Smart Grid Standards Adoption
Utility Industry Perspective

1. Summary

Across the United States many utilities have already or are in the process of implementing smart technologies into their transmission, distribution and customer systems based on several factors such as implementing legislative and regulatory policy, realizing operational efficiencies, and creating customer value. Smart Grid value realization by utility customers and society at large is, in part, linked to the pace of technology implementation that enables a secure, smart and fully connected electric grid. Utilities agree that the development and adoption of open standards to ensure interoperability and security are essential for a smart grid. In many cases, utilities have defined open standards in the requirements for smart technology. As noted futurist, Bill Gibson said, "the future is already here, it just isn't evenly distributed".

The smart grid is broad in its scope, so the potential standards landscape is also very large and complex. This is why "standards" adoption has become a challenge. However, the opportunity today is that utilities, vendors and policy makers are actively engaged. And, there are mature standards that are applicable and much work on emerging standards and cyber-security can be leveraged. Technology is not the barrier to adoption. The fundamental issue is organization and prioritization to focus on those first aspects that provide the greatest customer benefit toward the goal of achieving an interoperable and secure smart grid.

The basic challenges with accelerating Smart Grid standards adoption are;

a) The number of stakeholders, range of considerations and applicable standards are very large and complex which ***requires a formal governance structure at a national level involving both government and industry, with associated formal processes to prioritize and oversee the highest value tasks***.

b) The smart grid implementation has already started, and will be implemented as an "evolution" of successive projects over a decade or more. ***Standards adoption must consider the current state of deployment, development in progress and vendor product development lifecycles.***

c) Interoperability is generally being discussed too broadly and should be considered in two basic ways, with a ***focus placed on prioritization and acceleration of the adoption of "inter-system" standards***.

The primary issue is not that applicable, mature standards do not exist but rather how to get all the stakeholders focused on quickly prioritizing, adopting and implementing Smart Grid interoperability standards across such a broad and complex technical landscape with

many projects already underway. The utility industry and regulatory bodies recognize that the Smart Grid vision changes this operating premise and are collectively addressing interoperability standards issues through workgroups such as the GridWise Architecture Council and Open Smart Grid (OpenSG) Subcommittee of the Utility Communications Architecture International Users Group (UCAIug) as well as through policy action such as the National Institute of Science and Technology's (NIST) tasks under the 2007 Energy Independence and Security Act.

This paper proposes to accelerate Smart Grid standards adoption through four primary recommendations:

- NIST should immediately establish a more formal governance structure and related processes to prioritize Smart Grid standards selection and ensure an open unbiased process including key stakeholders.

- In 2009, Smart Grid standards should be selected for the following areas that can leverage existing standards to create significant value:
  - Common Information Model standards
  - Security standard applicable across inter-system interfaces
  - Inter-system boundary interface standards
  - Interoperable communications standards based on Internet or other open protocols and standards as applicable

- The Smart Grid standards selection process should follow four principles, Openness, Separation of Duties, Generational Compliance, and Loose Coupling for the purpose of creating a sustainable standards policy.

- Smart Grid certification guidelines for interoperability should be established. The guidelines should include mechanisms for interoperability enforcement and where appropriate leverage commercial certification activities.

2. Standards Evolution as the Grid Evolves

The grid will become “smarter” and more capable over time and the supporting standards must also evolve to support higher degrees of interoperability enabling more advanced capabilities over time. The implication of the smart grid evolution for standards adoption is that at any point in time the industry will be characterized by a mix of no/old technology, last generation smart technology, current generation smart technology and “greenfield” technology opportunities. Smart grid implementation is an evolutionary process involving long project development life cycles from regulatory approvals through engineering and deployment. Given that technology life cycles are much shorter than the regulatory-to-deployment cycle, it is very likely that the grid will continuously evolve in the degree to which intelligence is both incorporated and leveraged.

