U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Buildings to Grid Integration Technical Meeting:

National Renewable Energy Laboratory, Energy Systems Integration Facility

Golden, CO

December 2012

Welcome to the Buildings to Grid Integration Technical Meeting and to Golden, Colorado. On behalf of the U.S. Department of Energy Building Technologies Program, I would like to thank you for attending and for your active participation. I look forward to meeting you and hearing your perspective on enabling significant buildings to grid integration.

Everyone is here because we are working to make efficient transactions between buildings and the grid a commercial reality, whether it is through implementation within the utility, buildings or technology industries or through cutting edge research. It appears that many of us in this space have been working on one or two important aspects of the puzzle – but not all of it. One of my hopes for this meeting is to bring together thought leaders to forge a mutual understanding of our activities, issues, and opportunities in this space, an understanding we can then carry back to our organizations – to the collective benefit of the country. This meeting will begin to foster and support a community of thought around these topics and in particular how to unlock the inherent potential of building to grid integration in order to realize economic and energy benefits that could be nationally scalable.

Thanks again for your time. I look forward to a productive and stimulating meeting.

JOE HAGERMAN,

Joe Hagerman
Senior Policy Advisor
DOE/Buildings

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LOGISTICS INFORMATION

The meeting is being held at the NREL Energy Systems Integration Facility (as indicated on the map at the end of the book). Upon arrival to NREL, please park in the Visitor Center Lot and proceed to the Visitors Center to check in and receive a visitor badge. Please make sure you have the proper identification with you. (See the appendix for more information on identification). From the Visitor Center, you will be directed or guided to the appropriate meeting room in the Energy Systems Integration Facility.

Lunch is being provided on December 12th and the group is invited to an optional dinner and happy hour (no host) at a nearby restaurant – Union Brassiere. The meeting and an optional tour of the NREL Energy Systems Integration Facility will conclude before lunch on December 13th.

Directions to Union Brassiere in Lakewood, CO:

1. Head west on Denver W Pkwy toward Research Rd.
2. At the traffic circle, take the third exit onto S Golden Rd.
3. Turn right onto Indiana St.
4. Turn left to merge onto US-6 E.
5. Exit onto Union Blvd.
6. 195 South Union Blvd will be on your right.

If you need to arrange for transportation to or from the airport, please do so in advance. It takes about 40 minutes to get to the Denver airport from NREL.

CONTACTS

Your point of contact at NREL is Matt Leach. If you have logistical questions after landing in Denver, please contact Matt at Matt.Leach@nrel.gov or 303-384-7404 (office), 810-577-1962 (cell).

Ed Barbour, edward.barbour@navigant.com

Andrew Nicholls, ak.nicholls@pnnl.gov

Paige Crosby, paige.crosby@navigant.com

NREL Energy Systems Integration Facility **Tour Information**

Immediately following the final wrap-up session on Thursday, there is an optional tour of NREL's Energy Systems Integration Facility. In the appendix of this book you will find pertinent reminders for those attending the tour. For more information about the Energy Systems Integration Facility please visit: **http://www.nrel.gov/esi/esif.html**

MEETING OBJECTIVES

- Take a first step to establish a community of thought on how buildings can transact with the grid – to the benefit of both.
- Enhance our collective understanding of promising work in the buildings/grid area.
- Introduce and discuss the transaction-based controls approach and similar market-based concepts.
- Increase understanding of technical challenges in integrating transaction-based technologies from various perspectives.
- Increase understanding of technologies needed to enable integration and scale up in the market.

DAY 1: Wednesday, December 12

WELCOME & INTRODUCTIONS	
8:30AM	Welcome to NREL - *Dave Mooney, NREL*
8:40AM	Review of Agenda and Objectives - *Joe Hagerman, DOE* Round Robin Introductions – 1 minute per organization » Name, Organization, Area of Expertise » In 30 seconds or less - What is one thing you'd like to learn or further explore during this meeting?
PRESENTATIONS	
9:00AM	DOE Vision: Value Proposition to Buildings/Grid Integration & Transaction-Based Controls *Joe Hagerman, DOE* Introduction to Transaction Based Controls: Approach & Principles *Robert Pratt, PNNL*
9:30AM	Northwest Smart Grid Demonstration Project *Terry Oliver, BPA*
10:00AM	GENI Project *Carlos Santiago Grijalva, Georgia Institute of Technology*
10:30AM	IBM EcoGrid Denmark Project *Ron Ambrosio, IBM*
11:00AM	Simple Measurement and Actuation Profile (sMAP): Integrating and Managing Physical Data *Stephen Dawson-Haggerty, UC Berkeley Computer Sciences*
11:30AM	Next Generation Energy Measurement and Verification Service *Michael Cation, SmarteBuilding*
12:15PM	**Working Lunch** » Open Automated Demand Response Demonstration Project - *Ingrid Bran, EPRI* » Q&A for Presentation Speakers by Attendees

WORKING SESSIONS TO DISCUSS OPPORTUNITIES AND ISSUES	
1:00PM	From the Grid Perspective *Chaired by Robert Pratt, PNNL / Ben Kroposki, NREL*
2:30PM	**Break - 15 minutes**
2:45PM	From the Buildings End-Use Perspective *Chaired by Bill Livingood, NREL / George Hernandez, PNNL*
4:15PM	**Wrap-Up** » Review of the Day and Major Takeaways
5:00PM	**Adjourn**
OPTIONAL HAPPY HOUR AND DINNER, NO HOST	
6:00PM	Union Brassiere 1955 Union Blvd. Lakewood, CO 80228

DAY 2: Thursday, December 13

COFFEE MEETING	
8:30AM	Informal Review of Agenda & Coffee - *Joe Hagerman, DOE*
WORKING SESSIONS TO DISCUSS OPPORTUNITIES AND ISSUES	
8:30AM	From the Communications and IT Perspective *Chaired by Teja Kuruganti, ORNL / Michael Brambley, PNNL*
10:00AM	From the Economics Perspective - Round Table *Chaired by Bill Miller, LBNL*
11:00AM	**Meeting Wrap-Up** *Joe Hagerman, DOE*
OPTIONAL TOUR	
11:30AM - 1:00PM	Tour of NREL's Energy Systems Integration Facility **http://www.nrel.gov/esi/esif.html**

The National Value of Buildings to Grid Integration Using Transaction-Based Controls

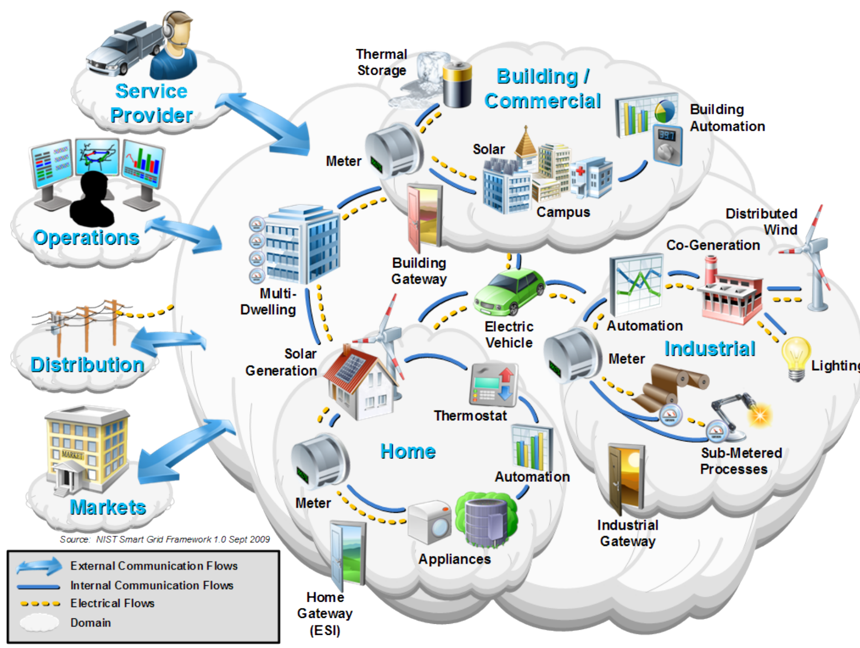
DOE Building Technologies Program

December 2012

Intermittent and/or variable generation sources and loads (e.g. EVs) are being installed on the grid in increasing numbers and at more distributed locations. For example, the US government, many states, municipalities and utility service areas are diversifying and distributing their generation mix, including a larger percentage of renewable sources for environmental, energy security, reliability and economic reasons.

