



## GRIDWISE ARCHITECTURE COUNCIL POLICY TEAM

### INTRODUCTION TO INTEROPERABILITY AND DECISION-MAKER'S INTEROPERABILITY CHECKLIST VERSION 1.5

#### INTRODUCTION TO INTEROPERABILITY

Historically, progress occurs when many entities communicate, share information, and together create something that no one individual could do alone. Moving beyond people to machines and systems, *interoperability* is the capability of systems or units to provide and receive services and information between each other, and to use the services and information exchanged to operate effectively together in predictable ways without significant user intervention. *When people talk about the “modern” or “smart” grid, interoperability is a necessary foundation of that concept.* Within the electricity system, interoperability means the seamless, end-to-end connectivity of hardware and software from the customers’ appliances all the way through the T&D system to the power source, enhancing the coordination of energy flows with real-time flows of information and analysis.

As telecommunications and banking illustrate, interoperability is a necessary platform for innovation of services and technologies that create new value for users. Consider telecommunications as an interoperable system. Once upon a time, there was the black rotary phone and one telephone company. Today 75% of American adults have a cell phone and use such devices to take pictures, listen to music, handle e-mail, watch a video, surf the Web, play games, vote for an American Idol – and even talk on the phone. Data traffic dwarfs voice traffic over the world’s telecommunications systems, and 73% of adult Americans use the Internet. All this happened not because some early visionaries preached “convergence,” but because the telephone companies needed common information protocols and architectures to exchange information more effectively across the phone network.

Interoperability has important economic consequences. *Systems with high interoperability have lower equipment costs and lower transactions costs, higher productivity through automation, more conversion of data and information into insight,* higher competition between equipment suppliers, and more innovation of both technology and applications. Those systems grow faster, use resources more efficiently, and create more value for their users. Such systems consistently prove that interoperability and standards enhance users’ choices, because those requirements create a framework within which vendors and competitors can innovate – as long as the finished products perform the needed functions and exchange data with other, related products.

Once interoperability has been established and implemented, users can choose between features (e.g., a camera or MP3 player in a cell phone) and vendors rather than technologies (e.g., Beta v. VHS, CD+ v. CD-ROM, cable v. satellite v. broadcast TV), because they know the devices will communicate and work together in predictable ways. Such devices can often be updated and upgraded (as through remote reprogramming of firmware and software to increase functionality or modify instructions) without becoming obsolete.

There are three types of interoperability. *Technical interoperability* covers the physical and communications connections between and among devices or systems (e.g., power plugs and USB ports). *Informational interoperability* covers the content, semantics and format for data or instructions flows (such as the accepted meanings of human or computer languages and common symbols). *Organizational interoperability* covers

the relationships between organizations and individuals and their parts of the system, including business relationships (such as contracts, ownership, and market structures) and legal relationships (e.g., regulatory structures and requirements, and protection of physical and intellectual property). All three types must be addressed to achieve effective interoperability in any system.

Creation of an interoperability platform for the grid will liberate and enable innovations and services that leverage today's electric system and add value while driving down the costs of electricity use in the decades ahead.

## **Interoperability and the Electric System**

What can interoperability do for the electric system? Advanced communication and information technology can connect together the whole power system, better integrating the parties in the network and improving energy flows. These richer information connections will produce a more efficient, resilient and reliable grid, and more robust competitive markets, enabled in part by better interaction and collaboration between power users and power suppliers.

***Interoperability will improve grid reliability*** by collecting more useful information and transferring it to operators and equipment to improve and protect grid operations. Interoperability and better data flows between transmission and generation devices -- complemented by better monitoring, communications and control systems and power management devices -- can provide timely, automatic, and seamless ways to operate the grid to deliver more energy more efficiently under normal and adverse conditions. This will reduce the need for drastic actions like involuntary load shedding and lower the risk of blackouts.

