the Proceedings of Grid-Interop 2009, November 2009, Denver, Colorado, pp. 35–41. http://www.gridwiseac.org/pdfs/forum_papers09/don-business.pdf

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

[6] http://www.powercentsdc.org

[7] Widergren, S., C. Marinovici, T. Berliner and A. Graves, “Real-time Pricing Demand Response in Operations.” In the Proceedings of the 2012 IEEE PES General Meeting, July 2012, San Diego, California, pp. 1-5

From the left, back row: Christopher Irwin, Ron Ambrosio, Robert Burke, Todd Halter, Farrokh Rahimi, Terry Oliver, Anna Scaglione, and Mahnoosh Alizadeh. Front row: Ron Melton, Rob Pratt, Ed Cazalet and Ali Ipakchi.

2011 Workshop Participants

Ron Melton, Pacific Northwest National Laboratory
Rob Pratt, Pacific Northwest National Laboratory
Todd Halter, Pacific Northwest National Laboratory
Chris Irwin, U.S. Department of Energy
Terry Oliver, Bonneville Power Administration
Ron Ambrosio, IBM T.J. Watson Research Center

Ali Ipakchi, Open Access Technology International, Inc.
Farrokh Rahimi, Open Access Technology International, Inc.
Anna Scaglione, UC Davis
Mahnoosh Alizadeh, UC Davis
Robert Burke, New England ISO
Ed Cazalet, TeMIX, Inc.

Attendees of the 2012 Workshop

2012 Workshop Participants

Ron Melton, Pacific Northwest National Laboratory
Rob Pratt, Pacific Northwest National Laboratory
Todd Halter, Pacific Northwest National Laboratory
Chris Irwin, U.S. Department of Energy
Terry Oliver, Bonneville Power Administration
Ron Ambrosio, IBM T.J. Watson Research Center
Eilyan Bitar, Cornell University
Robert Burke, New England ISO
Edward G. Cazalet, TeMix
William Cox, Cox Software Architects, LLC
Dario Gil, IBM Thomas J. Watson Research Center
Soumyadip Gosh, IBM Thomas J. Watson Research Center
Dave Hardin, SmartGrid Standards
Parithre Harsha, IBM Thomas J. Watson Research Center
Ali Ipakchi, Open Access Technology International, Inc.
James Mater, QualityLogic, Inc.
Farrokh Rahimi, Open Access Technology International, Inc.
Al Rourke, KEMA
Pamela Sporborg, Federal Energy Regulatory Commission
Michael Valocche, IBM Global Business Services
Mark Yao, IBM

READ AHEAD MATERIALS

For the First International Conference and Workshop all attendees were provided with read ahead material and the questions for discussion during the workshop sessions. The read ahead material included the proceedings from the two previous GWAC workshops on transactive energy along with a number of other documents. Web links to the read ahead material are provided in Appendix A.

Day One

Conference Welcome and Comments

Speakers: Dr. Ronald B. Melton, GridWise Architecture Council Administrator; Mr. Mark Knight, GridWise Architecture Council Chairman; Mr. Bill Nicholson, Portland General Electric Senior Vice President, Customer Service, Transmission & Distribution

The conference began with a welcome to Portland by Bill Nicholson from Portland General Electric. Mark Knight welcomed attendees on behalf of the GridWise® Architecture Council. Ron Melton provided a brief history acknowledging the participants in the previous GWAC transactive energy workshops and thanking the sponsors of this conference and workshop.

Welcome to the First International Conference and Workshop on Transactive Energy Presentation

DOE Interests in Transactive Energy

Speakers: William Parks, Deputy Director of DOE's Office of Electric Delivery and Energy Reliability

Roland Risser, the Director of DOE's Building Technologies Office

Bill Parks, the Deputy Director of DOE's Office of Electric Delivery and Energy Reliability and Roland Risser, the Director of DOE's Building Technologies Office, provided a framework for conference discussions, including the DOE vision for transactions-based approaches to energy, the potential national benefits to both the power system and to building owners of realizing it and an overview of DOE's R&D and implementation efforts.

The Role of Transactive Energy in Grid Moderations and Building Technologies Presentation

Plenary Panel – Elements of a Transactive Energy Framework

Moderators: Ronald Melton, (Battelle/Pacific Northwest National Laboratory; Martin Rosenberg, EnergyBiz Magazine

Speakers: Paul De Martini, Newport Consulting Group, LLC; Ron Ambrosio, IBM T.J. Watson Research Center; Jeffrey Taft, Cisco, Chief Architect, Connected Energy networks; Terry Oliver, Bonneville Power Administration

The overall purpose of this panel was to introduce the topic of transactive energy to the conference attendees and provide a common starting point for the workshop discussions. This began with a basic definition of transactive energy taken from the second GWAC workshop, some history of projects related to the topic, discussion of the convergence of economic and engineering needs and a preview of the elements of the Transactive Energy Framework document.

Initial architectural considerations were described, motivated by the Pacific Northwest Smart Grid Demonstration Project and by analysis of current control architectures versus those needed in a more distributed system. A key point from the latter was the notion of "Emerging Architectural Chaos" if new approaches are not undertaken.

Finally, a preliminary view of transactive energy value and services was described. This presentation provided some contrast between present approaches and transactive energy approaches. The need for "flexible resource values and services" was discussed with the example of the California future challenge of extreme aggregated wind ramps with high levels of variable energy resources. Three key challenge areas were described:

- affordability, reliability and sustainability convergence
- business model implications
- pathways to customer value creation.

Ambrosio – Transactive Energy Management: Value, Incentivization, Cost and Price Presentation

De Martini − Transactive Energy Presentations

De Martini − Transactive Energy Value Presentations

Taft − Grid Control Issues Presentations

From left: Jeff Taft, Terry Oliver, Ron Ambrosio, and Paul De Martini during plenary panel discussion

KEYNOTE – STATE REGULATOR'S VIEW OF TRANSACTIVE ENERGY

MODERATOR: CARL IMHOFF, PACIFIC NORTHWEST NATIONAL LABORATORY, MANAGER

PRESENTER: PHIL JONES, NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS (NARUC) COMMISSIONER

State Regulator's View of Transactive Energy: Implementing Transactive Energy. Philip Jones, Chairman WUTC and President of NARUC, discussed the issues of state regulation and the deployment of Transactive Energy applications within the electric power system.

1 Business and Policy Architecture Workshops

1A – Policy and Market Design

MODERATOR: JEFF GOODING, SOUTHERN CALIFORNIA EDISON

SPEAKERS: ED CAZALET, TEMIX, INC., FOUNDER; ALI IPAKCHI, OPEN ACCESS TECHNOLOGY INTERNATIONAL, INC., VICE PRESIDENT SMART GRID AND GREEN POWER; WARD CAMP, LANDIS + GYR

This workshop session explored the policy and market design considerations of emerging transactive energy implementations. Specifically, a panel of industry thought leaders discussed policy objectives, transactive energy markets' potential to contribute to sustainable energy goals, higher reliability expectations, integration of new energy technologies and requirements for new market-based mechanisms for managing an electric grid that integrates new energy technologies and expands the traditional energy supply chain. The session also examined potential constraints and market mechanisms that enable value realization across customer categories and requirements to maintain fair access to reliable and affordable power. The workshop addressed policy and market design theory and practice, including but not limited to such topics as balancing leading-edge customer expectations with trailing customers while maintaining utility operational requirements; impacts on customer costs and requirements to ensure transparency in the market; and lessons from the telecommunications and other technology sectors that can be leveraged by utilities to evolve and integrate new energy technologies and meet customer demands.

Gooding − TEC 2013 Workshop – 1A Policy and Market Design Presentation

Cazalet − Transactive Energy Public Policy and Market Design Presentation

Camp − Transactive Energy: A Policy-Maker's Perspective Presentation

Ipakchi – Considerations for Transactive Energy Framework Presentation

1B – Business Models and Value Realization

MODERATOR: PAUL DE MARTINI, NEWPORT CONSULTING GROUP, LLC, MANAGING DIRECTOR

SPEAKERS: STEVE WIDERGREN, PACIFIC NORTHWEST NATIONAL LABORATORY, PRINCIPAL ENGINEER; DIAN GRENEICH, DIAN GRUENEICH CONSULTING, LLC, FOUNDER AND PRINCIPAL; GREG ANDER, ENERGY FOUNDATION VICE PRESIDENT POWER AND EFFICIENCY

Transactive energy is at its core about the identification, communication and monetization of economic value related to customer participation in the power system. This session brought a strategic perspective and discussion related to advancing development of transactive products, valuation techniques and monetization methods that align power system needs and customer benefits to enable current and emergent business models. Key questions posed by the speakers were discussed by all participants in the session as input into the Transactive Energy Framework under development.

De Martini − TEC 2013 Workshop 1B – Business Models & Value Realizations Presentation

Ander − Business Value Streams Presentation

Grueneich − Transactive Energy – Business Models and Value Realization Session Presentation

2 Transactive Energy Architecture Workshops

2A – Transactive Energy Management Architecture

Moderator: Ron Ambrosio, IBM T.J. Watson Research Center

Speakers: Donald Hammerstrom, Pacific Northwest National laboratory, Pacific Northwest Smart Grid Demonstration Principal Investigator; Jeffrey Taft, Cisco, Chief Architect, Connected Energy networks

This audience-interactive session focused on architectural considerations and frameworks for both transactive energy electrical and information flows for achieving the direct and indirect value realization discussed in the Business and Policy sessions.

It explored transaction and control architectural issues from local to ultra-large scales and how they relate to various domains such as markets, grid management systems, renewable and distributed generation, building and premises interactions, micro grids and vehicles while enabling stable, coordinated transactive energy operations and planning.

Our purpose was to create the basis for a more in-depth discussion leading to architecture.

Ambrosio – Transactive Energy Management: System Architecture Presentation

Taft – Frameworks Presentation

Ron Ambrosio explaining Pacific Northwest Smart Grid Demonstration architecture

2B – Transactive Energy Functional Requirements

Moderator: Jeffrey Taft, Cisco, Chief Architect, Connected Energy networks

Speakers: William Cox, Cox Software Architects, LLC, Principal; Larry Lackey, Coergon; Chris Knudsen, AutoGrid Systems, Inc. Chief Technology Officer

This session focused on exploration of the high-level functional requirements for transactive energy implementations, building on the plenary presentations and architectural considerations from Session 2A. Frameworks introduced in the plenary session were used and briefly recapitulated in Session 2A aiding

in the discussion. Discussion focused on two key questions introduced by speakers who provided some brief general context and background.

Lackey – The Story of an Energy Services Interface (ESI) Presentation

Knudsen − Transactive Energy Requirements Presentation

Day One Closing Comments – Progress Towards a Framework

Presenters: Dr. Ronald B. Melton, GridWise Architecture Council Administrator; Mark Knight, CGI, Executive Consultant, Energy Solutions

The first day of the conference and workshop was marked by very interesting plenary presentations, more depth of discussion with the moderated plenary panel and time for audience questions. The workshop sessions engaged the participants with focused presentations and discussion questions.

Key takeaways from the first day included the following:

- The business model(s) of utilities will have to change. A number of things are driving this change, including increased use of renewable resources in the bulk power system and increased use of distributed energy resources. Additional factors include declines in retail electricity sales brought on by efficiencies in the buildings sector (and loss of manufacturing). The efficiency increases are, in turn, driven by minimum efficiency standards for many kinds of equipment.
- We are early in the discussion of transactive energy. There is great interest in the topic but much work to be done to bring the potential benefits of these approaches to fruition.