These resources have the potential to impact reliability of traditional electricity delivery. However, to support and enhance overall reliability given this new mix of generation sources, loads must have the ability to quickly vary their usage with a direct positive impact on the existing electrical system. Open markets should be able to reconcile the cost and benefits of these complementary transactions between all interested participants to support value streams (new or existing) in energy efficiency, cost reduction, customer specific service needs, and enhanced reliability of the electricity infrastructure. This optimization can be facilitated with a common integrated approach to the exchange of energy related data, and any associated financial data.

To promote a diverse, reliable, cost effective, and sustainable domestic energy economy, DOE should enable and promote the development of efficient, secure and reliable transaction based energy services markets, integrating energy supplies, demand, and related services.



The future energy economy will include an open, interoperable transaction system that facilitates physical transactions of energy, energy related services, and the financial settlements associated with these transactions. The characteristics of this system will include the development of common data taxonomy, robust open communication interfaces, and monetization scenarios for products and services for this fully integrated grid environment.

Benefits

A coordinated, holistic outcome that allows disparate companies, individuals, and government entities to select the policy, technical, and market based solutions, specific to their needs, is essential to reducing the costs and risks for all participants. Without a common platform to conduct the data and information transfer, and associated financials, proprietary solutions will continue to be developed, at great expense to all, many of which will likely become stranded as the grid evolves.

With DOE coordinating its strategies and activities to address this integration and optimization challenge, the following benefits will be realized:

» **Energy Security:** Reducing or eliminating the need for imported energy sources is critical to increased energy security.

» **Environmental Responsiveness:** Renewable energy and energy that uses more environmentally friendly feed stocks help reduce environmental impacts.

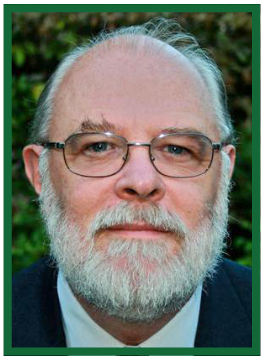
» **Enhanced Reliability:** Reducing the need for imported fuel, and moving some generation closer to the loads they serve, can improve energy system reliability.

» **Unlocking Financial Opportunities:** By using more energy sources that will not be subject to market price fluctuations, and by having a mix of generation sources that spreads cost risk, we reduce long term energy costs to the customer.

» **Enhanced Consumer-End User Benefits:** Increased asset valuation of the building. Improved comfort and reduced operation costs through better control and scheduling of systems. Third party solutions and financing enabled by this transaction platform can provide cost effective energy related solutions.

The four short white papers on pages 8-19 aim to explore some of the opportunities we will address and questions we will endeavor to answer at the meeting. The first three papers address opportunities and issues from the perspective of the Grid; Buildings End-Use; and Communications and IT. A fourth paper explores the potential national macroeconomic benefits of Buildings to Grid Integration Using Transaction-Based Controls

This new perspective of enhanced grid reliability and reliance due to higher fidelity of controls in components and buildings are opportunities for technologists to discover higher value with respect to emerging and new technology that engage in transactions. For example, if the grid can be monitored and controlled in a few seconds, there's added value in buildings and their ability respond across the same time scale. This response can replace conventional, less cost-effective resources that utilities deploy today while increasing the reliability of the grid and, perhaps, the comfort and efficiency of building occupants. The final white paper explores this new perspective of enhancing grid reliability as related to economics and utility models.



TERRY OLIVER has worked globally to advance sustainable energy and re-engage the electric utility industry in critically important research and development (R&D). He has worked for Bonneville Power Administration (BPA) since 1981. Terry led the world's largest residential conservation program and ground-breaking research in community-based conservation, designed the first Demand-Side Management programs ever undertaken by a developing country, created linkages between sustainable energy, jobs, and the local and global environment with non-government organizations throughout Asia, South Africa, and the Middle East. As Chief Technology Innovation Officer, Terry has tripled BPA's investment in R&D. He has transformed BPA's executive and staff engagement in defining and managing a research portfolio. And he led the creation of BPA's first public and formal research agenda. Terry advises the Electric Power Research Institute, Carnegie Mellon University's Electricity Industry Center, and the Smart Grid Policy Center.

Presentation Overview »

Northwest Smart Grid Demonstration Project

What problem are you solving? For several years now, utilities have been installing smart grid meters and equipment, but the value proposition of the equipment and these systems has not always been clear to consumers and stakeholders. The Pacific Northwest Smart Grid Demonstration Project will demonstrate those benefits on a very large scale. It is a five year project that is now entering its second phase. For two years now, 12 utilities have been installing tools such as smart meters, water heater load controllers, solar panels, and battery storage systems across five states. With the final installation of the Northwest Smart Grid Demonstration Project and the transaction based control and coordination network, scientists will be able to better understand the benefits that can be realized from smart grid technology. Project partners include a mix of public and private entities and will provide half of the funding. The second half of the funding is provided by the U.S. Department of Energy through American Recovery and Reinvestment Act stimulus funds. Such funds have been used to support regional smart grid demonstration projects across the U.S. DOE is interested in showing how smart grid technology can enhance the safety, reliability and efficiency of energy delivery on a regional and national level. The Project has four main objectives:

- Validate new smart grid technologies and business models
- Provide two-way communications between distributed generation, storage, and demand assets and the existing grid infrastructure
- Quantify smart grid costs and benefits
- Advance standards for "interoperability" (the smooth, seamless integration of all elements of the electric system) and cyber security

The project will run over the course of 5 years, across 5 states, and involve 12 utilities and 2 universities. It will reach up to 60,000 metered customers. Now, a couple of years into the project, project leaders will begin gathering data on smart grid performance from test sites that represent diverse terrain, weather, and demographics.

The transaction based control and coordination system sends signals that communicate the expected future cost of delivering power to specific locations, which allows loads and distributed energy resources to react to price incentives. Integration of this technology allows metered customers to be more informed and utilize energy savings practices more effectively, while on the energy supply side, utilities are able to better conserve, optimize and distribute energy, without any customer participation.

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SANTIAGO GRIJALVA is Associate Professor in the School of Electrical and Computer Engineering at the Georgia institute of Technology. He is the Director of the Advanced Computational Electricity Systems (ACES) Laboratory, where he conducts research on distributed real-time power system control, informatics, and economics, and renewable energy integration in power. Dr. Grijalva was recently appointed as the Strategic Energy Institute (SEI) Associate Director for Electricity Systems, responsible for coordinating large efforts on electricity research and policy at Georgia Tech.

Dr. Grijalva's background is in both computer science and power. His graduate degrees are from the University of Illinois at Urbana-Champaign, where he was also a post-doctoral fellow from 2003 to 2004. From 1995 to 1997, he was with the Ecuadorian National Center for Energy Control (CENACE) as engineer and manager of the Real-Time EMS Software Department. From 2002 to 2009, he was with PowerWorld Corporation as a senior software architect and developer of innovative real-time and optimization applications used today by utilities, control centers, and universities in more than 60 countries.

Dr. Grijalva is a leading researcher on ultra-reliable architectures for critical energy infrastructures. He has pioneered work on de-centralized and autonomous power system control, renewable energy integration in power, and unified network models and applications. He is currently the principal investigator of various future electricity grid research projects for the US Department of Energy, ARPA-E, EPRI, PSERC as well as other Government organizations, research consortia, and industrial sponsors.

Presentation Overview »

Green Electricity Network Integration Project (GENI)

Prosumer-Based Distributed Autonomous Cyber-Physical Architecture for Ultra-Reliable Green Electricity Networks (Energy Internet)

What problem are you solving? The future grid will consist of billions of devices and millions of actors. Formidable benefits can be achieved if these devices and actors can be coordinated to achieve new objectives associated with ultra-reliability, further economic optimization, sustainability, energy security and energy innovation. Currently there is no seamless mechanism to have everyone contribute to these objectives.

This project is developing a decentralized, autonomous, internet-like control architecture and control software system for the power grid. The new architecture is based on the emerging concept of electricity prosumers – economically motivated actors that can produce, consume, or store electricity. Under Georgia Tech's new architecture, all of the actors in an energy system are empowered to offer associated energy services based on their capabilities. The actors achieve their sustainability, efficiency, reliability, and economic objectives, while contributing to system-wide reliability and efficiency goals. This is in marked contrast to the current one-way, centralized control paradigm.

If successful, Georgia Tech's distributed control architecture would help integrate significantly more renewable energy into the grid and contribute to the following impacts:

» **Security:** A more efficient, reliable grid would be more resilient to potential disruptions from failure, natural disasters, or attack.

» **Environment:** Enabling increased use of wind and solar power would result in a substantial decrease in carbon dioxide emissions in the U.S. – 40% of which are produced by electricity generation

» **Economy:** This technology will enable more renewable generation to enter the market and meet growing demand. It will also enable consumers to receive payments for the electricity they generate.