Within the power system, achieving and exploiting the benefits of interoperability from the end user to the power plant to the grid operator's control room will require collecting and using information better, expanding interconnectivity (the flow of information and instructions between participants and their devices), and more automation (building more capability for electronic analysis, operations and control into the transmission and distribution system). The greatest impact from interoperability will occur when these communications and automation flow down from the grid to energy users and their buildings and equipment, enabling automatic interaction between energy uses and the electric grid.

***Interoperability down to the consumer and energy-using buildings and equipment – facilitated by making real-time electricity prices accessible to users -- will improve market operations*** by letting users react to electricity prices and grid conditions, reducing energy use when prices are highest or supply is tightest. This will lower consumers' electricity costs and improve service reliability and quality, while lowering costs and risks to wholesale power purchasers. It will also enable easier integration of renewable resources and distributed generation and storage, and simplify potential transformations such as those possible from widespread use of plug-in hybrid vehicles.

Over time, ***interoperability and integration will lower grid capital costs*** by using information to leverage and fine-tune capital investments. Utilities and grid operators will be able to use the information richness from advanced metering, customer data management systems, demand response and transmission and distribution automation to better size a new distribution or transmission line, precisely manage customer loads on hot days to protect heavily loaded distribution or transmission transformers, displace costly reliability-must-run generation for voltage support, and identify pre-blackout conditions and prevent a grid failure – all exploiting information and information technology to use conventional grid assets more effectively. Grid operational costs will fall as smart devices leveraging information technology and advanced electronics will soon perform the same tasks at lower costs and higher speeds than electromechanical devices, and they will be more easily integrated without costly rework when they are all designed to be interoperable.

***But interoperability doesn't just happen, it takes work.*** Underlying every interoperable system is hard work by many people over many years to converge around a common vision of the value of an interoperable system, develop common principles and architecture for the bones of the system and some early applications goals, agree to common information protocols and device identification -- and eventually, converge around the detailed standards that express and implement all of these things.

Recent predictions suggest that the U.S. electric industry will invest \$300 billion in new T&D facilities (including advanced meters) over the next decade, and \$400 billion in new power plants over the next 25 years. If we start now, we can build interoperability principles and capabilities into those investments and hasten the improvements in reliability, costs, innovation and value that interoperability can deliver. If we do not, more resources will be wasted, more assets stranded, and reliability threatened by our failure to move ahead with grid modernization and interoperability.

## THE GRIDWISE ARCHITECTURE COUNCIL

The GridWise Architecture Council (GWAC) is dedicated to the development and implementation of interoperability principles and standards for the modernization of the electric power network. The GWAC is a group of cross-industry experts formed by the U.S. Department of Energy, representing organizations across the sector including utilities, B2B (business to business electronic communications), utility software, demand response, building automation, information technology, academia, and more across the electricity value chain. The 13 GWAC members are volunteers and receive staff support from the Pacific Northwest National Laboratory.

Unlike other grid modernization proponents, the GWAC focuses only on interoperability principles and architectural frameworks to facilitate the smart grid. One of the GWAC's roles is to help key stakeholders understand these principles and to provide resources that facilitate development of an interoperable, modern, smart, electric power network that enables end-users and their energy facilities to become collaborators with suppliers in the grid's reliable, affordable operation.

## DECISION-MAKER'S INTEROPERABILITY CHECKLIST

The Decision-Maker's Interoperability Checklist is a tool to help regulatory and utility decision-makers evaluate options such as capital asset investments or new information technology opportunities to determine whether they have the characteristics and attributes that contribute to interoperability – i.e., facilitate and enhance the transactions and flows of energy, information and money across the electric grid, from electricity use through delivery to production. Decision-makers can use the checklist to review electricity-related policy or asset investment proposals, including the purchase of new distribution and transmission equipment, the specification of advanced meters, the design of a new demand response or distributed generation program, grid automation and SCADA (Supervisory Control and Data Acquisition system), the adoption of new energy end-use devices, system software, or the adoption of new market protocols.

