U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Building Technologies Office

Buildings Interoperability Vision Technical Meeting Proceedings

April 2015

Note of Appreciation

The advancement in information and communications technology (ICT) has revolutionized energy management in industrial facilities and some large commercial buildings. As ICT costs decrease and capabilities increase, buildings automation and energy management features could transform the small-medium commercial and residential buildings sectors. A vision of a connected world in which equipment and systems within buildings coordinate with each other to efficiently meet their owners' and occupants' needs, and where buildings regularly transact business with other buildings and service providers (such as gas and electric service providers) is emerging – and consumers want engagement. However, while the technology to support this collaboration has been demonstrated at various degrees of maturity, the integration frameworks and ecosystems of products that support the ability to easily install, maintain, and evolve building systems and their equipment components struggle to meet the needs of these same consumers. Through its Building Technologies Office, the United States Department of Energy's Office of Energy Efficiency and Renewable Energy (DOE) sponsored a meeting to consider a vision of interoperability for the integration of intelligent, connected buildings equipment and automation systems, understanding the importance of integration frameworks and product ecosystems to this cause.

For a day and a half in March, we assembled experts representing a variety of stakeholder groups in the connected buildings area to discuss the emerging ICT transformation of interconnected devices as inspired by Internet of Things (IoT) initiatives as well as the transformative directions underway in the buildings automation community. Our objective was to identify the desired contents for a vision of buildings interoperability looking toward the future. To help us frame the vision discussion, we reviewed the current landscape of buildings interoperability and heard from technology leaders about IoT and next generation buildings automation concepts and challenges. The attendees were then asked to consider four integration scenarios of buildings-related service interactions to emphasize the desired experience of integrating connected buildings technology that interoperability advancements should bring.

Interoperability is conceptually abstract, making it a challenge to articulate points and characteristics without using real-world examples. The examples in turn often bring up issues that distract attention from principles and attributes that contributors try to communicate. Add to this our request for the participants to imagine a desired technology integration experience 10 to 15 years in the future, and you have the ingredients for a meeting mutiny. Yet, instead of rebellion, we received critical, but constructive insights regarding the issues facing ICT integration in the buildings area and important aspects that should be addressed to advance interoperability going forward.

To their patience to bear with the vision stories, their respect to listen to the variety of viewpoints from their peers, and their valuable input to this effort and the role of government, we are most grateful and honored for the attendees' participation.

Sincerely,

Joe Hagerman
United States Department of Energy

Steve Widergren
Pacific Northwest National Laboratory

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9 April 2015

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Introduction

Buildings are an integral part of our nation's energy economy. For connected buildings ecosystems of products and services from various manufacturers to flourish, the ICT aspects of the equipment need to integrate and operate simply and reliably. Within the concepts of interoperability lie the specification, development, and certification of equipment with standards-based interfaces that connect and work. And beyond this, a healthy community of stakeholders who contribute to and use interoperability work products must be developed.

A previous DOE technical meeting[1] has taken stock of the interoperability of connected equipment and systems in buildings today. In addition a Buildings Interoperability Landscape report has been drafted to describe an interoperability framework for buildings, including lists of relevant use cases, stakeholders, and interoperability goals. This document can be found at http://energy.gov/eere/buildings/downloads/buildings-interoperability-landscape-draft. To encourage vibrant product ecosystems for connected buildings in the future, a series of technical meetings is proposed with the objectives of reviewing this landscape report and developing a roadmap of activities that advance connected buildings interoperability.

An initial step, and the focus of this first meeting in the roadmap process is to develop a vision for the interoperability of small to medium commercial connected buildings products and services. Even though interoperability advances will also pertain to large facilities, they are critical to support the business propositions of smaller buildings automation deployments where allocations for integration and operations support are minimal. By imagining the expectations of equipment integration and operation in these buildings 10 or 15 years from now, stakeholders can temporarily suspend incrementally addressing today's integration issues and look toward common features of a desired future state.

This meeting was designed to review the Buildings Interoperability Landscape report, and to stimulate thinking about the attributes of a future desired state, while setting aside how to build it. By engaging attendees representing a variety of stakeholder perspectives, we sought to find common characteristics that would lead to directional alignment.

The result of this meeting is a draft outline of contents for a buildings interoperability vision whitepaper. The content of the vision whitepaper was the concluding discussion subject of the meeting; however, important aspects also discussed included the desired attributes or requirements of interoperability that can be shaped into goals and metrics so that advancements can be assessed. Subsequent meetings will review and refine the vision and begin the process of defining a roadmap of activities that moves to bridge today's connected buildings situation with the vision.

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[1] Technical Meeting: Data/Communication Standards and Interoperability of Building Appliances, Equipment, and Systems, held at the National Renewable Energy Laboratory, Golden, Colorado, 1 May 2014. Summary notes and presentations can be found at http://energy.gov/eere/buildings/downloads/technical-meeting-datacommunication-standards-and-interoperability-building

Attendee List

Category	Organization	Attendee
Appliance Manufacturers (ApplMan)	Bosch	Charles Shelton
		Adam Wynne
	Samsung	Alan Messer
Building Automation and Control System Manufacturers (BldgAutoSys)	Building Intelligence Group	Paul Ehrlich
	Honeywell	Tariq Samad
	Independent	Allen Jones
	Lutron Electronics	Brent Protzman
	Siemens Building Technologies	David Kopczynski
		Craig Engelbrecht
Building Control Systems Integrators (BldgInteg)	Engenuity	Tracy Markie
	Iconics	Gary Kohrt
Industry Consortia (Consortia)	AllSeen Alliance	Ivan Judson
	SunSpec Alliance	Tom Tansey
Energy Service Companies (ESCO)	Energy Technology Saving, LLC	Jeff Hendler
	NorthWrite	Patrick O'Neill
	SkyFoundry	John Petze
	SmartCloud	Peter Hunt
	United Technologies Research Center	Allison Gotkin
		Stella Oggianu
Facility Managers-Owners-Operators-Occupants (FacilityMgr)	McKinstry	Mike Grush
		Stephen Kozlen
Government Agencies (Gov)	DOE	Joe Hagerman
		Henry Kelly
		Kevin Lynn
		Marina Sofos
HVAC and Water Heating Equipment Manufacturers (HVAC)	Carrier	Richard Lord
Industrial Equipment Manufacturers (IndustEq)	Eaton	Zhijun Tang
R&D Organizations and Academia (R&Dorg)	ANL	Keith Hardy
	Drexel University	Jin Wen
	LBNL	Eleanor Lee
		Bruce Nordman
	NREL	Dane Christenson
		Lieko Earle
	ORNL	Roderick Jackson
		Teja Kuruganti
	VPI (VA Tech)	Saifur Rahman
Testing Organizations (Test)	Quality Logic	James Mater
Utility Energy Providers (UtilEngProv)	Duke Energy	George Gurlaskie
Host	PNNL	Michael Brambley
		Charles Corbin
		Tamica Dickenson
		Dave Hardin, Upper Bay Systems
		George Hernandez
		Ebony Mayhorn
		Sean McDonald, Planit Meetings
		Andrew Nicholls
		Eric Stephan
		Dennis Stiles
		Weimin Wang
		Steve Widergren