» **Jobs:** Advances in grid software could result in new high-paying jobs in supporting sectors such as engineering and information technology.

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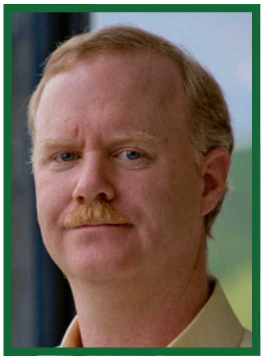

RON AMBROSIO leads IBM's Energy & Utilities Industry activities in its world-wide Research Laboratories. He joined IBM in 1981 at the T.J. Watson Research Center, working in a variety of areas including embedded real-time operating systems, distributed application frameworks, and pervasive computing environments, ultimately focusing on networked embedded computing with specific emphasis on what he coined "Internet-scale Control Systems" - the interoperability of sensor networks and control systems with enterprise systems and business processes. He established IBM's smart grid research program in 2000, and helped define and establish IBM's activities in both Intelligent Utility Networks and Sensors & Actuators.

In 2000 Ron also began working with the U.S. Department of Energy on the planning, collaboration and workshops that led to the establishment of the DoE GridWise® initiative in late 2002, and then helped plan and launch the GridWise Alliance industry consortium in 2003. In 2004 he was selected by the Department of Energy to sit on the 13-member DoE-convened GridWise Architecture Council (a separate entity from the GridWise Alliance), and continues as a member after having served as Chairman of the Council during 2009 and 2010.

Ron is the International Convenor of the ISO/IEC JTC 1 Special Working Group on Smart Grid, a member of IEC Strategic Group 3 on Smart Grid, Chairman of the National Institute of Standards and Technology (NIST) Smart Grid Interoperability Panel (SGIP) Architecture Committee (SGAC), and is editor of the ISO/IEC 18012 standard series on application interoperability in JTC 1/SC 25/WG 1 (Home Electronic System).

Presentation Overview »

Ecogrid EU Project

What problem are you solving? IBM has announced a collaborative project to help develop an energy grid that uses at least 50% renewable energy sources. The project is led by a European Union-funded consortium and will demonstrate a smart energy grid that will allow smart devices to use renewable electricity based on near real-time pricing and availability. EcoGrid EU is in support of the European Commission's 20/20/20 plan, which is to cut greenhouse gas emissions by 20 percent, increase renewable energy usage by 20 percent and to reduce energy consumption through improved efficiencies by 20 percent by the year 2020. Project scientists believe that by making this data easily available, eco-conscious Danes will choose to purchase renewable energy over fossil fuels, which will result in cost savings. The portal will also enable utilities to manage pricing based on supply, demand and available storage capacity.

The EcoGrid EU project will be piloted on the Danish island of Bornholm with 2,000 residents and commercial users, representing approximately every tenth house on the island. Using smart meters and a Web-based app, that runs on smartphones, tablets and PCs, consumers can schedule when to purchase electricity online and at what price. With 16 partners from ten different countries, the demonstration will continue for the next 48 months with set goals to increase consumer interest in smart grids, and develop new technologies that will improve energy forecasting and cost balancing, as well as reduce the congestion and losses across the distribution grid. Consumers will be at the forefront of this project with smart controllers being installed in all of the participating homes. These will be used to automate select appliances such as dishwashers, heat pumps and electric water heaters as energy prices adjust in five-minute increments. In addition, residents will receive relevant information about their electricity production, consumption, and price points, adding a new level of awareness and participation that should lead to increased energy savings.

IBM is involved in more than 150 smart grid engagements around the world, in both mature and emerging markets. IBM is the founding member of the Global Intelligent Utility Network Coalition, a unique collaboration of utilities from around the globe who are working to accelerate the use of smart grid technologies and move the industry forward through its most challenging transformation.

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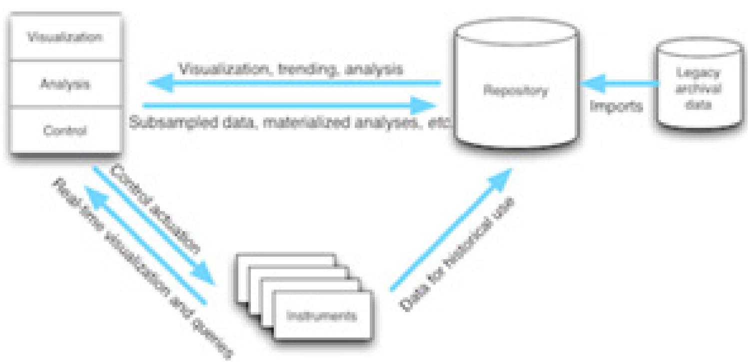
STEPHEN DAWSON-HAGGERTY is a 6th-year PhD student in the LoCal group in the Computer Science department at UC Berkeley. His current work is on a next-generation architecture for control systems for a future where time series from transducers is ubiquitous and systems are constructed by federating multiple heterogeneous components. He has a background in embedded sensing and networking, conducting large-scale deployments of wireless sensors in (and on) forests, volcanos, and commercial buildings. He is the principal developer of blip, the low-power IPv6 networking stack for the TinyOS operating system.

Presentation Overview »

sMAP – a Simple Measurement and Actuation Profile for Physical Information

What problem are you solving? Time-series data is increasingly ubiquitous and generated in large volumes and as more and more physical information becomes available, a critical problem is enabling the simple and efficient use and exchange of this data. Commercial buildings are a particularly rich source of this information generated by the building management system, computer networks, occupant activity, and many other systems. When put to use, this information could lead to significant reductions in energy consumption; however, the information is frequently siloed into proprietary systems, which are available only in batch, fragmentary, and disorganized. The Simple Measuring and Actuation Profile (sMAP) project allows instruments and other producers of physical information to directly publish their data. sMAP aims to create a simple, common foundation for collecting and organizing this data. It deals with heterogeneous data sources and provides a platform for building energy applications. The project aims to accomplish this by making available and usable:

- a specification for transmitting physical data and describing its contents,
- a large set of free and open drivers for communicating with devices using native protocols and transforming it to the sMAP profile, and
- tools for building, organizing, and querying large repositories of physical data.



The pieces of the sMAP system are designed to separate concerns and allow users to, for instance, run their own web front end while using hosted infrastructure for storing the actual data and metadata. The core object in sMAP is the Time series, a single progression of (time, value) tuples. Each Time series in sMAP is identified by a UUID, and can be tagged with metadata; all grouping of time series occurs using these tags. These objects are exchanged between all components in this ecosystem.

sMAP is currently used by groups at UC Berkeley, UC Davis and LBNL and is collecting hundreds of thousands of discrete channels of data, including BMS trend data, weather state and predictions, ISO generation data, electrical sub-metering data, and many other data sources. It forms the basis for applications which visualize and analyze energy consumption, indoor environment quality, and occupant activity.

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MICHAEL CATION is a seasoned technology executive with 28 years of experience in growing technology companies from initial concept to public markets. He is the Chairman and CEO of SmarteBuilding – a technology leading provider of real-time energy management services and systems. Previously he was the Founder & CEO of NovusEdge -- a provider of network based enterprise-class physical security solutions.

Prior to that, he was the co-Founder & CEO of Globeset which he grew from concept-stage to $22 million per year in revenue in the electronic payments market. Previously he was a Vice President of BT Ventures, a venture capital arm of Bankers Trust. Prior to that, he was one of three co-founders of Verity (NASDAQ: VRTY), a global market leader in information search and retrieval. He began his career as a research engineer at Advanced Decision Systems where he designed and managed the development of real-time distributed expert systems. He earned a BS in Computer Science from the Massachusetts Institute of Technology and an MBA from Stanford Graduate School of Business.

Presentation Overview »

SmarteBuilding Project

What problem are you solving? The disconnect between actual infrastructure energy use and measured infrastructure energy use creates a multitude of missed energy savings opportunities, but real-time energy consumption statistics allow consumers and building operators to make informed decisions about energy use. SmarteBuilding™ has developed a next generation measurement and verification (M&V) service that cost effectively manages tens of thousands of measurement points in complex buildings on a real-time basis. This level of analysis enables SmarteBuilding to measure and verify real-time energy consumption, by end use, in each individual area of a building and at the level of individual systems and equipment.

The SmarteBuilding Service™ enables real-time detailed analysis and comparison of the specific real world effectiveness of energy efficiency projects. The service also recognizes anomalies and sends alerts via text, email, and a variety of machine to machine interfaces.

Some of the uses of the SmarteBuilding Service include:

- Analysis and ranking of energy improvement projects by actual results
- Trending and alarming for usage anomalies and predictive maintenance notification
- Real-time energy monitoring and analysis on a personal scale
- Proactive occupant management of energy consumption
- Hyper-optimization of building control systems
- Automated Energy Star

The unprecedented level of visibility deep into facility infrastructures and the system's real-time responsiveness enables new insights, greater building management capabilities, and data driven cost savings opportunities in facilities.