*In every question on the checklist, an answer of Yes means that the project has an intent of advancing interoperability along the dimension outlined in that question; an answer of No or I Don't Know means that it may be possible to improve the proposal by modifying it to better address that interoperability criterion.*

*This checklist is a starting point for interoperability, not an end-point.* Regulators and utility managers are encouraged to learn more about interoperability and to scrutinize investment proposals more deeply after reviewing them against the points below. Several references are offered at the end of this paper, and the GWAC is working with industry members to articulate the technical details of the interoperability framework. Good work on interoperability and grid modernization is also available from companion organizations such as the EPRI Intelligrid, the Galvin Initiative, and DOE's Modern Grid Initiative.

*Given the nascent state of Smart Grid standards and interoperability,* it may be prudent for decision-makers to ask further questions aimed at understanding the reality of the asserted conformance to standards and interoperability. The Supplemental Interoperability Checklist includes a good starting point for further questions about the claims of interoperability aimed at utilities and their vendors.

## THE INTEROPERABILITY CHECKLIST

### Architecture and design

- 1) Does the proposal specify the points of interface, where this part of the system interacts with other elements (whether that interaction is with grid equipment, software, the market, other business

**organizations, or human users or operators)? Does the proposal lay out what information or functionality will flow across these interfaces? Does the proposal specify technology and information requirements only at the points of interface (and not inside the subsystem at issue)?**

Clarity about how things fit together at the interfaces within a system is crucial to avoid over-specifying or crushing innovation and competition for the elements inside or on either side of the interfaces. This allows designers and vendors to lower the cost of system integration; with the proper functional specifications and appropriate enabling technologies, it can even enable “plug and play” relationships (which require a higher degree of interoperability).

**2) Does the device/project use an open architecture?**

An open architecture is publicly known, so any and all vendors can build hardware or software that fits within that architecture, and the architecture stands outside the control of any single individual or group of vendors. In contrast, a closed architecture is vendor-specific and proprietary, and blocks other vendors from adoption. An open architecture encourages multi-vendor competition because every vendor has the opportunity to build interchangeable hardware or software that works with other elements within the system.

**3) Does the proposal maintain technology neutrality, in that it specifies performance results and outcome requirements rather than prescribing a specific technology or method to achieve those results?**

This allows vendors to innovate and compete by developing and improving technologies, which can create significant opportunities for new value.

**4) Can the device or project be supplied by multiple vendors?**

Competition between vendors encourages innovation in features and performance while driving down costs. This also reduces the likelihood that the buyer will become captive to “vendor lock-in” or that the system will be stranded if the vendor stops supporting the device.

**5) Does the system or device rely on open, published standards? Does the device or project connect to the electric system and communications network elements in ways that comply with applicable national or international standards for its type?**

Organizations promulgating relevant standards include ASHRAE, the IEC and ISO, NERC, IEEE, and industrial consortia such as OpenAMI, BACnet, ANSI, and EICTA.

Interconnectivity and security

**6) Does the device have the physical and electronic capability to interconnect with communications media (e.g., serial data ports or broadcast capabilities to access Ethernet or telecom lines or other communications capabilities)? Can the communications networks used by the system or device coexist or exchange data with the networks used by other devices or systems, built by other vendors or electricity providers?**

As communications technologies and protocols evolve, every device must have the ability and embedded intelligence for two-way data exchange with the rest of the system using more than one communications method.

**7) Does the device/project use standard communications protocols? Is there a single standard specification for the data formats (the information model) used by the system or device so it can be understood by a variety of communications technologies and devices?**

For data and meaning to flow effectively and be actionable, all of the related devices and systems must be able to understand its language and meaning. Communications protocols commonly used in the electric and related industries include Modbus, DNP3, and IEC 61850-8-1. Common information models include IEC 61968/61970 (the CIM) and IEC 61850-7.

**8) Does the device or system make basic data or information available to all authorized devices and users, such as energy usage and costs over metered intervals, grid condition metrics, or operational instructions?**

As information is made more widely available, it often creates greater insight and value for the networked

community of users. Flexibility in the types of data and information that can be recognized and used is valuable because system needs and capabilities evolve over time.