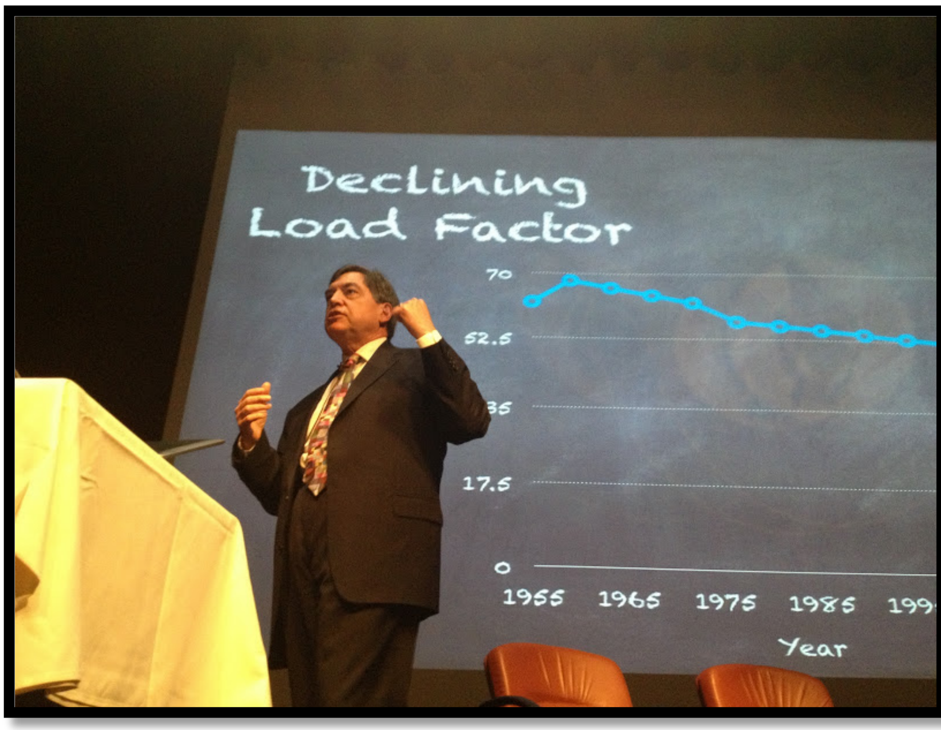
Day Two

Keynote – Our Changing Grid

Presenter: Jon Wellinghoff, Federal Energy Regulatory Commission (FERC)

FERC Chairman Jon Wellinghoff provided a view of challenges that transactive energy or other approaches must address in the power system of the future. He took the audience through "A Day in the Life of the Grid" via an hour-by-hour view of the hottest summer day in the Midwest Independent System Operator (ISO) territory, with wind providing very little power at 1 p.m. when it was 100°F.

A Day in the Life of the Grid Presentation



Chairman Jon Wellinghoff discussing a day in the life of the grid

Lunch Plenary – Implementing Transactive Energy'

Moderator: Terry Oliver, Bonneville Power Administration

Speaker: Stephen Wright, Bonneville Power Administration

There are practical considerations for the application of transactive energy techniques in a regional power system. This talk considered the importance of establishing a business case and organizing research around this and related practical considerations.

To emphasize the practical importance of a business case, the speaker drew on his own experiences, and provided examples of how robust understanding of benefits, cost, and alternatives resulted in successful but difficult decisions with billion dollar implications.

Then the talk looked forward to the challenges and opportunities becoming apparent to the electric industry, from high levels of variable generation on both edges of the grid - generation and end-use, to additional operational efficiency, reliability, and resiliency that could become reality; but only if good business cases are developed.

Finally, Mr. Wright called out the need for and benefits of truly professional and disciplined research and development by electric utilities and their partners, and noted that BPA had developed such an approach over the last few years that was already delivering significant progress and clear benefits, to BPA, and to the electric sector.

Cost-Benefit Analysis Presentation

Steven Wright explaining the importance of disciplined analysis

PLENARY PANEL – IMPLEMENTING TRANSACTIVE ENERGY; LESSONS LEARNED AND CASE STUDIES

MODERATOR: TERRY OLIVER, BONNEVILLE POWER ADMINISTRATION

SPEAKERS: DR. RONALD B. MELTON, BATTELLE/PACIFIC NORTHWEST NATIONAL LABORATORY; JEFF GOODING, SOUTHERN CALIFORNIA EDISON; ERICH GUNTHER, ENERNEX

This panel reviewed the progress of several projects implementing transactive energy techniques.

Gooding – Transactive Energy Exploration at Southern California Edison Presentation

Melton – Transactive Control Case Study: Pacific Northwest Smart Grid Demonstration Project Presentation

Gunther – Pragmatic Transactive Energy – A Green Field Campus Design Presentation

3 Enabling Cyber-Physical Infrastructure

3A – Enabling Cyber-Physical Infrastructure (Theory-Grid Integration)

Moderator: Erich Gunther, EnerNex

Speakers: Jeff Gooding, Southern California Edison; Huy Ngo, Bonneville Power Administration; Ali Ipakchi, Open Access Technology International, Inc.; Paul De Martini, Newport Consulting Group, LLC

In its simplest form, the overall architecture of the grid can be seen in three easy steps or domains—make, move, and use. In a transactive energy ecosystem, numerous components must work together to achieve the overall objectives of such a system. These components include numerous grid components—centralized and distributed energy sources, transformers, transmission and distribution lines and support structures, switching equipment, sensors, control systems, protective relays, energy storage devices, residential/commercial/industrial consumer distribution systems, energy consuming devices, energy management systems and more.

The architecture includes two cyber-physical networks—the electrically connected network and the communications networks necessary to monitor and control it. When the grid was first instantiated, there was no communications network of any kind so the grid was architecturally designed to perform its primary function with highly optimized local control to protect equipment and support safe operation of the grid. As the grid has evolved, an increasingly pervasive communications network has emerged to support the ever increasing demands on grid infrastructure and ensure the continued safe, reliable operation of the grid as a system of systems.

As we evolve the grid further to support the concepts and goals of transactive energy, we must transform the cyber-physical elements of the grid. New sensors, actuators, distributed and centralized control elements not necessary for the traditional operation of the grid must now be deployed. Existing (or legacy) systems must be pressed into service to support applications they were not originally designed to support. These devices and systems must support information gathering and automation in a manner that is much more flexible than has been needed for operating the traditional grid. Specifically, key architectural principles of asynchronous information exchange, disengaged data, staged data filtering and pruning and layered and loosely decoupled system interactions are key to achieving that flexibility.

Gooding – Enabling Cyber-Physical Infrastructure Presentation

Ipakchi – Enabling Cyber-Physical Infrastructure Presentation

Gunther – Enabling Cyber-Physical Infrastructure (Theory) Presentation

De Martini – Evolution of Distributed Power Systems Presentation

From left Ward Camp, Jeff Gooding, and Ali Ipackchi

3B – Enabling Cyber-Physical Infrastructure (Practice-Implementation Elements, M&V)

MODERATOR: AARON SNYDER, ENERNEX

SPEAKERS: CHRIS KNUDSEN, AUTOGRID SYSTEMS, INC.; SHAWN CHANDLER, PORTLAND GENERAL ELECTRIC; HUY NGO, BONNEVILLE POWER ADMINISTRATION

In its simplest form, the overall architecture of the grid can be seen in three easy steps or domains—make, move, and use. In a transactive energy ecosystem, numerous components must work together to achieve the overall objectives of such a system. These components include electric grid components and different communication system components to complete the ecosystem. Key among the cyber physical implementation elements are enterprise management system components including enterprise networks, databases, data warehouses, application servers, network management systems, cyber security appliances and more. All devices and systems must interact along well-defined points of interoperability.

This session focused on implementation, measurement and verification issues from the perspective of those who have started deploying, or are on the cusp of deploying, live systems.

Snyder – Enabling Cyber-physical Infrastructure (Practice-Implementation Elements, M&V) Presentation

Knudsen – Enabling Cyber-Physical Infrastructure (Practice-Implementation Elements, M&V) Presentation

PGE Transactive Node Development – Creating Intelligent Grids Presentation

4 Transactive Energy Building and Facility Integration Workshops

4A – Transactive Energy End-to-End with Emphasis on Facility to Grid

Moderator: Mark Knight, CGI

Speakers: Farrokh Rahimi, Open Access Technology International, Inc.; Fred Fletcher, Burbank Water & Power; David Holmberg, National Institute of Standards and Technology

This session focused on end-to-end elements of the Transactive Energy Framework. It specifically focused on facility-to-grid scenarios by looking at various end-to-end elements across different components of the traditional energy system from consumers/prosumers to distribution to bulk power operation and markets.

The term facility covers a broad range of potential entities from a residential household to a smart commercial building to a campus with many buildings. The common attributes that any facility has in this context is that it has multiple intelligent components/agents that are responsible for managing energy either directly or indirectly through management and analysis of energy data, including consumption levels, prices, etc. As such, these components form part of a control system for the facility that in turn interacts with external transactive energy elements across distribution and/or transmission systems.

These interactions are influenced by a number of factors that represent a classification of issues that cut across all layers of the of the Transactive Energy Framework that need to be focused on (technical, informational, organizational) in order to understand the constraints and enablers of transactive energy.

The end-to-end perspective provides a high-level view of the transactive energy landscape. As we now look to the future and focus on the impacts of transactive energy, where a mature transactive grid comprises optimization and control that is coordinated and distributed but largely decentralized and is associated with the parties, devices and systems that use and compose the grid and where transactions can be designated as either financial or physical, it is time to take a closer look at the cross-cutting issues, from the perspective of how they affect facility-to-grid transactions.

Knight – Transactive Energy End-to-End with Emphasis on Facility-to-Grid Presentation

Fletcher – Transactive Energy End-to-End with Emphasis on Facility-to-Grid Value to Self-Supplying Distribution Electric Utility in Urban Markets Presentation

Holmberg – Engaging Customer Systems Presentation

4B – Transactive Energy Applied to Buildings/Facilities Energy Management

Moderator: Ken Wacks, Home & Utilities Systems

Speakers: George Hernandez, Pacific Northwest national Laboratory; Ron Ambrosio, IBM T.J. Watson Research Center

This session focused primarily on the application of transactive energy techniques and capabilities within buildings/facilities. Buildings can benefit from transactive energy, both as stand-alone structures and as part of a collective such as a campus or neighborhood, and new value streams can be “unlocked” by allowing buildings to participate in ancillary and other service markets.

This session sets the stage by first discussing the value to the building community of interoperability and the application of the GWAC Stack. Real examples of transactive energy scenarios where equipment within a building, such as an advanced rooftop unit (RTU) for air conditioning, common on big box retail stores, can interoperate with other building devices including a building automation system and onsite generation (such as photovoltaics , backup generation, combined heat and power, etc.) and storage (such as thermal or electric) using transactive techniques to improve overall cost effectiveness. A building with this capability might participate in responsive demand (peak demand and generation following) and dynamic grid services (e.g., volt/volt-amp-reactive support, frequency) to generate a significant savings and potentially new revenues compared to day-ahead Demand Response. Buildings can be aggregated via transactive systems to balance loads on the rooftop units resulting in overall savings and reduced costs.

This session included two stages of discussion. First, the panelists summarized current and future activities related to the application of transactive techniques in buildings/facilities. These presentations described a future class of building technology. Then the audience was invited to discuss the application of transactive energy techniques as an integral part of building technology.

Wacks – Transactive Energy for Buildings Presentation

Ambrosio – Transactive Energy Management: Premises Energy Management Example Presentation

Hernandez – Buildings Technologies Office – National Energy Efficiency Starts Here Presentation

FRAMEWORK PROGRESS REPORTS AND SUMMARY: NEXT STEPS

The keynote presentations and panel sessions provided a view of the drivers for change in our electric power system, including the relationship between the power system and major uses of electric power in buildings and facilities. The opening plenary panel also sketched out the GWAC's plans for a Transactive Energy Framework document that is intended to help bring together the community of parties interested in the subject of transactive energy.

The day 2 plenary presentations reinforced many of the messages from day 1. FERC Chairman Jon Wellinghoff provided insight into the practical challenges for the current electric power system through his hour-by-hour look at prices and power availability on the hottest summer day in the Midwest ISO service territory. The variability through the day provided an example of the potential benefits of dynamic pricing that could enable an electric vehicle to charge at night when wind is providing lower cost electricity instead of during the day when wind is not blowing and other loads are driving demand up. During the question and answer period, he emphasized the need to clearly understand the business drivers—the return on investment in particular—to enable investments in new technology.

This theme was reinforced by Steve Wright's lunch presentation. Wright provided examples of challenges, such as the extreme aggregated wind ramps expected in California, and underscored the need for thorough understanding of the business drivers associated with new technology, operations and business models.

A key takeaway from the conference was the importance of the data being collected by current smart grid pilots or demonstration projects that include transactive energy elements. The morning plenary panel provided brief overviews of three such projects—two in the electric power system and one involving a major corporation's efforts to engineer a smart campus of the future.

The workshop sessions at the conference were structured to promote discussion around the core sections of the framework document. Notes from each session have been reviewed and are consolidated in Appendix C. The discussion in the individual sessions varied depending on the topic, the presentations by the panelists and the audience. For each session the notes include a statement of the focus area for the session, a summary of key takeaways, a short description of each presentation, including the name and affiliation of the presenter, and each discussion question with key points or takeaways for that question.

