Software Engineering Institute

Smart Grid Maturity Model

Model Definition

A framework for smart grid transformation

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Version 1.1

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Acknowledgments

The support and collaboration of the U.S. Department of Energy (DOE) enables the Carnegie Mellon Software Engineering Institute (SEI) to serve as steward of the Smart Grid Maturity Model (SGMM). The SGMM team is grateful for the DOE's support and collaboration toward the continued evolution, improvement, and promotion of the model and related offerings. The SGMM team acknowledges the DOE Office of Electricity Delivery and Energy Reliability (OE) and the DOE National Energy Technology Laboratory (NETL) for their direct contribution and support of this body of work.

Executive Summary

The purpose of this document is to fully describe the Smart Grid Maturity Model (SGMM). The document describes the levels and domains that compose the SGMM and provides introductory material to aid in understanding the purpose and use of the model.

The SGMM is a management tool under the stewardship of the Software Engineering Institute at Carnegie Mellon University. The model was originally developed by electric power utilities for use by electric power utilities. The model provides a framework for understanding the current state of smart grid deployment and capability within an electric utility and provides a context for establishing future strategies and work plans as they pertain to smart grid implementations. It is composed of eight model domains that each contain six defined levels of maturity, ranging from Level 0 (lowest) to Level 5.

Domains are logical groupings of smart grid related capabilities and characteristics. The following are the model's eight domains, which are fully described in Section 3:

1. Strategy, Management, and Regulatory (SMR)
2. Organization and Structure (OS)
3. Grid Operations (GO)
4. Work and Asset Management (WAM)
5. Technology (TECH)
6. Customer (CUST)
7. Value Chain Integration (VCI)
8. Societal and Environmental (SE)

An SGMM Compass assessment provides an organization with a maturity rating for each of the model's eight domains. The six levels of maturity represent defined stages of an organization's progress toward achieving its smart grid vision in terms of automation, efficiency, reliability, energy and cost savings, integration of alternative energy sources, improved customer interaction, and access to new business opportunities and markets. By assessing its current maturity level in each domain and taking steps to increase its levels as appropriate, an organization will move closer to obtaining the desired benefits of adopting and implementing smart grid technology. The maturity objective within each domain must be established in the context of an organization's overall business goals and regulatory environment; achieving higher maturity levels in the absence of a business driver is not recommended. To that end, achieving Level 5 in an SGMM domain is not necessarily the best option for every organization.

SGMM maturity levels organize the characteristics of the model's eight domains into hierarchical groupings. Each level builds upon the previous level; so an organization must achieve Level 1 in a domain to achieve Level 2 in that domain, and so forth. In order to achieve a given level within a domain, the organization must demonstrate that it has sufficiently implemented the expected characteristics defined for that level in that domain. While an organization will receive a specific level rating for each domain, that organization may also exhibit some characteristics from higher-

levels. Such a scenario might indicate that the organization is able to achieve grid modernization goals beyond those associated with the rated maturity level or that the organization is well on its way to a higher rating.

Abstract

The Smart Grid Maturity Model (SGMM) is a business tool stewarded by the Software Engineering Institute at Carnegie Mellon University. It was originally developed by electric power utilities for use by electric power utilities. The model provides a framework for understanding the current extent of smart grid deployment and capability within an electric utility, a context for establishing strategic objectives and implementation plans in support of grid modernization, and a means to evaluate progress over time toward those objectives.

The SGMM is composed of eight domains and six maturity levels as detailed in this document, which contains the full definition and description of the model. Introductory material to aid in understanding the purpose and use of the SGMM is also provided.

The primary audiences for the SGMM, and for this document, are electric power utilities that are seeking guidance related to the modernization of their operations and practices for delivering electricity. The audience also includes any related stakeholders for such utilities. Currently, the model is better suited for utilities with transmission and distribution operations than for pure generation utilities.

1 Introduction

1.1 The Need for Electrical Grid Modernization

An electrical or power grid refers to all or part of an interconnected network for the transmission and/or distribution of electricity. It connects suppliers of electricity, such as generation sources, with end users (e.g., residential, commercial, and industrial customers), and its operation has historically depended upon the intelligence and skills of power system operators working with a largely analog technology base. Because electricity supply and demand has to be kept in balance at all times, the grid infrastructure represents a massive just-in-time product delivery system and to date, this system has largely performed both economically and reliably.