- 9) **Can the system manage multiple devices (or influence multiple users) within the system using a common command or information feed from a central source?**  
This promotes greater efficiency and speed of action and response.
- 10) **Does the device/project use at least the basic cyber-security measures as recommended by the NERC Critical Infrastructure Protection standards? Does the device/project follow industry consortia (e.g. UtilityAMI, CEC PCT Reference Design) security and privacy recommendations?**  
As grid interconnectivity and interdependence increases, the grid becomes more vulnerable to threats from the failure of its information technology nervous system. This means that every element of the grid must incorporate cyber-security protections. Privacy protections are necessary to protect users' and grid entities' information and identities.
- 11) **If the device or system is mission-critical to the delivery of electricity or the well-being of the user, does it have sufficient redundancy or design to fail in a way that does not harm the system or the user?**  
As collaboration and interconnectedness between grid elements increases, we must make sure that the failure of one device does not overly compromise the rest of the system.

#### Evolutionary capability and service life

- 12) **Can the device be updated or have its functionalities upgraded by downloading new software and configuration information?**  
A device that lacks built-in intelligence, upgradeability, and connectivity and requires physical modification, whether to replace a chip-set or bolt on new equipment, is more difficult and more costly to upgrade and is likely to become obsolete and "stranded" faster.
- 13) **Can the device or project integrate easily with earlier versions and equipment on the system?**  
A device that can work with legacy installed equipment and systems (as long as they are worth maintaining and upgrading) will help to extract continuing value from the legacy base, while laying the foundation for other new equipment and systems to upgrade their capabilities over time.

#### Collaborator independence

- 14) **Does the device or project allow collaborators or users to make independent decisions (within defined parameters such as contractual provisions, NAESB wholesale agreements, electric market rules, or tariff)?**  
As the complexity of the electricity system grows, most interactions and transactions will require willing, consensual partners rather than command-and-control relationships. Therefore, it should allow users and other collaborators to modify automatic responses by user over-rides or permissions.

#### Supplemental Decision-Makers Interoperability Checklist

The questions below are intended to be used to probe proposals to deepen the understanding of the commitment to interoperability and claims of conformance and interoperability. As Smart Grid standards and technologies mature, the need for such additional probing will decline. But almost all projects today face major hurdles and costs to achieving interoperability. The risks are significant that projects will be more expensive and take longer than planned. Probing the issues around interoperability can illuminate these risks and lead to revisions to the plans and proposals that will end up being more accurate.

***For Utilities***, key supplemental questions include:

- 1) **Does utility subscribe to the Interoperability Framework of the GridWise Architecture Council?**  
Evidence of such commitment shows that the organization is at least aware of and supports interoperability as a

key factor enabling future Smart Grid implementations. Asking for specific evidence – e.g. such as attendance at a GWAC meeting, internal minutes adopting the Framework or some other evidence that is has been reviewed and adopted internally – will quickly reveal the level of commitment to interoperability principals.

