Fourth International Transactive Energy Systems Conference & Workshop

Maximizing Your Value: What Can Transactive Energy Systems Do For You?

Prepared by

The GridWise Architecture Council

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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.

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INTRODUCTION

June 2017's fourth International Conference and Workshop on Transactive Energy Systems again brought together representatives of government, industry, utilities, vendor organizations and academia to advance understanding and implementation of transactive energy systems. The core principle of transactive energy is to combine economic and control techniques, leading to improvements in power grid reliability and efficiency. It encompasses techniques for managing the centralized and local generation, flow, and consumption of electric power within an electric power system through the use of market-based methods while maintaining grid reliability.

Last year TESC 2016 provided a forum where lessons learned from the recently completed Pacific Northwest Smart Grid Demonstration Project and other projects were discussed and digested, and ideas for the future of transactive energy germinated. Pilot and demonstration projects have highlighted the utility of communicating pricing signals and future load predictions, as well as underscoring the need for more evolution of the technology. TESC 2016 built upon the success of the previous two conferences, offering a variety of worthwhile activities for energy professionals, policy makers and those seeking to enhance grid intelligence with a focus on value.

TESC 2017 continued to build on the suucess of the previous year's conference. Over the last few years transactive energy systems have moved from a topic of academic discussion to panel sessions at most energy conferences. We are seeing growing interest from regulators, utilities, and third parties. Among the questions that people pose are how does this impact me? Or what problems can this help address? With this focus on selfish optimization the byline for TESC 2017 was "Maximizing Your Value: What Can Transactive Energy Systems Do For You?"

The evolution of themes for TESC is part of the GridWise® Architecture Council 's (GWAC's) plan to gradually change the focus of this conference and workshops from an academic overview to ways to solve real life challenges. The conference featured keynote talks from energy industry leaders and expert panels, and presentations of selected papers on topics critical to the success of transactive energy. There were also workshops where attendees discussed and developed answers to important questions about the future of the intelligent electricity grid.

The 2017 conference continued a productive partnership between the GWAC and Smart Grid Northwest. Support for this conference at the World Trade Center in Portland, Oregon, on June 13 - 15 2017 was provided by Portland General Electric and other industry leaders.

ABOUT SMART GRID NORTHWEST

Founded in 2009 as Smart Grid Oregon, Smart Grid Northwest has expanded the regional focus and impact of the organization with a mission to promote, grow and enable the smart grid industry and infrastructure in the Pacific Northwest. The organization has 70 member companies and growing, representing regional utilities, smart grid industry companies, major energy users (corporations), service firms, higher education groups, government agencies, non-profits, and other grid development stakeholders. Smart Grid Northwest's efforts to promote a cluster of smart grid related companies, while also working to enable deployment of smart grid solutions, focuses in three priority areas: education, policy, and planning. More details are available at SmartGridNW.org.

The World Trade Center, Portland, OR

ABOUT THE GRIDWISE ARCHITECTURE COUNCIL

The GWAC was convened in 2004 by the U.S. Department of Energy (DOE), to promote and enable interoperability among the many entities that interact with the nation's electric power system, 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.

Day One

Conference Welcome and Comments

Speakers: Ronald B. Melton, GridWise Architecture Council

Larry Bekkedahl, Portland General Electric Vice President, Transmission & Distribution

The conference began with a welcome to Portland by Ron Melton on behalf of the GridWise® Architecture Council. Dr. Melton provided a brief history acknowledging the participants in the previous GWAC transactive energy workshops and conferences and thanking the sponsors of this conference and workshops. He outlined the theme of this year's conference which was "Maximizing Your Value: What Can Transactive Energy Systems Do For You?"

Larry Bekkedahl welcomed participants on behalf of Portland General Electric and provided background on related Portland General Electric activities.

Keynote – No Longer at a Loss for Words: an overview of previous, current and future activities.

Speaker: Chris Irwin, U.S. Department of Energy, Smart Grid Standards and Interoperability Coordinator

Slides: Available Here

Mr. Irwin provided an overview of past, current and planned activities by the U.S. Department of Energy. He started by thanking "the pillars of our community" i.e. the hosts and sponsors of the conference. Mr. Irwin thanked the attendees for investing their most precious and finite commodities, i.e their time, to attend the conference. Mr. Irwin noted that everyone at the conference has spent the same personal capital to attend and that everyone has the opportunity to absorb, and interact, with a large percentage of the leading thinkers and concepts that comprise Transactive Energy Systems.

Mr. Irwin noted there was one notable exception to the expert gathering and that the event was coming up on one year since the untimely death of Erich Gunther, a pillar of many communities, including transactive energy. In many ways, Erich epitomized what it means to be a member of a community: active, energetic, curious and flexible. There is a as-yet not fully funded scholarship fund in Erich's name and the donated funds (https://ieeefoundation.org/erichgunther) will allow for a few years of scholarships, but we are not over the hump that could yield a scholarship in perpetuity.

Mr. Irwin commented that Transactive Energy may represent a new way to think about existing and emerging challenges. It is an evolution of the language we use to frame challenges and express solutions, and the vocabulary, grammar and shared meaning we use today doesn't seem up to the task of expressing what you want to communicate, or even offer to the market. He discussed how Grid Architecture is part of what we believe is a necessary evolution of how we talk about the grid, how we establish cause and effect, and how we ensure that the qualities we hold most high are designed into the institutions, structures and processes we use to build the electric system. He also discussed the transactive energy systems valuation methodology and valuation meta model work being developed by PNNL.

Mr. Irwin noted that the nation's critical infrastructure powers our modern way of life and that industries rely on it. Electricity sits at the center of many of relationships between all critical infrastructures including the communication networks that share data across these systems, pumping stations, and fuel storage. Increased reliability, resilience, and security will keep our economy running, and improved efficiency, sustainability, and flexibility will lower the cost of doing so. Investment in our nation's electricity delivery system is an investment in our entire economy.

When asked what the DOE is doing to promote Transactive Energy Mr. Irwin responded that they are working on simulations and modeling, platforms that let you explore and compare different models and simulations. They are working to improve the discipline that's necessary for apples to apples comparisons between models. They are spending money on control theory – specifically engineering-economic control theory. They are working to improve the overarching architecture, standards and interoperability and hoping to hear from sessions at the conference about what else needs to be done, noting that there are no FOAs under transactive energy umbrella.

When asked about regulatory changes Mr. Irwin focused on the NY REV process where there is discussion about DSO (distribution system operator) and distribution level markets, the ability to sell VARs back to grid etc, which are very interesting ideas, and there is a reasonably solid idea of what regulators they want to see. The wording of the documents was not clean as it could have been. It is intended to explain what is wanted in English, and then it's reviewed to see what people have to say about it. To fix the issue of some lack of clarity in the wording of documents, the DOE expended money and diagramed out conflicts and distribution level markets competing for same resource, showing how this can destabilize the grid.These linkages were easier to understand in the diagrams, allowing people to start to modify the documents to allow for refined discussion by ensuring that regulators knew conflicts of interest could occur.

GWAC Foundational Session

Moderator: David Forfia, Electric Reliability Council of Texas

Speakers: David Forfia, Electric Reliability Council of Texas,
Farrokh Rahimi, OATI
Ron Melton, PNNL
Ron Ambrosio, Utopus Insights

Slides: Available Here

The GridWise Architecture Council used this session is to provide important background information to help establish common understanding of transactive energy system related topics for all conference participants. This year's conference focused on changes happening in the industry and the importance of addressing challenegs and developing standards. At the time of the conference GWAC was preparing to publish a draft Transactive Enrrgy Roadmap and the Foundational Session was constructed around the four tracks of the roadmap which were also described in a summary document available to conference attendees and which is available to download from the GWAC website.

David Forfia, GWAC Chair, introduced the session and there then followed four presentations discussing highlights of each track from the draft TE Roadmap with a summary of key benefits and enablers for each track. The GWAC transactive energy roadmap outlines a vision and path forward to achieve deployment of transactive energy systems at scale as an operational element of the electric power system to facilitate the integration of distributed energy resources and dynamic end-uses such as connected buildings. It also considers the application of transactive energy systems for the coordination and control for end-uses, for example, in managing energy in buildings and campuses.

The roadmap considers drivers of change, triggers for transactive energy system deployment, and required infrastructure for deployment at scale. Gaps in technology and infrastructure that may require investment are identified.

The roadmap captures potential changes over time (***Stages***) and organizes them by business and technical ***Tracks***. Within each Track it also groups potential changes into ***Swim Lanes*** that identify what it is that we hope to see, what it takes for this to occur, what we see as a result, and what these features do to add value.

The four tracks are:

- Regulatory and Policy
- Business Models and Value Realization
- System Design and Architecture
- Physical and Cyber Technologies and Infrastructure

Regulatory and Policy

SPEAKER: DAVID FORFIA, ELECTRIC RELIABILITY COUNCIL OF TEXAS

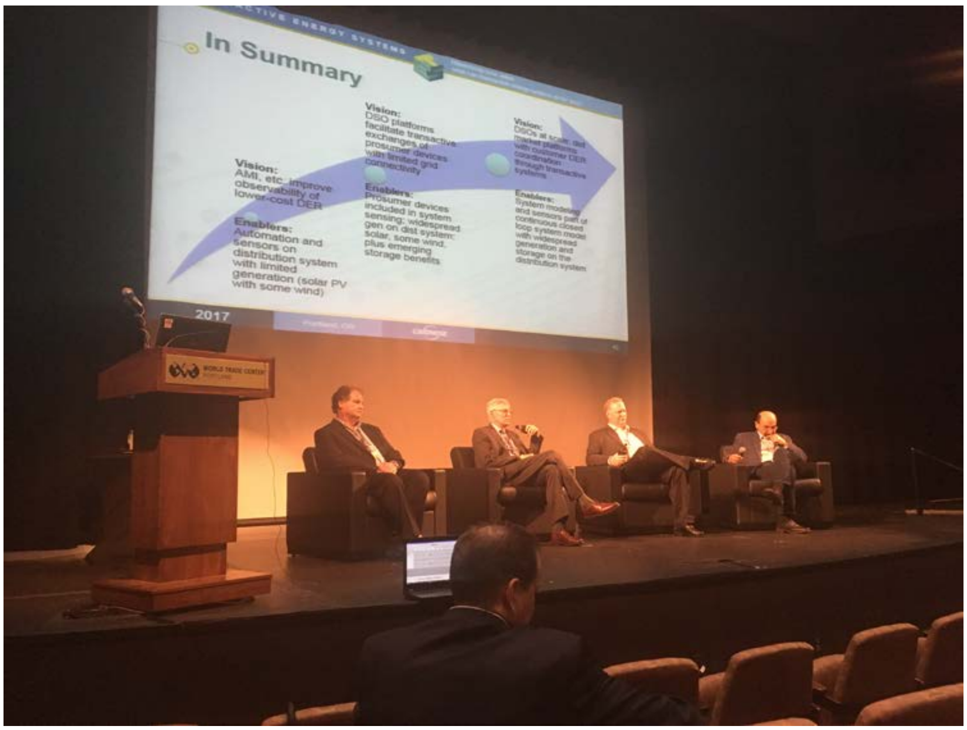
David Forfia provided an overview of some of the regulatory and policy elements of the TE Roadmap which describes the actions needed by regulators and other policy makers to enable TE systems as envisioned in each of the three stages. The objective of the actions in this track is to establish an environment that enables transacting parties to understand rules of engagement and compensation in addition to performance requirements. The actions also focus on achieving a consistency of approach across jurisdictions as much as possible to promote interoperability. The actions described may be carried out by different policy-making bodies depending on the individual jurisdictions and types of utilities.