Throughout the world, however, electric power infrastructures face a number of significant challenges to this continued performance. These include, but are not limited to, the following:

- Supply and demand challenges. Electricity demand has skyrocketed, but in many countries there has been significant under-investment in the corresponding infrastructure necessary to support this demand. Electric power infrastructures operating at close to their maximum generation and transmission capacity present significant reliability challenges. The adverse effects are particularly evident during peak periods of use, where consequences such as rolling blackouts can become far too commonplace.
- Environmental challenges. There is almost a universal desire to drive down the level of greenhouse gases, and electricity generation has been pointed out as a major contributor. Increasing environmental awareness has made some sources of electricity less desirable and inhibited the ability to build and operate additional generation plants.
- Affordability challenges. Rising fuel costs and system inefficiencies add significant costs to electricity production and transportation that are ultimately passed onto the end user. This can have significant impacts on not only the individual consumer's finances but to national economies as well.
- National security challenges. The economies of most of the modern world rely on the availability of electricity when and where it is needed. Most grids were not designed to be resilient in the face of an attack. A cascading series of intentional failures could bring a nation to a halt.

Not every electric power infrastructure in every country faces these challenges in the same way or to the same degree, but most face some combination and have led many to undertake major grid modernization efforts.

One of the most commonly considered modernization efforts includes support for *demand-side management*, an approach to managing the relationship between electricity suppliers and consumers. Demand-side management has been available to varying degrees for both commercial and industrial customers for some time, but now the goal is often to make this available across the entire spectrum of end users. Demand-side management is based on the concept that electricity generation resources are limited, and instead relies on the technical ability for consumers to automatically vary their demand for electricity based on the current “time-of-use” cost of electricity in the energy market. For instance, the cost of electricity would increase during periods of high demand, such as when there is extensive air conditioning use during a hot summer day and insufficient generation capacity to meet an unrestricted peak load, and the cost would decrease when there are efficiencies to be gained in adding load, such as when there is lots of wind generation available. A modern grid would support the ability for consumer equipment to automatically respond to pricing signals and lower its demand for electricity when prices are high, or consumers could permit their utilities to remotely raise the temperature for their thermostats in exchange for preferential pricing. The idea is to better connect the supply and demand sides of the market to make for a more cohesive system.

Another capability supported by most grid modernization efforts is the ability to support the two-way flow of electricity. Today, electricity generally follows a single path from the generation supplier to the consumer. The two-way flow of electricity is based on the concept that in order to meet growing reliability and flexibility needs, the grid must support new options in electrical generation (e.g., distributed generation and micro-generation) and storage (e.g., fuel cells and fly wheels), which in turn requires greater control of electricity flows on the grid. For example, a consumer with an electric vehicle might want to use the vehicle’s battery to store electricity when prices are cheap and to sell electricity back to the grid when prices are expensive. The consumer might also want to tap into that stored electricity in the case of an outage or other disturbance. The two-way flow of electricity would also help support the adoption of more efficient and reliable generation sources and would allow consumer-generated electricity (e.g., solar power and wind) to be connected to the grid. If this were the case, any excess generated electricity would flow onto the grid, and the consumer would be compensated.

Implementing demand-side management across the entire spectrum of end users and the two-way flow of electricity requires many significant changes, including changes to the structure of the electric power grid, to operational processes at electric utilities, to behaviors of electricity consumers, to regulations that constrain the operation of the grid, to the meters and other equipment that manage and control the flow of electricity provided by the grid, and to the appliances and other equipment that consume electricity provided by the grid. These are all significant challenges to grid modernization efforts.

1.2 What Is a Smart Grid?

“Smart grid” is the term commonly used to refer to an electrical grid whose operation has been transformed from a twentieth century analog technology base to the pervasive use of digital technology for communications, monitoring (e.g., sensing), computation, and control. In a smart grid, much of the intelligence and situational awareness necessary to understand the state of the grid and to maintain safe, secure, efficient, and reliable operation of the grid reside within the grid’s digital information infrastructure itself. This modernization enables the extensive use of computer-based automation to maintain grid stability and to enable modern grid features such as demand-side management, distributed generation, real-time pricing, and automated meter activation and reading. A smart grid should be a more stable grid because automated responses to threats to grid stability can be easily implemented. The ability to anticipate or detect emerging problems at a very early stage, where minor automated adjustments can easily rectify the condition, is realized with a smart grid.