The issue of evolution is particularly important because investments are a continuum based on policy imperatives, system reliability and creating customer value. Policy makers and utilities must balance these considerations regarding certain Smart Grid investments before a complete set of standards has been adopted and customer benefit dictates moving forward. In a number of instances across the nation, utilities and regulators have given much thought to balancing accelerating customer benefits, project cost-effectiveness and managing emerging technology risks. While there is no single “silver standards bullet” for legacy and projects currently in development, projects that are in the customers’ and public policy interest should proceed. However, not having clear standards going forward compounds the technology obsolescence risk – concrete action is needed in 2009 to standardize a few key aspects.

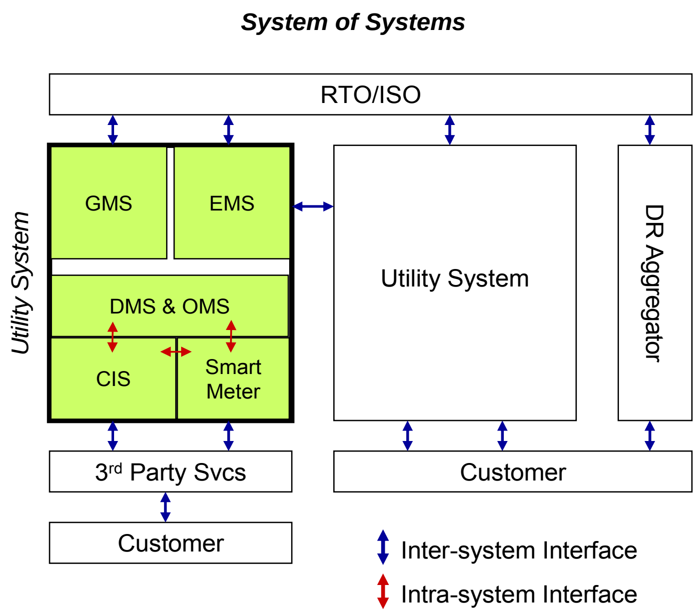
There is no technical reason to attempt to standardize all aspects of the Smart Grid today, if engineered and designed correctly. Nor is it likely possible given the lack of clear definition of all the elements and uses of the smart grid and complexity given the number of systems involved. Smart Grid systems architected appropriately should be able to accept updated and new standards as they progress assuming the following standards evolution principles are recognized:

- Interoperability must be adopted as a design goal, regardless of the current state of standards
- Interoperability through standards must be viewed as a continuum
- Successive product generations must incorporate standards to realize interoperability value
- Smart Grid technology roadmaps must consider each product’s role in the overall system and select standards compliant commercial products accordingly
- Standards compliance testing to ensure common interpretation of standards is required

These principles are being followed by many utilities implementing smart grid systems today by requiring capabilities such as remote device upgradability, support for robust system-wide security and identifying key boundaries of interoperability to preserve the ability of Smart Grid investments to evolve to satisfy increasingly advanced capabilities.

Determining what activities to prioritize and which Smart Grid standards to adopt and implement requires understanding the capabilities the standard supports in the context of the overall system. The Smart Grid is comprised of both a “utility system” which is composed of many individual systems including transmission, distribution and customer systems within the utility, other entity systems comprised of the many unique customer systems, services provider systems, systems and resources supplier systems and an overall macro-system such as a wide area control system and RTO/ISO systems. As these “utility systems”, other entity systems and macro-systems are linked the result is a “System of Systems”, illustrated in figure 1 below.

Figure 1. Smart Grid Systems of Systems



It is important to distinguish interfaces between the various systems (“inter-system[1]”) and those within a utility system (“intra-system[2]”) as **the most significant customer value to be derived from standards application in interoperability is with “inter-system” interfaces**.

To illustrate this point, let us look at just the customer facing elements of the smart grid and the opportunity to realize tremendous direct customer value from a few “inter-system” interface examples.

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[1] “inter-system” interfaces are those interfaces between the boundary of the utility’s transmission, distribution and customer systems and the boundary of another entity’s systems or devices (i.e., the interface between a utility meter and customer device, or between utility grid management system and RTO system)

[2] “intra-system” interfaces are those interfaces within the boundary of the utility’s system of transmission, distribution and customer systems (e.g., interface between utility meter and utility communication network or utility fault detector and distribution management system).