The GWAC will use this material as it writes the Transactive Energy Framework document. The plan is to complete a draft for review of a core document by September 30, 2013. This document will be released at the end of October. The document will include a small number of conceptual use cases illustrating applications of transactive energy in both the grid and in buildings. The GWAC is planning another workshop in early December 2013 and invites the entire community to also develop conceptual use cases to be discussed at this workshop.

The core framework document is intended as a beginning in promoting robust discussion within the grid and building technologies communities at all levels—from the policy and regulatory level, through the information management and controls down to specific technical interconnection and connectivity. As such, it is envisioned as a document that will grow beyond the core with elements that apply to each of these levels.

CLOSING COMMENTS & SPECIAL THANKS

The GridWise® Architecture Council and Smart Grid Oregon thank all of the speakers, session leaders, student volunteers and sponsoring organizations. Last, but not least, we thank the participants. The discussions during the course of the conference and the workshop sessions are very valuable in helping the GWAC prepare the Transactive Energy Framework.

Organizers

The Council organized the First International Transactive Energy Conference and Workshop as part of its mission to further advanced thinking about the guiding principles, or architecture, of a highly intelligent and interactive electric system.

Steering Committee

James Mater, QualityLogic, GWAC Member
Ron Melton, PNNL, GWAC Administrator
Mark Knight, CGI, GWAC Chair
Erich Gunther, EnerNex, GWAC Chairperson Emeritus
Paul De Martini, Newport Consulting, GWAC Member
Ron Ambrosio, IBM Research, GWAC Past Chairperson Emeritus
Terry Oliver, BPA
Jeff Taft, Cisco, GWAC Member

Operating Committee

Smart Grid Oregon
Portland General Electric

Downtown Portland

Our Sponsors

PREMIUM SPONSORS

GridWise Architecture Council

Pacific Northwest National Laboratory
Proudly Operated by **Battelle** *Since 1965*

Portland General Electric

Smart Grid Oregon™

GOLD SPONSORS

NIST

ALSTOM

Landis+Gyr

CISCO

SILVER SPONSORS

intel

OATI

openADR ALLIANCE

VERIS INDUSTRIES

PK energy Solutions

QualityLogic. Putting Technology to the Test

ACME

Center for Public Service

SUPPORTING SPONSORS

Bonneville Power Administration

CGI

RESNICK INSTITUTE science + energy + sustainability

best Oregon Built Environment & Sustainable Technologies Center

PointView

Equilibrium Capital

ENDORSING SPONSORS

Citizens' Utility Board of Oregon

NEBC northwest environmental business council

EP Electricity Policy Electricity Daily

DTHREE PRODUCTIONS

LONMARK® INTERNATIONAL

Northwest Power and Conservation Council

Pacific NorthWest Economic Region

NW Energy Coalition

Renewable Northwest Project

Tecnológico de Monterrey

Appendix A – Reference Material

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

Advanced Grid Planning & Operations
http://www1.eere.energy.gov/solar/pdfs/advanced_grid_planning_operations.pdf

AEP Demonstration Project website
http://www.smartgrid.gov/project/aep_ohio_gridsmartsm_demonstration_project

A Foundation for Transactive Energy in a Smart Grid World
http://www.pointview.com/data/files/2/1062/1878.pdf

Bain & Co. Distributed Energy Business Models
http://www.bain.com/publications/articles/distributed-energy-disrupting-the-utility-business-model.aspx

Caltech Resnick Institute Grid2020 Discussion Series
http://www.resnick.caltech.edu/learn/grid.html

Control of the Grid in 2020, and How Economics Can Help Us
http://www.newton.ac.uk/programmes/SCS/seminars/2013042409301.html

DOE Building Technologies Office
http://www1.eere.energy.gov/buildings/index.html
http://www1.eere.energy.gov/buildings/technologies/sensors_controls_research.html
http://www1.eere.energy.gov/buildings/commercial/index.html

Electric Utility Business Models of the Future
http://www.edisonfoundation.net/iee/Documents/Fox-Penner_IEE_071510_Final.pdf

Energy Interoperation Version 1.0
http://docs.oasis-open.org/energyinterop/ei/v1.0/cs02/energyinterop-v1.0-cs02.html

Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide
http://www.sandia.gov/ess/publications/SAND2010-0815.pdf

German energy consumers transform into local energy providers
http://www.guardian.co.uk/sustainable-business/blog/german-bioenergy-villages-energy-supply

Green Button
http://energy.gov/sites/prod/files/Green.Button.webinar.for_.DOE_.Apps_.Energy.pptx

Grid 2020: Towards a Policy of Renewable and Distributed Energy Resources
http://resnick.caltech.edu/learn/docs/GRID_2020_Resnick%20Report.pdf

GridWise Architecture 2011Transactive Energy Workshop
http://www.gridwiseac.org/

GridWise Architecture Council 2012 Transactive Energy Workshop Proceedings
http://www.gridwiseac.org/pdfs/tew_2012/tew_2012_proceedings.pdf

Integrated DER Pricing & Control
http://newportcg.com/wp-content/uploads/2012/11/CIGRE_DER_PricingControl082412.pdf

LBNL CERTS Distributed Resource Integration Website
http://certs.lbl.gov/certs-randm.html

Navigant - Potential Use of IOU Demand Response Programs for Integration of Wind and Solar Energy Needed to Achieve California's Renewables Portfolio Standard
http://www.cpuc.ca.gov/NR/rdonlyres/E77C1B30-2989-463F-A178-E8610410AEA6/0/UseofDRforRenewableEnergyIntegration.pdf

New utility business models: Experts predict the 3 stages of our evolution
http://www.smartgridnews.com/artman/publish/Business_Electronomics/New-utility-business-models-Experts-predict-the-3-stages-of-our-evolution-4481.html#.UYR-tmbn_IU

Pacific Northwest Demonstration Project website
http://www.pnwsmartgrid.org/publications.asp

Potential Role of Demand Response Resources in Maintaining Grid Stability and Integrating Variable Renewable Energy
http://www.calmac.org/publications/7-18-12_Final_White_Paper_on_Use_of_DR_for_Renewable_Energy_Integration.pdf

Renewable and Distributed Power in California
http://media.hoover.org/sites/default/files/documents/energy-policy-tf-grueneich-study.pdf

SGIP SGAC Conceptual Model and Details
http://collaborate.nist.gov/twiki-sggrid/pub/SmartGrid/SGIPCommitteeProductsSGAC/Smart_Grid_Conceptual_Model_20100420.pdf

Southern California Edison's Approach to Evaluating Energy Storage
http://www.edison.com/files/WhitePaper_SCEsApproachtoEvaluatingEnergyStorage.pdf

Standardization of a Hierarchical Transactive Control System
http://www.gridwiseac.org/pdfs/forum_papers09/don-business.pdf

Transaction-based Techniques for Bulk Power Operation Will Be Useful in Distribution
http://smartgrid.ieee.org/september-2011/158-transaction-based-techniques-for-bulk-power-operation-will-be-useful-in-distribution

Transactive Device Architecture and Opportunities
http://www.cazalet.com/images/GI12-Paper-12032012-Final_Cazalet_Sastry.pdf

Understanding Microgrids as the Essential Architecture of Smart Energy
http://www.gridwiseac.org/pdfs/forum_papers12/considine_paper_gi12.pdf

Ultra Large-Scale Power System Control Architecture
http://www.cisco.com/web/strategy/docs/energy/control_architecture.pdf
Virtual Power Plants, Real Power
http://spectrum.ieee.org/energy/the-smarter-grid/virtual-power-plants-real-power

Virtual Power Plants in Real Applications in EU
http://www.iwes.fraunhofer.de/de/publikationen/uebersicht/2009/virtual_power_plantsinrealapplications-pilotdemonstrationsinspai.html

Appendix B – Agenda

Thursday May 23, 2013

Time	Session	Room
7:00 am	Arrival and check-in	Auditorium Lobby
8:00 am	Welcome Comments	Auditorium
8:30 am	DOE Interests in Transactive Energy	Auditorium
9:15 am	Break – refreshments; sponsor information tables	Auditorium Lobby
9:30 am	Plenary Panel – Elements of a Transactive Energy Framework	Auditorium
11:30 am	Break – refreshments; sponsor information tables	Auditorium Lobby
12:00 pm	Lunch Keynote – State Regulator's View of Transactive Energy	Mezzanine 2, 3, 4
1:30 pm	Workshop 1A – Policy and Market Design	Skybridge A & B
	Workshop 2A – Transactive Energy Management Architecture	Auditorium
3:00 pm	Break – refreshments; sponsor information tables	Auditorium Lobby
3:20 pm	Workshop 1B – Business Models and Value Realization	Skybridge A & B
	Workshop 2B – Transactive Energy Functional Requirements	Auditorium
4:45 pm	Closing Comments – Progress Towards a Framework	Auditorium
5:00 pm	Evening Reception	Skybridge Terrace

FRIDAY, MAY 24, 2013

Time	Session	Room
7:00 am	Arrival and check-in	Auditorium Lobby
8:00 am	Keynote: Our Changing Grid	Auditorium
8:55 am	Plenary Panel – Implementing Transactive Energy: Lessons Learned and case studies	Auditorium
9:40 am	Break – refreshments; sponsor information tables	Auditorium Lobby
10:00 am	Workshop 3A – Enabling Cyber-Physical Infrastructure (Theory-Grid Integration)	Auditorium
	Workshop 4A – Transactive Energy End-to-End with Emphasis on Facility to Grid	Skybridge A & B
11:30 am	Lunch Plenary – Implementing Transactive Energy	Mezzanine 2, 3, 4
1:00 pm	Workshop 3B – Enabling Cyber-Physical Infrastructure (Practice-Implementation Elements, M&V)	Auditorium
	Workshop 4B – Transactive Energy Applied to Buildings/Facilities Energy Management	Skybridge A & B
2:30 pm	Break – refreshments; sponsor information tables	Auditorium Lobby
3:00 pm	Framework progress reports and summary: next steps	Auditorium
4:00 pm	Adjourn	Auditorium Lobby

Appendix C – Results

1 Business and Policy Architecture Workshops Workshop

1A – Policy and Market Design

This workshop focused on the necessary policy and market design changes needed to facilitate the transition to a transactive energy (TE) paradigm. Specifically, it focused on the role of regulators in establishing innovative and alternative regulation and what a TE marketplace might entail, and how the utility business models would have to evolve. The general consensus was that a complete overhaul of the existing market and regulatory structures might not be possible or desirable. Regulatory policy changes are dependent on utility business models and vice versa, so the two will have to move in conjunction with each other. One example is performance-based regulations—as opposed of cost-of-service-based operations—such as those being tested in the United Kingdom (UK).

The workshop started out with opening statements from three panelists. Ali Ipakchi from Open Access Technology International, Inc. (OATI) focused on various dimensions related to operational and technical aspects of TE. Ipakchi noted that the issues related to planning, forecasting, operating and settling in a TE paradigm will be different from those related to conventional energy, and they will require innovative market and regulatory constructs. The speaker suggested that power systems in such a world may be operated as hybrid systems, with a mix of centralized and distributed controls.

Ward Camp from Landis + Gyr suggested that all aspects of TE were difficult to implement in the current regulatory framework. He asked what the role of regulators was supposed to be when customers might avoid utilities completely in a TE world. Another question was the issue of involvement of federal and state regulators at the two levels of power system, and what might be needed to bring the two together.

Ed Cazalet from the Cazalet Group talked about the implications of TE from both policy and market perspectives and which would allow customers to participate in a decentralized manner while providing business opportunities to entities providing services to customers, respectively. The speaker also suggested specific market design elements that would be required to enable TE.

During the ensuing discussions, the workshop addressed several questions. The key objectives and attributes of an effective TE market needed to include price transparency. Prices, regardless of whether they were market driven or regulated retail rates, needed to be transparent. Only real prices had a meaning. Secondly, energy as a product was deemed to be a key in TE discussions. However, there may be too many products in the markets already and these products need to be tied to energy, which would not only reduce the number of products but also increase market transparency. Lastly, to avoid stifling technology innovation, participants cautioned not to be locked into any particular market design paradigm.

Several suggestions were made to outline alternative regulation needed to enable broad market participation, including existing and emerging market participants. On the topic of regulation, participants concluded that regulatory policies and market design may not need to be completely overhauled. It was important to recognize what works and then make incremental changes to extract maximum benefits. Alternative regulation did not necessarily mean less regulatory oversight. Typically, more policies mean more regulations and innovative regulation does not mean regulators get out of the way. What was needed was "simple" market and regulatory overlays that can be nationally applied so that enough private players get involved and provide a momentum going forward. It was also helpful to also consider the experience of other countries experimenting with alternative regulation, such as the new performance-based model RIIO in the UK.