Emerging smart grid technology, which is primarily based on two-way digital communication, allows for very fine-grained sensing and control. This enables highly flexible, efficient, and optimized operation, including full support for market-based, demand-side management and the accommodation of alternative generation sources, including sources of consumer-generated electricity.

A smart grid is defined as having the following seven principal characteristics, as specified by the U.S. Department of Energy's National Energy Technology Laboratory in its modern grid strategy [NETL 2009]:

- enables active consumer participation
- accommodates all generation and storage options
- enables new products, services, and markets
- provides power quality for the digital economy
- optimizes asset utilization and operates efficiently
- anticipates and responds to system disturbances
- operates resiliently against attack and natural disaster

A similar smart grid vision is put forward in the document *European SmartGrids Technology Platform – Vision and Strategy for Europe's Electricity Networks of the Future* [European Commission 2006].

1.3 The Smart Grid Maturity Model

The Smart Grid Maturity Model (SGMM) is a management tool originally developed by electric utilities for electric utilities and is now being stewarded by the Software Engineering Institute[1] at Carnegie Mellon University. The model provides a framework for understanding the current state of smart grid deployment and capability within an electric utility, and it provides a context for establishing future strategies and work plans to meet the challenges of grid modernization. It can also help organizations to bridge gaps between strategy and execution. The SGMM helps create and communicate a common vision of the smart grid for internal and external stakeholders. An electric utility can use the SGMM to identify its smart grid target, assess where it is on the journey to implementing the smart grid, prioritize options, and measure success.

The model describes a common framework with defined smart grid stages and options, as well as a common language for defining key elements of a smart grid transformation. It is composed of eight model domains that correspond with six defined levels of maturity.

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[1] The Software Engineering Institute (SEI) is a federally funded research and development center that is an international leader in the development and application of capability models. In particular, the SEI pioneered the Capability Maturity Model Integration® (CMMI®), an organizational process improvement approach that can be applied to (1) product and service development; (2) service establishment, management and delivery; and (3) product and service acquisition. The SEI also pioneered the development and use of the CERT® Resilience Management Model (CERT®-RMM) that focuses on helping organizations protect and sustain their critical business processes and services in the face of disruptions and unplanned events. CMMI® is registered in the U.S. Patent and Trademark Office by Carnegie Mellon University. CERT® is a registered mark owned by Carnegie Mellon University.

1.3.1 SGMM Scope of Coverage

As shown in **Error! Reference source not found.**, the primary scope of coverage for the SGMM is a utility's network assets, its processes and services, its customer interfaces, and its customer interactions. The other related businesses or communities represented are included only as they relate to operating a smart grid (i.e., the model focuses on enabling interaction). The model includes interaction with and enablement of retail, generation, supply chain services, and advanced features (e.g., distributed generation and storage); but, it is not intended to cover characteristics of retail-only companies, generation (macro or point of use), or industry suppliers. As an example, the model assumes that the smart grid utility provides all the necessary connectivity, function, services, and support to intelligently use distributed generation. The model does not describe an implementation approach for any of the connected distributed generation entities attached to the grid.

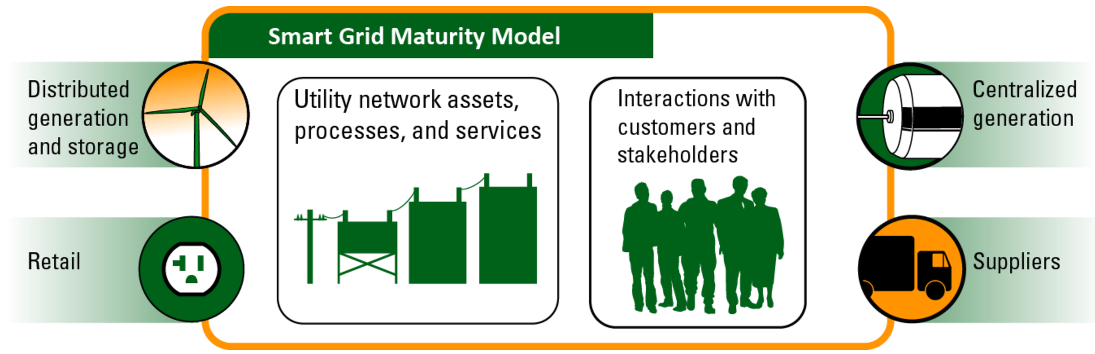

Figure 1: Smart Grid Maturity Model Scope

1.3.2 SGMM Structure

The Smart Grid Maturity Model is defined in two documents:

- *Smart Grid Maturity Model: Model Definition*
- *Smart Grid Maturity Model: Compass Assessment Survey*

This document is the *Smart Grid Maturity Model: Model Definition*; it presents the formal description of the model and includes an overview of the model architecture in Appendix A. The *Smart Grid Maturity Model: Compass Assessment Survey* contains the Compass questions used to assess an organization's progress toward smart grid implementation with respect to the model. While these two documents together define the model, there are a number of other additional components of the product suite available that support the use and adoption of the SGMM.

1.3.3 SGMM Product Suite

A suite of SGMM product components are available from the SEI to support understanding and use of the smart grid maturity model, including

1. *Smart Grid Maturity Model: Model Definition*
   The model is the core product suite element; all other product suite components are based on the model definition.

2. *Smart Grid Maturity Model: Matrix*
   This is a summary view of the model. It contains a shortened version of the expected characteristics contained in the model in a tabular format. The summary view is available in Appendix B of this document and is also available as a stand-alone document, which is available for download at http://www.sei.cmu.edu/smartgrid/start/downloads/.

3. *Smart Grid Maturity Model: Compass Assessment Survey*
   The Compass survey is intended for completion by or on behalf of utilities. Compass questions are designed to collect demographic and performance data and to characterize the status of the responding utility's smart grid implementation in the context of the SGMM. Completing the Compass survey and having it scored provides the utility with a maturity level rating for each domain in the model. In addition, each scoring report includes aggregate data from the other utilities that have completed the Compass survey, which can be used for comparative analysis. The Compass survey can be accessed at http://www.sei.cmu.edu/smartgrid/start/downloads/.

4. *Smart Grid Maturity Model: Navigator Process*
   The SGMM navigation process was developed to help organizations chart a technical, organizational, and operational path through their grid modernization effort. An SEI certified SGMM Navigator who brings expertise of both the SGMM product suite and the utility industry facilitates this process.

5. *Smart Grid Maturity Model: Training*
   Two courses have been developed to support the transition and use of the SGMM. The SGMM Overview Seminar was developed for anyone wanting to learn more about the SGMM model and product suite. The SGMM Navigator course is a three-day course that was developed to teach students to consistently and correctly use the SGMM product suite to assist utilities to effectively plan and implement grid modernization efforts.

1.4 About This Document

The purpose of this document is to fully define Version 1.1 of the SGMM, to provide introductory material to aid in understanding the purpose and use of the model, and to describe the related components of the SGMM product suite.

The primary audience for the SGMM, and for this document, are electric utilities and related stakeholders who are interested in modernizing and improving their operations and practices associated with delivery of electricity with a focus on transmission and distribution. More specifically, this would include

- prospective utilities that are considering using the model or who simply want to know more about it
- utility personnel who are preparing to take the SGMM assessment Compass and who may have questions when completing the Compass
- utility industry organizations, associations, user groups, and standards bodies
- vendors, including utility equipment providers and service providers
- consultants and system integrators
- regulators, public service commissions, government bodies
- press and industry publications
- the academic community and research institutions
- knowledgeable members of the public, including consumers

1.5 Document Overview

The next two sections of this document explore the structure of the SGMM.[2] Section 2 introduces and elaborates on the levels of maturity within the model, and Section 3 introduces the SGMM domains and describes the common domain structure. The next eight sections, Section 4 through Section 11, contain full elaborations of each of the model's domains. Section 12 provides a brief overview of how an organization can use the SGMM.

[2] A detailed overview of the model architecture can be found in Appendix A.