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INGRID BRAN is a Senior Project Manager in Energy Utilization EPRI. Ingrid has over twenty years of experience in energy and manages projects related to energy efficiency and demand response. Ingrid's research at EPRI has included the integration of utility energy management technologies with building automation systems, automated demand response, applications of electrotechnologies in industrial process heating, and the EPRI Electrotechnology Reference Guide. Prior responsibilities at EPRI include international technology transfer that focused on the Iberian Peninsula and Latin America. She also was Manager of R&D Planning and Analysis for the Customer Systems Group, identifying markets and implementing plans. Ingrid's work in the energy industry includes consulting and the utility industry. At Global Energy Partners (now part of EnerNOC) she performed analyses that focused on technical and economic aspects of the industry, and employed her expertise in the areas of load research, end-use data analysis, sampling and surveys, economic analysis, demand response, and market research. Ingrid worked at Pacific Gas and Electric (PG&E) in the design and execution of measurement and evaluation of statewide programs in energy efficiency. At Southern California Edison (SCE) Ingrid developed, analyzed, and reported on load research data in support of revenue activities. Ingrid received her B.A. degree in Economics from California State University, Fullerton. Her M.A. degree in Economics is from the University of California, Berkeley.

Presentation Overview »

Automated Demand Response and Ancillary Services Demonstration

What problem are you solving? Low-cost communication infrastructures may be able to reliably perform automated demand response (DR) and ancillary services or fast DR functions, but current standards do not take advantage of their cost structures. This demonstration project will perform research associated with emerging energy price and product messaging-protocol standards to take advantage of ubiquitous low-cost communication infrastructures. Internationally recognized standards for DR and ancillary services are a key enabler for the development of commercially available products that have largely been proprietary for the last 30 years.

This work is expected to increase market participation in the development of devices with this functionality directly built in and electric utilities as well as independent system operators (ISOs) are expected to gain an understanding of performance capabilities load types, infrastructure requirements, product availability, and market opportunities associated with the advancement of this smart grid application.

This project may provide the following benefits:

» Accelerate Standards Development of Protocols to Automatically Manage Loads for Demand Response (DR) and Ancillary Services

» Contributions to the development of Standards and Products that use the Standards for DR & Ancillary Services functions

» System and Load Performance and Benefits Analysis for Demonstration Host-Sites.

This project will focus on the interactions between the utility or ISO and a facility while validating Open Automated Demand Response (OpenADR) platforms and systems. Standardized DR is an important component of the smart grid to deliver dynamic price signals to achieve economic and reliability objectives. With a standardized communications data model, utilities and ISOs can directly interface with building and energy management systems. This project will synchronize with these groups to continue progress to automate DR programs and acceptance by many controls and device manufacturers.

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MICHAEL BRAMBLEY has over 30 years of academic and research experience related to energy technologies and policy, focusing for the last 22 years while at Pacific Northwest National Laboratory (PNNL) on developing technologies for improving building energy efficiency. At PNNL, Dr. Brambley has served in a variety of roles including principal investigator and research contributor, project and program manager, technical group leader, department chief scientist, and leader of several initiatives. Most of his work over the last 15 years has focused on improving the actual operating efficiency of buildings and other energy systems. For 6 years before joining PNNL, Dr. Brambley was a faculty member at the Washington University Engineering School in St. Louis. Dr. Brambley received his BS in Mechanical Engineering from the University of Pennsylvania, and his Masters and PhD in Engineering Sciences from the University of California, San Diego. His research interests are Intelligent buildings, automated fault detection and diagnostics, self-correcting, fault-tolerant controls, automated commissioning, condition-based and predictive maintenance, energy analysis in support of policy and planning research wireless sensing, supervisory control, and re-tuning building systems.

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JOSEPH HAGERMAN is a Senior Advisor at the U.S. Department of Energy's (DOE) Energy Efficiency and Renewable Energy Office focusing on building energy efficiency and new building technology development. He is at the forefront of the effort to develop clean, healthy, competitive building technologies for the 21st century. Formerly, Mr. Hagerman was the Team Leader for the Commercial Building Initiative (CBI) team within the Building Technologies Program at DOE. The CBI team is aggressively working to improve the performance and decrease the energy consumption of commercial buildings. Mr. Hagerman is leading the accelerated adoption of clean and efficient domestic energy technologies in commercial buildings. Before joining DOE, Mr. Hagerman was the project manager for the Building Technologies group at the Federation of American Scientists (FAS). As project manager, Mr. Hagerman conducted research in new building technologies while demonstrating these technologies in the public sector. His efforts helped address environmental and energy injustice in affordable housing through the development of energy efficient advanced wall systems.

In 2005, Mr. Hagerman won the Metropolis Next Generation Design prize for developing a manufacturing strategy to cost-effectively deliver bio-remediating plant material inside open cell interlocking concrete pavers entitled "biopavers" He was also awarded the 2005 Rafael Vinoly Fellowship giving him the opportunity to conduct architectural based research with Rafael Vinoly Architects (RVA), an internationally renowned design firm. During his fellowship, Mr. Hagerman researched new environmentally high performance building materials and demonstrated new green roofing technologies.

Mr. Hagerman received his Bachelor of Architecture from Mississippi State University and his Masters in Civil Engineering at the Fu Foundation School of Engineering at Columbia University. His academic work focused on engineering mechanics and construction technology.

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

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BENJAMIN KROPOSKI is the Director of Energy Systems Integration at the National Renewable Energy Laboratory (NREL). At NREL he leads NREL's strategic research in the design and performance optimization of electrical, thermal, and fuel pathways for energy systems at all scales. He received his BS and MS in Electrical Engineering from Virginia Tech and PhD in Engineering Systems from the Colorado School of Mines. His expertise is in the design and testing of renewable and distributed power systems and grid integration. He has written more than 100 publications in these areas and is the guest editor for *IEEE Power & Energy Magazine* special issues on solar energy integration. Dr. Kroposki is also an Editor for both the *IEEE Transactions on Sustainable Energy* and *IEEE PV Journal*. Dr. Kroposki also participates in the development of distributed power and renewable standards and codes and served as the Chairman for IEEE 1547.4 *"Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems"*.

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From the Grid Perspective

Robert Pratt, PNNL and Ben Kroposki, NREL

In 2009, the US government started investing in a smarter electric power grid with the award of $4B in ARRA stimulus grants and demonstration projects which were mostly focused on deployment of enabling infrastructure for automated metering, distribution substation automation, and advanced sensors. At the same time, utilities began introducing large investments in clean energy technologies such photovoltaic and wind turbines into their generation portfolio at unprecedented rates. To achieve the nation's objectives for utilities to accommodate high levels of clean energy generation – while improving reliability and maintaining the cost-effectiveness of the power grid – the installed grid infrastructure must be utilized in a way that optimizes day-to-day, moment-by-moment grid operations. This solution will primarily come from the ability to harness millions of small, distributed assets such as demand response in buildings, distributed generation and storage and electric vehicles to provide valuable grid services which increase reliability and resiliency.

Our collective challenge is to ensure these assets provide the smooth, stable, and predictable response required, when they are primarily owned and operated by customers or 3rd-parties rather than directly controlled by grid operators. The purpose of transaction-based control schemes for these assets is to:

» Seamlessly integrate them into a collaborative, incentive-based network that, from the perspective of grid operations, functions as a virtual control system;

» Enable and motivate them to transact and deliver energy services to the grid at the lowest possible cost using distributed control approaches.

The energy services provided must help meet a wide range of grid operational objectives, including:

» Reduce investments in new capacity and improve asset utilization by relieving peak loads on generation, transmission, and local distribution systems;

» Reduce the cost of providing balancing (ancillary) services needed to keep the grid stable, reducing operating costs and mitigating future costs for capacity to manage variable renewable energy sources;

» Mitigate wholesale energy production costs and market prices;

» Reduce congestion costs and transfer more renewable power by providing emergency reliability services that allow transmission capacity limits to be relaxed;

» Accommodate high penetrations of customer-level distributed solar generation by coordinating inverters and loads to mitigate variations in output (in some cases very rapid) that affect distribution system voltages;

» Support potentially high levels of electric vehicles by managing vehicle charging to minimize impacts on peak loads and coordinating energy services that can be supplied by their batteries.