Lastly, Public Utility Commissions (PUCs) could only focus on certain value streams that may potentially be extracted using TE mechanisms. Because utilities were not compensated for information technology (IT), innovation, research and development (R&D), among others, these services might be provided by third-party providers unless the utility business model changes from cost-of-service to some performance-based returns.

Participants had several ideas in response to a question about the policy changes needed to allow investments in technologies to provide their optimal value, while protecting the public interest.

Because regulators are typically very risk averse, protecting financial integrity of utilities and the interest of rate payers are key considerations, even though the two objectives are not always weighted equally. In addition, while regulators may not be comfortable allowing R&D to be burdened on ratepayers as a cost of service, it may be necessary to refocus on standards directing amount of R&D spending by utilities. This was especially true because high tech firms spend up to 10% of their revenues on R&D, while utilities only spend a small fraction of 1%. Currently, the rate payers and shareholders equally foot the burden of unsuccessful endeavors, while the shareholders enjoy a greater share of successful ones.

Other participant questions/comments:

- How to determine the price of energy purchased from neighbor who owns a solar generator: Should that be the cost of generation or the same as retail price?
- Write legislation for innovations and R&D so it encourages PUCs to fund in rates.
- Product service providers (utility or third party) need to be able to offer their services nationally (without having 50 different versions).
- How do we engage and educate the public about this changing paradigm?
    - Distributed energy generation and storage is an opportunity to educate an otherwise apathetic public.
- Technical terms need to be clearly defined with some common taxonomy, e.g., decentralized vs. distributed, price vs. cost, etc.
- How can transactions be monitored, approved, etc., to mitigate reliability impacts?
- Provide forward transactable prices to fully incentivize customers.
- There needs to be an element that allows for optimization at any part of energy use.
- There must always be a continuous and long-term positive return on investment.
- As TE becomes pervasive, there will be less cost certainty in ROI for transactive assets. With less cost certainty, it will be difficult to finance TE assets.
- Specific services attained by “market concepts” of supply and demand vs. others that require regular oversight need to be separately identified.

1B – Business Models and Value Realization

This workshop focused on designing a framework to extract value that TE can help unlock and support various business models. At the core of TE is the idea of identifying, communicating and monetizing economic value related to customer participation. The Transactive Energy Framework should be designed with the purpose of advancing products and services from strategic perspective of maximizing customer participation, while simultaneously serving the needs of the power system. Major themes for discussion were the value propositions and business models, value identification, services/products and value realization.

It is essential that the utility business model changes to extract maximum value out of the Transactive Energy Framework. There were plenty of lessons learned from other industries, such as telecommunications and airlines, when they were transitioning from fully to partially regulated modes. The transition to a TE future is estimated to cost trillions of dollars' worth of investment, where the greatest cost is that of capital. Yet since utilities' credit ratings have dropped from AAA in the past to BB today, capital at low cost is no longer available. It may be possible to leverage other entrants in TE space to make more capital available for utilities to invest in infrastructure. In addition, more investors would lead to lower capital costs because of diversification of risk, while some of the TE mechanisms may lead to lower revenues for utilities, which may be significant sources of local, state and federal taxes. The issue of lower tax revenues may need to be addressed. However, utilities may recover lost energy revenues by providing other services.

To create additional value streams that free up additional capital for utilities while providing value streams for customers, TE products and services need to be designed to serve the needs of the power system. All value streams may not be revealed at the same time, but incremental approaches may open up more products and value streams. One example is large-scale photovoltaic penetration in distribution systems, which has opened a need for voltage and frequency control in distribution systems and could be served using TE mechanisms. It also may be possible to unbundle existing products and services to serve different needs of customers from different economic classes.

Former California Public Utilities Commission Commissioner Dian Grueneich suggested that valuation of the Transactive Energy Framework needs to be done from the following three perspectives: 1) reliability, 2) affordability, and 3) sustainability. An understanding of the impacts of TE on these three aspects affecting customer services and new modeling tools to explore various TE frameworks are needed.

Gregg Ander from the Energy Foundation presented various drivers for new value streams to be unlocked using TE mechanisms. He also presented examples of new business models being explored by various research entities across the United States and key barriers to market participation and value realization.

Pacific Northwest National Laboratory's (PNNL's) Steve Widergren laid out a roadmap to value realization in a TE paradigm that includes addressing clear value propositions, developing the appropriate markets and identifying clear steps for integration with existing systems. The speaker also mentioned that TE was an inherently distributed multi-objective frameworkthat has potential for market abuse/manipulation by participants, and hence, proper safeguards need to be in place.

Other participant questions/comments:

- What impact would the shale oil boom have on Renewable Portfolio Standards and in turn TE services and models?
- Some good ideas, but a lot of verbal arm-waving.
- Are we also looking at barriers to TE?
    - Cultural inertia at utilities and lack of incentives to move away from traditional business model.

2 Transactive Energy Architecture Workshops

2A – Transactive Energy Management Architecture

During this session most of the audience participation involved questions raised, rather than answers or candidate answers to the guiding questions. This may be a reflection of it being one of the first interactive sessions and people were still in a mode of absorbing information rather than expressing ideas.

Given these circumstance, the moderator, Ron Ambrosio from IBM, gave candidate answers to several of the proposed questions. The characteristics of a market/transaction participating entity to be able to participate in transactions were described and include having the ability to manage (influence and monitor) a responsive energy asset, exchange transactive signals with neighboring TE entities, and to transform business operational objectives and constraints to and from economic representations. Ambrosio also stated that at conceptual level, there should be little or no difference with respect to methodology at the macro and micro levels. There needs to be a commitment period for stability. Each node needs to account for all of its own constraints.

Ambrosio added that by transacting as savings or cash flow and by linking bids to priority or productivity, economic value could be represented and incorporated into business and operational objectives and constraints, and operational and business objectives and constraints could be monetized without exposing participants' strategies and policies.

One of the key takeaways from the session was the recognition that many of the participants arrived with more questions about TE concepts than with formulated thoughts and understanding. The uncertainties ranged across the range of basic high-level questions from what constitutes "micro" vs. "macro", to whether these transactions were automated or processed by humans, whether signals are related to instantaneous (current) or future states and to how utilities are incentivized to be market arbitrators.

Don Hammerstrom from PNNL introduced a question concerning how operational objectives may be monetized without divulging sensitive information. The speaker drew on his experiences leading the Olympic Peninsula GridWise and Pacific Northwest Smart Grid demonstrations and the architectures used by these two demonstrations.

CISCO's Jeffrey Taft presented and described the GWAC Stack and the TE Market Point of View from the National Institute of Standards and Technology; also provided a control abstraction stack and a value generation stack and related these to the GWAC stack.

Other participant questions/comments:

- What is [the definition of] macro and micro? (Classical RTO, RTO-RTO, Zonal)
- How do you bid across micro-grids?
- How much information is in a transactive signal?
- "Load-centric market" – invert the model inside the premises
- Philosophy [should be] as simple as possible to avoid irrational decisions.
- Can an asset be put into a class?
- Interchangeable products (can products be interchangeable?)
- How do you "talk to the market"?
- Information accumulation/aggregation diminishes real information (i.e., information is lost during aggregation).
- How is conflict resolution handled? How does one know when a conflict exists?
- Is there (must there be) human involvement or just machine-to-machine?
- Are value signals instantaneous or future?
- The market must find equilibrium for competitive bidding.
- Power is not always top priority.

- How can utilities be incentivized to arbitrate markets?
- "Monetize fish with same semantic understanding as other factors."

2B – Transactive Energy Functional Requirements

While this session did not produce many direct answers to the guiding questions that were posed, the interactive discussions were productive and raised several key points that were reiterated during other workshop sessions as well. One such point was the recognition that markets are needed at multiple time scales. A second point was that electricity markets differ from other markets because of the physical constraints associated with the grid and its stability requirements. This fact significantly complicates the implementation of transactive markets within the grid environment.

Larry Lackey gave an overview of an Energy Services Interface for a facility or customer domain and described examples with business-driven objectives, such as Google's proposal for Renewable Energy Tariffs, and Wal-Mart's 100% renewable energy goal by 2020. He went on to list examples of flexible residential options, such as the Pecan Street project, a TruSmart Energy subscription pricing in Texas and the benefits of the Green Button initiative.

Chris Knudsen outlined a strategic approach to progress with TE, targeting a standardized and open market at a national scale, empowering private sector and taking incremental steps. He emphasized the architectural concepts of scalability, observability and controllability and notions of federation, disaggregation, constraint fusion and coordination. Knudsen closed by suggesting that the technology components needed already existed and that policy was the key barrier ahead.

The moderator, William Cox from Cox Software Architects, LLC, outlined three dimensions of the TE problem—management relationship, semantics of price, and transactive techniques—and gave high-level descriptions of each.

During the general discussion, several key comments were made. On the topic of markets, participants mentioned that there was a need for markets within multiple time scales. Also, the electricity market differed from other markets in that it involves a product with inviolable physical constraints and system dependencies and impacts. The concept needed to clearly identify what can be delivered and optimized around that.

Other participant questions/comments:

- Flows of electricity, value, and information can (should?) be decoupled.
- The distribution system complicates [the implementation of] transactions.
- Utilities paid for power [infrastructure]; ancillary services go to private market.
- Time synchronization issue requires definition of unit, time, duration to market 27+ benefits.
- [Should] omit transactive signal from feedback signal
- [Should] use novelty, and keep engaged at human interface
- Possible transactive signal for reliability – "non-traditional values"
- [Should] combine management and economic controls
- There are "too many" open issues.
- [Should] put value to agents [transactive controllers?] before they can proceed.
- Do we need clock sync for transactions?

3 ENABLING CYBER-PHYSICAL INFRASTRUCTURE

3A – Enabling Cyber-Physical Infrastructure (Theory-Grid Integration)

The architecture to enable the TE ecosystem to survive involves two cyber-physical networks—the electrically connected network and the communications networks necessary to control and monitor the electric network. New sensors, actuators, distributed and centralized control elements not necessary for traditional grid operations are needed to support applications in the new paradigm. This workshop focused on architectural principles of asynchronous information exchange, disengaged data, staged data filtering and pruning, layered and loosely decoupled system interactions, etc., needed to support the cyber-physical infrastructure in a TE ecosystem.

The relative newness of the concept of TE and the resulting lack of TE instances and applications leads to a dearth of reference models from which to learn. The required training to operate, manage and regulate in the new TE ecosystem alone needs to be provided through specialized courses at universities. Different services may also be required and performed at different time scales, and across geographical boundaries, raising issues of clock synchronization and differences in local, state and federal jurisdictions. On a systemic note, participants commented that the infrastructure of the system needs to be robust in order to accommodate plug-and-play devices. End devices need to be set up with intelligent controllers who possess knowledge of the local topology in order to participate in a TE ecosystem. It also may not always be possible to verify the quality of TE signals from participants, which may render their participation somewhat useless and may cause more instability in the system.

On the topic of cybersecurity, participants commented that it will need to be addressed at all hierarchical layers of the power system. There also might be elements in society who may instantiate cyber-attacks only to prove a point, but not with the intent of causing widespread harm. Regardless, a unified theory needs to be developed to study such attacks.

Other participant questions/comments:

- Not all devices/customers may be able to provide all services in a cost-effective manner because of issues such as communication latency and the cost of the communications infrastructure.
- Business case and value streams would need to be identified to make appropriate investments.
- Risk-averse behavior, as epitomized by utilities, would limit the products and services offered by customers, and hence, there is a need to transition from risk-averse to risk-adaptive modeling of participants.

3B – Enabling Cyber-Physical Infrastructure (Practice-Implementation Elements, M&V)

Most traditional grid components have a lifecycle of 20 to 50 years, while IT technologies have 3- to 5-year lifecycles. In addition, it may take three to five years to finish rollout and complete training at a utility. This disparity in time scales and lifespans of emerging technologies and those of existing grid assets needs to inform any discussion of introducing new technologies to the grid. Several startup vendors have already been leaving the market because of seemingly insurmountable challenges that exist with rollout and acceptance of new software products.

Another comparison was with existing grid technology. Demand Response (DR) has been implemented by several utilities, such as Southern California Edison, for over 20 years and grid operators have become comfortable with methods used for DR forecasting. However, DR forecasting is still not mature enough to be sold as a market product, like wind forecasting. On that note, Huy Ngo from the Bonneville Power Administration suggested that the largest resistance to DR came from real-time operations because DR

was not deterministic, and hence, North American Electric Reliability Corporation-Critical Infrastructure Protection analysis may not be possible.