2 SGMM Levels

Six levels of maturity are defined in the SGMM as shown in Figure 2. The levels of maturity represent defined stages, described in terms of organizational capabilities and characteristics, of an organization's progress toward achieving its smart grid vision in terms of automation, efficiency, reliability, energy and cost savings, integration of alternative energy sources, improved customer interaction, and access to new business opportunities and markets.[3]

The lowest maturity level in the model is 0, which represents the default position or entry point in the model. A utility that is operating a traditional, analog, non-modernized grid would likely be characterized as performing at Level 0 across all eight domains in the model. As the utility begins to implement and integrate the various changes that are consistent with a modernized grid, the utility's maturity rating would be elevated across one or more of the domains.

A utility can establish its current maturity level by completing the SGMM Compass and having it scored. With this baseline, or starting point, in mind, the utility can establish objectives for the timing and extent of its grid modernization efforts by setting maturity level targets for each of the domains in the model for a particular time window. Additional assessments can be completed to track progress toward the established objectives.

While higher levels of maturity in the model are consistent with an organization that is successfully adopting and benefiting from its grid modernization efforts, it is important for each organization to establish its own target maturity levels based on its own unique operating profile, strategy, and timeline. Achieving Level 5 in any domain is not necessarily the goal for an organization and is unlikely to be an appropriate goal for many organizations.

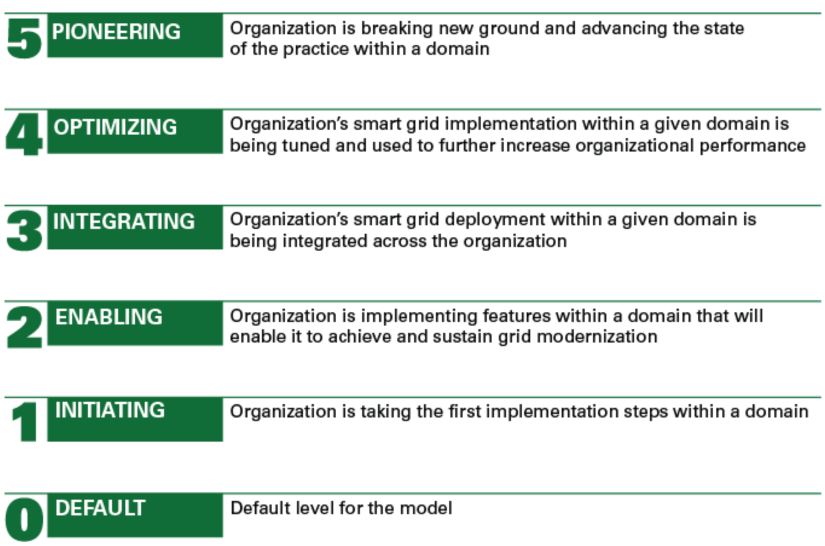

Figure 2: Smart Grid Levels

[3] Readers familiar with the CMMI will quickly notice that the SGMM is a very different type of maturity model than the CMMI. The focus of the CMMI is on organizational process improvement and the levels are an expression of organizational maturity. The SGMM does not have a process improvement focus. Instead it is an implementation model, where the levels are an expression of the extent of implementation.

An SGMM assessment provides an organization with a maturity rating for each of the model's eight domains.[4] Domains are logical groupings of smart-grid-related capabilities and characteristics. The model's eight domains are shown below and are described in Section 3.

1. Strategy, Management, and Regulatory (SMR)
2. Organization and Structure (OS)
3. Grid Operations (GO)
4. Work and Asset Management (WAM)
5. Technology (TECH)
6. Customer (CUST)
7. Value Chain Integration (VCI)
8. Societal and Environmental (SE)

The levels of maturity organize the *expected characteristics*[5] for each domain into hierarchical groupings. Each level builds upon the next, so an organization must achieve Level 1 in a domain in order to achieve Level 2 in that domain, and so forth. In order to achieve a level within a domain, the organization must demonstrate that it has sufficiently implemented the expected characteristics defined for that level in that domain area. While an organization will receive a specific level rating for each domain, that organization may possess some characteristics associated with higher maturity levels.

The following sections provide additional detail on each of the six maturity levels. Appendix A provides additional information on the maturity levels from a model architecture perspective. The specific meaning of each level as applied to specific domains is defined in Sections 4 through Section 11.