Many of the actions described in this track support development and implementation actions described in the following Business Models and Value Realization track, and to a limited extent, the actions included in the System Design and Architecture and Physical and Cyber Technologies and Infrastructure tracks.

Business Models and Value Realization

SPEAKER: FARROKH RAHIMI, OATI

Farrokh Rahimi provided an overview of some of the business model and value realization elements of the TE Roadmap which focus on the various stakeholders, their roles in TE and how their business models need to evolve for them to provide and realize value in each of the three stages. While the regulatory and policy track describes the actions policymakers need to take to establish the needed TE environment, this track focuses on the actions to assess and implement needed business model changes by various stakeholder types.



System Design and Architecture

SPEAKER: RON MELTON, PNNL

Ron Melton provided an overview of some of the system design and architecture elements of the TE Roadmap. This track focuses on system design and architecture actions necessary to support each stage specifically dealing with information interoperability to support TE valuation, and operation and control aspects to understand and manage the impacts on the electric grid. This track depends on the business model to define required information exchange between TE parties in content and timing.

Physical and Cyber Technologies and Infrastructure

SPEAKER: RON AMBROSIO, UTOPUS INSIGHTS

Ron Ambrosio provided an overview of some of the physical and cyber technologies and infrastructure elements of the TE Roadmap. This track focuses on the changing Cyber-Physical needs and required actions through the progression of the three stages. This track addresses the technical layers of the GWAC Stack and the physical layers of the Control Abstraction Stack. It includes the activities aimed at the electrically connected network and the communications networks that are necessary to monitor and control the electric grid. This track depends on the information exchange requirements considered in the system design and architecture track to ensure the ability to exchange information in support of transactions without detrimentally affecting the reliability of the electrical network.

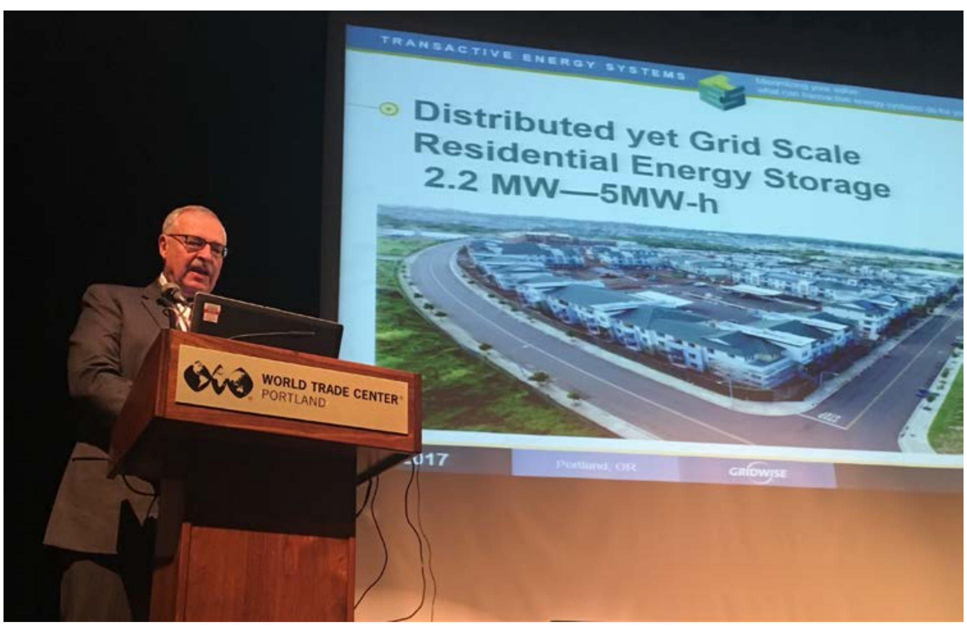
DAY TWO

PLENARY KEYNOTE: KEYNOTE VENDOR TECHNOLOGY PANEL

MODERATOR: FARROKH RAHIMI, OATI

PANELISTS: PAUL STEFFES, STEFFES CORPORATION
MICHEL KOHANIM, UNIVERSAL DEVICES
TAKAHIRO TSUKISHIMA, HITACHI
FARROKH ALBUYEH, OATI

Instead of a keynote talk, this "keynote" was a plenary panel with a difference. Previous keynotes in prior years of this conference have included regulatory and utility perspectives but this year this keynote took a vendor perspective. The panel session started with a keynote presentation by the panel moderator, Dr. Farrokh Rahimi, describing the challenges the electric power industry is facing due to proliferation of prosumer-side distributed energy resources (DERs). These include both operational and business issues the utilities and system operators are increasingly facing. The panelists then each described how their solutions address these emerging challenges, and how they intend to leverage (or are leveraging) the Transactive Energy System principles (possibly also leveraging DSO functionality) to augment their solutions.



Grid-Interactive Energy Storage

SPEAKER: PAUL STEFFES, STEFFES CORPORATION

SLIDES: Available Here

Paul Steffes discussed space and water heating and how it could be used to provide low cost distributed yet grid scale flexible energy storage assets. He noted that space and water heating are the largest users of energy in the home, representing 60+% of energy use within the home and a combined energy storage capability of several TWh. These assets represent low cost distributed yet grid scale flexible loads.

Mr. Steffes explained that space and water heating represented a combination of consumption flexibility with energy storage that is able to respond to real time Transactive signals and bid into ancillary markets.

Mr. Steffes explained how Grid–Interactive Electric Thermal Storage (GETS) uncouples energy usage from electricity consumption and provides better use of existing distribution infrastructure.

Retail Automated Transactive Energy System

SPEAKER: MICHEL KOHANIM, UNIVERSAL DEVICES

SLIDES: Available Here

In his presentation Michel Kohanim described a joint project of Universal Devices, Inc. and TeMix Inc. funded by the California Energy Commission, with support from Southern California Edison and the California ISO. This project proposes that customers subscribe to and pay for energy usage at regular intervals and will be installed in up to 200 SCE residential and small and medium businesses.

The presentation addressed the project's perspective about what transactive energy is and what it is not, with some of the inclusions being

- Transactions at specific locations and time intervals
- Energy related products such as real and reactive power
- Transport related products such as two-way energy transport
- That a two-way transport tariff recovers more fixed costs at higher prices when circuit is more heavily loaded in either direction

Towards high penetration of DER

SPEAKER: TAKAHIRO TSUKISHIMA, HITACHI

SLIDES: Available Here

Takahiro Tsukishima described current demonstration projects that Hitachi is participating in such as an EV aggregation demonstrator in Hawaii (Maui Island) which reflects emerging challenge in Maui ("Duck Curve"), and a heat pump aggregation demonstrator in the UK which utilizes demand response with residential heat pumps.

The presentation also included an overview of the Universal Smart Energy Framework (USEF).
- Provide a framework of "a new market model"
- Sell flexibility of demand and/or supply in Prosumer
- Additional framework on top of conventional trading schemes
- Each balancing group is allowed to define details
- Congestion management in distribution network

Dr. Tsukishima also described a future scenario (with USEF Scheme) and required enhancements compared to a conventional scheme with "smart" devices.

Distribution System Platform for End-to- End Electric Power Transactions

SPEAKER: FARROKH ALBUYEH, OATI

SLIDES: Available Here

Farrokh Albuyeh provided an overview of Key OATI distribution system platform functional capabilities which included descriptions of transactions and information flow as well as an overview of a transactive node. Dr. Albuyeh also refered to the three-stage evolutionary framework[1] for the distribution system driven by its aggregate growth of DERs and stated that stage 3 is almost here and that stacked value streams can be realized through DER participation in local, distribution level, markets.

TRANSACTIVE ENERGY SYSTEMS IN PRACTICE PANEL

MODERATOR: RON AMBROSIO, UTOPUS INSIGHTS

PANELISTS: GERALD GRAY, EPRI
FARROKH RAHIMI, OATI
KENNETH WACKS, HOME, BUILDING & UTILITY SYSTEMS
JOSHUA WONG, OPUS ONE SOLUTIONS
MARK YAO, UTOPUS INGIGHTS

This panel session offered practical perspectives from transactive energy systems that have already been implemented.

[1] Distribution systems in a high distributed energy resources future, Paul De Martini and Lorenzon Kristov, LBNL-1003797, 2015

Blockchain: the potential key to DERMS/DER transactions

SPEAKER: GERALD GRAY, EPRI

SLIDES: Available Here

Gerald Gray's presentation explored how a distributed ledger system, such as used in Ethereum, might be used to facilitate DERMS/DER (or other participant, e.g. prosumer) interactions of the frequency and granularity, that the future grid will require.

As interface definitions and use cases have matured relative to the creation of Distributed Energy Resource (DER) management systems (DERMS) Dr. Gray noted that there remains the problem of transacting the value of these services both as the amount of DER increases and the frequency of when balancing load and generation are called upon.

He stated that in the past, even traditional demand response systems, while more mature and now standardized (via OpenADR) are called infrequently, normally only in instance of an event, for example, 100-degree day, and at the conclusion of the event, the device returns to nominal operation.

While communication to smart inverters has been standardized (IEC 61850-90-7) and enterprise integration is in the process of being standardized (IEC 61968-5), Dr. Gray observed that as DER penetration increases (making the use of a DERMS more likely) the operator may "pull the lever" on either DER or DR capability to deal with grid challenges. But for the system operator there is limited capability to compare how much pulling each lever may cost at the distribution level.

Dr. Gray then described how blockchain's distributed ledger technology promises to enable transactive exchanges between multiple DER parties, albeit, not without some challenges. For example, he noted that Bitcoin (probably the most well-known of the cryptocurrencies) requires over 3 GBs of compressed data to hold the entire blockchain, obviously outstripping the capabilities of smart inverters. However, there are alternatives for participating in a distributed ledger exchange such as using "wallets" that facilitate a device being able to participate without the requirements of holding the entire blockchain.

TES evolution in the quadrants of grid modernization

SPEAKER: FARROKH RAHIMI, OATI

SLIDES: Available Here

Farrokh Rahimi's presentation focused on Grid Modernization with a view to four main practical areas of interest to grid operation, which he referred to as the "Quadrants of Grid Modernization," namely: Economics, Reliability, Resiliency, and Customer Service. The presentation discussed the required functionality of Transactive Energy Systems (TES) to support the end-to-end grid and market operations as the grid evolves across these four quadrants in time.

He presented a diagram which showed the evolution of TES with respect to the four quadrants of Grid Modernization. For each stage, the presentation will discussed the required functional elements of the Distribution System Platform (DSP) including enhancements in Distributed Energy Resource Management Systems (DERMS), Advanced Distribution Management Systems (ADMS), distributed supervisory control and data acquisition (SCADA) systems, and peer-to-peer transactive markets.

DMP: a metric for transactive energy distribution costs

SPEAKER: KEN WACKS, HOME, BUILDING & UTILITY SYSTEMS

SLIDES: Available Here

Ken Wacks stated that ascertaining costs in a distributed grid is a pre-requisite for creating a Transactive Energy market for distributed energy resources (DER). Transactive Energy includes elements of a commodity-trading market tempered by the physical constraints and performance of the distribution grid. To create a market for Transactive Energy, value must be assigned to the energy delivered based in-part on costs for Transactive Energy participants to use the distribution grid for delivery from seller to buyer.