Complexity was another topic that participants commented on. Shawn Chandler from Portland General Electric suggested that smart grids needed to be thought of as complex adaptive systems, where behaviors of various participants may lead to complex interaction patterns. A utility in such a system may not be fully equipped to understand everything that happens in the power system. Complexity was further increased due to hundreds of additional constraints, millions of new “generation” and decision points and inordinate amounts of data. For Chandler, it will be very challenging, but important to simulate such fuzzy systems to fully study the impacts.

Several other challenges existed. The interoperability, interchangeability and stochasticity of system operations and decision making were deemed a major theme across new systems and devices. Yet there were also more basic challenges in training students in the arts and sciences of the new TE paradigm at the universities, especially in light of required multi-disciplinary learning to help determine what customers want, rather than “forcing” solutions on them.

4 Transactive Energy Building and Facility Integration Workshops

4A – Transactive Energy End-to-End with Emphasis on Facility to Grid

During the workshop, the distinction between distribution and transmission became more blurred because many utilities already have both transmission and sub-transmission, or distribution and high-voltage distribution. The mechanisms that leverage transactions will continue to erode this distinction.

While many of the sessions at this workshop focused on energy transactions that were essentially managing load or generation for balancing, Farrokh Rahimi pointed out that other aspects of managing the grid, such as the provision of ancillary services, need to be considered. He also stated that it was possible that collections of collaborating buildings will have the capability to help with phase balancing, volt/volt-amp-reactive optimization and frequency response, for example.

David Holmberg pointed out that thermal storage was relatively easy to do, could be done now, and was cheaper than battery storage if properly thought out. He also made a key point that traditional system operators (i.e., utilities) were looking to building response as a way to help them manage the grid.

Fred Fletcher made a key point with his “if you can bill it you can build it” comment. While there were great discussions taking place about the theoretical applications of TE, practical implementation requires an environment where the basic infrastructural services are available and the regulatory policies do not prohibit the various parties from participating. Wherever there is a practical need and value to be derived, an ability to bill for a service or product will exist, leading the private sector to engage and find ways to make it happen. The technology itself was considered far in advance of our ideas for implementation or for policy. Understanding current rate cases and market mechanisms is therefore critical to determining how to enact these changes.

Several workshop participants mentioned concerns about needing humans in the decision-making loop for executing transactions, and how this would be unaffordable to building owners. Yet several others made points that help clarify this matter. Manual intervention was not outside the theoretical scope of TE and may be appropriate at some levels of implementation, depending on the time scales involved. Most transactive processing, however, will need to be embedded effectively inside the utility’s overall controls as a subordinate system. Because a slower control system could not be embedded inside faster ones, it will be necessary and expected that much of the transactive processing will be highly automated. Building owners, for example, may be in the decision-making loop by declaring their operational goals such as heating, ventilation and air conditioning (HVAC) comfort ranges. This occurs on a time scale of days or

weeks. But the time scale of decisions regarding energy transactions to realize these operational goals would take place on a time scale of minutes or seconds, and would need to be performed by automated transactive controllers without any humans in the loop.

This session also defined specific needs of the grid from buildings. These needs included aggregation services, load profiles, responsiveness, reliability, storage, weather, sub-metering, DR forecast, market transactions/characteristics and reliable forward forecasts. For utilities, these services led to benefits in the area of avoiding infrastructure costs as they acquire operational flexibility.

Other participant questions/comments:

- Battery storage is about 10 times the cost of configuring a building for DR.
- Transactive energy is better (more comprehensive and useful) than DR signals.
- If you have shiftable loads + storage, then you need forward prices and information on grid events.
- Balancing services are relatively small, so why have buildings respond?
- Response: These services are required to provide energy to customers…they CAN provide these services, but they don't NEED to.
- Can potentially reduce utility distribution equipment with building equipment (e.g.,. solar inverters).
- Regarding customer (building) transactions with each other→ all the benefits are financial.
- If one considers all the resources that could be supplied by buildings (as described by Farrokh Rahimi in his presentation), approximately what percentage of these are the same services that a utility would have to supply (in a historical "one-way" scenario) with generators? Have any assessments been done on this?
- Use Local Marginal Price
    - Energy Services limited.
    - Other service, more
        - kWh/yr. (potential benefits)
        - non-spinning $1.50/MW/hr.
        - spinning $5.00/MW/hr.
        - capacity.

4B – Transactive Energy Applied to Buildings/Facilities

This session produced a wide range of comments and observations, many spanning beyond the intended scope of TE within the building or facility. The following are some selected observations that tended to arise multiple times within this and other sessions.

Several workshop participants stated that economic transactions, settlement methods and financial tools are already used throughout the market system and that these ought to be, or need only be, applied to the realm of the smart grid. This seemed to indicate that there is a need for greater analysis and clarification regarding how electricity, as an economic product, has distinct differences when compared to conventional commodities and assets that are bought and sold in transactive markets. The grid, as a massively interconnected delivery system, imposes inviolable physical constraints that cannot be readily decoupled from the economic exchanges involved in market transactions. While this concept is taken for

granted by many of the more expert stakeholders, and was explicitly stated at times throughout the conference, it appears to be not well understood and is widely overlooked within the broader community of participants.

A second takeaway that arose in comments from multiple people was the concern for potential gaming of any transactive system that may be conceived in theory and then implemented. This emphasizes the need not only for practical implementation projects like those discussed by the presenters, which in general demonstrate how well various systems perform under “friendly” conditions, but also for more use of modeling and simulation techniques wherein proposed transactive market systems can be stress tested and thoroughly explored for potential vulnerabilities and unexpected complex behaviors prior to any practical deployment. The importance of aggregating building data in order to present larger loads and responsive positions to the grid was also recognized. As one participant put it “”The Grid thinks MV, buildings think kV.”

On the topic of markets, participants noted that markets, settlement methods and financial tools are already in place, so there is no need to invent them. What is needed, though, is a functioning spot market, which would help participants get experience so they can abstract into the future and develop forward curves. It isn’t necessary to begin with a capacity market. This market needed careful crafting, so as to not repeat the experience of California, for example, where market designers didn’t think about gaming very much and the market had almost no way to take forward positions. Formal relationships, contracts and provisions are needed to prevent gaming. A Security and Exchange Commission-like entity could furthermore oversee the market for regulatory purposes. But at the end of the day, the TE market platform needs to support many options from innovative third parties to support user participation and, not exclude these prospective commercial entrants.

Participants also distinguished between the needs of buildings communicating with the grid. On the buildings side there is an initial need to be aware of the needs of the grid. Buildings also needed an incentive to react to these needs, most likely in the form of a payment or value exchange. Other needs included quality of service and look-ahead pricing, a transparent price if markets are used, a forward looking price, so as not to rely on spot market alone, and the ability to have an input on the price (need not to be just a price-taker).

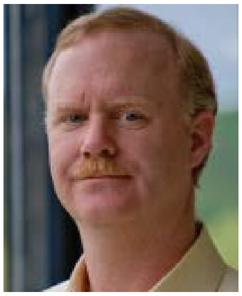
There were also needs and requirements for inter-building exchanges. These include aggregation to present a larger load and better position to the utility, and issues about sharing power between buildings and its legality. One participant stated “Buildings do not need much from each other.”

Other participant questions/comments:

- There is a prospect of a market within a building behind a meter.
- There is the idea of modulation of load instead of curtailment, using variable frequency drives or direct current inside buildings.
- Should hide the complexity from end users. It’s going to be complex under the hood, but needs a simple interface for customers, like cars.
- Buildings need to know what the grid needs from them and how badly does it need it…hard to express that without a price. They need to know what the grid’s needs are and how important those needs are (this may only be expressed as an economic value).
- The question is related to what the needs of the grid are. The grid needs to use buildings as responsive assets.
- The buildings also need the ability to be not just a price-taker
- Awareness of building owners is needed; many don’t know much about the electricity sector.

- Need to think about this in a more cooperative and financially beneficial way. The thing that is lacking is appropriate data. Grid thinks MW, buildings think kW.
- One of the fundamental problems is expressing to people what the problem is. We need to be able to explain why we have spent money and time on this issue. There is a bigger world that wonders why we are doing this.
- The building owners need more awareness. Building owners compete for being "green." If building managers knew that to go green, they needed to participate in these types of programs… Buildings need a reason (financial − either profit or penalty).
- Most control systems have many of the controls we want to effect and many of the sensors we want to read. We do not necessarily need to embed transactive technology within the devices themselves.
- We need to have what the energy produces and makes (make the building more comfortable, reduce the cost of insurance).
- Just need to be aware of potential buyers and sellers within their space to know about potential bilateral agreements.
- We make the assumption that the transaction system will be in place.
- There was a translation layer (decision-makers or tenants). The analogy we look at was airline tickets. The first layer here are things like dates, class, stops.
- When I translate this to buildings it is going to be expectations such as economy, comfortable and renewable.
- Need to transcribe more definitions to energy.
- If you set up a TE system you are going to need a legal framework (e.g., contract). You have to put some game theory into how this is set up for the potential of gaming.
- In addition to getting a price signal, you need the ability for people to know modulation − variable operation of HVAC or other systems.
- We need to learn from the design of the market (e.g., black pools, high frequency trader). Set up platforms or exchanges with certain requirements (e.g., have all meet a requirement to record transactions and make them available to regulators).
- Transactive techniques can be applied wherever you choose to have a market. If you have a robust forward market, you may not have a need to choose a capacity market.
- If we make this complex to end users, this will delay its adoption.
- We need to hide the complexity from the end user (transparency).

APPENDIX D – SPEAKER'S PROFILES



Ron Ambrosio

Global Research Executive, Energy & Utilities Industry, IBM T.J. Watson Research Center

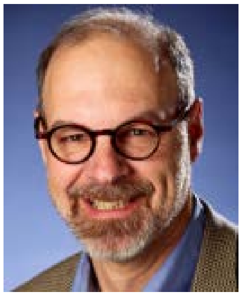
Ron Ambrosio oversees IBM's Energy & Utilities Industry activities in its eight world-wide Research Laboratories. Ron joined IBM in 1981 at the T.J. Watson Research Center, working in a variety of areas including embedded operating systems, distributed application frameworks and pervasive computing environments, ultimately focusing on networked embedded computing with particular emphasis on what he coined "Internet-scale Control Systems" – the interoperability of sensor networks and control systems with enterprise systems and business processes. He helped establish IBM's activities in both Intelligent Utility Networks and Sensors & Actuators.

Gregg Ander

Vice President, Power and Efficiency, Energy Foundation

Gregg D. Ander is the Vice President of Power and Efficiency at the Energy Foundation in San Francisco, where he oversees a portfolio of initiatives including energy efficiency, demand response, renewables, gas, coal, smart grid and financing. Previously, he held numerous senior management positions during his 30-year career at Southern California Edison, worked at the California Energy Commission, and he was in private practice in Wisconsin and Arizona. Mr. Ander was the executive producer of seven environmentally focused television programs for NBC, CBS and PBS. One program, "Greener Buildings/Bluer Skies," won an Emmy award from the National Academy of Television Arts and Sciences.

Mr. Ander serves on the Board of Directors of the Sustainable Building Industry Council (SBIC) and the New Buildings Institute (NBI). He has authored more than 70 energy- and environment-related articles and has won awards for various energy-related projects from the U.S. Department of Energy American Institute of Architects American Society of Heating, Refrigeration and Air Conditioning Engineers and the National Academy of Television Arts and Sciences. He was elevated to "Fellow" by the American Institute of Architects for his body of work and accomplishments in energy and environmental issues. In addition, Mr. Ander has participated in sustainability charities for residential, retail, K-12 schools, offices and the greening of the White House and Old Executive Office buildings. He is the author of the book, "Daylighting Performance and Design," published by John Wiley & Sons (second edition).



Ward Camp

VP, Regulatory & Environmental Policy, Landis + Gyr

A 30-year veteran of the energy and utility industry, Ward Camp is VP, Regulatory and Environmental Policy for Landis +Gyr Energy Management Solutions N.A. He is a current board member of the GridWise Architecture Council, Co-Chair of the SGIP Business and Policy, Domain Expert Working Group and the Demand Response and Smart Grid Coalition (DRSG). He is also a member of the GridWise Alliance and the Association for Demand Response & Smart Grid (ADS). Previously, he served in executive roles as part of the Senior Management of DCSI (now Aclara), USPowerSolutions and Avistar, a Public Service Company of New Mexico subsidiary. Mr. Camp has worked extensively with utilities and public utility commissions throughout the United States. He spent the first 17 years of his career as an attorney with a focus in energy and utilities. Mr. Camp obtained his Juris Doctor from the University of Oklahoma.