- Adopting an "inter-system" standard for the interface between the smart meter and Plug-in Electric Vehicle (PEV),
- A standard "inter-system" interface is needed for service providers to access customer data from utility back-office systems for web presentment through an application programming interface (API),
- Enabling in-home energy displays, energy smart appliances, smart thermostats and energy smart home automation involves "inter-system" standards adoption.

These three "inter-system" interfaces alone have the potential to enable a significant reduction in greenhouse gas emissions, reduce dependency on foreign oil for transportation and help utility customers save between 5-15%[3] on their monthly energy costs. Prioritizing standards adoption based on customer and societal value is paramount given the significant capital cost and implementation effort.

Accelerating Smart Grid standards adoption can be achieved by focusing industry efforts on the right tasks in the right order. A Systems Engineering[4] approach provides a formal, requirements-based method to decompose a complex "System of Systems", such as the Smart Grid, from a high inter-systems view through a very structured process to a lower intra-systems view. Applying systems engineering to Smart Grid capabilities and supporting standards reveals that it is more important to create a unifying design for the entire system operationally, than to focus on implementing individual elements at the risk of future systems operations. This means that **it isn't necessary to first resolve interoperability of "intra-system" interfaces within the utility's Smart Grid implementations before projects can proceed**. This is true, as long as the important "inter-system" boundaries are well understood and the following interoperability design concepts are preserved.

- Prioritization of interoperability
- Standard selection principles are followed
- Operational prioritization is understood

As the systems engineering process is applied to the development of the Smart Grid design, trade-off decisions must be made in selection of applicable standards, products (standards compliant vs. not), integration designs, schedule, product availability, cost and the need to enable the capability can be made. These value engineering activities must take the priority of preserving interoperability within the Smart Grid system design process into account.

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[3] Based on research conducted at Oxford University and referenced by the California Public Utilities Commission Division of Ratepayer Advocates

[4] The systems engineering methods as set forth in the Systems Engineering Handbook published by the International Council on Systems Engineering (INCOSE) as used by EPRI for the IntelliGrid project and various utilities' smart grid development efforts.

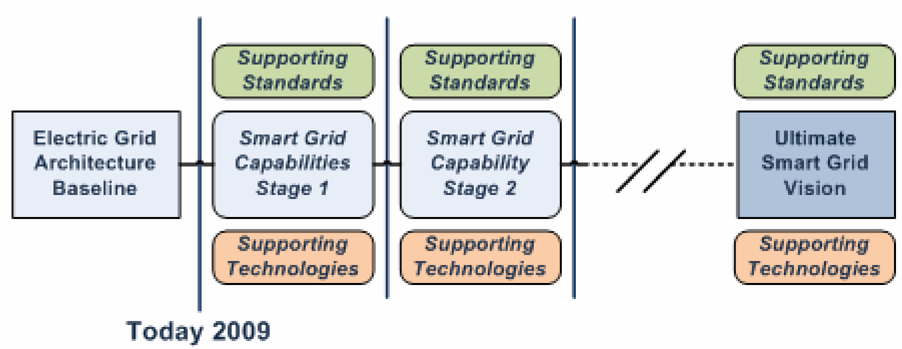
3. Standards Adoption Tasks

The application of the three stated principles; interoperability prioritization, standards prioritization and operational prioritization together produce a set of defendable recommendations. It should be noted that a significant amount of work has gone into various standards cataloging and frameworks by organizations such as Enernex[5], EPRI[6] and GWAC[7]. These catalogues are useful, and provide menus of available standards. Further, these catalogues and the GWAC framework provide general operational guidance on the applicability of a given standard for a given application. While this paper does not list standards it uses the prioritization principles, and makes specific recommendations to manage the process of accelerating the adoption of Smart Grid standards.

The principle of interoperability as a continuum recognizes existing investments, and realities associated with product development. Using this principle, Smart Grid related developments can be organized into stages. These temporal stages will have a set of specific interoperability goals. Stage one will focus on utility system to other entity's systems and macro-system interoperability. Later stages will focus on advancing intra-system interoperability within a utility system.