To accommodate grid-edge DER resources, utility cost-analysis must become more granular than traditional central plant analysis and regional load forecasts. Cost measurements are needed throughout the grid in order to determine prices for DER transactions. Distributed Marginal Price (DMP) metrics provide these cost measurements, said Dr. Wacks, by predicting node-by-node costs over a wide range of time scales and grid requirements in terms of both magnitude and timing. DMP is an extension of LMP (Localized Marginal Price) used by some transmission operators who manage a competitive market among central-generation resources.

This presentation introduced DMP, how measurements are gathered, and the creation of a logical base-map of the grid and operating parameters.

Bringing transactive energy to the distribution system operator

SPEAKER: JOSHUA WONG, OPUS ONE SOLUTIONS

SLIDES: Available Here

Opus One Solutions and National Grid have partnered to develop and deploy a single Distributed System Platform (DSP), or transactive energy market that can accommodate a complete range of business models – including ownership, operatorship and revenue from Market Based Earnings (MBE).

Joshua Wong explained how the DSP will communicate local distribution system needs to the point of control ("POC") and send dynamic pricing signals to local customers based on the LMP+D+E value stack. The DSP will test what price signals and/or other revenue opportunities will motivate customers with DER capabilities to actively participate in the DSP whether customer participation will increase as the offered electricity prices increase or other revenue opportunities are made available and whether prevailing electricity prices or other revenue opportunities can provide sufficient motivation for customer investment in new DERs and participation in animated markets.

System peak load management with transactive DER

SPEAKER: MARK YAO, UTOPUS INSIGHTS

SLIDES: Available Here

In his presentation Mark Yao discussed an ongoing pilot project with the Vermont Electric Company (VELCO) where the objective is to manage the monthly peak load on the transmission system. VELCO is a transmission company that is responsible for providing power to the local Distribution Utilities (DUs) in the state of Vermont. For the case under discussion, the monthly system peak is reduced by harnessing the flexibility provided by the Distributed Energy Resources (DERs) managed by the DUs.

Dr. Yao described the business model of VELCO, then outlinde why this business model makes Peak Load Management (PLM) a challenging problem, and illustrated how this PLM application can be cast as a Transactive Energy System (TES). Many DUs manage several types of DERs that can provide flexibility to the transmission system, given an accurate prediction of the system peak. Since these DERs are managed by individual DUs, the final control on these resources can only be exercised by the owning DU.

Dr. Yao described how various types of DER resources are modeled at both a generic abstraction level (non-rechargeable and rechargeable types) and at the specific physical asset level (e.g., utility-scale or customer batteries, water heaters, etc.) and how a coordinated control action by member DUs shall lead to an optimal solution as compared to the one where each DU acts independently.

Real World Technology, Design & Policy Challenges Panel

Moderator: Gerald Gray, EPRI

Panelists: Jim Waight, OMNETRIC Group
Ed Cazalet, TeMIX
Thomas McDermott, PNNL
Steve Widergren, PNNL
David Boundy, Intel

This panel focused on a broad spectrum of challenges for transactive energy systems from system design to policy challenges.

A transactive energy marketplace: architecture and design challenges

Speaker: Jim Waight, OMNETRIC Group

Slides: Available Here

Jim Waight's presentation described a reference architecture framework for a distribution system transactive energy market place. The framework built on already established concepts from bulk power markets that have been operational for years, with adjustments described by Mr. Waight to simplify current bulk power procedures to allow automation with little input from end users at the distribution level. The concept called for end users to select usage profiles with price preferences to create subscriptions of energy needs. Suppliers with on-site generation typically from solar PV rooftop installations and energy storage devices, then enter characteristics of their installations along with offer data for energy products (energy, ramping, regulation, and reserves).

Mr. Waight described how forecast local imbalances arising from excesses or shortages at the distribution level are satisfied at the bulk power level, with bulk power market clearing and locational prices. These three sets of data are inputs to a multi-round auction that clears the market in stages: day-ahead and real-time. Mr. Waight explained how cleared markets result in schedules which are then stored on a public ledger using blockchain technology for billing and settlement. The presentation also discussed architecture and design challenges that are foreseen to arise in developing this IT/OT integration framework, along with promising and emerging standards in this area including the role TE can play in enabling higher network resiliency.

Policy makers toolkit for transactive energy

Speaker: Ed Cazalet, TeMix

Slides: Available Here

Ed Cazalet described how the continued evolution of the U.S. electricity system and distributed energy resources are becoming an increasingly significant presence on the grid, and how policymakers – particularly at the state regulatory level – will be confronted with proposals and choices that are starkly different from the traditional ones that have been associated with electricity policy. He noted that these will involve proposed investments in new technologies, redefined roles for the electric utility, new methods of pricing electricity and other grid services, and the regulation of entities and services that were nonexistent in the traditional model. Policymakers must be prepared to confront new issues and new questions, said Dr. Cazalet. By anticipating what these questions will be, they can begin to explore answers and solutions before these questions even arise.

Dr. Cazalet presented the critical questions that will begin to appear – if they have not appeared already – as the grid evolves, and he put them in context: explaining why they are important, what resources will be required to effectively address them, key considerations, and what particular methods are recommended to best arrive at useful solutions. Together, Dr. Cazalet explained how these questions will comprise a "policymaker's toolkit", and will enable regulators, legislators, and their staffs to be better prepared to tackle the hard decisions and issues that will move to the forefront as America's electricity system incorporates new technologies and energy sources. It will also help, he explained, as the system moves toward a framework that is more transactive, with many more agents playing an active role in providing and managing electricity services on the grid.

Transactive energy simulation platform

SPEAKER: THOMAS MCDERMOTT, PNNL

SLIDES: Available Here

Tom McDermott opened by providing an overview of a new Transactive Energy Simulation Platform (TESP) that has been developed for virtual testing of different transactive agents and market mechanisms on large systems. Message schemas and data structures have been designed for co-simulation of electric generation, transmission and distribution, with separate software agents for market mechanisms and transactive control. Users can develop and test their transactive software on large system models, interoperating with transactive software from other providers. Dr. McDermott described how this provides a uniform framework for defining test systems and evaluating performance. Customization and development effort is limited to just the modules of interest so users don't have to develop and test their own grid modeling software, only their transactive software. He also noted that TESP is open-source with one of the least restrictive license terms (BSD-new). It runs on Linux, Windows and Mac OS X.

TESP uses GridLAB-D(tm) for the distribution grid and single-family residential buildings, EnergyPlus(tm) for larger commercial buildings, and MATPOWER (or PYPOWER) for the bulk generation and transmission grid. These simulators interact with each other and the separate Transactive Energy Agents (TEAgents) over a Framework for Network Co-Simulation (FNCS), which provides messaging and time synchronization services. TEAgents have been implemented in C/C++ and Python, but other languages such as Java may also be used.

Dr. McDermott explained that messaging schemas and data structures for metrics have been defined in the Unified Modeling Language (UML), for implementation in Javascript Object Notation (JSON). Any TEAgent or co-simulator code may participate in TESP by supporting the published JSON messages and metrics. Examples have been provided in Python for double-auction market clearing, dual-ramp thermostat controller, passive demand response controller, and load shedding controller. Others are planned for implementation this coming year, including a grid-to-building interface for VOLTTRON(tm) controllers. Valuation examples have also been provided in Python. These key elements are the easiest to customize or extend in TESP. It's also possible to substitute different grid simulators (i.e. GridLAB-D, MATPOWER / PYPOWER, EnergyPlus) but that would require more skill and effort.

By incorporating bulk system dispatch into the model, Dr. McDermott explained how TESP can help users evaluate the two-way impacts of the bulk transmission and the distribution systems on each other. With sufficient computing power, he said that TESP can simulate several interconnected transactive distribution systems in detail. The growth model is another new feature in TESP it supports more realistic multi-year simulations. At monthly to yearly time steps, the growth model simulates evolution of system infrastructure over time. This evolution is based on investment and adoption decisions made by various stakeholders, using information available to them at that simulated point in time. The operational model serves as an inner loop within the growth model, running at (typically) 15-second power flow steps and 5-minute market clearing steps.

Dr. McDermott concluded by saying that work has begun to simulate the Smart Grid Interoperability Panel (SGIP – now part of SEPA) transactive use cases in TESP. As this work continues, TESP users will be better able to evaluate new transactive designs and policies before deployment in the field.

A TE spin on interoperability

SPEAKER: STEVE WIDERGREN, PNNL

SLIDES: Available Here

Under its Grid Modernization Initiative, the U.S. Department of Energy (DOE), in collaboration with industry, is pursuing a multi-year plan to modernize the electric grid. Steve Widergren described how one of the foundational topics to accelerate modernization efforts is interoperability. Interoperability was recognized by GWAC since its inception as crucial for enabling the smart grid and it is one of the eleven key TE attributes identified by GWAC. Transactive designs involve negotiations between parties enabled through the exchange of information. Steve noted that the transactive agents, acting on behalf of the people they represent, must be able to connect and exchange information, understand the context and meaning of that information, and use that information to accomplish workflows in support of their negotiated agreements. For transactive systems to thrive, the way transactive devices and systems integrate needs to be simple and reliable.

Mr. Widergren discussed characteristics that make transactive approaches attractive from an interoperability point of view. He introduced the audience to the DOE grid modernization interoperability project that offers a strategic vision for interoperability that can be applied to the TE community. This involves developing stakeholder buy-in on the desired future state, and then applying a roadmap methodology to understand the current interoperability situation for integrating transacting parties, identifying interoperability gaps, and articulating the major steps needed to move toward the desired future state.

Mr. Widergren also noted that one of the six TE Principles in the TE Framework states that transactive energy systems should be scalable, adaptable, and extensible across a number of devices, participants, and geographic extents. He described how this is consistent with important interoperability characteristics in the GWAC Interoperability Maturity Model, which has been updated by the GMLC project as a tool to support the roadmap process. He also covered the scope of the project and how structured approaches to improve interoperability can lead to the establishment of technical, informational, and organizational interoperability for transactive energy systems.

Microservices for grid stability

SPEAKER: DAVID BOUNDY, INTEL

SLIDES: Available Here

David Boundy began by describing the trend toward electrification of heat and transport combined with the falling cost of computing and communications, the ability to provide and validate micro services and make micro payments represents an opportunity to revolutionise the operation and business models associated with the grid. He stated that his work focuses on the monitoring and control of highly disaggregated loads for example space and water heaters and electric vehicles. By comprehending their service delivery requirements combined with their storage capabilities they can determine the inherent flexibility they can provide to support system services within the grid. Taking the individual loads and their corresponding flexibility profiles they aggregate these with other loads within the network and provide an optimised schedule that meets their service delivery needs while comprehending the constraints within the grid.

In order to receive payment for the provision of these micro services Mr. Boundy explained that grid operators will require a method for independent verification. As part of Intel's work they are exploring secure trusted low cost methods for measurement of the provision of these micro services without the need for physical metrology attached to each appliance.

To validate and further Intel's research Mr. Boundy described how they are partnering with a broad consortium across the electrical supply ecosystem in a large scale proof of concept spanning three European countries and 1250 homes. RealValue is a collaborative project funded under the EU H2020 program. Partners are from energy generation companies, transmission system operators, distribution network operators, utility retailers, technology providers, appliance manufactures and research organisations. Mr. Boundy said that the project is testing the benefit of Smart Electric Thermal Storage (SETS) in the three jurisdictions, studying end user acceptance and modelling of the benefits across all European countries and the development and testing of associated business models.