Ed Cazalet

CEO, The Cazalet Group

An internationally recognized electric industry expert, Dr. Cazalet is a leader in the analysis and design of markets for electricity and the analysis of transmission, generation and load management investments. For his industry contributions, Public Utilities Fortnightly magazine in 2000 named Dr. Cazalet "Innovator of the Year". Ed is also Vice President and Co-Founder of Megawatt Storage Farms, Inc., storage advisory and project development firm. He formerly was a Governor of the California Independent System Operator and founder and CEO of both Automated Power Exchange, Inc. (APX) and Decision Focus, Inc. (DFI). He has a PhD from Stanford in Engineering-Economic Systems. Dr. Cazalet is Co-Chair of the OASIS Energy Market Information Exchange (eMIX) Technical Committee and a member of the OASIS EnergyInterOp and WS-Calendar Technical Committees.

Shawn Chandler

Smart Grid Architect, Portland General Electric

Shawn Chandler is the Smart Grid Architect at Portland General Electric, Oregon's largest electric utility. Mr. Chandler provides expertise regarding technical process development in support of next-generation electrical system design and smart-grid development. His prior management roles include Chief Technology Officer for Camouflage Media, a pervasive technology implementer and Director of Information Systems for Enkido, a North American optical telecommunications carrier. Mr. Chandler is a member of Smart Grid Oregon, the Smart Grid Interoperability Panel (SGIP), the executive project committee for the Solar Electric Power Association and a member of the Interoperability and Standards Working Group for the DOE Pacific Northwest Smart Grid Demonstration Project. Mr. Chandler is a graduate of Portland State University and Atkinson School of Management, Willamette University.

William Cox

Principal, Cox Software Architects, LLC

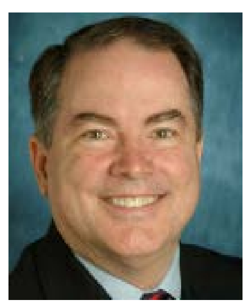
William Cox is a leader in commercial and open source software definition, specification, design and development.

He is active in the NIST Smart Grid Interoperability Panel and related activities and contributed to the NIST conceptual model, architectural guidelines and the NIST Framework 1.0.

Dr. Cox is Co-Chair of the OASIS Energy Interoperation and Energy Market Information Exchange Technical Committees, past Chair of the OASIS Technical Advisory Board, member of the Smart Grid Architecture Committee and the WS-Calendar Technical Committee.

Bill has developed enterprise product architectures for Bell Labs, Unix System Labs, Novell and BEA, and he has done related standards work in OASIS, ebXML, the Java Community Process, Object Management Group and the IEEE, typically working the boundaries between technology and business requirements.

He earned a PhD and MS in Computer Sciences from the University of Wisconsin-Madison.



Paul De Martini

Managing Director, Newport Consulting Group, LLC

Paul De Martini has over 30 years' experience in the energy industry in both competitive and regulated businesses across the value chain. Over the past 20 years, he has been actively involved in technology development and implementation for clients' worldwide and internal development.

De Martini earned an MBA from the University of Southern California and a bachelor's degree from the University of San Francisco. He also earned a certificate in technology management from the California Institute of Technology. De Martini is currently a Fellow of the Wharton School, University of Pennsylvania.

Fred Fletcher

Assistant General Manager, Burbank Water & Power

Fred Fletcher has led electric utility planning, operations and engineering from metering through distribution protection, substation, switching stations, transmission lines, energy control centers, power plants, power trading, risk management and project finance for many years. He started his career in South Dakota, first with Black Hills Power and then as part of the first management team of Missouri River Energy Services. In 1986 he became Assistant General Manager at Burbank Water and Power. He focuses on the operational and the creative approaches of business development in publicly owned electric utilities.

Since 2006 he has been addressing the challenges of renewable energy and demand control/ management/response. He was the first Chair of the BWP Smart Grid Network Council. In 2010 he took a leave from BWP to work in private industry in developing advanced solutions for demand control and integration for a year. His experience in private industry helped him better understand how to apply these new tools. So he has re-doubled his efforts and is in the midst of revamping Burbank power system so that it incorporates these new tools and takes advantage of these new options.

Jeff Gooding

General Manager, Smart Grid Engineering, Southern California Edison (SCE)

Jeff Gooding, IT General Manager of Smart Grid Engineering at Southern California Edison, is responsible for managing the architecture and engineering team that supports the Edison SmartConnect project, SCE's Advanced Metering Infrastructure (AMI) Program.

In 2005, Jeff joined the Edison SmartConnect Program in 2005, where he supported SCE's development of power procurement and nuclear software applications for the Energy Supply & Marketing (ES&M) department and San Onofre Nuclear Generating Station (SONGS).

Prior to joining SCE in 2003, Jeff was a Senior Manager at Cap Gemini Consulting where he served in the Advanced Development & Integration Division of the Utilities practice. He served as an architect and technologist on projects at the California ISO, Ontario IMO, Portland General Electric and PG&E. Earlier, Jeff was President of Rapid Access Systems (RAS), a software company focused on developing decision support applications. Jeff holds MBA and BS degrees from California State Polytechnic University, Pomona.

Dian Grueneich

Founder and Principal, Dian Gruenich Consulting

Dian Grueneich is a nationally and internationally recognized energy expert with 35 years' experience. Her expertise covers energy efficiency, demand response, smart grid, renewable energy resources, transmission and climate change. She has extensive experience in all facets of energy policy and regulation, utilities, market development and innovation and key factors driving U.S. and global energy investments.

Dian served as a Commissioner on the California Public Utilities Commission from 2005 to 2010 and led

its efforts on energy efficiency, developing the California Long-Term Energy Efficiency Strategic Plan and overseeing a 40% expansion of California's energy efficiency funding, resulting in a three-year, $3.8 billion program, the largest efficiency program in the UnitedStates. Dian also streamlined California's transmission siting process and led the successful permitting of three major new transmission lines to carry renewable energy, a $6 billion in new energy infrastructure now under construction. Dian initiated the California Renewable Energy Transmission Initiative (RETI), helped launch the Western Renewable Energy Zone Initiative (WREZ) and served as the first Chair of the Western Governors' Association's Demand Side Management Committee for Western transmission planning.

Dian's professional recognitions include the American Council for an Energy-Efficient Economy (ACEEE) 30th Anniversary Award for outstanding contribution in the field of energy efficiency, the National Association of Regulatory Utility Commissioners' Clean Energy Award, eeGlobal Forum's first "Visionary Award" for energy leadership and ACEEE's National Champion of Energy Efficiency Award.

Dian currently serves on the U.S. Department of Energy (DOE) Electricity Advisory Committee, the DOE-EPA State Energy Efficiency Action Plan Leadership Group, the Leadership Council of the China-U.S. Energy Efficiency Alliance, the Advisory Council of Stanford University's Precourt Energy Institute, the Global Cool Cities Alliance and the Advanced Energy Economy Advisory Board. Dian also serves as a Clean Energy Education & Empowerment U.S. Ambassador.

Dian is a graduate of Stanford University and holds a J.D. from Georgetown University.

Erich Gunther

Chief Technology Officer, EnerNex

Erich Gunther is the Chairman and Chief Technology Officer for EnerNex Corporation in Knoxville Tennessee where he helps EnerNex clients define their strategic direction in basic R&D, technology and product development. Mr. Gunther has 30 years of experience in design and development of innovative solutions to a wide array of power system problems, most notably ways to take advantage of communications networks and technology to improve the efficiency, operating practices and security of the electric power system. Erich has a leadership role in many of the key grid modernization groups and standards organizations including the GridWise Architecture Council, IEEE PES Intelligent Grid Coordinating Committee and the Utility Communications Architecture International Users Group as the chairman of those organizations. He is presently serving as the administrator for the NIST SGIP effort and is working with several utilities developing their smart grid development roadmaps.

Erich received his Masters of Engineering degree in electric power from Rennsaelaer Polytechnic Institute in 1984. He is a registered professional engineer in Tennessee and speaks geek in multiple languages including power systems engineering, computer science, enterprise architecture, and communications technology. Presently he is applying his skills in promoting the application of systems engineering principles to smart grid development, and he is actively facilitating information exchange among the many organizations and institutions working on smart grid development.

Donald Hammerstrom

Senior Research Engineer, Pacific Northwest National Laboratory

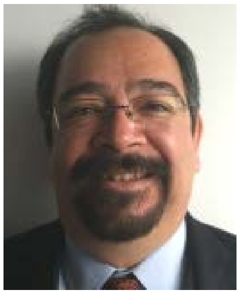
Dr. Hammerstrom is a Senior Research Engineer for Energy Technology Development at the Pacific Northwest National Laboratory in Richland, Washington. He received his PhD in Electrical Engineering from Montana State University in 1994.

Dave Hardin

Senior Director, SmartGrid Standards

Dave has more than 25 years of experience designing, integrating and managing industrial information management and control systems. He specializes in energy systems architecture and design. Dave is holds a Bachelor of Electrical Engineering degree from the University of Delaware. He is a Registered Professional Engineer (DE/MD),

an IEEE Certified Software Development Professional and a PMI Project Management Professional.



George Hernandez

Staff Scientist, Pacific Northwest National Laboratory

George Hernandez joined PNNL in 2009 and works in the Building Energy Controls group. Mr. Hernandez is a senior demand side management professional with innovative and detail-oriented knowledge to develop and produce successful programs that deliver products and services to the commercial and industrial energy marketplace. Mr. Hernandez is distinguished by exceptional execution skills that enable efficient concept to product delivery. Accomplishments demonstrate coordination abilities, creative thinking, developmental organization, strong leadership, management skills and strategic planning. Mr. Hernandez has extensive knowledge, skills, and capabilities derived from a substantial career in demand side utility management across a wide variety of commercial and industrial sectors and utilities as both a corporate employee and an independent consultant. Mr. Hernandez received his BS in Mechanical Engineering from California State University and his Masters in Mechanical Engineering from the University of California at Berkeley. He is a Licensed Professional Engineer (PE) by the State of California.

Roger Hicks

SGO Board – Programs Chair, Smart Grid Oregon Consulting

Roger Hicks is the principal at Roger Hicks Consulting and specializes in evaluating new market opportunities, strategic business planning and product management development.

With experience in engineering, market management and strategy director roles over the past three decades, Roger has been involved in managing numerous new businesses, product launches and acquisitions while working for many leading technology companies like Intel, Tektronix and Planar Systems.

The range of industries where Roger has explored new growth opportunities includes renewable energy, food processing, test and measurement, displays, diagnostic imaging and many more.

In addition, Roger has a long history of being active in local business community and has been a management professor for the Oregon Health and Science University and involved in leading activities at PDMA, TIE and AEA and as a board member of SGO.

Roger holds a BSME from the University of Akron and an MBA from Case Western Reserve University.

David Holmberg

Mechanical Engineer, Engineering Laboratory, NIST

David Holmberg serves in the NIST Engineering Laboratory, Energy and Environment Division. His work focuses on building integration into the smart grid. David represents the buildings community on the NIST Smart Grid Team and leads the Building-to-Grid (B2G) domain expert working group. He is currently convener of the Smart Grid Working Group (SG-WG) of the ASHRAE BACnet committee, co-convener of the IEC PC118 Smart Grid User Interface WG2 and Co-Chair of the OASIS Energy Interoperation Technical Committee. He is NIST lead for PAP09 and PAP19.

David received his PhD from Virginia Tech, and joined NIST as a post-doc in 1997. Since joining the Mechanical Systems and Controls group, David has worked on BACnet network security, utility interaction and communication of building data to emergency responders, prior to actively working on smart grid standards. Dr. Holmberg is a member of ASHRAE.