Figure 2 below shows the evolution of capabilities supported by equivalent evolutions in standards and technologies that enable the capabilities.

Figure 2. Smart Grid Standards Adoption Stages



The principle of selection prioritization builds on the principle of interoperability as a continuum and can be used as a ranking mechanism within a given stage. Stage one's

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[5] Smart Grid Standards Assessment and Recommendations for Adoption and Development, draft v0.82, Enernex for California Energy Commission, February, 2009

[6] EPRI Technical Report: Integration of Advanced Automation and Enterprise Information Infrastructures: Harmonization of IEC 61850 and IEC 61970/61968 Models, EPRI, Palo Alto, CA 2006. Product ID 1013802.

[7] GridWise Architecture Council Interoperability Context-Setting Framework, http://www.gridwiseac.org/pdfs/interopframework_v1_1.pdf

inter-system communication focus will require a set of interoperability standards. These standards should be a natural extension of the stakeholders needs and will require a set of formalized requirements with associated interoperability standards. EPRI's Intelligrid systems engineering based process which is now an IEC standard for capturing requirements for energy systems is a model that has been widely used by utilities and several states' efforts[8]. This formal requirements process can clearly identify high value technology applications and areas for standardization. The prioritization principle can be used both for requirements and standards selection.

Application interoperability typically involves several layers of standards. These layers of standards define the physical connectivity, transport and network interactions and the application information exchange. When needed, the principle of operational prioritization can be used to prioritize application development. Smart Grid applications have information which is specific to the operation the application is performing. There is data associated with these operations. When this data is used for command and control or information sharing, the specific format and content must be precisely defined. Standards associated with this definition are commonly referred to as Common Information Models (CIM) and should be prioritized by operational need. Certain Smart Grid capabilities that have higher priority and activities associated with interoperability of the supporting applications should be developed first.

Task One: Complete selections in 2009

The scope of task one is to complete the first stage of interoperability and security focused on inter-system interoperability or more generally stated, standards development activities that impact interoperability across parts of or all of the Smart Grid system. Specifically, using the standards selection criteria (standards prioritization) the following standards work should be the focus of stage one:

- Common Information Model standards (i.e. IEC 61970/61968/61850 CIMs)
- Security standard applicable across inter-system interfaces
- Inter-system boundary interface standards that cross discreet organizational entities (i.e. utility to distributed resources, utility to customer home area network devices, etc)
- Interoperable communications standards based on Internet or other open protocols and standards as applicable

The CIM provides a mechanism for standardizing interfaces between systems across an enterprise and can also be used for external system-to-system integration. In most system to system interoperability scenarios there exists an adequate transport mechanism such that the CIM standards application definitions will achieve interoperability.

[8] EPRI's systems engineering based approach utilizes use cases to initiate formal requirements development. The process has been widely used in the industry including Southern California Edison, Consumers Energy, Duke Energy, and the State of Illinois to name a few.

Where an adequate transport mechanism does not exist we recommend sourcing standards which are called out in the OpenSG Networking Guidelines Document, currently under development. Additionally, where overlap between standards is identified the standards development organizations themselves may harmonize the information models.

Security is also an important Stage One consideration. Smart grid applications place special emphasis on security as the creation of a ubiquitous communication system reaching the remote ends of the grid places the utility in completely new and unexplored territory. The utility will have millions of end points, direct and indirect control of load, and limited physical access control options on assets within easy reach of the bored, curious, and/or malicious adversary. The utility must incorporate an appropriate evaluation of security risk into its business models in order to adequately defend choices and decisions going forward. Further, the industry must use security solutions which are proven and allow utilities to implement robust products. The industry must move beyond "security via obscurity".

The risk management and systems engineering approach for security is comprised of three phases of work that together form an arc for problem solving in the complex environment. This approach is defined by the phases of reduction, decomposition, and direction. Execution of these phases provides the utility with a solid understanding of the problem space, comprehension of drivers and tendencies, and ultimately a means to control and navigate the territory.