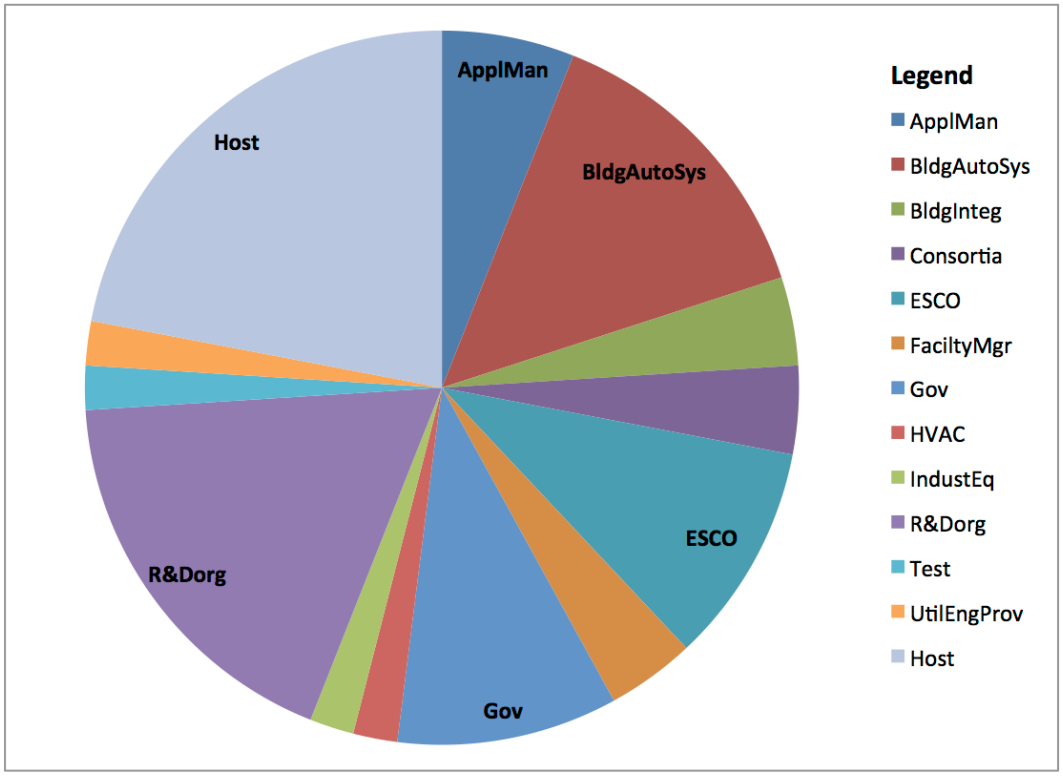

Figure 1: Attendee representation by organization category

Agenda

11 March 2015	
8:00 am	Welcome and Introductions
8:15 am	Overview: Sensors, Controls, and Transactional Network Program, Joe Hagerman, US Department of Energy (DOE), Building Technologies Office - BTO
8:30 am	Meeting Context • Purpose, goals, desired results and deliverables • Review Buildings Interoperability Landscape draft document
9:30 am	Vision Stories and Interoperability Requirements • Provocative ideas of what buildings automation integration may look like in the future • Interoperability characteristics • Selected scenarios that span buildings automation use case actor perspectives
10:30 am	Transformational ICT Directions – Internet of Things Ecosystems Presentations • Samsung: Alan Messer • Bosch: Charles Shelton, Adam Wynne • SmartCloud: Peter Hunt • Honeywell: Tariq Samad • The Allseen Alliance: Ivan Judson (Microsoft)
Noon	Working Lunch: Presentation from Kevin Lynn, DOE-EERE Grid Integration Initiative
1:00 pm	Breakout Session Topic 1: What does the future look like? • Orientation: interoperability scenarios from main actor perspectives • Facilitated discussion and results capture
2:45 pm	Breakout Session Topic 2: What are the interoperability attributes to consider? • Orientation: interoperability scenarios from main actor perspectives • Facilitated discussion and results capture
4:15 pm	Summary reports from breakouts
5:15 pm	Adjourn

12 March 2015	
7:45 am	Greeting and review of Topics 1 and 2 results
8:00 am	Buildings Automation Transformation - Industry Directions Presentations • Siemens: David Kopczynski • Iconics: Gary Kohrt • SkyFoundry – Project Haystack: John Petze • Energy Technology Savings (ETS): Jeff Hendler
10:00 am	Group Session Topic 3: What should a buildings interoperability vision include? • Orientation: example vision whitepaper outline • Facilitated discussion capturing a vision whitepaper outline
11:30 am	Closing comments – Joe Hagerman, DOE • Importance of a national strategy for the interoperability of connected equipment • Next steps and meeting adjournment
Noon	Adjourn

Presentations

Two panel sessions explored building interoperability issues from ICT and Buildings Automation perspectives by industry professionals representing a cross section of companies currently working in the small and medium commercial buildings space. Copies of the presentations are available for download from http://energy.gov/eere/buildings/listings/buildings-grid-meeting-summaries-presentations.

Panel 1: Transformational ICT Directions – Internet of Things Ecosystems Presentations

- Dr. Alan Messer, Vice President of Advanced Software Technologies. Samsung Electronics Silicon Valley R&D Center.
- Charles Shelton, Senior Research Engineer. Robert Bosch Research and Technology Center. Adam Wynne – Senior Research Engineer, Robert Bosch Research and Technology Center.
- Peter Hunt, Director of Sales for Energy and Utility Applications. SmartCloud, Inc.
- Tariq Samad, Corporate Fellow. Honeywell Automation and Control Solutions.
- Ivan Judson, Senior Software Engineer. Microsoft. Representing the AllSeen Alliance.