To meet this challenge, solutions must include:

- Advanced controls for these assets that achieve multiple grid objectives in response to signals such as prices or incentives, while serving the needs and desires of their owners in an automated fashion;
- Mechanisms that express the true value of electricity and energy services, by time and by location within the grid infrastructure, in the form of prices or incentives at the retail level;
- An open, secure, scalable, self-organizing information architecture that expresses and communicates these values and allows distributed, 3rd-party assets to transact for these energy services in real time;
- Approaches that address variation in the regulatory framework, ranging from wholesale market-based systems to fully-integrated utilities, to create a level playing field for all types of distributed assets and the existing utility infrastructure.

Questions for Discussion:

1. **Can transaction-based approaches reduce the information that must be shared across enterprise boundaries to fundamental commodity transactions as simple as quantity, price or incentive, and time?** Will doing so simplify interoperability protocols? Minimize privacy concerns? Reduce the risk profile of cyber-security breaches? What is the minimum amount of information that needs to be passed between utilities and customers to enable transactive approaches?
2. **How can transaction-based control schemes and incentive structures be designed to serve multiple operational objectives from the same distributed asset?**
3. **How can transaction-based approaches be designed to delight consumers, empowering them to reduce their energy bills, earn incentives, and participate in reducing the grid's environmental footprint?**
4. **How can transaction-based approaches be designed for a variety of incentive mechanisms, including real-time dynamic prices and peak-time rebates?** How are these coupled to provide the feedback for control and the measurement/verification/billing required by the incentives?
5. **How can such approaches be designed to maintain the customer's free will in the use of electricity?**
6. **How can transaction-based approaches be adapted to support viable financial and business models for utilities under a variety of regulatory frameworks ranging from fully-regulated, vertically-integrated utilities, to publicly-owned utilities, to de-regulated wholesale markets with distribution and load service providers?**

From the Communications & IT Perspective

Teja Kuruganti, ORNL and Michael Brambley, PNNL

Integration of distributed energy resources into buildings' operations requires fine-grained adaptive synchronization of various loads and energy resources. Optimal whole-building controllers are needed for the next generation of high performance buildings that will be grid integrated. A gap that is currently not addressed is how clusters of buildings should respond to smart grid signals.

To achieve efficient buildings to grid integration, a coordinated, holistic transaction system that allows disparate companies, individuals, and government entities to select the policy, technical, and market based solutions, specific to their needs, is essential to reducing the costs and risks for all participants.

Communications and control systems play an important role in achieving this integration. The objective is to efficiently integrate buildings to the grid by seamlessly communicating utility needs and constraints to building systems and vice versa. The goal of this session is to explore the issues and opportunities associated with achieving this objective.

The energy services provided must help meet a wide range of communication and IT objectives, including:

» Cybersecurity requirements to reduce risks for the transactions including the security of data, data privacy, and security from malicious attacks.

» Interoperability to support open, common communication protocols and proprietary "standards" both within buildings, building-to-building, and buildings-to-grid.

» Control strategies and requirements to perform building to grid integration and benefit the building owner/tenant.

Questions for Discussion:

1. **What are the underlying IT and communication needs to support building-grid transactions?** Do we need new architectures? Are open standards available and are they sufficient? What needs exist for new or enhanced open standards for communications, data formats, taxonomies, and transactions? What are the cybersecurity requirements?
2. **Must both wired and wireless systems be supported?** Is the existing physical infrastructure adequate? What needs exist?
3. **Who will be able to participate in building-grid transactions?** Building owners? Tenants? Employees/end users? Automated agents on behalf of others? Aggregators? Owners of distributed generation assets in buildings? Third party service providers?
4. **Who owns the communications infrastructure between buildings and the grid?** Who maintains it? Can the infrastructure be multi-use for grid integration, energy efficiency, and building control?
5. **What should the market transactions look like?** What kinds of transactions should be supported? Electricity purchases, demand response, other ancillary services, distributed generation, on-site and community storage? How will data exchanged between parties be valued in the transaction system?
6. **What are the communication performance requirements?** Throughput? Latency? Reliability?
7. **How should the building controls operate?** Simple extensions of the transaction network of the grid or with an interface between the grid and building management and control systems? Portfolios of buildings or single buildings? Centralized vs. decentralized control? If centralized, who owns and operates?

From the Buildings End-Use Perspective

Bill Livingood, NREL and George Hernandez, PNNL

Commercial and residential buildings use more than 70% of the nation's electricity, and the Energy Information Administration projects buildings will drive most of the load growth for the next 20 years. Thus, buildings play a key role in optimizing grid interactions because they can control, manage, and dispatch internal generation (renewable energy and combined heat and power), storage (batteries and thermal), and loads to benefit their occupants and the grid. An initial step is to develop a comprehensive understanding of the full potential of this role and the motivations that already exist or need to be established in order to maximize impact. An important aspect of this step is to gather current successes with optimizing buildings to grid interactions.

DOE aims to enable and promote the development of efficient, secure, and reliable transaction-based energy services markets. These markets must meet a wide range of objectives that benefit or affect end uses, including:

» Integrate energy supplies, demand, and related services,

» Adhere to open, interoperable transaction system,

» Interface and be controlled by robust open communication interfaces,

» Present monetization scenarios for products and services.

Questions for Discussion:

1. **How would consumers or end users be able to assess the availability or value of their assets (component, system, or building) in an automated real-time fashion?** How can they determine which products, services, or actions are beneficial to them, financially or environmentally?
2. **What kinds of products and services could include energy efficiency, ancillary services, operations and maintenance, storage, electric vehicles, photovoltaics, and comfort?** How could these be leveraged?
3. **How would manufacturers or service providers leverage enhanced or new solutions as they are developed and implemented?** How can they integrate with an open transaction platform that they can use to provide proprietary technology or value-added services?
4. **How would common data and solution technology taxonomies be developed to enable common valuation metrics?**
5. Given that open source, common communication protocols (e.g., BACnet, oBIX) have been developed to improve interoperability, **what are the characteristics of solutions that would offer broad, plug-and-play interoperability?** What solutions are necessary to make the point mapping process more consistent, automated and error free?
6. **What are the necessary steps to make control algorithms "universally" applicable while minimizing the need for customized building-by-building configurations?** What would a market look like that facilitates the development and adoption of these "universal" algorithms?
7. **What security vulnerabilities have been encountered or are anticipated?**

Economics Round Table Discussion

Bill Miller, LBNL

The potential national macroeconomic benefits of buildings to grid integration using transaction-based controls needs to be carefully discussed – and that is the purpose of the final working session at this meeting. This new perspective of enhanced grid reliability and reliance due to higher fidelity of controls in components and buildings are opportunities for technologists to discover higher value with respect to emerging and new technologies that engage in transactions. For example, if the grid can be monitored and controlled in a few seconds, there is added value to the grid, and to buildings, if buildings can respond within the same time scales. This response can replace conventional, less cost-effective resources that utilities deploy today. The result will increase the grid's reliability and lower energy costs to building owners and operators and maintain the amenities and services to building occupants. Building and equipment controls, which have the capacity for broad transactions, introduce a spectrum of economic opportunities and enhancements for utility business models, allowing new stakeholders to provide:

- Enhanced grid reliability and reliance due to higher fidelity of controls in components and buildings;
- Opportunities for technologists to discover higher value with respect to emerging and new transaction enabling technology;
- Added value in buildings and their ability respond across the same time scale as grid monitoring and control.

Successfully developing transaction-based controls requires carefully assessing the benefits and value of products at both the macro-scale and for specific situations in which this value could support private markets. The former approximates the value to the United States of reducing regulation in electricity markets opening them to greater innovation, participation and the development of real markets. The latter indicates the business cases where private markets might first develop.

The discussion will start with Sila Kiliccote (LBNL) providing background information on the current level of demand side participation in organized markets by utilities and other entities. This frames the current products traded and the overall value of those transactions. Joe Eto (LBNL) will then indicate where rising levels of renewable resources will create opportunities for new technologies to ensure grid reliability. The group will then discuss new potential transactions enabled by advances in transactional technology and suggest methods for assessing the benefits to participants and any unrealized benefits.

We will also discuss approaches to determining the overall benefit of an electric market in which transactions of all types and scales are ubiquitous. The last challenge will be to begin to delineate and sketch out approaches to determining that overall value.