Currently, there is a focused joint utility industry and Department of Energy effort on Smart Grid security underway. We recommend supporting these efforts and accelerating the production of deliverables. Specifically, Smart Grid security specifications should be completed through the following proven process:

1) Requirements documents are developed within a users group as opposed to a formal standards development organization, thus allowing rapid evolution of the requirements, and
2) Utilities form a collaborative task force with DoE to directly fund a group of subject matter experts to dedicate time to developing draft implementation standard proposals for adoption consideration under the proposed NIST led governance structure.

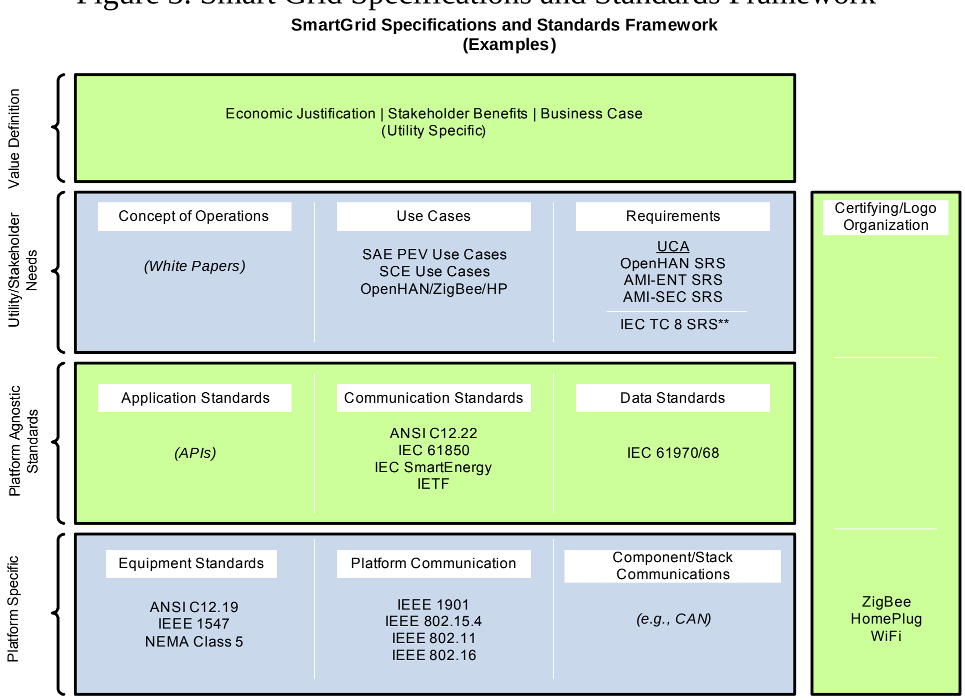
Many inter-system boundary interfaces are already clear and supported by existing standards. These are typically boundaries that cross organizations and require standardized interfaces. We recommend a process to evaluate existing interfaces to determine if they can be extended to support additional Smart Grid capabilities and ensure these standards are broadly formalized through a standards development organization.

Finally, a compliance program that ensures common interpretation of standards is required. Industry organizations are responsible for certification of products but industry lacks a common frame work and validation process. As a result many certifications do not guarantee interoperability across different vendor products. Smart Grid certification guidelines for interoperability should be established. The guidelines should include mechanisms for interoperability enforcement and where appropriate leverage commercial certification activities. An interoperability test lab, with associated certification through a Smart Grid Standards Group should be considered. This industry lab would include a national reference system for interoperable interfaces and audit process to set the expectation that products will be required to be certified and to align the industry on a common certification framework. The overall compliance effort will drive quality to vendor products, reduce product development and implementation costs, spur innovation and speed time to market.