PLENARY PANEL - EXPERIENCES FROM SMART CITIES

MODERATOR: RON BERNSTEIN, RBCG LLC

PANELISTS: TIM WOLF, ITRON
CURT KIRKEBY, AVISTA UTILITIES
WILFRED PINFOLD, CONCURRENT SYSTEMS
RON SEGE, ECHELON CORPORATION

ERIK CALDWELL, CITY OF SAN DIEGO
STEPH STOPPENHAGEN, BLACK & VEATCH

A smart city is a vision to integrate multiple information and communication technology (ICT) and Internet of things (IoT) solutions in a secure fashion to manage a city's assets, just as smart grid is for the electricity infrastructure. As the grid considers the need to substantially scale the use of flexible distributed energy resources, and has devoted growing attention to the need to address not only the economics, but also the control system implications to ensure grid reliability, smart cities have similarly complex challenges. For smart cities the economics need to be optimized over multiple utilities, transportation, and other departments while making more efficient use of physical infrastructure through artificial intelligence and data analytics to support a strong and healthy economic, social, cultural development. This sounds a lot like transactive energy and this panel explores the similarities by asking:

- What challenges did the cities set out to address, and what were the main challenges in meeting them?
- How much focus was placed on the use of energy between utilities/services (gas, water, electricity, transport, safety, etc.) and optimization of the dependencies?
- Were there areas where optimization techniques would have provided improved decision making?
- Have you looked at how Transactive Energy Systems could help?

Transactive Energy and Smart Cities

SPEAKER: TIM WOLF, ITRON

SLIDES: Available Here

Tim Wolf made a presentation that opened with a discussion of Envision Charlotte. Mr. Wolf explained that this is a unique public private partnership building a smart city that will lead to the most sustainable urban core in the country. It is planned to use technology to find efficiencies that will reduce the cost of doing business in Charlotte while driving reductions in energy, water, waste and air. To achieve this Mr. Wolf mentioned that the measurement, management, and analysis of energy and water production, delivery, and consumption are critical and he reviewed the evolution of technology and its role in electricity measurement.

Urbanova - A living laboratory to design cities for the future

SPEAKER: CURT KIRKEBY, AVISTA UTILITIES

SLIDES: Available Here

Curt Kirkeby described Urbanova as a living laboratory to design cities for the future. Located in Spokane, Washington, data is harnessed to gain insights, empower people and solve urban challenges in new ways. Mr. Kirkeby described the goals as healthier citizens, safer neighborhoods, smarter infrastructure, more sustainable environment, and a stronger economy. He then proceeded to describe the innovation model, their shared information platform, and describe some of their initial projects.

Mobility Hubs

Speaker: Wilfred Pinfold, Concurrent Systems

Slides: Available Here

Wilfred Pinfold's presentation described mobility hubs and challenges and how mobility hubs can be smart grid nodes to provide local, regional, and emergency value. He noted that transit oriented development works well for communities within ½ mile of transportation hub (3/4 sq miles) but technology can be used to expand this to 2 miles (12½ Sq miles), servicing a larger community more cost effectively while maintaining a walkability score.

The questions, he said, are whether we can use technology to increase safety and security at these transportation hubs thus improving ridership and reducing cost and whether we can use these transit hubs for cargo, commuters and casual users.

By making these improvements Dr. Pinfold asserted that costs can be reduced so as to service all citizens in Portland and make all communities desirable and walkable, reducing displacement.

Smart City Applications Based on Connected Outdoor Lighting

Speaker: Ron Sege, Echelon Corporation

Slides: Available Here

Ron Sege opened his presentation by stating the importance of building a platform for communicating with and controlling "things" from day 1. Mr. Sege discussed a platform that can run multiple applications, uses distributed processing, and which can scale at low cost and with low latency. He also stressed the importance of open interfaces. He also discussed the fast transition to LEDs, and the benefits that embedder connectivity can create with the expectation of large opportunities to leverage this for connected outdoor lighting. He then discussed a project in Cambridge, MA, with 12+ zones each with different on/off/dimming schedules and another project in the Northwest that involves school zone beacon control. He concluded by discussing building and lighting management integration, and how bridging the gap between interior and exterior building systems can increas efficiency by consolidating system controls under a single management system.

San Diego's smart city progress

Speaker: Erik Caldwell, City of San Diego

Erik Caldwell did not use any slides for presentation and gave an overview of current smart city activities going on within the city of San Diego. The City of San Diego is one of 10 U.S. cities selected to join Envision America, in which cities will leverage technology collaborators and businesses to address climate change challenges and improve city services. More information can be found here.

Smart City drivers and trends

SPEAKER: STEPH STOPPENHAGEN, BLACK & VEATCH

SLIDES: Available Here

Steph Stoppenhagen opened by stating that governments have many values to balance with infrastructure resilience but how much resilience is enough? And how do we measure the consequence of failure?

Ms. Stoppenhagen then reviewed the major forces driving the adoption of smarter technologies and data analytics including the primary drivers of Smart City initiatives and the systems most important to invest in first and noted that smart cities need smart utilities.

Ms. Stoppenhagen concluded her presentation with some observations including

- The smart city movement has lot of momentum and stronger understanding
- There is a growing urgency to implement smart city models in the next 5 to 10 years
- Overcoming barriers requires education, new mechanisms and mindsets
- The planning emphasis indicates a shift to a more holistic approach
- Governments place high value on public-private partnerships and on utilities playing leadership roles.

Day Three

Plenary Keynote - A battery-equivalent model for DER services

Speaker: Rob Pratt, PNNL

Slides: Available Here

Rob Pratt described how distributed energy resources (DER) are becoming an increasingly valuable part of the resource mix in the electricity grid. This proliferation brings with it a set of challenges and barriers that have to be accommodated. These include shifts in the system net load curve, bidirectional power flow, and reliability issues. Left to operate on their own DER can introduce challenges to grid control and reliability but when coordinated to respond to grid operational needs Mr. Pratt described how they offer tremendous potential for improved resiliency and reliability.

In this address Mr. Pratt also discussed work being performed at Pacific Northwest National Laboratory to model DER as batteries since a battery is like a general power plant with storage and every DER can be represented as a battery but to do so requires a common uniform set of properties and constraints.

Mr. Pratt explained how the PNNL project developed a general model which can be used by simulations. In turn, this general model can represent the many specific instances of different distributed energy resources.

Standardization for Transactive Energy Panel

Moderator: Gordon Matthews, Bonneville Power Administration

Panelists: David Holmberg, NIST,
Ron Melton, PNNL,
Rish Ghatikar, EPRI,
Ken Wacks, Home, Building & Utility Systems,
James Mater, QualityLogic

This panel provided a logical progression from the challenges facing the industry. Since temporary solutions or pilot systems often become long term solutions, the objective of this session was to identify areas of standardization where:

- Different approaches to Transactive Energy Systems can converge
- Existing standards can be adapted to Transactive Energy Systems,
- There are common challenges amenable to common approaches and standards,
- Vendor support and sharing of best practices would develop.

TE Principles for Customer DER integration

Speaker: David Holmberg, NIST

Slides: Available Here

David Holmberg's presentation examined the integration patterns and kinds of communication standards that will promote innovation and ultimately effective integration of customer DER. He discussed the principles that should guide an architecture for connecting devices within buildings within microgrids within larger grids and asked what is the value and use of traditional DR and more direct (or indirect) load control by entities outside the customer space compared to viewing the customer interface as a black box providing services to the grid?

Dr. Holmberg asked the attendees to consider what things are we doing now, during transition, which are impediments to longer term goals? And he examined these questions in light of the current grid environment and desired future TE environment, and provided a set of principles for the grid architect, regulator and utility for considering what standards can best be used for transactive resource negotiations.

Considerations for a Modern Distribution Grid

SPEAKER: RON MELTON, PNNL

SLIDES: Available Here

Ron Melton's presentation summarized the Department Of Energy's DSPx (next generation distribution system platform) initiative's application of the GWAC Stack & Grid Architecture to develop a standardized framework for policy and business architecture for the modern transactive grid. Dr. Melton described how this initiative is responding to requests from several state regulatory commissions to develop a standardized framework to determine the functionality, technology and implementation considerations for a modern distribution grid. The focus is on customer and policy driven needs to enhance reliability and operational efficiency, DER integration and utilization of DER services through transactive mechanisms. Dr. Melton's presentation also highlighted key learnings from regulator and industry feedback.

Transactive Incentive Signals to Manage Electricity Consumption (TIME)

SPEAKER: RISH GHATIKAR, EPRI

SLIDES: Available Here

Rish Ghatikar described how the electric grid of the future is inextricably linked with technological and regulatory advancements to realize business and consumer benefits. In the United States (U.S.), one key driver for the future of the electric grid is the transformation from centralized to a distributed energy generation across the Smart Grid. This transformation contributes to extreme spatial and temporal variability in electricity generation—on the order of megawatts and gigawatts.

System-wide integration of variable generation can further increase costs in the absence of expanded balancing such as might be provided by demand response (DR) resources responding to actual system needs in real time and Mr. Ghatikar explained that standardized information and communication technologies offer an opportunity to address variability via transactions with the electric grid by leveraging flexibility among electricity producers and consumers using existing systems. He stated that advanced energy technologies and markets have shown an average of 11% demand reduction in response to economic incentive signals but the key question that needs to be addressed is how can existing capabilities be used to design and operationalize standardized transactive signals?

California has for the first time embarked upon a public- and market-benefiting project to test and operationalize a system for such transactive load management. Rish Ghatikar stated that the fundamental premise is that the existing programs and electricity rates do not provide a customer participation incentive structure that accurately reflects real-time system conditions or costs. The project goal is to use transactive signals, in the form of proxy prices, to overcome these barriers and mobilize flexible DR from utility customers and other recipients.

In this instance, DR has substantial potential to act as either a demand- or supply-side resource for the electricity system. Mr. Ghatikar discussed the need, challenges, and a framework of transactive signals designed to provide consumers with electricity cost-based information they can use to manage their flexible demand in response to energy system needs. He reviewed how the transactive signals can be transported via proven standardized protocols and used by DR projects and technologies for field validation with a diversity of distributed energy resources (e.g., energy storage) and consumer loads (e.g., lighting).

The design considers existing practices and suggests a transactive energy framework and roadmap to garner consensus. The proposed design and operational plans have the potential to reveal challenges and common approaches to standards and electricity system interoperability. This may help policy makers and industry to develop new practices for widespread adoption of economics-driven transactive signals for an integrated electric grid of the future.

Transactive Energy Standards for Customer Equipment

SPEAKER: KEN WACKS, HOME, BUILDING & UTILITY SYSTEMS

SLIDES: Available Here

Automated customer equipment is essential for effective Transactive Energy. Ken Wacks' presentation examined interface and communication standards issued and under development as American and international standards by ANSI and ISO/IEC. These standards facilitate the participation of customer devices and appliances in Transactive Energy. Among the standards discussed by Dr. Wacks were:

- ISO/IEC 15067-3, "Model of a demand-response energy management system" (approved for the SGIP Catalog of Standards)
  This framework standard specifies the Energy Management Agent (EMA) for autonomous energy management. The EMA allocates energy according to appliance requirements and operating modes, energy price and availability from sources both local (renewables and storage) and grid-based (microgrids and the public utility), customer's budget, and customer's preferences. Extensions of the EMA to Transactive Energy will be discussed.
- ISO/IEC 15067-3-3, "Model of a system of interacting Energy Management Agents (EMAs) for demand response energy management"
  This standard (under development) extends the EMA concept to an apartment complex with multiple buildings and apartments. The management company could enter into

transactions with energy suppliers and use the EMAs to allocate power efficiently through automated negotiation with EMAs and smart appliances.