Panel 2: Buildings Automation Transformation - Industry Directions Presentations

- David Kopczynski. Sales Executive, Siemens.
- Gary Kohrt, Vice President of Solutions and Services. Iconics.
- John Petze, C.E.M. and Partner. SkyFoundry.
- Jeff Hendler, Chief Executive Officer. Energy Technology Savings.

Breakout Session Vision Stories

The following section describes a set of user stories through which building interoperability needs and requirements can be viewed. Though not exhaustive by any measure, these stories were the context for breakout sessions held on the afternoon of 11 March 2015. In these sessions, attendees were divided into four smaller groups, each tasked with addressing the questions from the perspective of one of the four interoperability user stories described below: Building Internal Interaction, Building Service Provider, Market Service Provider, and Distribution Service Operation. Attendees were provided a handout with the following context and stories prior to the breakout sessions.

Building Story Context

The following building interaction stories depict first person scenarios, or stories, inspired from existing building use cases contained within the Transaction-Based Building Controls Framework, Volume 1: Reference Guide[2]. Settings for the stories are described by the Buildings Interoperability Vision section of the Buildings Interoperability Landscape Draft document[3]. This vision portrays key

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[2] "Transaction-Based Building Controls Framework, Volume 1: Reference Guide," prepared for the U.S. Department of Energy by Pacific Northwest National Laboratory, PNNL-23302, December 2014. Accessed March 2015 at http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23302.pdf

[3] Buildings Interoperability Landscape – DRAFT, prepared for the U.S. Department of Energy by Pacific Northwest National Laboratory, PNNL-24089, February, 2015. Accessed March 2015 at http://energy.gov/eere/buildings/downloads/buildings-interoperability-landscape-draft

actors, such as building operators, interacting with intelligent software applications running on an ecosystem-supported hardware-software system platform. Intelligent applications, also referred to as intelligent agents, execute logic on behalf of the building operator. The stories represent hypothetical but realizable scenarios that could enable key visionary interoperability objectives such as ease-of-interaction, cost-effective integration, and deployment at scale.

Each use case from the reference guide has multiple paths of execution (i.e., threads). The stories that follow choose a specific use case thread, which is summarized in each story. The threads selected are not intended to be rigorous scenarios for product development. Their purpose is to provide a visionary context for extracting interoperability requirements that enable a variety of methods for enabling a range of services similar to the ones depicted. Details relating to specific interactions such as service messaging payload contents, message syntax and transport are important to the extent that the interoperability requirements extracted do not limit specific future interactions.

Certain philosophical assumptions were applied in developing the stories below. The next section introduces the importance of these assumptions to support interoperability goals.

System Integration Philosophy

Interoperability makes the integration of buildings automation equipment and systems simpler and predictable. To manage the complexity of a large number of connected equipment and systems over a long time horizon, the philosophy of system integration must consider enduring qualities such as the ability to evolve the system and its equipment over time and the ability to scale up to integrate greater numbers of components. These considerations have led to focus on the interface where things connect and the boundary within which qualities such as authority, responsibility, security, and privacy can be clarified. The following philosophical considerations are borrowed from the GridWise® Interoperability Context-Setting Framework[4].

Agreement at the Interface: The interface agreement captures the interaction between parties, including any assumed actions. It is about the goods and services exchanged, price, scope, schedule, quality, and consequences for failure to perform. It is about what is delivered and the process to get it, not how the deliverable is generated.

Boundary of Authority: The agreement is situated in the transactive stream at the place where responsibilities are clearly defined. This forms a boundary of authority for addressing rights of privacy and security, and separates the way business is conducted on either side of the interface. Requirements between transacting parties for the way business, privacy, and security are dealt with need to be reflected in the interface agreement along with appropriate mechanisms for auditing.

Decision Making in Very Large Networks: For networks of things to scale, they need to delegate responsibility to the end points. One can draw a bubble around an end-point (equipment, subsystem, building?), but the hyper-network of end-points relies on these areas of automation acting in their own best interests while conforming to policies (rules) that support the health of the overall system. Hierarchical approaches have their place in complex systems as well and are helpful for defining lines of responsibility that are important to the above 2 points.

Role of Standards: Open standards have obvious interoperability benefits and should be encouraged, but they are not the full story. The use of standards should be a

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[4] GridWise Architecture Council, *GridWise Interoperability Context-Setting Framework v1.1*, 2008. Accessed March 2015 at http://www.gridwiseac.org/pdfs/interopframework_v1_1.pdf.

technical/design/business choice and not a hard policy. This is because technology and standards change over time and this evolution needs to be accommodated rather than stifled. Policy is best when it sticks to results-oriented performance requirements and ecosystem necessary conveniences, such as VIN numbers on vehicles.

Building Internal Interaction Story

Use Case: Automated Building Energy Efficiency

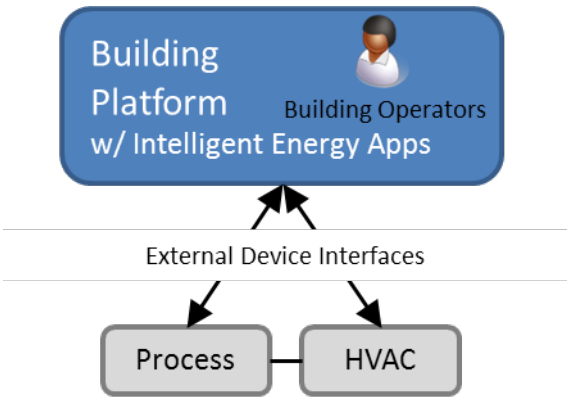
Actors: Building Operator (BO)

Description: A first person view of applying automation to a small building through the eyes of its operator. It focuses on technology integration but draws from familiar interaction patterns.

Value Proposition: Improving the ability of building devices and systems to interoperate will result in lower costs and other benefits including increased energy optimization and efficiency.

Story Sequence:

- BO purchases a "Building Platform" based on ability to integrate with existing equipment
- BO downloads an app that discovers the building and begins monitoring devices
- BO adds HVAC and kitchen appliances using "Black Boxes"
- BO downloads an app that monitors building energy and provides guidance and control
- BO interacts with the "Cyber Intrusion Agent" and has privacy concerns



I own and operate a decent-sized food restaurant. Some other building owners in the area have "Building Platforms" and I'm thinking about buying one. They rave about how easy they are to install and use, and the comfort, security and savings they get.