2.1 Level 0 - Default

Level 0 represents a maturity level that precedes an organization's taking significant initial steps toward the adoption of smart grid technology. Level 0 is not defined by characteristics but rather is the default level for an organization that has not sufficiently implemented the expected characteristics to achieve Level 1 for a given domain.

Organizations that are assessed at Level 0 within a domain may not have carefully contemplated a smart grid transformation or its possible impact on the organization and its customers. The organization may not yet have developed a vision, strategy, or business case for smart-grid-related acquisitions, implementations, or operations. An assessment of Level 0 in a domain, however, does not imply that there is a complete absence of smart-grid-focused activities within that domain.

[4] Previous versions of the SGMM included an "overall" maturity rating; in version 1.1 that overall rating is no longer included as part of the assessment. The domains are sufficiently independent such that an "overall" maturity rating does not help to inform strategic planning and was open to significant misinterpretation.

[5] Expected characteristics are the capabilities and characteristics that an organization must implement in order to achieve a given level of maturity within a domain, and are explained in more detail in Section 3 of this document.

2.2 Level 1 - Initiating

Initiating conveys the notion that an organization is taking the first implementation steps within a domain. Organizations achieving Level 1 for a domain have decided to move toward a smart grid and are taking initial steps in that direction. At this level

- The organization has identified performance measures within a domain that smart grid implementations should improve.
- The organization may have programs in place to actively track and measure these performance measures.
- An initial motivation and vision for grid modernization is developing and may already be in place.
- Options for grid modernization are being explored and evaluated, which may include conducting small-scale, proof-of-concept experiments.
- Business cases and strategies for smart grid implementations may be in development.

2.3 Level 2 - Enabling

Enabling is used for Level 2 because the focus of this level is on implementing features that will enable an organization to achieve and sustain grid modernization. At this level

- Business cases and strategies are in place, and integrated modernization strategies are emerging.
- Additional management support is emerging; this support includes resource commitments.
- Internal and external dependencies are being explored, and relationships are being established.
- One or more pilots or proof-of-concept projects are underway to evaluate the impact of potential changes.
- Pilots and projects are more likely to be compartmentalized than integrated across functional units.
- Security, resiliency, and interoperability requirements are among the evaluation criteria for the pilots and projects.

2.4 Level 3 - Integrating

Integrating is used for Level 3 because smart grid deployments at this level are being integrated across the organization. At this level

- There is an organization-wide commitment to an integrated grid modernization strategy and plan.
- Grid modernization projects that are underway are integrated across the organization.
- Performance (with respect to a variety of quality attributes) is measurably improved, and visibility into the integrated operations of the organizations and its external dependencies is increased. For example, performance against security, resiliency, and interoperability requirements shows measurable improvement.

2.5 Level 4 - Optimizing

Optimizing is used for Level 4 because smart grid implementations within a given domain are being fine-tuned and used to further increase organizational performance. At this level

- Management and operational systems rely on, and take full advantage of, increased visibility into and integrated control across the enterprise.
- Features such as prediction of problems and automated real-time correction are starting to emerge.
- There is increased information sharing and collaboration both within the organization and with its external stakeholders, including its customers.
- Security, resiliency, and interoperability requirements recognize dependencies beyond organizational boundaries.

2.6 Level 5 - Pioneering

Pioneering is used for Level 5 because organizations at the highest level within a given domain are breaking new ground and advancing the state of the practice. At this level

- Organizations are providing industry-leading innovation and may be highly involved in the development of smart grid standards and best practices by taking a leadership role in industry consortia and public-private partnerships.
- Organizations are collaborating with other grid stakeholders to optimize overall grid operation and health.
- Features such as increasingly integrated operations, novel collaborative strategies, extensive external information sharing (e.g., sharing of grid health data), and leadership in community-wide responses to security issues are appearing.
- Organizational strategies and vision are aligned with national, regional, and local interests.

3 SGMM Domains

Domains are logical groupings of smart-grid-related capabilities and characteristics for which the SGMM defines a maturity progression. Each level of maturity within a domain builds upon the next, so an organization must achieve Level 1 to achieve Level 2, and so forth. Each level of maturity within a domain is fully described by a set of *expected characteristics* and a set of *informative characteristics*.