- ANSI/CEA-2045, "Modular Communications Interface (MCI) for Energy Management" (approved for the SGIP Catalog of Standards)
  This standard specifies an AC and a DC interface for devices to exchange energy management data via a variety of communication protocols, both wired and wireless. Widely adopted application languages for conveying energy prices, event notices, and control message are supported. An ISO/IEC version of this standard is in the final stages of approval.
- ISO/IEC 15045 series, "Gateway"
  The gateway is primarily a protocol translator between external and internal communication networks. However, as the Internet of Things proliferate, the gateway will become a line of demarcation for the consumer domain and a filter for message authentication, including Transactive Energy data, to protect customer privacy, safety, and security. Extensions of the gateway standard have been proposed for:
    - A local certificate management authority for authorizing attachment of smart devices to the home or building network.
    - Adapters in the gateway for accommodating legacy devices.
- ISO/IEC 18012, "Product guidelines for interoperability"
  This series of standards enables products conforming to a variety of communication protocols to interoperate and function cooperatively. These standards were created in recognition of the competitive marketplace for network technologies that is likely to be encountered at the grid edge where prosumer equipment participates in Transactive Energy. This standard has already been used for the Pacific Northwest Transactive Energy Demonstration project.
- ISO/IEC 14543 series, communication protocols
  A choice of widely-deployed communication protocols is available as international standards to interconnect appliances and devices via the MCI standard to the gateway in order to participate in Transactive Energy.
- ISO/IEC 15067-3-2, "GridWise Interoperability Context-Setting Framework"
  This document was recently approved and published as an international technical report.

The interplay of these standards in a Transactive Energy environment was discussed by Dr. Wacks as well as opportunities for Transactive Energy participants to shape international standards for Transactive Energy.

Leveraging Existing Communications Protocol for DER and Transactive Energy Communications

SPEAKER: JAMES MATER, QUALITYLOGIC

SLIDES: Available Here

James Mater commented how the management of the growing portfolio of distributed energy resources (DER) in the electric grid is becoming an issue of great concern and opportunity for the industry. One of the major challenges, he said, with DER is the siloed nature of both requirements and communications protocols for DER integration. Requirements and communications standards for solar PV, battery storage, electric vehicles and demand response have been developed at times quite independently and with differing business and operational objectives. Yet, for grid operators, the goal is to manage a constantly changing set of potential DER resources as an integrated grid asset optimized for efficiency, costs and effectiveness.

Mr. Mater described a project undertaken by EPRI and the OpenADR Alliance, SunSpec Alliance and others which developed a landscape perspective of the requirements and communications standards for DER from an integrated management perspective. Transactive Energy Use Cases and Requirements are included in the landscape. He discussed how the project brought together industry experts who are working across the different DER asset classes to simplify the communications platforms required for integrated DER management.

Mr. Mater described that the primary goal of the DER Communications project was to identify the grid requirements and standards that are used (or planned to be used) for DER communications today and to identify how the OpenADR or other standards can be extended to address the critical gaps that exist in the communications landscape. One the gaps described was support for transactive energy messaging and Mr. Mater discussed how currently used standards support Transactive Energy communications requirements and what extensions are required to support the long-term vision of Transactive Energy messaging.

PLENARY PANEL - WHAT IS BLOCKCHAIN'S ROLE IN TRANSACTIVE ENERGY SYSTEMS?

MODERATOR: DAVID HARDIN, SEPA

PANELISTS: KARL KREDER, CONSENSYS,
LAWRENCE ORSINI, LO3 ENERGY
JOSHUA WONG, OPUS ONE SOLUTIONS
SHAWN CHANDLER, NAVIGANT CONSULTING

Blockchains are an enabling component of secure, digital crypto-currencies, such as Bitcoin and Etherium. These currencies provide a medium for value exchange using cryptography to secure the transactions and to control the creation of additional units of the currency. All transactions are stored in cryptographically-immutable distributed ledgers called blockchains while trusted executable "smart" contracts implement transaction logic and other business process behaviors. This combination of components helps provide the transaction transparency and tamper-resistance needed for building and maintaining trust between transacting parties.

This panel, moderated by Dave Hardin, discussed the application of blockchains and cryptocurrencies to transactive energy and looked at the technology from technical, economic, and utility perspectives while exploring the following questions:

- What characteristics of blockchains and smart contracts could provide value for TE systems?
- What role could smart contracts provide in creating TE systems?
- Devices exist today to build TE systems so where are the best non-hardware areas for standardization?

- Are there common challenges from existing pilot implementations that are amenable to common approaches and standards?
- What are the main road blocks to implementing blockchain and smart contracts for retail energy markets (regulatory, business model, architecture, technology)?

After the presentations the panelists addressed the question of whether using blockchain on the grid make us more vulnerable to hackers/cyber-attacks. The panel stated that blockchain's architecture makes it nearly impossible to hack. If hackers were to overcome the encryption used by blockchain, any other software providing similar services would be equally vulnerable.

Another question addressed the issue that as DERs continue to proliferate on distribution feeders, the utility will begin to look like just another prosumer node so could blockchain take over at every level as the backend of a DSO? The panel's view was that this is the natural outcome for such a system. The main challenge now is getting regulators and policymakers to understand it, so laws can be written that allow us to get the full benefits of using blockchain for TE systems.

Another audience question asked whether in designing a blockchain for TE systems, is it useful to create a token, or is it better to just measure energy and save yourself the trouble? The panel responded that tokens are incredibly useful in order to send additional data beyond just kW. Tokens can have all sorts of data: voltage, power angle, frequency, etc. Using the blockchain to facilitate sending all this data can free up other communication lines. Additionally, the tokens can be "colored" to represent green generation sources, ancillary services, or other types of value. However the benefits of using tokens to convey all that on the blockchain have to be weighed against using off-chain methods that are faster, especially if the infrastructure is already there (i.e. smart meters).

Wrapping up the session, the final question asked at the end of the day, where is the value added from blockchain to TE systems? The panel responded that blockchain's use as an immutable, public ledger makes it valuable for any transactive system. Additionally, as the power system becomes more decentralized, blockchain's decentralized architecture will become more of a benefit. The ability to make self-executing contracts between machines facilitates a much faster, more secure way to buy and sell in a network of peers.

Energy + Blockchain

SPEAKER: KARL KREDER, CONSENSYS

SLIDES: Available Here

Karl Kreder noted that to better understand what blockchain is, and the influence it will have moving forward, drawing analogies to the internet are helpful. In his presentation Mr. Kreder described where he saw three major opportunities for blockchain in energy markets:

- Providing consumers direct access to wholesale markets
- Commoditizing and trading renewable energy credits
- Creating P2P markets which will incentivize DERs

Local energy networks using community microgrids

SPEAKER: LAWRENCE ORSINI, LO3 ENERGY

VIDEO: Video Available Here

As an alternative to presenting slides and addressing the slide content, Lawrence Orsini made some introductory remarks about decentralized application platforms and then played a video to show an example of a community microgrid in Boerum Hill, Gowanus and Park Slope in New York in support of Governor Cuomo's goal of creating local energy networks with the ability to separate from the larger electric grid during extreme weather events or other emergencies.

The community microgrid featured in the video was created to build a local energy network with a focus on:

- Working with community leaders, utilities and technology partners to identify the best fit for distributed energy resources and critical infrastructure upgrades
- Developing locally generated energy that provide resiliency for emergency needs of local communities
- Reducing customer costs and promoting clean, renewable electricity, energy efficiency and energy storage options within my community
- Managing these distributed energy resources for times of power outages and emergencies to protect my community and local economy
- Identifing and create new financial incentives and business models to drive community involvement and jobs, boosting the local economy.

Evolution towards the distribution grid as a service platform

SPEAKER: JOSHUA WONG, OPUS ONE SOLUTIONS

SLIDES: Available Here

In the recent past Block-Chain has been vetted as a solution to managing micro grids and DERs. However, due to the complexity of the distribution grid, the Block-Chain concept cannot simply be transferred from the financial sector to a power grid. When observing the fact that distribution charges, losses, congestions, and other physical grid limitations may lie between two trading parties, Joshua Wong noted that it is essential that the transaction reflects the usage and constraints of the distribution grid. He explained that for Block-Chain to play a role as a mechanism for a trading platform, it would require a distribution market based on Distribution System Platform to provide accurate valuation of the DERs. In conclusion, he stated that a deployment of Block-Chain will have to see some sort of transactive energy elements, and Block-Chain will have to prove itself against other mechanisms and solutions.

The realities of "peer-to-peer" transactive energy using blockchain

SPEAKER: SHAWN CHANDLER, NAVIGANT CONSULTING

SLIDES: Available Here

These days, clean energy media and the utility industry are abuzz with talk about peer-to-peer (P2P) energy, the idea that power generation and consumption can be fully decentralized. Startups around the globe have latched upon the concept of prosumers selling their power directly to their neighbors. They promise platforms that empower customer choice, support local green energy, and sometimes even save or make the customer money in the process. Invariably, the solutions involve blockchain technology. Because of this pairing of P2P energy transactions with blockchain technology, many people equate transactive energy with blockchain P2P. However, Shawn Chandler explained that transactive energy represents a broad set of activities that includes much more than this type of solution.

A more fundamental question Mr. Chanfler asked, is whether true P2P energy transactions are even possible. Traditionally, P2P transactions occur when peers make their resources directly available to other participants without central coordination. While there are a few scenarios in which this type transaction can take place between power grid customers, most situations – including most of the blockchain TE projects in progress – will not be P2P.

Mr. Chanfler focused his talk on what makes a TE implementation peer-to-peer and identified situations in which true P2P can take place, as well as those where it cannot. He also described the value that blockchain can offer to TE at the distribution grid level, regardless of whether the solution is P2P or not.

Finally, Mr. Chandler discussed the reality of claims made by many of the blockchain TE developers, that their customers form a microgrid and that they can rely on that "microgrid" for resiliency. He addressed the difficulties inherent in creating an islandable microgrid within the context of prosumer DER on a developed power grid.

Closing Comments & Special Thanks

The GridWise® Architecture Council and Smart Grid Northwest thank all of the speakers, session leaders, student volunteers and sponsoring organizations. Last, but not least, we thank the participants. The event brought together representatives of government, industry, utilities, vendor organizations and academia who have an interest in advancing transactive energy. The discussions and exchanges of ideas and experiences during the course of the conference and the workshop sessions are very valuable in helping the Transactive Energy Systems community to grow. We would especially like to thank Portland General Electric for making the facilities available for the conference.

The attendance, active discussions, and response to the call for papers indicate a growing community of interest and practice for the topic of transactive energy systems. In spite of this growth in interest and activity there is much work to be done. This challenging work is interdisciplinary and cuts across traditional stovepipes within the electric power system industry, the end uses of electricity, and between the two.