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South Table Mountain Campus

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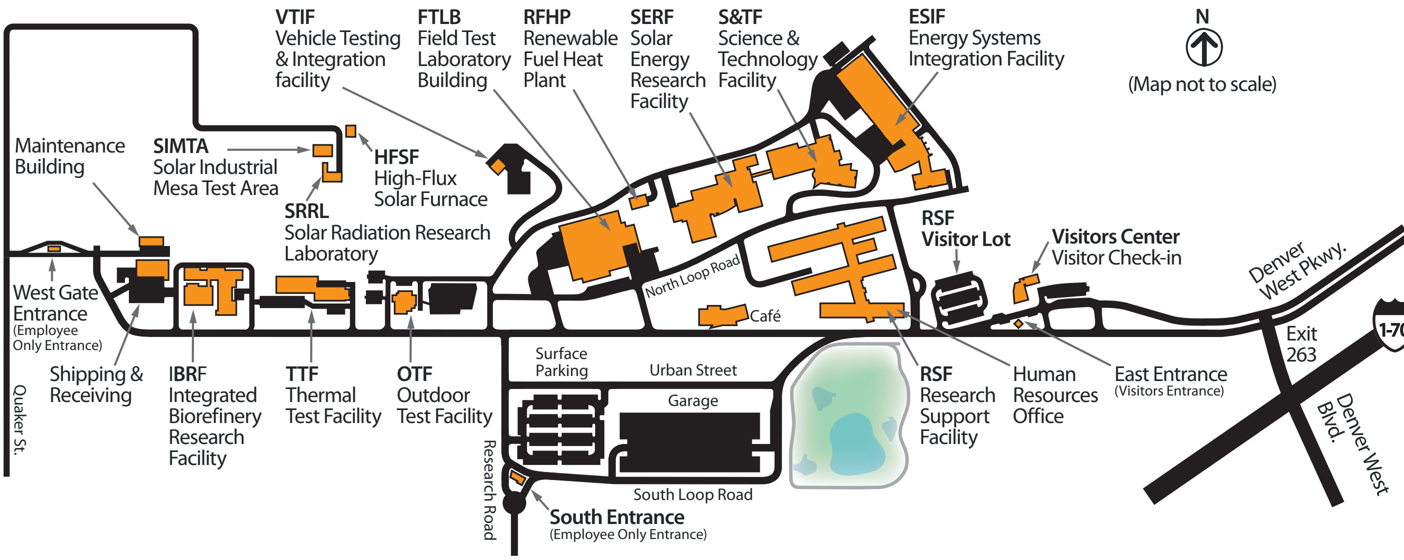
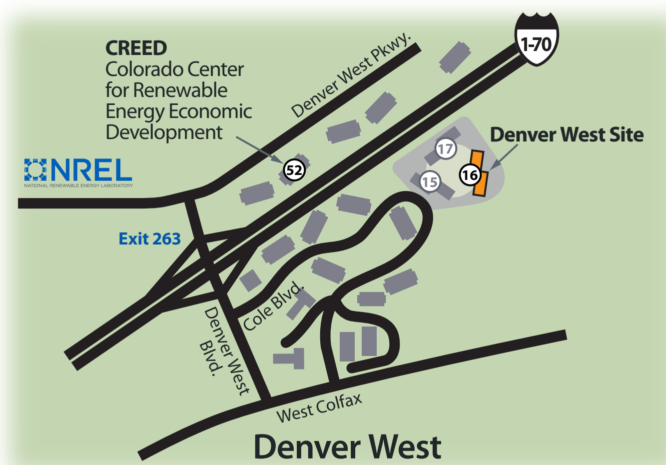
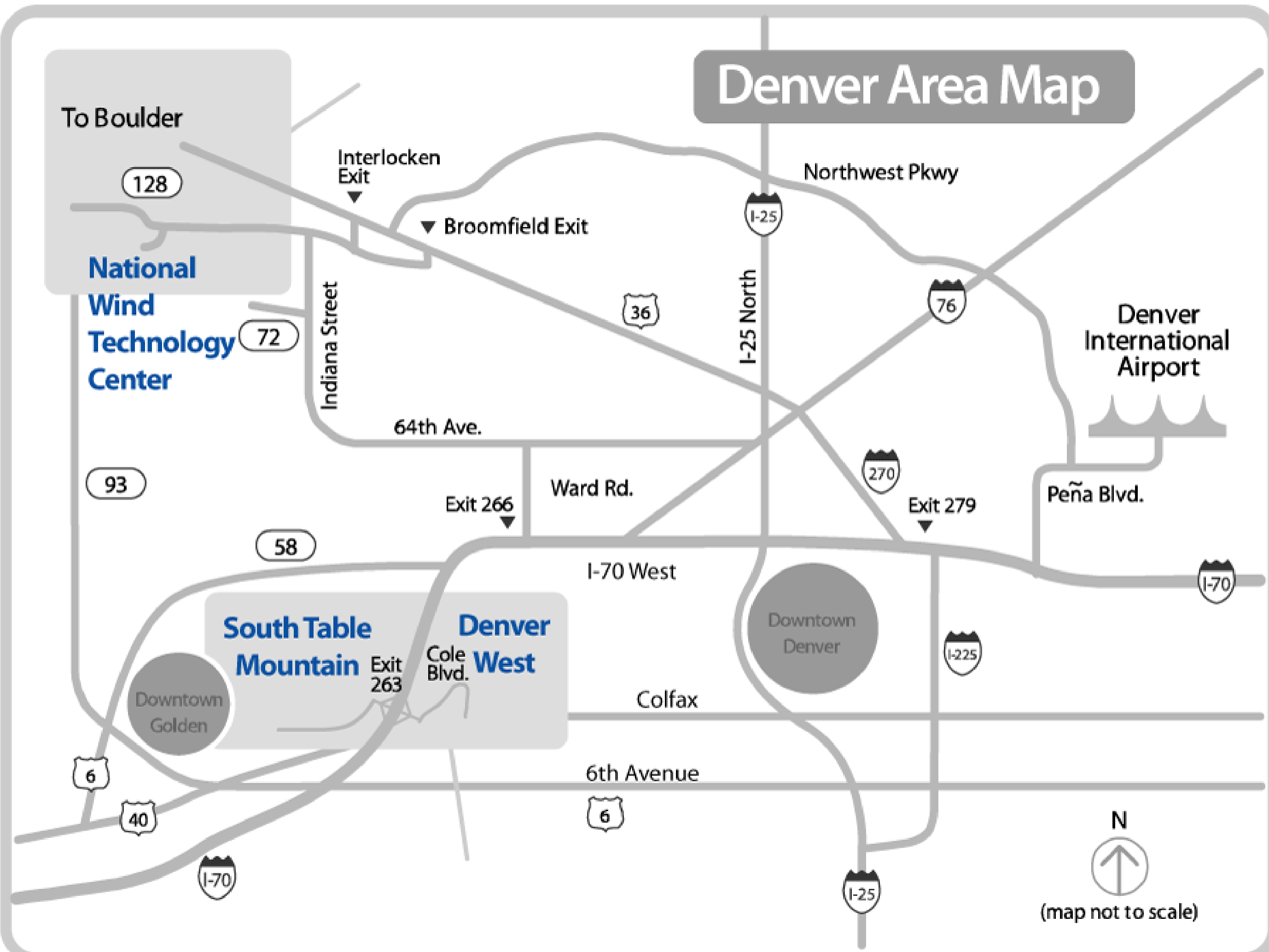




The meeting will be held at the Research Support Facility (as indicated on map). However, guests must go to the Visitors Center first to check in. Guests should park at the Visitor Center Lot.


Denver Area Map
To Boulder
128
National Wind Technology Center
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Indiana Street
Interlocken Exit
Broomfield Exit
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Northwest Pkwy
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Denver International Airport
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Ward Rd.
Exit 266
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I-70 West
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South Table Mountain
Exit 263
Cole Blvd.
Denver West
Downtown Denver
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Downtown Golden
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NREL VISIT REMINDERS

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» Each guest must have a valid government issued photo I.D. (such as a driver's license). If you are a U.S. citizen, this is all the identification required to gain access to NREL Facilities. There is no exception to this rule.

» If you are a non-U.S. citizen (Canadian, permanent resident alien or resident aliens are included in this category), you will need to contact the NREL Visitors Program five business days in advance to complete a foreign national data card.

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» Remember to wear comfortable walking shoes. Sandals, flip flips, open toe shoes or sling back shoes are not allowed in NREL laboratories.

» Shorts are not allowed in NREL laboratories, remember to wear long pants.

» Water bottles or other liquids are not allowed in NREL laboratories.

» Follow the instructions of your NREL host and security personnel at all times – especially in case of sounding alarms or other emergencies.

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› Alcohol

› Firearms or explosives

› Dangerous weapons or materials

» The onsite speed limit is 25 miles per hour (mph), except where otherwise posted.

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Please note: Tours may be cancelled or terminated at any time as necessitated by safety/security conditions.