The Smart Grid Maturity Model, Version 1.1 includes the following eight domains:

1. Strategy, Management, and Regulatory (SMR)
2. Organization and Structure (OS)
3. Grid Operations (GO)
4. Work and Asset Management (WAM)
5. Technology (TECH)
6. Customer (CUST)
7. Value Chain Integration (VCI)
8. Societal and Environmental (SE)

3.1 Expected and Informative Characteristics

Expected characteristics are the capabilities and characteristics that an organization must implement or exhibit to achieve the corresponding maturity level within a domain. Each expected characteristic is presented as a concise, declarative statement to support the consistent evaluation of its implementation and its independence from other characteristics at the same level within the model.[6] While it is possible that an organization may exhibit expected characteristics associated with several maturity levels within a domain, the model requires that for a given level of maturity to be achieved, the expected characteristics for that level and all lower levels in that domain must be sufficiently implemented. For an organization to achieve Level 2 in a given domain, for example, it must sufficiently implement the expected characteristics for both Level 1 and Level 2 in that domain.

Every expected characteristic in the SGMM corresponds to a single question in the SGMM Compass, the instrument used for measuring an organization's current maturity profile. The SGMM uses a simple labeling system to uniquely identify each expected characteristic in the model. The label for a given characteristic is defined by its domain abbreviation, the maturity level where it resides, and its characteristic number. The label VCI-2.3, for example, refers to the third expected characteristic, at maturity Level 2, for the Value Chain Integration domain. This labeling system is also used in the Compass assessment survey to identify questions, and it allows for easy cross-referencing.

[6] It is acknowledged that interdependencies exist between the domains. At this time the model does not specifically identify these, but future work is planned to identify and leverage these interdependencies.

Informative characteristics provide additional descriptive material that may provide some insight into whether an organization has achieved a given level of maturity within a domain. These might include examples, potential features, or additional explanatory information. These characteristics are not numbered and are not used to evaluate whether an organization has achieved a specific level of maturity. Informative characteristics are not a required feature, so within a given domain, at a given maturity level, the model may have only expected characteristics and no informative characteristics. Examples and additional explanatory information are often contained within the expected characteristics themselves in italics.

3.2 Domain Structure[7]

The next eight sections (Section 4 through Section 11) of this document contain detailed descriptions of each domain. Each domain follows the same structure, consisting of a brief domain overview followed by maturity elaborations for each of the five levels.

The domain overview establishes the domain's boundaries and provides an overview of the maturity progression. The maturity elaboration for each level begins with a brief summary statement followed by a numbered list of expected characteristics and supporting information (except for Level 0, which has no characteristics and is not included in any of the domain descriptions). An unnumbered list of informative characteristics sometimes follows the list of expected characteristics and provides some additional descriptive material.

[7] Appendix A provides additional information on the domain structure and the relationship between the levels and domains from a model architecture perspective.

4 Strategy, Management, and Regulatory (SMR)

The Strategy, Management, and Regulatory (SMR) domain represents the capabilities and characteristics that enable an organization to successfully develop a smart grid vision and strategy, establish internal governance and management processes, and promote collaborative relationships with stakeholders to implement that strategy and vision. The integration, communication, and management of the mission, vision, and strategy guides the way through a successful smart grid transformation.

As the organization matures, the management processes across lines of business will increasingly reflect the smart grid vision and strategy. Smart grid leadership will have sufficient explicit authority within the organization and with external stakeholders, including regulators, to implement the vision. Smart grid modernization will drive organizational strategy and direction, and new business opportunities will emerge that capitalize on the smart grid as a platform for the introduction of new services and product offerings.

SMR-1: Initiating

The organization develops and begins to implement a smart grid vision. Discussions with regulators and other stakeholders about the vision and its implementation take place.

Expected Characteristics

SMR-1.1 Smart grid vision is developed with a goal of operational improvement.

SMR-1.2 Experimental implementations of smart grid concepts are supported.
Organizational support means executive encouragement, or at least acceptance. Support generally also means funding. Examples of experimental implementations could include deploying smart meters, testing line monitoring, or conducting Plug-in Hybrid Vehicle (PHV) pilots.

SMR-1.3 Discussions have been held with regulators about the organization’s smart grid vision.