Plenaries and keynotes at previous conferences have focused on utility and regulatory perspectives but this year the conference included plenaries by the Department of Energy, vendors, applications for TE such as Smart Cities, an intriguing look at implementation possibilities with a packed auditorium for the final plenary on blockchain, and a lunchtime talk looking back at the last ten years of progress by Terry Oliver who has been a valued contributor to and supporter of GWAC. Thanks, Terry!

With that in mind we look forward to continued activity and progress and your participation in the 5th International Conference and Workshop on Transactive Energy in 2018.

Organizers

The Council organized this 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.

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

Resnick Institute Report – Grid 2020: Towards a Policy of Renewable and Distributed Resources
http://www.energy.ca.gov/2012_energypolicy/documents/2012-11-07_workshop/2012-11-06_Resnick_Institute_Report-Grid_2020_Towards_a_Policy_of_Renewable_and_Distributed_Energy_Resources_TN-68383.pdf

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

SGIP TE Application Landscape Scnarios paper
http://www.sgip.org/wp-content/uploads/SGIP_White_Paper_TE_Application_Landscape_Scenarios_12-15-2016_FINAL.pdf

Southern California Edison's Approach to Evaluating Energy Storage
http://www.energy.ca.gov/2011_energypolicy/documents/2011-04-28_workshop/comments/TN_60861_05-20-11_Southern_California_Edison_Company_Comments_Re_Energy_Storage_for_Renewable_Integration.pdf

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

IEEE PES Magazine May/June 2016 – Transactive Energy
http://magazine.ieee-pes.org/may-june-2016/

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/c/dam/en/us/products/collateral/cloud-systems-management/connected-grid-network-management-system/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.energiesystemtechnik.iwes.fraunhofer.de/de/presse-infothek/publikationen/uebersicht/2009/virtual_power_plantsinrealapplications-pilotdemonstrationsinspai.html

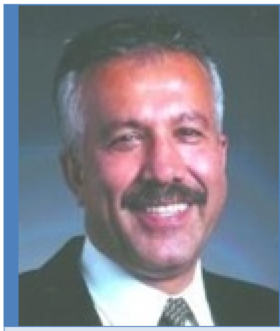
APPENDIX B – AGENDA

TUESDAY JUNE 13, 2017		
Time		**Session**
12:30pm	1:30pm	Conference Registration and Welcome
12:30pm	1:30pm	Welcome and Opening Remarks
2:00pm	3:00pm	Opening Keynote – Chris Irwin
3:00pm	3:30pm	Networking Break
3:30pm	5:30pm	GWAC Foundational Session – The TE Roadmap
5:30pm	7:00pm	Networking Reception

WEDNESDAY, JUNE 14, 2017		
Time		**Session**
8:00am	8:30am	Registration and Networking
8:30am	9:30am	Plenary Keynote - Vendor Technology Panel
9:30am	10:30am	Transactive Energy Systems in Practice Panel
10:30am	11:00am	Networking Break
11:00am	12:00pm	Real World Technology, Design & Policy Challenges Panel
12:00pm	1:30pm	Lunch and Keynote - Perspectives on a Decade of Progress
1:30pm	2:00pm	NIST TE Challenge Overview and Invitation
2:00pm	3:30pm	Plenary Panel - Experiences from Smart Cities
3:30pm	4:00pm	Networking Break
4:00pm	5:30pm	Real World Technology, Design & Policy Challenges Workshop
4:00pm	5:30pm	Transactive Energy Systems in Practice Workshop
5:30pm	7:00pm	NIST TE Challenge Phase II Scenario Workshop

THURSDAY, JUNE 15, 2017		
Time		**Session**
800am	8:30am	Registration and Networking
8:30am	9:30am	Plenary Keynote - A battery-equivalent model for DER services
9:30am	10:30am	Standardization for Transactive Energy Panel
10:30am	11:00am	Networking Break
11:00am	12:00pm	Standardization for Transactive Energy Workshop
12:00pm	1:30pm	Lunch
1:30pm	2:30pm	What is Blockchain's Role in Transactive Energy Systems?
2:30pm	3:00pm	Closing Plenary

Appendix C – Speaker's Profiles

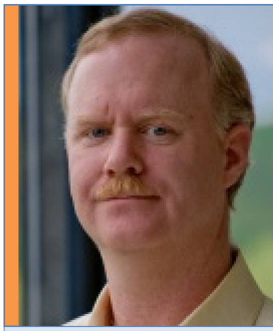


Farrokh Albuyeh

Senior Vice President, Smart Grid Projects
OATI

Farrokh Albuyeh received his B.S., M.S. , and Ph.D. degrees in Electrical and Computer Engineering, with emphasis on Power Systems, from the University of Wisconsin-Madison. He is currently Senior Vice President, Smart Grid Projects at Open Access Technology International (OATI), where he is involved in the development of software solutions and products for Smart Grid as well as for energy markets.

Prior to joining OATI in 2004, he worked for AREVA T&D as the Director, Market Participants, where he was involved in the development of products and solutions for participants in energy markets. From 1985 to 1999 he worked for ABB as the Director, Product Development and Marketing where he was involved in the design and implementation of advanced transmission system analysis, and generation scheduling applications for Energy Management Systems and market applications for ISOs and RTOs.



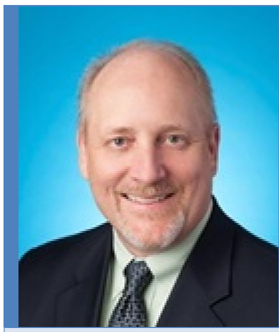
Ron Ambrosio

Chief Scientist and Co-Founder, Utopus Insights, Inc.
GWAC

Ron Ambrosio is the Chief Scientist and Co-Founder of Utopus Insights, Inc. (UI), a company specializing in advanced analytics, modeling and optimization for the utility industry, with solutions for renewable generation and demand forecasting (including behind-the-meter solar PV), asset health analytics, and DER integration and optimization (including agent-based Transactive Energy Systems). UI has a strategic partnership with Vermont Electric Company, and has minority investment from both IBM and Boston Consulting Group.Prior to Co-Founding Utopus Insights, Ron was an IBM Distinguished Engineer and Chief Technology Officer for IBM's Smarter Energy Research, overseeing the Energy & Utility Industry technical activities in the company's research laboratories around the world.

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 interaction of control systems and sensor networks with enterprise systems and business processes. He helped establish IBM's activities in both Smart Grids and the Smarter Planet.

In 2000 Ron began working with the U.S. Department of Energy, NIST and FERC on future energy system requirements and architecture, interoperability, distributed energy resource management including transactive energy, and related policy and regulatory issues. He was selected by the Department of Energy to sit on the 13-member GridWise® Architecture Council beginning in 2004, serving as Chairman in 2009-2010, and he served as Chairman of the Smart Grid Interoperability Panel (SGIP) Architecture Committee for its first five years.



Larry Bekkedahl

Vice President, Transmission and Distribution Portland General Electric

As vice president, transmission and distribution, Larry Bekkedahl is responsible for PGE's transmission and distribution engineering and operations functions. He oversees the company's Transmission and Reliability, Engineering and Design, Distribution Services, Asset Management, System Control Center and Dispatch, and Substation Operations sections. He joined PGE in 2014.

Bekkedahl was previously senior vice president for transmission services at the Bonneville Power Administration, and has held other leadership and management positions at BPA, Clark Public Utilities, PacifiCorp and Montana Power Company.

He holds a Bachelor of Science degree in electrical engineering from Montana State University, and serves on the Electric Power Research Institute's transmission executive committee, as a U.S. board member for the International Council on Large Electric Systems (CIGRE), and on the member's advisory committee for Peak Reliability, the reliability coordinator for the western grid. He is a strong supporter of technological innovation and has led efforts to deploy smart grid technologies, road maps, and wide-area visualization tools.

Bekkedahl also has international utility experience gained by participating in a six month exchange program with Hokuriku Electric Power Company in Toyama, Japan, developing hydro projects in the Philippines, and participating in United States Agency for International Development (USAID) exchange projects in Bangladesh, the Republic of Georgia, and the Philippines.

David Boundy

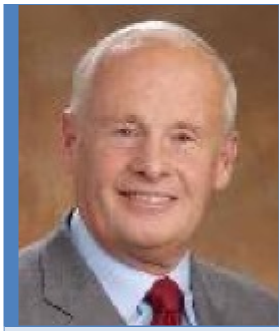
Director of IoT Innovation, Intel

David Boundy manages a cross disciplinary teams focused on researching, developing and demonstrating disruption in industry verticals with an emphasis on the energy sector.

Erik Caldwell

Director of Economic Development, City of San Diego.

Erik Caldwell is Director of the City of San Diego's Economic Development. Erik's prior experience includes working for a cleantech startup and having served as a policy advisor to numerous local and State elected officials. Erik holds a BA in Political Science from CSU San Marcos and an MBA from San Diego State University.



Ed Cazalet

CEO
TeMIX Inc.

Ed is CEO and Founder of TeMIX Inc, a transactive energy services provider, and VP and Co-founder of MegaWatt Storage Farms, Inc., a storage advisory and project development firm.

An internationally recognized electric industry expert, Dr. Cazalet is a leader in the analysis and design of markets for electricity. For his industry contributions, Public Utilities Fortnightly magazine named Dr. Cazalet "Innovator of the Year".

Dr. Cazalet has over forty years of electric power and related experience as an executive, board member, consultant, and entrepreneur.

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.

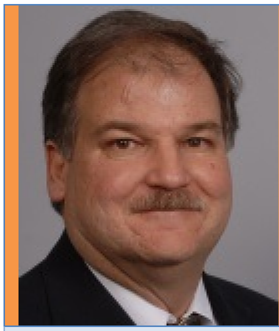
Dr. Cazalet is co-chair of the OASIS Energy Market Information Exchange (eMIX) Technical Committee, and a member of the OASIS EnergyInterOp and WS-Calendar Technical Committees.

Shawn Chandler

Director
Navigant Consulting

Shawn Chandler is a Director within Navigant's Global Energy practice. He advises clients on topics related to grid modernization, drawing upon 25 years of technical experience developing intelligent system solutions combining communications, operational and information technology. His work covers the development of real-time power operations, power markets and transactive systems, microgrids, customer energy and distribution control systems.

Shawn is the Chair of the IEEE Power & Energy Society (PES) Smart Buildings, Loads and Customer Systems technical committee, and the IEEE PES Technical Council's liaison to the global IEEE Smart City initiative. His publications include works on transactive energy, systems interoperability, smart city, and intelligent grid control & system architecture.

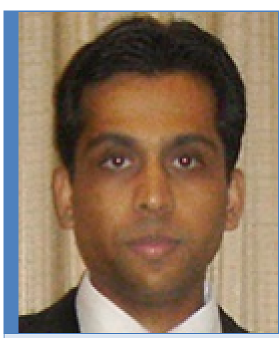


David Forfia

Director, Enterprise Architecture & IT Transformation Electric Reliability Council of Texas

GWAC

David Forfia is Director of Enterprise Architecture and IT Transformation at the Electric Reliability Council of Texas, or ERCOT, where he is responsible for the architecture for the systems which operate the Texas electric grid operations and implementing the programs that transform the delivery of IT services to ERCOT's stakeholders. During his tenure at ERCOT, he has served in many roles including Director of Infrastructure & Operations, Director of Application Services and multiple roles on the Texas Nodal implementation.
He has more than 25 years of experience in the industry, and began his career at Austin Energy in 1987. Forfia received his bachelor's from the University of Texas and MBA from St. Edward's University, both in Austin. Forfia is PMP certified and currently serves on the Smart Grid Interoperability Panel Board of Directors where he Chairs the Nominating and Governance Committee and serves on the Executive, Technical and Audit committees.