Carl Imhoff

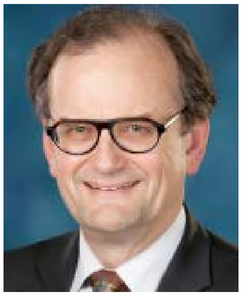
Manager, Pacific Northwest National Laboratory

Mr. Imhoff manages the Electric Infrastructure market sector within Pacific Northwest National Laboratory's Energy and Environment Directorate. The market sector conducts advanced electric infrastructure research and product development with the U.S. Department of Energy, state governments, vendors and commercial energy firms. In this role he is responsible for PNNL's research and development programs on innovations in the areas of advanced power transmission reliability concepts, demand response, development of improved integration concepts for renewable energy generation technologies, policy and strategy for smart grid concepts and cross-cutting grid analytic tools in visualization and high performance computing. It is widely recognized that PNNL's grid activities bring substantial impact and thought leadership to the nation's smart grid agenda. During his 30 years at PNNL, Mr. Imhoff has conducted and managed a broad range of energy research. His technical work emphasizes systems engineering and operations in the areas of power system reliability, smart grid, energy efficiency, energy storage and clean generation. He has been actively involved in a number of electric power system organizations and bodies, including the North American Synchrophasor Initiative, the GridWise Alliance, the Consortium for Electric Reliability Technology Solutions and the Western Electric Coordinating Council.

Ali Ipakchi

Vice President of Smart Grid and Green Power, OATI

Dr. Ipakchi has over 30 years of experience in the application of information technology to power systems and electric utility operations. As the Vice President of Smart Grid and Green Power at OATI, he is responsible for growth of the business in these emerging areas. Prior to OATI, he was Vice President of Integration Services at KEMA, assisting utility clients with roadmaps, specifications and business and implementation strategies for automation and technology projects. Prior to KEMA, Dr. Ipakchi held various senior management positions at leading vendors supporting power application development and system solutions delivery to the power industry. He has led new business-line and organizational development initiatives, and he has managed product development and delivery teams. His areas of experience include smart grid, utility automation, power systems operations, enterprise and operational IT systems, systems for ISOs/energy markets, utility control centers, trading floors, power generation, distribution operations and advanced metering. He holds a PhD from University of California at Berkeley, and is co-holder of three U.S. patents on power systems applications and instrument diagnostics.



Philip Jones

President, NARUC

Appointed by Governor Gregoire in March 2005, re-appointed in January 2011 and confirmed unanimously by the State Senate, Commissioner Jones is currently President of NARUC and serves as chair of its Board of Directors and its Executive Committee. He previously served on the Board of NRRI (National Regulatory Research Institute) and as its chair and co-chaired the Washington Action Program. Commissioner Jones is a member of the International Relations and Telecommunications Committees of NARUC. Prior to his commission appointment, he served as managing director of Cutter & Buck (Europe), BV in Amsterdam, the Netherlands for five years.

From 1983 to 1988 he served as senior legislative assistant to Senator Daniel J. Evans, the former U.S. Senator from Washington State, and staffed him on energy policy issues before the Senate Energy and Natural Resources Committee, as well as international trade policy. He was responsible for a broad range of energy issues, including hydroelectric re-licensing, nuclear waste management, energy conservation and renewables and the Bonneville Power Administration.

Jones is a native of Spokane, Washington. He graduated from Harvard College with honors with a degree in East Asian Studies in 1977.

Mark Knight

Executive Consultant, Energy Solutions, CGI

Mark Knight is an Executive Consultant in CGI's USEM IP Solutions & Onshore Delivery Business Unit where he works with Utilities to enhance operations and business practices. Mr. Knight draws upon 25 years of experience to deliver business solutions that leverage the integration of people, business (processes, systems, data) and technology to support innovative, effective and practical solutions for CGI's clients.

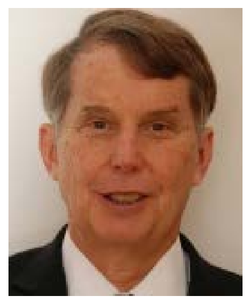
Mr. Knight's background includes a mix of information technology work and business process work both as a consultant and as a utility employee in the United Kingdom and the United States and has spanned several areas including distribution, transmission, metering, systems integration, deregulation, interoperability, asset management and risk management.

Mr. Knight is a graduate of Imperial College, London and is also a member of the GridWise Architecture Council, a group formed by the U.S. Department of Energy to promote and enable interoperability among the many entities that interact with the nation's electric power system. The GWAC has broad, balanced representation among its 13 members selected to represent the full spectrum of industry and academia.

Chris Knudsen

Chief Technology Officer, AutiGrid Systems, Inc.

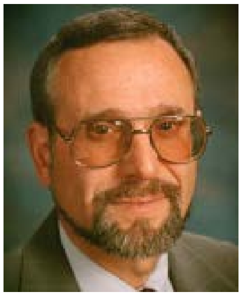
Chris Knudsen is currently the Chief Technology Officer for AutoGrid Systems, Inc. Auto Grid is bringing Big Data Analytics to the grid by applying best practices on platform, standards-based interfaces and highly sophisticated analytics, machine learning and optimization with millions of connections and petabytes of data at scale. Chris previously chaired the Open SmartGrid Technical Committee within UCAIug, and sat on the NIST SmartGrid Architecture Committee. Chris is currently a Board member of the OpenADR Alliance, and he advises the UC Berkeley Graduate Research LoCal Lab. Prior to AutoGrid, Chris held the position of Director, Technology Innovation Center at Pacific Gas & Electric, Chief Technical Officer for Wireless Wide Area Networking Standards & Mobile Performance Labs within Intel's Mobile Wireless Group, spent three years at Paul Allen's Vulcan Capital focusing on early stage wireless investments and led Metricom's Ricochet development as Vice President of Hardware Engineering. Earlier, he founded a startup developing energy efficient home automation system. Chris started his career designing and developing radio systems for defense electronic applications. Chris holds a BS degree in Electrical Engineering from the University of California at Davis and has completed work towards a Master of Technology Management at Santa Clara University.



Larry Lackey

Coergon

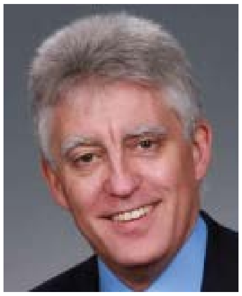
Larry Lackey has over 25 years' experience connecting transactional systems within enterprises and to customers—focusing on low latency, Straight through Processing (STP) and Complex Event Processing (CEP) in financial services, telecom and smart grid industries. At TIBCO Software he developed OEM relationships with pre-IPO to Fortune 500 hardware and software companies. He was technical lead for the largest OEM license deal in the group's history and was responsible for major agreements with Cisco, Siemens, Silver Spring Networks, International Game Technology, CA, Investment Technology Group, Thomson Reuters, IBM and other companies. He conceived and created prototypes for multiple new products and represented the company on the OASIS Energy Interoperation, OASIS Web Services Distributed Management and RosettaNet RNIF—participating on ebXML standards committees as well as conducting interoperability tests for the initial RosettaNet deployments. At Coergon and Cibar, he created an innovative trade banking system that electronically manages and routes transactions when and where they are required between client and bank offices in multiple countries. Customers included Citibank, Scotiabank and the headquarters and overseas offices of three other money center banks. His PhD is in geology from the University of Michigan.



James Mater

General Manager and Smart Grid Director, QualityLogic, Inc.

James Mater co-founded and has held several executive positions at QualityLogic from June 1994 to the present. He is currently Co-Founder and Director working on QualityLogic's Smart Grid strategy, including work with GWAC, the Pacific Northwest Smart Grid Demonstration Project, the SGIP Test and Certification Committee and UCA's OpenSG Conformity Work Group, which includes giving papers and presentations on interoperability. From 2001 to October 2008, James oversaw QualityLogic as President and CEO. From 1994 to 1999, he founded and built Revision Labs, which merged with Genoa Technologies to become QualityLogic. Prior to QualityLogic, James held product management roles at Tektronix, Floating Point Systems, Sidereal and Solar Division of International Harvester. Mater holds a BS degree in physics from Reed College, Portland, Oregon and an MBA from the Wharton School, University of Pennsylvania.



Ronald Melton

Administrator, GridWise Architecture Council, Pacific Northwest National Laboratory

Ron Melton is the administrator of the GridWise® Architecture Council (GWAC) and a senior power systems engineer at Pacific Northwest National Laboratory. He is also Project Director for the Pacific Northwest Smart Grid Demonstration Project, managed by the Pacific Northwest Division of Battelle.

Dr. Melton has over 25 years of experience in systems engineering applied to interdisciplinary problems. He received his BSEE from University of Washington and his MS and PhD in Engineering Science from the California Institute of Technology.

Huy Ngo

Hardware Systems Manager, Bonneville Power Administration (BPA)

Huy Ngo is the hardware systems Manager of the Bonneville Power Administration (BPA) Transmission Control Centers. He also is the manager responsible to implement the requirements of the North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) standards and those mandated by the Federal Information Security Management Act of 2002 (FISMA).

Mr. Ngo is a 16 year veteran of the BPA Control Center, managing since 2008. Before joining the BPA Transmission Control Centers, Huy worked as a BPA customer service engineer with Orcas Power and Light Cooperative (OPALCO). In that assignment, he saw first-hand the value that demand-responsive technologies offer utility operating practices. OPALCO has been a pioneer in piloting demand-responsive technologies to contend with energy supply constraints resulting from undersea cable failures. Those experiences combined with his current assignment provides him a unique perspective to not only understand the value offered by Transactive Energy, but to also reflect knowledgably upon how these technologies must be adapted to address grid operator security concerns and regulatory requirements

Bill Nicholson

Senior Vice President, Customer Service, Transmission & Distribution, Portland General Electric

As senior vice president, Bill Nicholson oversees Transmission, Distribution, Customer Service and Customer Strategies & Business Development.

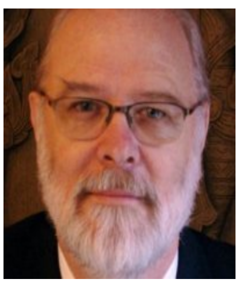
He previously served as Vice President of Distribution Operations and was Vice President of Customers & Economic Development for two years. Nicholson joined PGE in 1980 as an engineer at the Trojan Plant

and has served in a variety of capacities in Distribution Operations and Generation Engineering.

Nicholson earned a BS degree in nuclear engineering from Oregon State University in 1980 and has successfully completed the Harvard University Program on Negotiation, the Utility Executive program from the University of Idaho and the American Leadership Forum, where he serves as a senior fellow. A registered professional engineer, Nicholson belongs to the American Society of Mechanical Engineers and the National Society of Professional Engineers.

He is also involved with a number of community organizations and currently serves on the boards of Associated Oregon Industries, Oregon BEST (Built Environment & Sustainable Technologies) and the board of regents for the Museum at Warm Springs.

Nicholson and his wife, Kathy, live in Northwest Portland.



Terry Oliver

Chief Technology Innovation Officer, Bonneville Power Administration

Terry Oliver has worked globally to advance energy conservation and renewable energy. He has worked for BPA since 1981.

In the Pacific Northwest (PNW), he managed one of the world's largest residential energy conservation programs, the PNW Residential Weatherization Program, led ground-breaking research on community-based energy conservation applications in the Hood River Conservation Project, and established two enduring icons of energy efficiency innovation, the Lighting Design Lab and the Energy Ideas Clearinghouse.

In 1992, he moved to Bangkok, Thailand, to lead the Asia Regional Office of the International Institute for Energy Conservation (IIEC).

In 2000, Terry returned to BPA where he worked on BPA's EnergyWeb concept and its application to the PNW. As part of this effort he helped create BPA's Non-Wires Solutions initiative, participated in EPRI's Intelligrid grid architecture initiative and led the GridWise Alliance Demonstrations Working Group.

In June 2005, Terry was appointed as BPA's first Chief Technology Innovation Officer, responsible for re-energizing, focusing and managing BPA's research and development activities.

William Parks

Deputy Director, DOE Office of Electricity Delivery and Energy Reliability

Mr. Parks leads the technology development group activities in Electricity Transmission and Distribution. Key areas include Control and Monitoring Systems, Storage and Power Electronics, Distributed Generation and High Temperature Superconductivity. He assists in electricity policy development and has briefed Congress, State agencies, FERC and national and international forums on energy issues.

Mr. Parks has led and participated in the development of several major U.S. Department of Energy (DOE) initiatives including the development of technology roadmaps in hydrogen, advanced power systems, biopower, and industrial programs. He was a contributor to the development of several new offices and activities in DOE including the Office of Electricity Delivery and Energy Reliability, the Office of Power Technologies and the Industries of the Future programs. He initiated the Advanced Turbine Program, the Distributed Generation Program and the Combined Heat and Power Program for DOE.

Mr. Parks received Engineering and Science degrees from Virginia Polytechnic Institute and State University. Before joining the DOE, Mr. Parks managed corporate research and development programs at Babcock and Wilcox and Dresser Industries, including three years supporting a new business venture in advanced ceramics.