There are two that seem very popular. One, the "iBuilding", has the reputation of being very easy to use and has a bunch of cool features. Most new kitchen appliances, security systems and heating and lighting systems are compatible with it. The other, the "LightSaver", is very much like the iBuilding and seems to have the same features and functions. The one thing I did notice is that it has support for a bunch of older appliances and HVAC systems. This is important to me because my building is 20 years old and has older kitchen appliances and HVAC system. I can buy these little boxes called "Black Boxes" that plug into the freezer, frig and HVAC that let them work with the LightSaver. I decided that this feature was a "must-have".

I ordered the LightSaver and all I had to do was plug it in and download an app called "The Agent" into my phone. The Agent quickly walked me through the process of discovering my building after I got past the security and privacy screens. It found the electric and gas meters and the security and fire alarm system. Everything communicates by wireless so that makes installation easy. I can see my energy usage and my security cameras from anywhere, at any time from my phone, tablet or PC!

I ordered and plugged in Black Boxes for my HVAC and appliances. Bingo! My Agent found them and now I can see and change the temperature as well as check out how the appliances are operating. I can even change the temperature setting on my freezer and frig if I want to.

I go to the online Agent store and download an app called "The Breeze" that monitors my energy usage then shows me where I'm spending my money and how much I could save if I made some changes. It's important that my kitchen is fully functional during breakfast, lunch and dinner but I have flexibility between these times. I also don't mind if my lighting dims but it needs to be above a certain level during dinner. After walking through some screens where I tell it what my needs are, it responds by letting me know what information and resources it needs access to. It doesn't ask for everything, but for each capability, it lets me know what's needed to perform the job and asks for and obtains my permission beforehand. The access policies are established under pro forma language agreed to by the Smart Buildings Better Business Society, which works with state and federal legal groups on consumer rights and privacy issues.

Once the initial set up is complete, it begins monitoring the energy usage of my building and my appliances. If anything goes wrong, I get text and email messages with links to a website that provides more information on the problem and summarizes my building's operation.

I like the way the LightSaver is sensitive to the privacy aspects of my business, but I've been reading about major banks and businesses getting hacked. I started looking into this more deeply and found that the system is equipped with an cyber intrusion detection agent that allows me to configure my potential risk exposure while letting me know the trade-offs in performance and functionality of the apps I've deployed. I regularly get notices for security upgrades and occasionally an event occurs when an immediate patch is recommended. It also has the capability to move into degraded modes of operation changing its behavior if it detects an abnormal situation. Part of the operating agreement with each app is that they supply the fail-safe aspects of each building component so that devices can go to a default safe place while not necessarily shutting off.

Building Service Provider Story

Use Case: "Diagnostics and Automated Commissioning Services" (see Transaction-Based Building Controls Framework, Volume 1: Reference Guide)

Actors: Building Operator (BO), Building Service Provider (BSP)

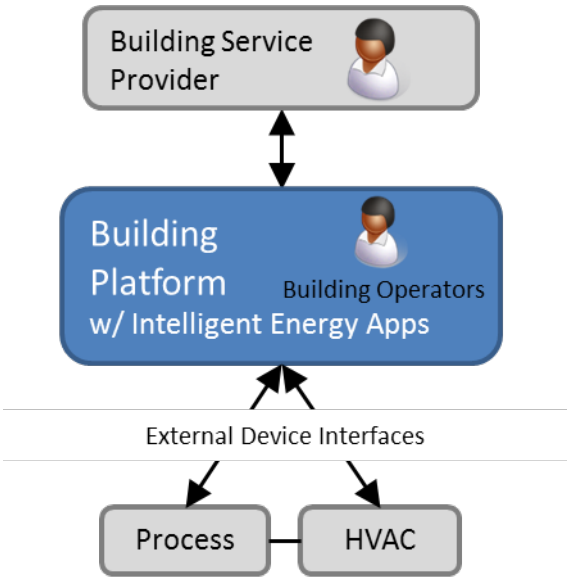
Description: A first person view of how a building operator might interact with a third-party that provides building commissioning services, energy guidance and diagnostics on behalf of the building operator.

Value Proposition: Minimizing the costs of supporting efficient operation of building systems and providing value-added services.

Story Sequence:

- BO already has "Building Platform" but needs help in maintaining the system
- BSP wants to provide energy services but needs access to building data
- BO downloads and configures a "Diagnostic Gateway" app and BSP app

- BSP interfaces with Gateway app to discover and monitor the devices connected to the building platform
- BSP updates app with energy information, diagnostics and guidance
- BO interfaces with BSP app



As the BO, I've been living with my Building Platform for a while now and have accumulated a collection of smart apps and devices. Using my smartphone, I can see if my devices are operating and turn them on and off manually. If an appliance doesn't seem to be working correctly, its app sends me a notification but it's now a pretty complex system. It sure would be nice if these parts were integrated together.

As a BSP, we've got the domain knowledge and expertise to help BO's manage their building energy costs but I need access to their building data. We work closely with customers to make sure they are comfortable working with us. The more data we have access to, the more services we can provide. We also need to keep our costs down so that our customers can afford to use our services. This is difficult because buildings differ and we need to scale to large numbers so we use a standard interface to integrate building data into our energy cloud. We also have a building platform app that accesses our cloud through standard interfaces and provides the BO with information and guidance. By using standard interfaces, we can help minimize app development costs. The BO can purchase the app outright or sign an agreement with us to split the energy savings and not have to pay upfront. This is a win-win.

As the BO, I download, install and run the BSP's app. As a prerequisite, I need to install another app called a "Building Diagnostics Gateway" from MicroFirm. This app acts as my agent to the outside world and lets me have control of what data I share and who I share it with. After registering with the BSP website, the BSP app guides me through a workflow to setup security, privacy and other basic app information. I allow it to store my data in the cloud so that I have access to historical reports and graphical trends from anywhere. It finds and interrogates my devices and appliances, asks permission to access each one of them, determines how to communicate with them and extracts metadata and energy data from the devices (or from somewhere) to build and initialize an energy model of my building. It shows me a diagram of my energy system. The app starts monitoring

building sensors while it tunes the energy model. The app also allows me to configure my business workflow, schedule, priorities and constraints easily.

As the BSP, I've been collecting and analyzing the building's data and generating historical, current and forecast views of the BO's building energy system along with past and projected costs associated with each appliance. We're leveraging several indirect techniques such as using NOAA for weather data, detecting occupancy using manual entry and power consumption from product specs but after we've collected sufficient data, we'll show the BO a prioritized list of changes that would be worthwhile to improve system monitoring and energy performance. Using our app, the BO can understand where energy is being used and lost through a detailed (but easy-to-read) energy balance display.