Task Two: Continue development in 2009 with selections beginning in 2010

Task Two is focused on sustaining current standards development and supporting the development of intra-system interoperability and security for selection and adoption in Stage 2 beginning in 2010. As with Task One, security is a critical consideration for Task Two. Intra-system communication channels and points of interface are likely points of attack, and must receive strong scrutiny and guidance to enable system longevity. The process of intra-system standards selection and integration will take time. This is because implementation of smart grid technology within the utility system boundary is an evolutionary process involving long project development life cycles from regulatory approvals through engineering and deployment. However, without ongoing standards and industry compliance programs interoperability will not be achieved. The standards adoption and development process is underway and should yield initial results in 2010, but will also require prioritization leveraging a robust governance model using a comprehensive framework as shown in Figure 3 below to focus our resources on the minimum common set of standards activities to accelerate the process.

Figure 3. Smart Grid Specifications and Standards Framework



4. Governance and Formal Processes

To facilitate the acceleration of Smart Grid standards adoption an organized and structured governance model and related processes should be established by NIST to prioritize activities and ensure an open formal process including key stakeholders. Department of Energy (DoE) and NIST would provide joint oversight for this governance council.

The governance model for Smart Grid standards adoption should include a steering group of key stakeholder representatives, including utilities, RTOs/ISOs, and other key stakeholder segments to oversee the activities of the Domain Expert Working Groups (DEWGs). The DEWGs should be structured to allow open participation, but clearly recognize the respective key stakeholders, including utilities for each DEWG in the selection process. Additionally, NIST should prepare formal charters, document the evaluation/selection processes and establish the roles and relationships of key contributors including Standards Development Organizations (SDOs), User Groups (OpenSG, EEI), vendor groups (NEMA), multi-party groups (Gridwise Alliance), and other relevant non-commercial technical advisory groups (EPRI, Gridwise Architecture Council).

Success will be dependent upon establishing a governance model that ensures participation and "buy-in" from industry, promotes transparency and ensures that priorities are identified and accountability for interoperability is established. It is important that the process of evaluation and selection be done openly and without commercial or individual bias. This governance model would augment regulatory oversight.

5. Standards Selection Principles

Throughout the Smart Grid systems design process a clear set of standards selection principles should be followed with the purpose of creating a sustainable standards policy that:

- Pushes technology along the market adoption curve
- Accommodates the current generation of Smart Grid investments
- Stabilizes standards through convergence
- Allows for open and appropriate participation
- Creates a Win-Win proposition for all stakeholders

The standards selection principles supporting these goals are as follows:

Principle 1: Openness
As a general principle, the industry should adopt openly available standards. For purposes of this positioning statement, open is taken to mean readily available in acquisition and participation. Using this definition, certain activities are viewed as “more open” from a comparative point of view.

Principle 2: Separation of Duties
As a general principle, the industry should adopt standards which have been openly vetted and do not have an embedded commercial bias. That is, work associated with development and publishing of standards should be distinct and separate from work associated with commercial labeling and certification. The role of regulators and NIST is to ensure that an open, unbiased process is conducted to develop policy related to standards selection and adoption. This principle does not diminish the role of the commercial or regulatory entity.

Under this principle, commercial organizations, such as the ZigBee, HomePlug, WiFi, WiMAX alliances would take responsibility for choosing openly available standards and guaranteeing interoperability through certification. SDOs are responsible for creating and maintaining standards. The regulatory agencies are responsible for setting policy and ensuring policy compliance. NIST is responsible for managing a formal, national Smart Grid standards evaluation process leading to recommendations for policy compliant standards.

Principle 3: Generational Compliance
The industry should adopt a policy of generational compliance to minimize stranded assets. Generational compliance, in this context, is based on (1) supporting currently available products through backward compatibility and (2) enforcing a more rigorous set of criteria on the next generation of products. This principle provides market momentum and decreases the risk associated with first generation product procurement.

Principle 4: Loose Coupling
The industry should continually push the principle of “loose coupling”. This principle involves segmenting elements of a technology into the appropriate layer (e.g., application versus communications). Under this principle, changes in one element or one layer do not require changes in another layer or system element, and selection of lower layer technologies can vary based on the portion of the Smart Grid system they are supporting without impacting the interoperability of higher application layers that implement Smart Grid functionality (e.g, the ability to mix IP and non-IP communication protocols in an interoperable Smart Grid implementation).

Prepared for Smart Grid Utility Executive Working Group and OpenSG Subcommittee

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