- 2) **Does the utility support, participate and follow the recommendations of the NIST Smart Grid Interoperability Panel (SGIP)?** NIST is charged by the US Congress with establishing Smart Grid Interoperability Standards and is doing so through the industry activity known as the SGIP. Membership is currently free and active members can both influence the adoption of industry standards and maintain up-to-date awareness of the status of Smart Grid standards. Smaller utilities could gain the benefits of membership through their industry associations if they are active in the SGIP. Commitment of resources to participate in the SGIP is another indicator of commitment to Smart Grid interoperability.
- 3) **Has the utility adopted requirements for meeting specific open interoperability standards?** Does the utility require vendors to conform to these standards in their proposed products? Asking for specific evidence of such requirements – e.g., RFP mandated requirements or general RFP guidelines used for acquiring grid assets – will quickly reveal whether the organization is following through on its commitment to interoperability.
- 4) **Where national standards are not yet adopted – e.g., OpenADR – how does the utility support adoption of a standard?** Do they belong to the standards working groups? Are they active in them? Which ones? The level and internal reputation of those assigned to further the standards efforts tells a lot about the organizations' commitment to implementing open, interoperable Smart Grid standard technologies. Smaller utilities could encourage their industry associations to participate in the standardization efforts.
- 5) **When specifying standards, how does the utility deal with optional and proprietary extensions that could render a product non-operable with other products?** Most adopted standards allow for optional features that can render otherwise interoperable components non-operable. How well an organization deals with this issue is indicative of the level of sophistication they it brings to the challenge of interoperability.
- 6) **When requesting proposals for grid components does the utility look for at least two competing and comparable solutions that claim to meet the same standards?** Further, do they have an efficient method for validating the claimed interchangeability of the products? Until Smart Grid products can be easily substituted for one another the promise of lower costs through competition among vendors will not be realized.
- 7) **What does a utility do when only one vendor exists for a particular solution?** If possible, does the utility re-design the project so that each component can be supplied by multiple vendors? Do they actively cultivate competition when a re-design is not feasible? Simply accepting that only one vendor can supply a critical project component furthers the status quo of expensive, non-interoperable one-of-a-kind solutions. The benefits that Smart Grid interoperability can achieve won't be realized if utilities continue to accept unique, non-standard solutions.
- 8) **How does a utility validate claims of conformance to specified open standards?** Does it require evidence from vendors such as a recognized independent certification? Do they perform internal validation testing? Do they contract with a third party to do validation testing? How they do the validation is not nearly as important as the insistence that conformance and interoperability claims are validated.
- 9) **What do they do if the testing shows a lack of conformance to the claimed standard?** Setting clear conformance and interoperability standards is critical. Just as critical is holding vendors accountable for meeting those standards. This might be done through withholding partial payments until a conformance or certification test is passed or the product meets internal testing criteria. Alternatively, products can be rejected from a bid outright until they meet the specified standards and interoperability requirements.
- 10) **How does the utility plan for evolution of adopted standards?** Is there an intentional feedback mechanism to the Standards Setting Organization (SSO) for improvement? This is part of the overall commitment to furthering interoperability of Smart Grid technology. An active feedback loop to the SSO can have a significant impact on standards development. Planning for and achieving active feedback to the SSO responsible for a standard is evidence of both a sophisticated and committed organization relative to Smart Grid interoperability.

The supplemental questions for *vendors* (by utilities) are similar:

- 1) **Does the vendor subscribe to the Interoperability Framework of the GridWise Architecture Council?** Evidence of such commitment shows at least that the organization is aware of and supports interoperability as a key enabling factor in future Smart Grid implementations. Asking for specific evidence –e.g. such as attendance at a GWAC meeting, internal minutes adopting the Framework or some other means of showing that

is has been reviewed and adopted internally – will quickly reveal the level of commitment to interoperability principals.