As the BO, the apps have been running for a while now and have detected some abnormal conditions and sent operational status updates and events to my smartphone. They provide very clear error and warning messages when it finds something wrong with a device, or with the system as a whole, and tells me how to correct the error or who to contact for help. The energy guidance has been valuable and has lowered my bills.

As the BO, it sure is a good thing that the app has great security and privacy or I'd be turning it off about now. If I hear that the BSP has a security breech then I will. They stand behind a privacy agreement that spells out what information is accessed, who has access to it and how that information will be used. If I want someone else to have my data, I can securely give them appropriate approvals.

Distribution System Operations Story

Use Case: "Transactive Acquisition of Ancillary Services" (see Transaction-Based Building Controls Framework, Volume 1: Reference Guide)

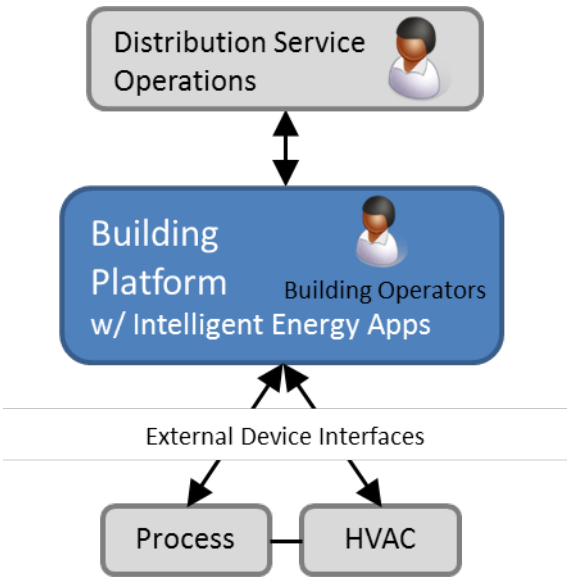
Actors: Building Operator (BO), Distribution Service Operator (DSO)

Description: A view of how a BO might supply spinning reserves to a DSO ancillary service market, and how the DSO may interact with the BO.

Value Proposition: Increased renewables are resulting in more grid fluctuations. Buildings can be a less expensive near-term alternative than distributed generation. Winning bidders are compensated for their ability to reduce load if called upon.

Story Sequence:

- DSO runs an hourly reserve program for spinning reserves
- BO connects to this interface using apps provided by the DSO or third parties
- BO configures his app and devices to respond to the DSO program and bid messages
- DSO clears the program's market hourly and the cleared price is broadcast to all BOs
- When needed, DSO broadcasts a reserve event and all BO's who won the bid curtail demand
- When expired, BO and DSO reconcile contract performance.



As the DSO, I monitor the system and run an hourly reserve market for feeder locational real-time pricing for BOs to participate in a spinning reserve ancillary services program. I define the pre-requisites for a building to qualify for the market. That includes the minimum amount of power and energy to bid, the range and speed of response that is acceptable for performance, and how the payment for the service will be reconciled (including measurement and validation requirements). This is reflected in the ICT interface to this DSO program.

As the BO, I can connect to this interface using apps provided by the DSO or third parties who use the same reserve market interface and may offer services to integrate with my buildings automation platform. I am able to discover the DSO offering from their website, fill out the qualification material, and once qualified obtain a secure sign-in code for interfacing with the DSO interface. I configure my automated equipment to be able to respond to the DSO reserve program. I use a third party app that the DSO website suggested as compatible with my Building Platform and the DSO program's interface to help do this. I give the app permission to discover my equipment and my system schedules and preferences for operation. It is smart enough to figure out where I have connected equipment that may have some flexibility and offers me options for setting my preferences on ranges of operation (e.g., space and refrigeration temperatures) that I'm willing to live within. Once set up, the app connects to the DSO program for real-time operation.

As the DSO, I confirm that the BO is signed up and available for the program. Reserve market messages periodically are sent to the BO indicating opening and closing of the market and market clearing results.

As the BO, my app monitors the building state and forecasted electricity needs within my preferences and sends the DSO Operator a bid curve of price and quantity of demand reduction.

The DSO reserve market clears hourly using the last bid from each BO. The cleared price is broadcast to all BOs. This indicates whether they are on-call to deliver demand reduction in the next hour.

As the DSO, I broadcast a reserve event and all BOs who won the bid automatically notify their building system to affect the demand reduction. Appropriate data is collected per the contract agreement to support their response. Once the crisis has finished, I remove the reserve event. BOs' systems respond with the appropriate information for reconciling the contract performance. My reserve program notifies the billing system of information, which reconciles the BO's bill for the

service provided. In the case that no spinning reserve event is called, the bill is reconciled in accordance with the compensation for being on-call.

Market Service Provider Story

Use Case: "Transactive Energy Market Exchange" (Transaction-Based Building Controls Framework, Volume 1: Reference Guide)

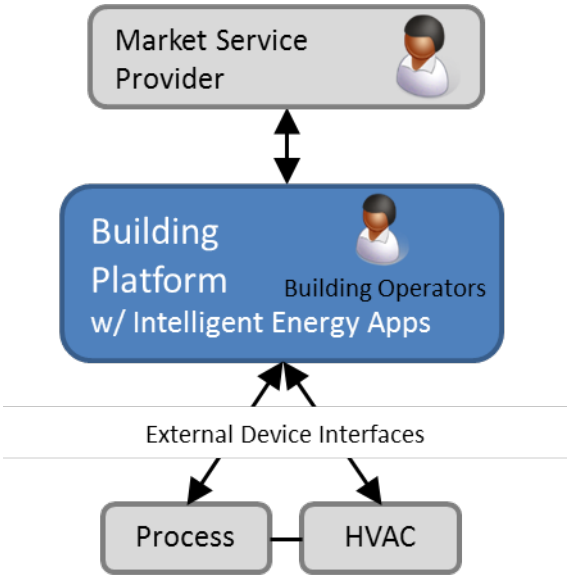
Actors: Building Operator (BO), Market Service Providers (MSP)

Description: A view of how a building operator might purchase energy from an energy market and how a market operator may interact with the owner/operator.

Value Proposition: Forward contracts may result in reduced peak demand and congestion, increased operational efficiency, better capacity planning, and increased integration of renewable resources. Energy consumers will have a broad range of purchasing options to better manage their energy costs with their demand flexibility.

Story Sequence:

- MSP works with wholesale energy providers to create buy/sell forward products
- MSP runs a forward contracts market for energy that exposes an interface
- BO connects to this interface using apps provided by the MSP or third parties
- BO configures his app and devices to select contracts automatically
- As agent for BO, app buys/sells contracts according to anticipated and historical consumption
- In monthly billing period, BO and MSP reconcile contract performance. BO's app uses this information to improve future contract selection.