Rish Ghatikar

Technical Executive EPRI

Girish Ghatikar is a smart grid, and clean energy and clean transportation technology innovator. Over the years, Ghatikar has successfully led technology development for electric grid transactions and automated demand response, early-stage analysis for electric vehicle grid integration, and enabled California to adopt dynamic pricing programs and mandatory grid automation in building codes.

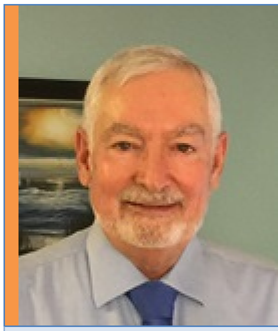
Rish Ghatikar's work has appeared in over 75 publications and he is regularly asked to speak at events and conduct training related to clean transportation and clean energy. Ghatikar holds Masters degrees in Telecommunication Systems, Computer Technologies, and Infrastructure Planning.

Gerald Gray

Senior Program Manager EPRI

GWAC

Dr. Gray leads the EPRI enterprise architecture and integration program and in this capacity participates in the development of numerous industry standards attempting to reduce the barriers to systems integration. He is also a member of the GridWise® Architecture Council. Dr. Gray earned a Masters of Administrative Sciences in Managing Information Systems from the University of Montana and a Doctor of Philosophy in Organization and Management with a specialization in Information Technology from Capella University.



Dave Hardin

Chief Architect
SEPA

GWAC Emeritus

Dave Hardin is Chief Architect for the Smart Electric Power Alliance (SEPA). He has extensive experience designing, integrating and managing enterprise information and automation in the energy and manufacturing sectors. Before joining SEPA, Dave held senior technical and management positions at EnerNOC and Schneider/Invensys and has been active in Smart Grid initiatives since 2006.

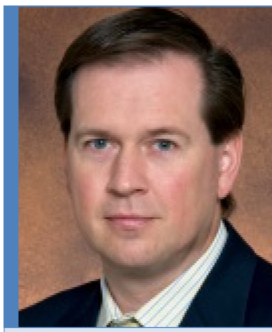
He has served on the OpenADR Alliance Board of Directors, SGIP Board of Directors, and SGIP Architecture Committee. Dave is also serving on the OPC Foundation Technical Advisory Council and is member emeritus of the GridWise Architecture Council, a Registered Professional Engineer, Project Management Institute Project Management Professional, and an IEEE Certified Professional Software Engineering Master.

David Holmberg

Mechanical Engineer,
Engineering Lab
NIST

David Holmberg serves as a mechanical engineer in the NIST Engineering Laboratory, Energy and Environment Division. His work focuses on building integration with the Smart Grid, looking at building system operation in a transactive energy environment. He is currently the leader for the NIST TE Modeling and Simulation Challenge for the Smart Grid. He serves as secretary of the SGIP TE Coordination Group.

In addition, David represents the buildings community on the NIST Smart Grid team, serving as convener of the Smart Grid Working Group of the ASHRAE BACnet committee and co-convener of the IEC PC118 Smart Grid User Interface WG2 Power Demand Response.



Christopher Irwin

Smart Grid Standards and Interoperability Coordinator
U.S. Department of Energy

Christopher Irwin has spent over 17 years in a diverse spectrum of high technology fields from HVAC to III-V semiconductor manufacturing, and most recently in communication networks for advanced metering (AMI) and Smart Grid infrastructure. He is a member of the Department of Energy team administering the Smart Grid Investment Grants, and is responsible for standards and interoperability activities, including participation in the NIST-led Smart Grid Interoperability Framework.

Prior to joining the Department of Energy, he served as Director of Products at an AMI communications vendor, also participating in Technology Discovery and Business Development. In that role, he gained a full market perspective on the electric energy sector, as well as natural gas and water infrastructure. This experience, combined with his semiconductor and satellite communications background, contributes to a unique perspective on the US energy business under transformation. Chris holds a B.S. in Mechanical Engineering from the University of Maryland, College Park, and an M.B.A. from the W.P. Carey School of Business at Arizona State University.

Curt Kirkeby

Fellow Engineer
Avista Utilities

Curtis Kirkeby is a registered professional engineer in the state of Washington and has extensive experience in the electric and gas utility industry, including 18 years in GIS, 11 years in research and development, 6 years in substation design and experience with outage management, asset management, advanced metering systems, and engineering modeling. Curt is currently responsible for innovation and applied research and development with Avista Utilities, focusing on smart grid technologies. He was the principal investigator for the Avista smart grid project in Pullman, WA, which was a subproject of the Department of Energy-sponsored Pacific Northwest Smart Grid Demonstration led by Battelle. He also holds that role for the Pullman energy storage project funded by the Washington State Clean Energy Fund.

Curt holds the title of Fellow and also sits on the Board of Directors for the Washington Clean Technology Alliance. He serves as an advisor to both the Akron Smart Sensor Board and the Clean Energy Institute Technical Advisory Board. He holds a bachelor of science degree in electrical engineering (BSEE) from Montana State University and a Masters in Engineering Management (MSEM) from Washington State University.

Michel Kohanim

CEO
Universal Devices

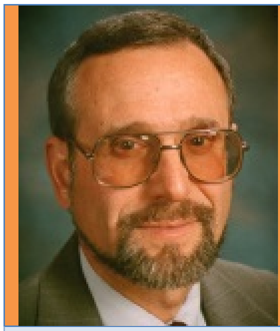
Michel Kohanim holds BS in Computer Science from USC and MS in Artificial Intelligence from Santa Clara University.He worked for IBM from 1996 to 2007 and in a variety of roles including developer and all the way up to Enterprise Architect and Strategist.

He joined Universal Devices in 2007 because he found the vision of the company matching his own: development of intelligent, autonomous, and low cost products that facilitate and orchestrate interactions between devices, agents, systems, and and human beings. Energy management, SmartGrid, and Transactive Energy are just different facets of these interactions. Universal Devices' products address these interactions natively and autonomously.He's also the chairman of the Semantics Working Group at IPSO Alliance and one of the original spec editors for OpenADR 2.0a/2.0b.

Karl Kreder

Director of Energy
Consensys

Karl graduated from The University of Texas at Austin, where he received his PhD in Materials Science researching advanced battery technologies. Prior to attaining his PhD, Karl worked at Southwest Research Institute where he started the Energy Storage System Evaluation and Safety (EssEs) consortium which performed testing, characterization, and research on large format lithium ion batteries for >10 kWh energy storage. The EssEs consortium had 12 industry members from 3 continents with a budget of more than $3mm. Before joining full time, Karl served as a subject matter expert advisor for the Energy group at ConsenSys. He is now the Director of Energy at ConsenSys.

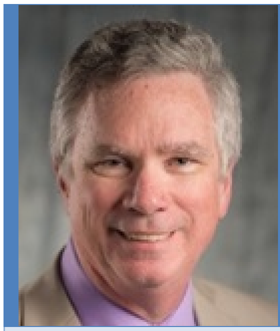


James Mater

General Manager, Smart Grid and Director
QualityLogic, Inc

GWAC

James Mater co-founded and has held several executive positions at QualityLogic from June 1994 to present. He is currently Co-Founder and General Manager of QualityLogic's Smart Grid business. He is a member of GWAC and Chair of Smart Grid NW. He was an original member of the SGIP Test and Certification Committee, and has been giving papers and presentations on smart grid standards and interoperability since 2009. Prior to QualityLogic, James held Product Management roles at Tektronix, Floating Point Systems, Sidereal and Solar Division of International Harvester. Mater holds a bachelor's degree in physics from Reed College, Portland, OR and an MBA from the Wharton School, University of Pennsylvania.



Thomas McDermott

Chief Engineer
PNNL

Thomas E. McDermott is Chief Engineer, Integration, Electricity Infrastructure at Pacific Northwest National Laboratory, with over 35 years of experience in consulting, software development and research. His technical interests include modeling and simulation, transactive energy, lightning protection and sustainable energy. He is an IEEE Fellow and registered professional engineer in Pennsylvania, with a B.S. and M.E. from RPI and a Ph.D. from Virginia Tech.

Mr. McDonnell has authored numerous publications on diverse topics including Section 111(d) of the Clean Air Act, Renewable Energy Credits in Arizona, and business models that engage and empower consumers. Mr. McDonnell earned his Juris Doctor from the University of Arizona and a B.A. in Finance from Michigan State University.

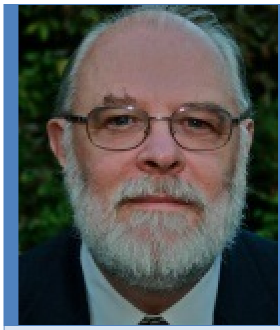
Ron Melton

Senior Power Systems Engineer PNNL

GWAC

Ron Melton is the administrator of the GridWise Architecture Council (GWAC) and a senior power systems engineer at Pacific Northwest National Laboratory. He was the 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.

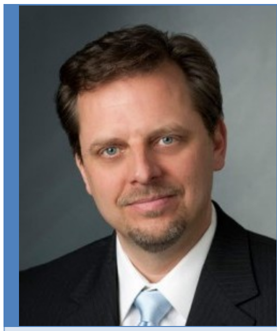


Terry Oliver

BPA (retired)

Between 2005 & 2017, Terry led the management of BPA's $17 million annual direct investment in research, development, and demonstration, which represents approximately $60 million annually in leveraged R&D investments, and an investment nearly 5 times the average US utility. Under his leadership, BPA's Technology Innovation program has enabled breakthroughs and operational improvements in nearly every area of the agency's core businesses: marketing wholesale hydropower, operating more than 15,000 circuit miles of high-voltage transmission lines, advancing energy efficiency and integrating renewable resources. Recent successes include the use of synchrophasors for wide-area control, helical connector shunt innovation and the exploration of end-use-to-generation smart grid integration.

He formerly served as a member the board of directors of the Electric Power Research Institute, and of the GridWise Alliance. He is also a member of the International Advisory Board for the International Journal of Innovation and Technology Management and the Advisory Council of the Engineering and Technology Management Department in the Maseeh College of Engineering and Computer Science at Portland State University. In addition he served as member of Southern California Edison's technical advisory board, Carnegie Mellon University Electricity Industry Center advisory board, Oregon Institute of Technology Renewable Energy Engineering Program industry advisory committee, and the technical review panel for the National Renewable Energy Laboratory Wind Program. Notably, he champions a disciplined research management approach, including benchmarking, technology roadmapping, and effective portfolio management, which led to an unprecedented level of success for BPA's R&D program. Terry has been honored as a Fellow with the Portland International Center for the Management of Engineering and Technology, and with BPA's Administrator's Meritorious Service Award, the agency's highest award.



Lawrence Orsini

CEO
LO3 Energy

With more than ten years of experience in all aspects of commercial energy efficiency programs – design, management, implementation and marketing – as well as a strong understanding of the Energy Efficiency policy and regulatory environment, Lawrence is well versed in the inner workings of the efficiency industry.

Lawrence's broad industry experience runs the gamut, from field auditing to managing relationships with Fortune 100 utility and corporate clients, affording him a unique ability to draw connections between policy driven utility energy efficiency program requirements and bottom line driven business spending.