- 2) **Does the vendor support and participate in the NIST Smart Grid Interoperability Panel (SGIP)?** NIST is charged by the US Congress with establishing Smart Grid Interoperability Standards and is doing so through the industry activity known as the SGIP. Membership is currently free and active members can both influence the adoption of industry standards and maintain up-to-date awareness of the status of Smart Grid standards. Smaller vendors could gain the benefits of membership through their industry associations if they are active in the SGIP. Commitment of resources to participate in the SGIP is another indicator of commitment to Smart Grid interoperability.
- 3) **Which Smart Grid Interoperability Standards does the vendor Support and Implement in their Products?** The focus of a specific project will only be on a few specific standards. Insuring the vendor supports and implements those standards should be a standard part of an acquisition process.
- 4) **What specific aspects of the vendor's offerings further the interoperability goals of the industry?** Vendors can support the industry interoperability goals both organizationally and with product architecture. Questions about commitment and the level of staff involved with national and international standards illuminate the overall commitment to interoperability. Product architecture can support or hinder interoperability speed and quality. For instance, software architectures that separate communications or interface functions from internal functionality should be faster and cheaper to adapt to changes in standards. Also, hardware architectures with easily re-programmed or replaced controller and interface modules can enhance progress towards interoperability.
- 4) **Where national standards are not yet adopted – e.g., OpenADR – how does the vendor support adoption of a standard?** Do they belong to the standards working groups? Are they active in them? Which ones? The level and internal reputation of those assigned to further the standards efforts tells a lot about the organizations' commitment to implementing the Smart Grid.
- 5) **When implementing standards, how does the vendor deal with optional and proprietary extensions that could render a product inoperable with other products?** Most adopted standards allow for optional features that can render otherwise interoperable components inoperable. How a vendor implements the standard can either enhance or inhibit interoperability. Decision-makers may well want to look for commitments to insuring that a product will interoperate easily with any other product that conforms to the standard.
- 6) **When standardization is not possible, does the vendor make available interfaces of their products under a reasonable licensing agreement to encourage interoperability?** Even when a vendor uses a proprietary interface, they can encourage interoperability by licensing the interface specification to other vendors in the field. This encourages interoperability and allows the vendor to build an eco-system around their products.
- 7) **How does the vendor enhance or inhibit competition for its products?** While successful vendors have a strong incentive to insure that their offerings are unique, the most successful ones recognize that being the first to develop products based on standardized, open technology yields far greater benefits than resisting competition. These companies implement new technologies that becomes de facto and then adopted standards for the industry – e.g., Microsoft, HP, Google, IBM, etc.
- 8) **How does a vendor validate claims of conformance to specified open standards?** Do they submit their products for recognized independent certification? Do they perform internal validation testing using industry-standard tests? Do they contract with a third party to do validation testing? How they do the validation is not nearly as important as the insistence that claims of conformance and interoperability are supported by valid evidence.
- 9) **What do they do if the testing shows a lack of conformance to the claimed standard?** Setting clear conformance and interoperability standards is critical. Do vendors deliver products that are not thoroughly tested and certified to the standard? Do they offer strong commitments to correct interoperability issues based on the industry-standard tests and criteria for interoperability? Vendors should expect their customers to demand conformance and interoperability and should be aggressively pursuing such before having to be asked by their customers.
- 10) **How does the vendor plan for evolution of adopted standards?** Is there an intentional feedback mechanism to the Standards Setting Organization (SSO) for improvement? This is part of the overall commitment to furthering interoperability of Smart Grid technology. An active feedback loop to the SSO can have a significant impact on standards development. Planning for and achieving active feedback to the SSO responsible for a standard is evidence of both a sophisticated and committed organization relative to Smart Grid interoperability.

**References:**

- EICTA, “EICTA Interoperability White Paper”, 2005.
- EICTA, “EICTA White Paper on Standardisation and Interoperability”, November 2006.
- EnerNex Corporation, “Advanced Metering and Demand Responsive Infrastructure: A Summary of the PIER/CEC Reference Design, Related Research and Key Findings,” Draft Report prepared for the California Energy Commission, June 1, 2005.
- GridWise Architecture Council website, <http://www.gridwiseac.org/>
- GridWise Architecture Council Interoperability Constitution White Paper (November 2005),  
[http://www.gridwiseac.org/pdfs/constitution\\_whitepaper\\_v1\\_1.pdf](http://www.gridwiseac.org/pdfs/constitution_whitepaper_v1_1.pdf)
- GridWise Architecture Council, Interoperability Path Forward White Paper (November 2005),  
[http://www.gridwiseac.org/pdfs/interoperability\\_path\\_whitepaper\\_v1\\_0.pdf](http://www.gridwiseac.org/pdfs/interoperability_path_whitepaper_v1_0.pdf)
- GridWise Architecture Council Interoperability Context-Setting Framework Draft (January 2007),  
[http://www.gridwiseac.org/pdfs/interopframework\\_v05%20070129.pdf](http://www.gridwiseac.org/pdfs/interopframework_v05%20070129.pdf)
- QualityLogic, Inc., “Verifying Interoperability Claims”, presented at Connectivity Week, May 2009
- QualityLogic, Inc., “GWAC Decision Makers Checklist – Proposed Additions” (June 2009), presented to GridWise Artchitecture Council

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