As a MSP, I work with electricity generation, transmission and distribution providers to develop products that allow individual building owners to participate in a retail market. The products I develop are electricity contracts that can vary by contract duration and energy quantity. These

contracts are bought and sold by electricity producers and consumers alike in an "energy stock market".

As a BO, I would like to shop for electricity in the same way I shop for other commodities. I need a mechanism for buying/selling forward contracts in the market operated by the regional MSP. The Building Platform I've purchased allows me to participate through apps designed to interface with the market.

As a MSP, I want to grow my market, so I expose a standardized market interface to enable a variety of 3rd party building platform apps. I also supply a free app called MyEnergyMarket app. This app is capable of integrating historical information from a building platform, using a standard software interface, to enable smarter electricity purchasing decisions automatically.

As a BO, I install the MyEnergyMarket app and it walks me through a set of contractual, security and privacy forms, and registers me as a participant in the forward energy market. The app recognizes my energy assets and appliances through an interface exposed by the Building Platform and can access my historical energy usage. I also have the option use the MyMarketOptimizer app that is available from MicroFirm. This app will evaluate the cost of operation under a contract and either; a) selects different contract duration, and/or b) adjusts operation to reduce energy cost.

As a MSP, I offer forward contracts ranging from 5 minutes to one year in duration by the various energy suppliers in our network. These contracts help my network of energy providers manage the operation of their assets and address system constraints through the pricing of their contracts. For example, Electricity Provider Inc. may increase the cost of 5-minute contracts to reflect congestion in their distribution system.

As a BO, I am offered recommendations by the app for purchasing energy based upon how I have used energy in the past. The app shows me a list of providers in my area and the types of energy contracts for which the app can bid. Some of these are short-term contracts on the order or minutes and others are longer term on the order of months. The app can dynamically buy and sell these contracts in order to minimize my energy cost. I review the options MyEnergyMarket app suggests based on my historical usage and configure the app to automatically buy and sell contracts on my behalf based on my energy use.

As a MSP, I maintain a highly secure, automated system that tracks and verifies the transactions between supplier and consumer using advanced metering and the openly available standardized, but very secure, software service interfaces that apps use to interact with the market. This system allows me to accurately reconcile contracts with BOs on a monthly basis.

Breakout Session Summaries

The following section summarizes the questions posed to each of the four breakout groups and their respective responses. Output from each breakout sessions is organized according to session topic and user story.

Session Topic 1: What does the future look like?

Questions Posed

1. Does this story evoke a desired vision of a user interaction experience?
    a. Are there key steps or player interactions missing from the story?
    b. Are there major concerns or unreasonable assumptions depicted in the story?
    c. What other techniques can help portray a vision for buildings interoperability?
2. What types of user interactions do you foresee in the future?

    a. What is level of user interaction do you envision for the steps in the story?
    b. What is being exchanged in an interaction?
    c. How much of the interaction would you expect to be automated?
3. What is needed in a vision for successful technology deployment?
    a. Do you foresee ecosystems of products and services?
    b. Do you foresee buildings platforms for successful deployment?
    c. What deployment approaches and promising trends deserve representation in a vision?

Building Internal Interaction Response

- Building owner should not be turned into an operator
    - Need to consider an integrator role separate from an owner with appropriate configuration expertise
    - Systems should be automated and run in the background
    - Do not require additional interaction
    - Centralized oversight may be needed for security, but not for control of buildings
- Scenario should capture user choice of products, services, sophistication
    - Players missing: lessee or lessor, customer, regulatory body
- Scenario only considers electricity, needs to consider
    - Resources such as gas and water
    - Systems such as security and safety
    - Link between systems
- Interaction must provide choice of actions along with who gets what information
    - Data analytics needed to provide advice and support
    - Machine learning needed for demonstrating equipment self-learning and verifying preferences
- Lack economic drivers for manufacturers, app developers to exchange information from their process or application to benefit another that they did not develop
- Scenario focused too much on management, not about how devices need to interact
    - All devices need to be considered with their own platforms with upgradable firmware, software.
    - Maintenance and upgrades are important to consider

Building Service Provider Responses

- Differing views expressed between story less than visionary to a futuristic dream
    - Lacks automation, less manual effort
    - Story oversimplifies
    - Story assumes magical interoperability, unreasonable assumptions about data
    - Manual entry of occupancy problematic
    - Does owner really know his needs, benefits and KPIs?
- Vision should not require gateway application
    - System should be enabled to provide data for these purposes
- Security cannot be based on “vendor says”.
- System monitoring and energy performance suggestions in paragraph 4
    - Some things correctly involve BO but others should not
    - Should be configurable
    - Should provide indirect detection techniques in addition to direct
- Story needs more detail on what results are presented to user
- Vision should mention metadata to auto build a model

    - Efficacy of building model is dependent on available metadata
    - Needed to achieve self-auditing based on energy data
- Vision presented by story will require more sensors than described
    - Tie into equipment performance models + data
- The following points are needed for successful technology deployment
    - Information model standards
    - Comfort/productivity/happiness measures
    - Monetization path
- Commissioning is essential to ensure system does what is expected and to enable story.
- Need buy-in and enforcement of specifications and requirements by entire value chain including owner and commissioning standards
- Building platform should allow independent app development
    - Open platform to other providers to add value
- Role of building owner's business processes is equally important
- Interoperability of user experience is important
- In an interoperability platform, need a way to control and confirm apps don't break things
- Need to address legacy system integration
- Need to ensure regulations support the necessary investment

Market Service Provider Response

- Vision suggests opportunities for "day trading" in the energy market
    - Relating to the stock market was well thought-out
    - But in buildings, many sunk costs compared to day trading
    - Does the same model apply to different building sizes?
    - Who is participating? Facility operators, renters, home owners?
- From the MSP perspective, aggregation makes it easier
- Story does not address:
    - State regulations. Does PURPA apply?
    - Contractual agreements
- Assumption that buildings are intelligent, story requires better monitoring, control capabilities
- Need for trust in "system"
    - True-up measurements could provide transparency
- How does facility person respond to "unexpected" results?
    - System needs to be auditable and provide real-time feedback
- Needed for successful technology deployment
    - High level of storage (even beyond traditional batteries)
    - Regulation of energy markets and market service provider
    - High level of interoperability
    - New tech development in modeling, communications, data analytics
    - Policy alignment
    - Economic alignment among parties. Inequity of benefits would hinder success.