Wilfred Pinfold

Concurrent Systems

Wilfred Pinfold is an accomplished computational scientist who has used computers to model some of the most interesting engineering and scientific challenges of our time. After completing his PhD in computational fluid dynamics he applied computer simulation to engineering challenges in aerospace, automotive and offshore structures, scientific challenges in climate modeling, astrophysics, chemistry, and genomics and control challenges in power grid, smart cities and large test facilities.

He is an accomplished innovator and entrepreneur having studied business at Stanford he launched numerous business initiatives including in bioinformatics and analytic software. He has experience leading large system deployments including the successful delivery of ASCI Red to Sandia National Labs, the first Terascale supercomputer. He has lead numerous advanced research programs including those with DARPA and DOE to design next generation Exascale hardware and software.

Dr. Pinfold teaches innovation and entrepreneurship at Portland State University has served on numerous commercial and non-profit boards and is an active member of several professional societies.

Rob Pratt

Distribution & Demand Response Business Line Manager
PNNL

Mr. Pratt leads PNNL's distribution and demand response market sector, responsible for technology and business strategy associated with a wide range of smart grid devices and systems. As one of the early thought leaders behind the "smart grid" in 2000, he led PNNL's GridWise Initiative that was seminal to the formation of the GridWise DOE Program, industry Alliance, and Architecture Council, and managed PNNL's Smart Grid Program from 2005 to 2013.

He leads PNNL's focus on transactive control technology which focuses on real-time price- or incentive-based closed-loop coordination schemes for DERs of all types and valuation of the benefits derived from DERs.

Mr. Pratt is an expert in advanced demand response and energy efficiency technology with deep knowledge both theoretical, empirical, and design aspects of residential and commercial buildings and end-use loads. He conceptualized DOE's GridLAB-D smart grid simulation, an open-source tool spanning distribution power flow, loads, distributed energy resource device models, and distribution/retail market operations. Mr. Pratt specified GridLAB-D's end-use load and demand response models.

Farrokh Rahimi
Senior Vice President
OATI

GWAC

Farrokh Rahimi is Senior Vice President of Market Design and Consulting at Open Access Technology International, Inc. (OATI), where he is currently involved in analysis and design of power and energy markets and Smart Grid solutions. He has a Ph.D. in Electrical Engineering from MIT, along with over 40 years of experience in electric power systems analysis, planning, operations, and control, with the most recent 5 years in the Smart Grid area.

Ron Sege
Chairman & CEO
Echelon Corporation

Ron Sege has served as a Director, President, and Chief Executive Officer of the company since August 2010, and has been Chairman of the Board of Directors since October 2011. He has also been a Board member of the Silicon Valley Leadership Group and Ubiquiti Networks since 2012.

Before Echelon, he served as President, Chief Operating Officer, and Board member of 3Com Corporation from 2008 through its acquisition by Hewlett Packard. Earlier, Ron was President and Chief Executive Officer of Tropos Networks, President and Chief Executive Officer of Ellacoya Networks, and Executive Vice President of Lycos. Ron holds an MBA from Harvard Business School and a bachelor's degree in economics from Pomona College.

Paul Steffes
CEO
Steffes Corporation

Paul Steffes is the CEO for Steffes Corporation, an American manufacturer of residential, commercial and industrial electric thermal storage (ETS) space and water heating systems. He has 25 years of experience designing load and demand management products to better utilize electric utility assets. He has worked with hundreds of power companies across the US and Canada helping them to evaluate the economics of off-peak programs as a means to improve operational efficiency and reduce cost.

Today, Paul's work focuses on transforming ETS into aggregated grid-interactive and dispatchable assets that assist utilities with balancing supply and demand in real-time. Paul has been a presenter at many national conferences on topics related to demand management, fast regulation, renewable integration, and cost effective scalable electric storage for grid reliability, stabilization, and optimization. Paul is a Registered Professional Engineer and a charter member of the Smart Grid Interoperabity Panel (SGIP). He is nationally recognized by the Electric Power Research Institute (EPRI), the National Rural Electric Cooperative Association (NRECA) and others as an expert in ETS technology and is called upon often to provide insight and expertise into the ETS industry. He has received numerous local, state, and national awards for his entrepreneurial spirit and commitment to innovation.

Steph Stoppenhagen

Business Development Director, Smart Cities
Black & Veatch

Steph Stoppenhagen is the Smart Cities Business Development Director for Black & Veatch's Smart Integrated Infrastructure business. She is recognized as a technology solutions expert, strategizing with clients to deliver value from smart infrastructure, networks and data. Her success includes creating consortiums to deliver complex, integrated smart city programs and products.

Stoppenhagen was responsible for the development of the technical mapping team of solar experts that have defined a patented methodology called SAFE Method (Solar Automated Feature Extraction) which automates the process of examining the Photovoltaic (PV) potential of rooftops/reduces the time to analyze this potential by 75 percent. Prior to joining Black & Veatch and CH2M HILL in Portland, she served as a geo-integration officer and business consultant internationally with the Department of Defense in the United Kingdom. Stoppenhagen also was a Senior Consultant and Project Engineer with SCHLUMBERGER focusing on water and electric utilities. Steph has a strong history with the EPA and a background in Secret Service projects.

Takahiro Tsukishima

General Manager
Hitachi

Takahiro Tsukishima holds a Ph.D. in Industrial and Management System Engineering from Waseda University, along with over 25 years of experience in the electric company. In his current role as General Manager, IoT Business Promotion Division at Hitachi, Ltd. Dr. Tsukishima oversees development of new projects and consulting activities, and is also a key contributor to Hitachi's social innovation business activities.

Kenneth Wacks

President
Home, Building & Utility Systems

GWAC Emeritus

Dr. Wacks has been a pioneer in establishing the home systems industry and a management advisor to more than 150 clients worldwide. His business spans home and building systems (IoT), energy management services, and digital entertainment networks (including HDTV, 4k, and IPTV). He also provides due-diligence for investors and expert witness services for litigants including patent cases.

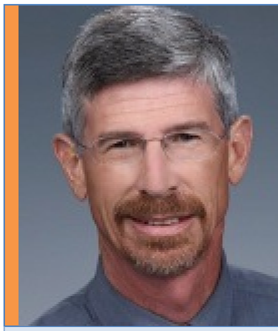
His worldview, insights, and expertise are valued by executives for enabling competent decisions on complex technology issues. Dr. Wacks is a founding member of the Smart Grid Interoperability Panel (SGIP, now part of SEPA, the Smart Electric Power Alliance) where he chairs the Home/Building/Industry-to-Grid committee. He has worked with the United States Department of Energy GridWise Architecture Council to develop smart grid strategies for reliable and efficient distribution of electricity while accommodating distributed energy resources such as wind, solar, and storage.

Dr. Wacks is a frequent speaker and panel session organizer at industry conferences. He has written and delivered more than 250 papers and presentations, and has been granted patents in home systems. Dr. Wacks chairs the Editorial Advisory Board of the CABA magazine 'iHomes and Buildings' (available at www.caba.org) and is a featured contributor under the byline “Ken Wacks’ Perspectives.” 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 Ph.D. from MIT as a Hertz Fellow and studied at the MIT Sloan School of Management.

Jim Waight

Senior Manager
OMNETRIC

Jim Waight is a Senior Manager in the Grid Operations practice of the OMNETRIC Corp, a new Siemens and Accenture joint venture company. Jim has a broad background including fifteen years of experience as a product lifecycle manager for key Siemens products in the area of Energy Market Management, Distribution Management Systems, Enterprise Application Integration, Service Oriented Architecture, Shared Architecture, Wind Power Forecasting and the Smart Grid Engineering Manager; as well as leadership roles in International Standards Development Organization (IEC CIM). He also has twenty years of technical management and client experience in the implementation of numerous projects at Siemens in the areas of Energy Management Systems, Distribution Management Systems, Energy Market Management and Integration Projects. Registered as a Professional Engineer in the state of Minnesota.



Steve Widergren

Principal Engineer
Pacific Northwest National Laboratory

GWAC Emeritus

Steve Widergren is a principal engineer at the U.S. Department of Energy's Pacific Northwest National Laboratory where he directs electric power research projects. He is a member of the board of the Smart Grid Interoperability Panel and was the founding administrator for the GridWise Architecture Council – both groups formed with the mission to enable interoperability of automated systems related to the electric grid. His industry experience includes working at utilities and with an energy management system supplier. Applications include information modeling, SCADA systems, and reliability assessment tools. He received his BS and MS degrees in electrical engineering from the University of California, Berkeley, and is an active member of IEEE.

Tim Wolf

Director of Marketing for Electricity and Smart Grid Solutions
Itron

Tim Wolf is the Director for Marketing for Smart Grid Solutions at Itron Inc. Mr. Wolf is responsible for developing strategy and overseeing Itron's marketing communication programs for Itron's global electricity and smart grid business line. Prior to "rejoining" Itron in 2010, Mr. Wolf spent nearly three years as a senior consultant at R.W. Beck and SAIC (now Leidos), focusing on Smart Grid consulting services for both investor-owned and municipal utilities in the U.S. Before that, he worked at Itron for 10 years, leading Itron's corporate marketing communications team.

He received his BA in journalism and political science from the University of Minnesota and spent five years as a newspaper reporter before transitioning to a career in marketing, PR and corporate communications. He is a frequent speaker and presenter at global energy and utility industry conferences, and writer in the industry trade press. He also serves on the DistribuTECH Conference Steering Committee, and is a member of the Boards of Directors for the Smart Grid Consumer Collaborative and Cleantech San Diego.

Joshua Wong

CEO
Opus One Solutions

Joshua is the President and CEO of Opus One Solutions. Prior to Opus One, Joshua was the Director of Engineering at eCAMION Inc., a leading grid-scale energy storage provider. Moreover, Joshua was head of smart grid at Toronto Hydro Electric System Limited, where he led the policy, strategy, regulatory, business, and engineering development of Toronto's smart grid infrastructure, including Toronto's 25-year smart grid roadmap.

Joshua is a licensed Professional Engineer in the Province of Ontario. He holds a degree in Electrical Engineering from the University of Toronto, Masters of Electric Power Engineering from the University of Waterloo, and completed executive programs from MIT Sloan, IMD Business School and Harvard Business School.

Mark Yao

Senior R&D Engineer
Utopus Insights

With more than 18 years' experience of research and development in industry and academia, Dr. Yao's work focused on distributed, event-driven and agent-based distributed computing system. He was a domain expert in networked intelligent sensor & actuator system, Cyber-Physical System (CPS), Internet of Things (IoT).

Prior join of Utopus Insights, Dr. Yao was the research scientist and senior software architect at IBM Thomas J. Watson Research Center in Yorktown Heights, NY. He was the technical lead and solution architect for several joint research project sponsored by U.S. government department of energy, including 2010-2015 Pacific Northwest Smart Grid Demonstration Project and 2007 Olympic Peninsula Gridwise Testbed project. He was the lead designer and developer of Internet-scale Control System (iCS), a software framework of developing agent-based, event-driven and distributed control system and had been used and deployed in numerous internet-scale enterprise distributed applications. He won numerous IBM Research Outstanding Technical Achievement Awards, Solution & Innovation Awards. Before his career of industry research, Dr. Yao was adjunct professor and and researcher in several universities in New York state. Dr. Yao has Ph.D. of physics, with specialty of photonics & optoelectroincs.