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 PhD 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 8 years with Macro Corporation (subsequently KEMA Consulting); 5 years with Systems-Europe, Brussels, Belgium; 1 year with Brown Boveri (now ABB), Baden, Switzerland; 10 years as a university professor, researcher and consultant in power and industrial control systems; and 2 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.

Roland Risser

Director, Building Technologies Office, Department of Energy

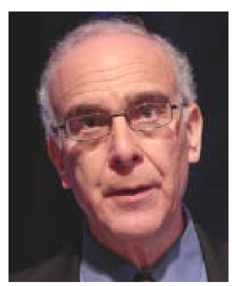
Roland Risser is the Director for the Building Technologies Office (BTO) at the U.S. Department of Energy (DOE). BTO's goal is to optimize U.S. energy savings opportunities and help create a self-sustaining market for building energy efficiency by developing innovative new energy efficient technologies, accelerating the energy efficiency, speed and scale of codes and standards and supporting cost effective deployment of solutions for highly energy efficient buildings and homes. He has briefed Congress, State agencies, FERC and national and international forums on energy issues. BTO is responsible for managing a portfolio with a total annual budget of approximately $220M/year. Program results produced to date are expected to save U.S. consumers $91 billion and 32 quads of energy by 2030.

Prior to holding this position, Roland served as the Director of Customer Energy Efficiency for Pacific Gas and Electric Company (PG&E). He was responsible for developing and implementing the strategies to support PG&E's delivery of customer energy savings and strategies to support a Net Zero Energy future. In addition, he was responsible for assessing and deploying new technologies and products into PG&E's energy efficiency portfolio, managing a building and appliance codes and standards program, as well as PG&E's Pacific Energy, Energy Training, and Food Service Technology Centers. This program delivered over 200 MW of customer energy savings a year.

During his 31-year tenure at PG&E, Roland held several other positions, including Director of Energy Efficiency (which included Low Income, Solar and Demand Response programs); Director, Tariffs and Compliance; Manager, Business Account Services and Corporate Sales; Manager, New Energy Markets; and Manager, Customer Systems Research and Development. In addition, while on a one year executive loan from PG&E, he served as the Executive Director of the Washington D.C. based Electric Vehicle Association of the Americas.

Prior to working for DOE, Roland was a member of the National Action Plan for Energy Efficiency Leadership Group, Chairman of the Consortium for Energy Efficiency, an advisor to the Institute of Electric Efficiency and a board member of the American Council for an Energy Efficient Economy (now ex officio). Currently, Roland is the Chairman of ISO Technical Committee 242 (ISO 5001 – Energy Management standard).

Roland has an MS degree from the California Polytechnic State University in San Luis Obispo and a BS degree from the University of California, Irvine. He also graduated from the Haas School of Business, Executive Program, at the University of California, Berkeley.



Martin Rosenberg

Editor-In-Chief, EnergyBiz

Martin Rosenberg is editor-in-chief of EnergyBiz, a national publication covering the energy industry that circulates to 24,000 senior executives and managers of the electric and natural gas industry, energy experts, analysts and regulators.

In 2005, 2006, 2007, 2008 and 2010, the magazine received prestigious Eddie Award gold medals in a competition sponsored by Folio magazine. The awards were for best execution of editorial mission by publications covering the "energy/utilities/engineering" sectors.

Martin Rosenberg has written extensively about energy, technology, finance and international

business. His freelance work has appeared in the New York Times, USA Today, Seattle Times, Japan Times and other publications. He previously was editor-in-chief of Utility Business, a monthly publication that won numerous journalism awards.

He was a business writer at the Kansas City Star from 1985 to 1998 and worked for newspapers in Oregon. He was a Fulbright Fellow to Japan, where he studied economics, and he received a grant from the German Marshall Fund of the United States to study international energy and economic issues.

He is a graduate of Reed College and holds a Master's degree from Northwestern University's Medill School of Journalism. He and his wife, Matilda, reside in Kansas City and have three children.

Aaron Snyder

Director, Smart Grid Labs, EnerNex

Aaron Snyder obtained his education from Virginia Tech in Blacksburg, Virginia, and the Institute National Polytechnique de Grenoble (INPG) in Grenoble, France. He is currently a Director of Smart Grid Labs at EnerNex in Knoxville, Tennessee, and actively participates in smart grid and advanced metering infrastructure organizations. He serves on numerous metering standards development committees at national (ANSI) and international (IEC, IEEE, OIML) levels. He is an Executive Committee member of UCAIug and a Senior Member of IEEE.

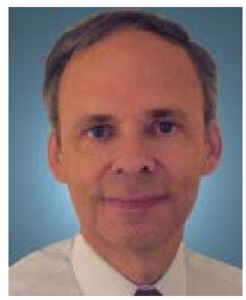
Jeffrey Taft

Connected Energy Networks Chief Architect, Cisco

Jeffrey Taft's focus is on the development of architectures for ultra-large scale systems, including smart grids and other smart structured physical systems, through the application of distributed sensing, data management and analytics and decision/control/optimization, supported by advanced low latency networking, to produce business outcomes.

His professional experience includes technology and technology strategy development, system architecture development, product and project engineering, process and methodology development, staff development and training, marketing, and management of business operations with P&L responsibility.

Specialties: Advanced architectures and integration for ultra large-scale systems utility systems, devices, operations, intelligent grid analytics, networking for utilities, signal processing, distributed and hierarchical decision/control/optimization, distributed and real time analytics and data management architectures.



Kenneth Wacks

President, Home & Utility Systems

Dr. Wacks has been a pioneer in establishing the home systems industry and a management advisor to 150 clients worldwide. His business spans home and building systems, utility customer services and digital entertainment networks (including HDTV and IPTV).

Corporate managers depend on Dr. Wacks to identify business opportunities in emerging markets with clear and practical advice relevant for product development and market positioning. Dr. Wacks serves companies of all sizes from startups to the Fortune 500. His worldview, insights and expertise are valued by executives for enabling competent decisions on complex technology issues. Clients seek his help to locate strategic business partners, financing and new customers. He also provides due-diligence for investors and expert witness services for litigants.

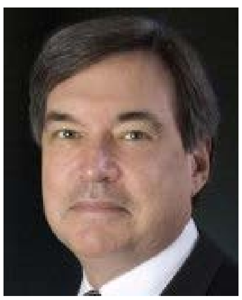
He was appointed by the U.S. Department of Energy to the 13-member GridWise Architecture Council to develop smart grid strategies for reliable and efficient distribution of electricity. For electric and gas utilities, he has designed and demonstrated new customer services by linking utility communications with home automation to deliver demand response and value-added services.

The Consumer Electronics Association chose Dr. Wacks to chair the international committee (ISO/IEC) establishing world standards for home and building automation. In addition, he has written American National Standards in home automation. He contributed to the development of standards for networking home appliances under the auspices of

the Association of Home Appliance Manufacturers (AHAM).

Dr. Wacks is a frequent speaker and panel session organizer at industry conferences. He has written and delivered more than 200 papers and presentations, and has been granted patents in home systems.

Dr. Wacks chairs the Editorial Advisory Board of the CABA magazine iHomes & Buildings (available at www.caba.org) and is a featured contributor under the byline "Ken Wacks' Perspectives." He was honored with the inaugural CABA Volunteer of the Year Award. Dr. Wacks authored the book *Home Automation and Utility Customer Services*, distributed by Aspen Publishers. As an entrepreneur at a venture-backed startup, he developed UNIX workstations for the semiconductor industry. Dr. Wacks received his PhD from MIT as a Hertz Fellow and studied at the MIT Sloan School of Management.



Jon Wellinghoff

Chairman, Federal Energy Regulatory Commission (FERC)

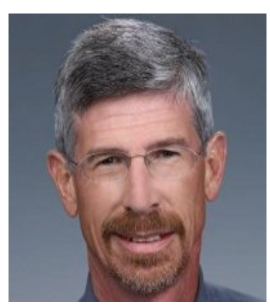
Jon Wellinghoff was named Chairman of FERC, the agency that oversees wholesale electric transactions and interstate electric transmission and gas transportation in the United States, by President Barack Obama on March 19, 2009. A member of the Commission since 2006, the U.S. Senate reconfirmed him to a full, five-year FERC term in December 2007.

Chairman Wellinghoff is an energy law specialist with more than 34 years' experience in the field. Before joining FERC, he was in private practice focusing exclusively on client matters related to renewable energy, energy efficiency and distributed generation. While in the private sector, Chairman Wellinghoff represented an array of clients from federal agencies, renewable developers and large consumers of power to energy efficient product manufacturers and clean energy advocacy organizations.

Chairman Wellinghoff was the primary author of the Nevada Renewable Portfolio Standard (RPS) Act. The Nevada RPS is one of the two state standards to receive an "A" rating from the Union of Concerned Scientists. The Chairman worked with clients to develop renewable portfolio standards in six other states. He is considered an expert on the state renewable portfolio process and has lectured extensively on the subject in numerous forums including the Vermont Law School.

His experience also includes two terms as the State of Nevada's first Consumer Advocate for Customers of Public Utilities. While serving in that role, Chairman Wellinghoff represented Nevada's utility consumers before the Public Utilities Commission of Nevada, the FERC and in appeals before the Nevada Supreme Court. While Consumer Advocate, he authored the first comprehensive state utility integrated planning statute. That statute has become a model for utility integrated planning processes across the country.

Chairman Wellinghoff's priorities at FERC include opening wholesale electric markets to renewable resources, providing a platform for participation of demand response and other distributed resources in wholesale electric markets, including energy efficiency and local storage systems such as those in plug-in hybrid and all electric vehicles (PHEVs and EVs), and promoting greater efficiency in our nation's energy infrastructure through the institution of advanced technologies and system integration. As Chairman, he created FERC's Office of Energy Policy and Innovation (OEPI), which is responsible for investigating and promoting new efficient technologies and practices in the energy sectors under FERC's jurisdiction. Chairman Wellinghoff is Co-Chair of the Smart Response Collaborative launched jointly by FERC and the National Association of Regulatory Utility Commissioners (NARUC) and a member of NARUC's Committee on Energy Resources and the Environment. He is a member of the Advisory Committee of the Institute for Electric Efficiency and served as an advisor to the Defense Science Board's Energy Policy Task Force. He is also the Co-Chair of the Executive Leadership Team of the Electric Power Research Institute's (EPRI's) Green Transmission Efficiency Initiative. Chairman Wellinghoff also advises the Energy Foundation and the Natural Resources Defense Council on China-U.S. energy policy matters. He was designated by the Obama Administration to be a Principal in the Joint U.S./China Strategic and Economic Dialog and recently returned from China where he participated in diplomatic discussions with China's energy leaders including China's Energy Minister, Zhang Guobao.



Steve Widergren

Principle Engineer, Pacific Northwest National Laboratory

Steve Widergren contributes to new solutions for reliable operation of electric power systems. Common throughout his career is the application of information

technology to power engineering problems, including simulation, control and system integration. He is a principal engineer at Pacific Northwest National Laboratory and from 2009 to 2012 was Plenary Chair for the Smart Grid Interoperability Panel, a group established by NIST to advance interoperability of smart grid devices and systems through the coordination of standards and best practices. He was the founding administrator for the GridWise Architecture Council—a group formed to enable interoperability of automated systems related to the electric system. Prior to joining the Laboratory, Steve worked for PG&E, AEP and ALSTOM, where he engineered and managed energy management systems products for electric power operations and supported power system computer applications. Application areas include information modeling, SCADA systems and power system reliability assessment tools. Steve received his BS and MS degrees in electrical engineering from the University of California, Berkeley. He is actively involved in the IEEE Power & Energy Society and participates in standards efforts that bridge power engineering with information technology.

Stephan Wright

BPA CEO /Administrator (Ret.), Stephen Wright, LLC.

The Bonneville Power Administration (BPA) has announced that its administrator and CEO, Steve Wright, will retire at the end of January 2013.

Wright has led the agency since November 2000—first as acting administrator and then as permanent administrator, a role he was selected for in February 2002. Wright is the second-longest-serving BPA administrator and first joined BPA in an entry-level position in 1981.

Wright has been planning this decision based on his eligibility date for retirement and decided to make this announcement ahead of his retirement in order to allow for an orderly transition to a new agency leader, BPA says.

Wright will continue to serve as administrator until his replacement is selected. He plans to stay on to support the transition to his successor until his retirement in January. The U.S. Department of Energy (DOE) will have a competitive process conducted under the federal civil service rules to select a new administrator. DOE Deputy Secretary Daniel Poneman will be the selecting official.