Distribution Service Operations Response

- Does this story evoke a desired vision of a user interaction experience?
    - The building owner doesn't need to know they are participating as a spinning reserve
        - Keep rationale on each side opaque, but the interchange visible
    - There are complex liability issues for different cases:

        - Building owner downloads app and offers service
        - 3rd party service provider contracts with buildings to provide service
        - Distribution service operator installs app
- What types of user interactions do you foresee in the future?
    - Must be user friendly, esp. for small building owners with limited resources
    - User needs to understand the risks
    - System must allow exchange of internal and external inputs to building load
    - M&V (measurement and verification) must be delivered to distribution service operator and building owner
        - How are opt-outs dealt with, and is this different depending on who initiates them?
    - Cybersecurity is a major concern
        - Some information should not be shared with distribution service operator and vice-versa
- What is needed in a vision for successful technology deployment?
    - A mechanism to understand the app's past trends and performance
    - Vision must address complex issues
        - Liability
        - Cybersecurity
        - Data privacy
    - Distributed intelligence
    - Certain buildings may not be good candidates, need a way to screen for the 'right' assets

Session Topic 2: What are the interoperability attributes to consider?

Questions Posed

1. What attributes are desired to support an ecosystem of interoperable products and services?
    a. For apps and services to flourish?
    b. For interoperability testing, certification, branding?
2. What attributes are desired to establish the interaction agreements between parties?
    a. To define the information exchanged? Information models?
    b. To establish business processes (flow of interaction)?
3. What attributes are desired to simplify configuration and enable technology evolution?
    a. For discovering services/apps/resources/information models?
    b. To ensure scalability and migration to newer versions or technology?
    c. To identify, configure, and manage resources?
4. What attributes are desired to support security, privacy, and safety requirements?
    a. To identify and assess security risk?
    b. To establish and support privacy policies?
    c. To ensure safety under failure scenarios?
5. What attributes are desired to support reliable operation and performance?
    a. To define quality of service, time, and scheduling agreements?
    b. To define order, dependency, sequencing, and synchronization of time?

Building Internal Interaction Response

- Key attributes
    - Openness
        - Access to data

        - License free
        - Low barrier to expose data to end users
    - Standard information bus for different types of enterprises
    - Negotiated interface with security embedded
    - Universal interoperability over 5 dimensions
        - Building type, Device type, People (age, ability), Geography and Time
    - Standard way to recognize devices and apps
    - Easy to upgrade
- Interaction agreements between parties
    - Layers of responsibility
    - Clarity in data access and control
    - Set of necessary data that must be reported from systems and subsystems
- The market will answer a lot of these questions
    - Industry needs to see the value in playing nicely together
    - Industry usually gets a regulatory requirement, then collaborates on how that requirement will be met
- Incentivize a major player, so that the others will follow
    - Right now there is no economic incentive from the manufacturer perspective
- Virtuous cycle scenario – regulatory mandate reporting on a desired metric and an incentive to reach a desired level
- Path to pursue:
    - Making data accessible
    - Determining what data should be reported
    - Encourage interoperability through challenges like the DOE RTU challenge
    - Create an ecosystem transformation
    - Understand how open is pragmatic and necessary
    - Get the bigger companies to buy in
    - Make audit reporting necessary depending on who the interaction is with

Building Service Provider Response

- Attributes to support an ecosystem of interoperable products and services
    - Open protocols
    - Data semantics standard
    - Flexibility of what is automated and what requires user interaction
    - Market incentives
    - Ability for third parties to develop apps
    - Implementation of business process standards + transparency
    - Training/staffing of all parties in value chain
    - Clarity that interoperability will actually make things easier/better
    - Modularizing both components and functionalities
- Attributes to establish the interaction agreements between parties
    - Protocols and data models
    - Certification
    - Data management process protocols
    - Clarifying roles of BO and BSP
    - Service level agreements
    - Security
    - Privacy policies

- Attributes for simplifying configuration and enabling technology evolution
    - Tools that expose and advise what the products can do
    - Meta data standard
    - Build on accepted IT standards
    - Leveraging infrastructure investments for multiple services
    - Test beds, certification agency
    - CARFAX for buildings (supply the building's history)
    - BIM, COBie building design models bridge to operational models
    - Defining data categories and their value for other systems
    - Pushing more intelligence to the edge
- Attributes to support security, privacy, and safety requirements
    - IT type firewalls. Intrusion detection built into the systems
    - Independent testing
    - More IT knowledge in the entire value chain
    - IT needs more security knowledge
    - Local resilience/failover when intelligence is at the cloud
    - Business models that define and provide known benefits to share data
    - Improved clarity on privacy issues by data type
    - Unified regulatory framework
- Attributes to support reliable operation and performance
    - Resilience, islanding
    - Analytics/key performance indicators
    - Standard operating procedures, maintenance standards
    - Auditing (e.g., DR)
    - Protocol like OpenADR with confirmation of response
    - Access to external data sources relevant to operation and processes
    - Defining line/roles between network operating centers and in-building actions/services

Market Service Provider Response

- Attributes to support an ecosystem of interoperable products and services
    - Regulation requiring interoperable products
    - Customer-driven desire for interoperable products
    - Organized ecosystem and alliances among manufacturers and vendors
    - Clear value proposition for customers and vendors
    - Test and certification programs
- Attributes to establish the interaction agreements between parties
    - Test and certification program
    - Layering of interoperability stack
    - Open market for products and services
    - Standard, open interface to market
- Attributes for simplifying configuration and enabling technology evolution
    - SGIP IMM addresses many of these attributes
- Attributes to support security, privacy, and safety requirements
    - SGIP IMM CE goals address many of these attributes
    - Good use cases & requirements
    - Good industry standards & interoperable, low cost solutions
    - Compelling economic model and viable market mechanism
- Attributes to support reliable operation and performance

    - Large participation for aggregated load management
    - Flexibility for individual buildings to opt-out
    - Regulated markets will provide confidence to building owner

Distribution Service Operations Response

- Attributes to support an ecosystem of interoperable products and services
    - See SGIP IMM SS1-SS4 (security and safety attributes)
    - Exchange information such as power profile
    - Equitable method for base-lining that reduces gaming
- Attributes to establish the interaction agreements between parties
    - Standard way for building owner to indicate load flexibility
        - OpenADR might be an example
        - Standard non-proprietary protocol at the building edge
        - Building needs real-time meter data
        - Information model that can request
            - Amount of load
            - Duration of load change
            - Bids and offers (bi-directional market)
- Attributes for simplifying configuration and enabling technology evolution
    - "Smart Defaults"
    - Automatic tuning
    - High level of automation
        - Self-learning
        - Plug and play
        - Coordination of response between devices, buildings
- Attributes to support security, privacy, and safety requirements
    - See SGIP IMM SS1 for security
    - See SGIP IMM SS2 for privacy
    - See SGIP IMM SS3 for risk assessment and management
    - See SGIP IMM SS4 for auditing
- Attributes to support reliable operation and performance
    - Record keeping for auditing
    - Clear M&V metrics and mechanisms
    - Accurate sensing and measurements
    - Same meter and clock used between distribution service operator and building owner

Group Discussion Session

The meeting agenda concluded with a group discussion by all attendees. This session was intended to assist with the creation of a draft interoperability vision document outline. Questions posed during the session and the resulting responses are summarized below.