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Identification	Driver's license, Military ID, DOE Badge, Passport, or other Govt'-Issued photo identification	Passport	Driver's license, Military ID, DOE Badge, Passport, or other Govt'-Issued photo identification	Passport	Passport or Driver's License	Passport
Lawful Status	Not Applicable	Visa	Permanent Resident Alien Card or U.S. Citizenship and Immigration Services (USCIS) Form I-551	Visa or I-94W Nonimmigrant Visa Waiver Arrival/ Departure Form or Visa Stamp	Visa or Driver's License and Birth Certificate	Visa or Form DSP-150 (laser visa) (BCC-border crossing card)

*** Visa Waiver Program - Participating Countries:**

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From: The U.S. Department of State.

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MEETING NOTES

Comments from Attendees during the Working Sessions at the Buildings to Grid Integration Technical Meeting, Dec. 12-13, 2012

From the Grid Perspective

Question #1:

Can transaction-based approaches reduce the information that must be shared across enterprise boundaries to fundamental commodity transactions as simple as quantity, price or incentive, and time? Will doing so simplify interoperability protocols? Minimize privacy concerns? Reduce the risk profile of cyber-security breaches? What is the minimum amount of information that needs to be passed between utilities and customers to enable transactive approaches?

Key Topics

» Need to demonstrate the amount of info being passed along is sufficient for maintaining reliability.

» But it is situationally dependent—amount of information is different during normal operations than during reliability situations.

» Transactive approach more complex and could confound and not improve grid operation. Opportunity is great for better operation - but so are the challenges.

» In a blackout situation, there is an expectation that devices will behave in a certain way and sometimes they don't.

» How much information is sufficient to maintain reliability standards that we have for the grid? Could it be dangerous to minimize the amount of information that you have and are passing back and forth?

» Amount of information you need during normal operation may be different than the amount you need during a disturbance or other event.

» How do you turn the information into actionable items?

» The time scale is important and needs to be differentiated for different situations. In a transactional-based scenario, there may be market reasons that agents wouldn't want to advertise their strategy; for robustness, the system needs to be aware of what others actions would be in a critical situation

» Emergent phenomenon in these complex systems is critical, need to think about system management

» How do we sample the system to detect emerging phenomenon? Stochastic sampling technique can help.

» We don't actually know what the metrics should be to make decisions given particular parameters.

» Need to step back and consider metrics and codify those metrics before it becomes a research project. Can we reduce the quantity of messages and the complexity of messages?

» Paradigm is currently reactionary, but shifting towards proactive.

Question #2:

How can transaction-based control schemes and incentive structures be designed to serve multiple operational objectives from the same distributed asset?

Key Topics

» Answer to question depends on what your objectives are (e.g., environmental) at the distribution level.

» Price has all the information needed to clear markets. Distribution companies translate wholesale price signals into demand response programs, for example.

» Does “the grid” need to know how the various customers will respond to a type of signal and maybe even the magnitude of the signal?

» Value signals originate from different sources and flow to different places and are modified as they go. There isn’t one system-wide value signal.

» If the user gets a price or other value signal (no matter how that value is represented), doesn’t that same user need to know how others are responding to the same signal?

» Do you need to have something that complements the price signal? How do the end users know if they want to participate or not?

» System five years from now have to be able to accommodate price and other parameters that we want to respond to then, which maybe be different from now.

» System has to be able to adapt to the learning that’s going on amongst the participants as they use it.

» Lots of reasons why system operators are not addressing building loads now. Not a technology issue per se. Mostly market and institutional barriers. And risk is a big deal for building owners.

Question #3:

How can transaction-based approaches be designed to delight consumers, empowering them to reduce their energy bills, earn incentives, and participate in reducing the grid’s environmental footprint?

Key Topics

» If large amounts of responsive load—ability to forecast becomes untenable. At some point, do you shift from open loop control planning to closed loop control at the system level?

» Feedback signal is in load signal which may not be in real-time.

» Loads not being actively managed currently because of regulatory and policy barriers, rather than technology problem.

» Risk is a big concern for building owners—need to demonstrate to consumer the value.

» Buildings themselves can be active participant in operations, but have to ask those not comfortable with the risk to embrace it and hedge the reliability—integration and implementation issue where need to demonstrate value.

Question #4:

How can transaction-based approaches be designed for a variety of incentive mechanisms, including real-time dynamic prices and peak-time rebates? How are these coupled to provide the feedback for control and the measurement/verification/billing required by the incentives?

Key Topics

» Not directly addressed during the Session.

Question #5:

How can such approaches be designed to maintain the customer's free will in the use of electricity?

Key Topics

» Not directly addressed during the Session.

Question #6:

How can transaction-based approaches be adapted to support viable financial and business models for utilities under a variety of regulatory frameworks ranging from fully-regulated, vertically-integrated utilities, to publicly-owned utilities, to de-regulated wholesale markets with distribution and load service providers?

Key Topics

» There has to be a mechanism for separating an incentive based on performance and actual coincidental load reduction that happens at the same time.

» What are the pieces of information that would be good to have for this endeavor and what are the ones that are necessary?

» Different perspectives from different markets (e.g., vertically integrated utility, regional market, etc.) to give indication of how easy/hard it is to turn these different markets around.

» Reliability is a closed loop system, and you know what you are going to get. But price signals are open loop and need to be oversubscribed to ensure response occurs when needed.

» There are limits to what market can dictate/solve and then you need regulation.

» Response of the population is what really counts, not the response of the individual responder. 50% response rate in demand reduction programs. But not so true when it comes to incentivization issues.

» More likely approach would be prioritization and sharing of different customer end use loads, rather than across feeders, where customer can manage priorities.

From the Buildings End-Use Perspective

Question #1:

How would consumers or end users be able to assess the availability or value of their assets (component, system, or building) in an automated real-time fashion? How can they determine which products, services, or actions are beneficial to them, financially or environmentally?

Key Topics

- If we were to enable some sort of a transaction platform or mechanism, what are the things that could be improved and create a margin for someone – want to encourage entrepreneurs to play in this space.
- How do you manage renewable energy integration and the variability of those generation assets?
- Most building control systems focus on comfort and not on energy.
- FSGIM (Facility smart grid information model) provides transaction information you would use to talk to a utility or another market.
  - A definition of objects in buildings (an object model that focuses on energy).
  - Need a cookbook/set of recipes to do DR for building operators so you can map against the resources you do have including chillers and unitary equipment.
  - Holes in area of getting building customer base to participate.
- Need standard algorithms for handling demand response, an area where we know a lot about value already.
- How do building owners know the value of implementing these approaches for transacting in these situations is even worth paying attention to? E.g., we have some indication of value of DR today, but when you look at ancillary services (depending on region) it's harder to answer this question in advance. Maybe first step is providing building operators with tools to answer this question?
- We have a hard time determining what an individual building can do. A self-commissioning tool would be very valuable.
- Companies that do whole building sub-metering that can differentiate loads within the building.
- Submetering is a point of time measurement and those conditions change with time and availability is key to offering services to Grid. And may not capture problems with use or with controls.
- Building and model degrade over time so would benefit from periodic, if not continuous, updating of building model.

Question #2

What kinds of products and services could include energy efficiency, ancillary services, operations and maintenance, storage, electric vehicles, photovoltaics, and comfort? How could these be leveraged?

Key Topics

- One way to manage voltage control is with batteries. Don't currently know true cost of voltage control. But building operator could install batteries and provide power to grid with virtually no transaction costs.
- What other innovative service are being provided or demonstrated today of which we should be aware?
  - BuildingIQ and B2G Innovation, Inc. (used to be Clean Urban Energy) – Arbitrage of real-time pricing signals for preconditioning buildings within comfort constraints.
  - Enbala using step controls of pumping loads (municipal, industrial) and large thermal system from many customers to sell regulation in PJM and trying to get into ERCOT. EnerNOC dispatching standby generators.
  - Electric vehicle fleet for regulation (LA Air Force Base through DOD)—unknown is battery capacity, but car companies not making this information available because they want to figure it out themselves first.
  - Johnson Controls looking at 2nd life for car vehicle batteries to do regulation.
  - McKinstry with City of Boulder DOE project with A/C and EVs in market with relatively high demand charges—moving car chargers and A/C and photovoltaic systems. Research findings being finalized right now with RMI and University of CO Boulder.
  - EPRI work in EVs looking at patterns of use and storage in Knoxville.
  - Electricite France water heater program that turns off WH at 11pm and comes back on at 6am—predictable, tried and tested 20 year program.
  - ORNL Community-Energy Storage project with 50 kW storage that can be placed outside building on distribution side but on building site (may not be ORNL's project).
  - SDG&E response to Microgrid and CAISO nodal price, PNNL partnered to do wholesale-retail price conversion that gets passed down to consumer to reduce load—gets passed thru HAN (PCTs, load control switches—typical suite of res devices and energy storage). Doesn't affect customer bill (simulated price), but know price thresholds and can forecast amount of DR would achieve—broadband for messaging and signal + smart meter that is used for consumption data + HAN.
  - Modern City Manheim Project in Germany—at res level, systems react to price signal and separately aggregate in clusters and send back response into demand system.
  - 2-way system being bid into ERCOT this summer—results will be sharable. Good results from last summer from residential.
  - DOE Energy Storage database that tracks all bulk energy storage in the world.

Question #3

How would manufacturers or service providers leverage enhanced or new solutions as they are developed and implemented? How can they integrate with an open transaction platform that they can use to provide proprietary technology or value-added services?

Key Topics

» What are you seeing in this manufacturing, hardware space that could add value to a transactive system? E.g., smart plugs with ability to communicate back to circuit breaker panel.

» In terms of market entry, it will be whole buildings, not singular appliances. This is going to be a tough value proposition.

» Demostrations are underway at DOE to evaluate a transaction-based platform specifically around rooftop air-conditioning units to demonstrate all the value streams associated with this equipment, including demand-response, fan control, etc.

» PC power management tools are being integrated into building control systems. Can do this today with technology for IT loads which are often 10% of total buildings use; if lower this 10%, then can realize 1% savings in buildings – that's significant if done at scale. Some companies are offering this kind of service.

» Buyers saying they want certain functionalities, manufacturers saying they've been wanting to do that for years, so there is a market for these things. People want to engage buildings in a new and more meaningful way.

Question #4&5

How would common data and solution technology taxonomies be developed to enable common valuation metrics?

Given that open source, common communication protocols (e.g., BACnet, oBIX) have been developed to improve interoperability, what are the characteristics of solutions that would offer broad, plug-and-play interoperability? What solutions are necessary to make the point mapping process more consistent, automated and error free?

Key Topics

» 70% of the market uses BACnet. So we should start there.

» Hearing from customers that interoperability still a huge issue—what are characteristics that would offer true plug-and-play?

» What incentives to equipment vendors are needed to produce inter-operable devices? Incentive is for the consumer, but does the consumer have enough power in the market to drive the vendors? They have the power but you have to show them they want to exercise it.

» Have to get people focused on the total cost of ownership, not just fixed costs.

» Role of BACnet evolving, but as an application layer needs to have features set defined more by building end users and should have forum to define what it should do (whether it can actually do it or not). Need forum to explore these issues in more detail.

Question #6

What are the necessary steps to make control algorithms "universally" applicable while minimizing the need for customized building-by-building configurations? What would a market look like that facilitates the development and adoption of these "universal" algorithms?

Key Topics

- Supercomputer algorithms that locate problems; doesn't tell you how to solve problems, but can ID them.
- Critical to have universal platform on which to run algorithms.
- Issues with developing query as well as best answers and how to quantify answers. Need to have some sort of domain knowledge model.

From the Communications and IT Perspective

Question #1:

What are the underlying IT and communication needs to support building-grid transactions? Do we need new architectures? Are open standards available and are they sufficient? What needs exist for new or enhanced open standards for communications, data formats, taxonomies, and transactions? What are the cyber security requirements?

Key Topics

- The implementation has got to be able to incorporate different kinds of data at different speeds for the same transaction and it's important that the architecture can handle this.
- 3 standards for ISO to communicate to generators and loads. But at distribution level are as many standards as there are utilities. Much more complex challenge.
- A world where you have a battery in front of the house to manage frequency that is responding automatically to the grid, transactions are cycle speed, but settlement is on a longer time interval.
- Going to have heterogeneous protocols, so how do we start to insulate the application layers and models—focus on developing an application that lets us describe the application mode.
- Should discussion be broken into automation vs. market standards?
  - Open ADR is the only one that is truly viable today in the market standards category.
  - Market standards: how you fit in/clear/are accepted by a market (all are unfamiliar to building systems).
- Also notion of top nodes and end nodes and OpenADR can accommodate this to define the market in a different hierarchy.
- ISO/IEC 18012 good at dealing with different protocols. 18012 allows for development of virtual thermostat – embed the intelligence in the software not in the hardware. Allows for open ADR functionality – create it outside of the physical device.

- Proposed approach: if we had hierarchical markets (lowest level at distribution), you as building must decide where to hook up to in the market and register yourself. Then you don't need to know the rest of the market above that, because the one you're hooked up to fronts the resources you need rather than you doing it yourself.
- A lot of the feedback capabilities are under used because there is no real-time forecast that we can feed back into the grid.

Question #2:

Must both wired and wireless systems be supported? Is the existing physical infrastructure adequate? What needs exist?

Key Topics

- Important (physical infrastructure = lower levels of stack) that we don't cook what we're doing all way down thru layers and let the layers be evolving. Don't want every crank turn to ripple up through layers.
- Run into issues where there is lack of coverage in the wireless side, parts of buildings where there is no wireless access, including with metal HVAC systems.
- Wireless can be added, but is it worth the cost? And do you have the personnel who can install?
- It is possible to drop CAD 5 backbone into a 1 million SF building with for a few thousand dollars, so it can be done.
- What is the problem with wireless—outside or inside the building?
  - 3G/4G cellular networks had some issues of drop rates and lost data especially with shorter time spans.
  - But happens very infrequently. Very reliable system overall.
  - Need to consider when going to 2-4 seconds.
  - Constant stream or intermittent use?
  - Most mesh providers can't handle this.
  - Don't define things as wireless/wired/etc.—going to have a mixture. In our interest to determine what's the structure of that data, no matter what the physical infrastructure. Don't overspecify and create rigid architectures.
  - Case-by-case basis, depends on geography, local character, etc.

Question #3:

Who will be able to participate in building-grid transactions? Building owners? Tenants? Employees/end users? Automated agents on behalf of others? Aggregators? Owners of distributed generation assets in buildings? Third party service providers?

Key Topics

» Occupants are more forward thinking than other parties that are bound in other business models, so put things in their hands.

» One of reasons you don't see building transaction based controls is because incentive isn't there—occupants often not even paying their own utility bills.

» Need to think about the psychology of occupants, how do we incentivize people to act? Need to increase amenity levels as way to increase buy-in for efficiency.

» Not a command and control system, but flip it around so that you make the experience better, make people want to do it, drive individual behavior.

» If it affects the comfort of the employee and they want to change things so they can work better, then it is helpful.

» Would small commercial buildings and residences be left out because they would not be swept up by aggregators? From a political perspective, you can't ignore residential. They might still be transactive, but might prefer to do so via an aggregator.

» Aggregators, from a business perspective, may be needed to make economics work, but then have to look at how customers participate with aggregators.

» Residential small loads are of interest to utilities, even without aggregators. Look at utility programs for homes.

» But data collection and settlement can be a challenge with residential due to volume of transactions.

» A lot of what we're talking about resembles financial payments, related to credit market economics. "Four corner" model of credit card system provides relevant insight into risk and securitization of risk.

› Ultimately it is all about settlement. Actual transactions occur between issuing and merchant banks and there are regulations on all issuing and merchant transactions.

› To hedge risk, take different classes of risk/users to get diverse derivative markets that can provide liquidity. At end of day, our risk management needs to drop into this world (which has been developed over centuries) to manage risk.

» Complicating factor is that not only financial risk, but also can we use same kind of model for operational risk? We're also worried about reliable grid operation. Electrons and dollars are different.

Question #4:

Who owns the communications infrastructure between buildings and the grid? Who maintains it? Can the infrastructure be multi-use for grid integration, energy efficiency, and building control?

Key Topics

» There are boundaries in ownership and the systems put in buildings would be owned by building owners, but could also see service providers installing and owning equipment, as well as providing benefits and getting share of benefits.

» Clear who owns stuff in buildings and clear who owns the grid, but transactive piece doesn't yet have a great model for who should "own" and benefit from it.

» Need to carry what we've learned about wireless generally into the buildings space. Must be reliable.

Question #5:

What should the market transactions look like? What kinds of transactions should be supported? Electricity purchases, demand response, other ancillary services, distributed generation, on-site and community storage? How will data exchanged between parties be valued in the transaction system?

Key Topics

» Not directly addressed during the Session.

Question #6:

What are the communication performance requirements? Throughput? Latency? Reliability?

Key Topics

» What are the requirements to make this system work?

» Application layers are needed to make it work, design reliability with user in mind.

Question #7:

How should the building controls operate? Simple extensions of the transaction network of the grid or with an interface between the grid and building management and control systems? Portfolios of buildings or single buildings? Centralized vs. decentralized control? If centralized, who owns and operates?

Key Topics

» Have schedules and interface for customer to decide if going to get into the market (typically daily). Pretty manual right now. Would be nice if more automatic.

» In a market, building energy management systems are the products so where it's going is to standardize the products so you can actually have a market.

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