Group Session Topic 3 What should a buildings interoperability vision include?

Questions Posed

1. What major elements should the document include?
    a. Vision statement?
    b. Strategic Goals?
    c. Integration stories and use cases?

    d. Interoperability attributes and metrics?
2. What topics should be included for realizing this vision?
    a. Is this a pure technology play?
    b. Are there legal or regulatory policy barriers?
    c. What roadmap efforts/actions are needed to move towards the vision?
3. Who can help realize this future and what are their roles?
    a. What is government (DOE's and others) role?
    b. Industry/standards/testing associations?
    c. Other stakeholders?
4. Who else should be involved in the development of this vision/document?
    a. What organization or market player is not currently represented?

Discussion Summary

- Articulate a vision statement with objectives and desired outcomes
    - How do you measure success?
    - Consider 5 and 10 year goals
- Identify the audience, customer, user of the vision
    - Value propositions, open opportunities
- Emphasize distributed control first
- Anticipate arguments of naysayers
- User stories, but describe need and differences with use cases
- Building classifications with desired interoperability targets
- Interoperability metrics and assure they are measureable
    - Interoperability functional layers
    - Benchmarking process/service
    - Scalability – need simulation of scalability and demonstrations
    - User interface interoperability
- Heterogeneous technology mix with legacy investments must be accommodated
- Shared information model for buildings
- Education on interoperability for buildings needed
- Commitment to safety, cybersecurity and privacy issues
- Create a smart building index (like EnergyStar)
- Leverage expertise from other IT communities (IoT, IETF, W3C, etc.)
- Who needs to be involved?
    - Self-organizing associations, colleges, suppliers, owners/REITs, occupants, standards bodies, energy service providers
    - Encouraging government policy, states, clean-energy agencies, Corps of Engineers has interop specs
- Marketing and promotion needs to be part of the plan

Vision Outline Draft Contents

The previous section summarized the comments on the topics that a buildings interoperability vision should cover. This section is a *preliminary* synthesis of that information to begin to structure an outline for such a vision document. This is only a draft that will be refined with further discussions over time, but it represents a start to solicit additional comment and thoughts.

- Why do we need a vision document: background and context
    - National strategy for buildings interoperability purpose and objectives
    - National vision effort as step to support interoperability roadmap development
    - Audience for the document
        - Customer and user of the vision
        - Audience value propositions
        - Open opportunities
- The future of buildings interoperability
    - Buildings interoperability vision statement
    - Vision Objectives
        - Desired outcomes
        - Measuring success
        - 3, 5, and 10 year goals
    - Building classifications with desired interoperability targets
- Interoperability background
    - Principles, concepts, definitions (to ensure agreement)
        - Boundaries of responsibilities
        - Distributed coordination and control
    - Framework for buildings interoperability
    - Challenges for advancing buildings interoperability
        - Anticipate arguments of naysayers
    - Value propositions
- Integration stories
    - Illustrate interoperability need
    - Describe difference with formal use cases
- Interoperability requirements
    - Metrics and assure they are measureable
        - Scalability – need simulation of scalability and demonstrations
        - User interface interoperability
        - Heterogeneous technology mix with legacy investments must be accommodated
        - Shared information model for buildings
    - Benchmarking process/service
    - Commitment to safety, cybersecurity and privacy issues
- Topics to address in a buildings interoperability roadmap
    - US government roles and responsibilities
    - Stakeholder engagement
        - Self-organizing associations, colleges, suppliers, owners/REITs, occupants, standards bodies, energy service providers
        - Encouraging government policy, states, clean-energy agencies, federal facility interoperability specifications
        - How might they engage?
    - Education on interoperability for buildings needed

        - Leverage expertise from information technology communities (IoT, IETF, W3C, etc.)
    - Marketing and promotion needs to be part of the roadmap
        - Create a smart building index (like EnergyStar)
    - Reference implementations
        - Describe the role that early examples of integration methods can play to demonstrate the types of interoperable interactions supported in the vision

Next Steps

The information collected from the Buildings Interoperability Vision Meeting produced contents and a direction for developing a vision document. The information captured in these proceedings is distributed to the meeting attendees for their review and comments so participants have an opportunity to clarify or correct the information reported. In addition, the proceedings will be distributed to the other parties we reached out to for engagement in this topic and who indicated their interest in this work and their potential future involvement. Finally, the proceedings and copies of the presentations from the meeting are available on the Energy.Gov website http://energy.gov/eere/buildings/buildings-grid-integration so others who may become interested in this topic have the material to examine what we discussed and become involved. We encourage you to share this material with your colleagues who you think could benefit from knowledge or involvement in this work.

At the meeting, the participants were encouraged to review the Buildings Interoperability Landscape draft document. We have begun to receive comments on this document and intend to issue a revised version in the coming months based on those comments and things that we learned from stakeholder engagement.

Education about interoperability and the reasons to address this topic is an important message from the meeting:

- Why is interoperability important?
- What are its benefits and to whom do they accrue?
- What can be done to advance simple and reliable integration of connected equipment and interactions with other parties outside the building?

To help address this issue and reach a wider audience, we intend to hold a webinar on interoperability for buildings that will include important points from the meeting.

Lastly, we intend to begin the effort to draft a buildings interoperability vision document. The outline created above is already a step in this effort. We intend to call upon those who volunteered to help in this work and expect to submit the resulting material for review by the meeting attendees and other interested parties. The vision document will help launch us on a course for developing a roadmap for a National Strategy for Connected Equipment that identifies the near, medium, and longer-term actions and roles that everyone can use to advance the nation towards an interoperable future.