Informative Characteristics

- Budgets for funding smart grid activities are established, but not necessarily from smart-grid-enabled cost recovery.
- Informal discussions are held with other utilities, vendors, and stakeholders regarding smart grid experiences and lessons learned.
- Strategic planning increasingly addresses implementing the smart grid vision.
- A smart grid vision is a high-level description of an envisioned future state of the organization in which a set of desired organizational and stakeholder goals are being fulfilled through the implementation of smart grid technology.

SMR-2: Enabling

The organization works across functional units to move toward implementing a smart grid vision with a distinct budget. Priorities and decisions increasingly implement or increasingly inform the smart grid vision. Relationships with internal and external stakeholders are established to implement the smart grid vision.

Expected Characteristics

SMR-2.1 An initial smart grid strategy and a business plan that is aligned to the smart grid vision are approved by executive management.
Smart grid strategy and business plans encompass aspects from all SGMM domains such as Customer, Grid Operations, and Societal and Environmental, and include attributes such as security, privacy, and interoperability.

SMR-2.2 A common smart grid vision is accepted across the organization.
Smart grid vision may have originated at the unit level, but it is recognized and accepted throughout the organization.

SMR-2.3 Operational investment is explicitly aligned to the smart grid strategy and business plan.

SMR-2.4 Budgets are established specifically for funding the implementation of the smart grid vision.

SMR-2.5 There is collaboration with regulators and other stakeholders regarding the implementation of the smart grid vision and strategy.
Current and planned initiatives are aligned to the smart grid strategy. Collaborating with regulators can include exchanging ideas, working in synch, or working together on at least some smart grid issues. Examples of "stakeholders" could include the DOE, financial institutions, local governments, associations such as the American Association of Retired Persons (AARP) or building groups such as the Apartment and Office Building Association (AOBA).

SMR-2.6 There is support and funding for conducting proof-of-concept projects to evaluate feasibility and alignment with the smart grid vision.
Proof-of-concept projects are selected and pursued based on their potential to realize the smart grid vision and reflect regulator perspectives and plans.

Informative Characteristics

- The organization participates in industry groups to share experiences, pool knowledge, and standardize key processes for the purpose of accelerating the implementation of its smart grid vision.
- Initial smart grid leadership in the organization is identified.

SMR-3: Integrating

The smart grid strategy is integrated into management processes across lines of business. There is an organization-wide commitment to and increased cooperation with stakeholders on an integrated grid modernization strategy and plan.

Expected Characteristics

SMR-3.1 The smart grid vision, strategy, and business case are incorporated into the organization's vision and strategy.
Return on investment (ROI) on business case for smart grid investment is understood and measured.

SMR-3.2 A smart grid governance model is established for smart grid management and decision-making roles, processes, and tools.
A smart grid governance model would provide a foundation for higher level managers' responsibility for overseeing, directing, and guiding the smart grid management and decision making. Higher-level managers set expectations for smart grid and communicate these expectations to those who are responsible as appropriate. Regular reviews are performed and reported to higher-level managers.

SMR-3.3 One or more smart grid leaders with explicit authority across functions and lines of business are designated to ensure effective implementation of the smart grid strategy.

SMR-3.4 Any required authorizations for smart grid investments have been secured from stakeholders.
Stakeholders can include regulators, stockholders, or taxpayers. Regulators authorize smart grid investments on visible aspects such as Advanced Metering Infrastructures (AMI) as well as less visible supporting infrastructure projects. Authorized means that regulators have either approved that the utility can spend money on smart grid, and/or that cost recovery methods have been approved.

Informative Characteristic

Organizational strategy expands to leverage new smart-grid-enabled technologies funded by new revenue opportunities or enhanced cost recovery with elevated rates of return.

SMR-4: Optimizing

Smart grid modernization is a core component of the business strategy and provides opportunities for enhanced business models and synergistic external relationships. There is increased information sharing and collaboration within the organization and with external stakeholders.

Expected Characteristics

SMR-4.1 Smart grid vision and strategy drive the organization's strategy and direction at the highest level (i.e., enterprise or corporate level).
This would include investments, design of operations and services, collaboration with key external stakeholders, and evaluation and incorporation of new technologies. Method of governance is reevaluated to address unique investment requirements of the smart grid (strategic investments that will be significant in magnitude/impact, long-

lived, and subject to upgrade as technologies mature). Costs and benefits of investments are measured and managed.

SMR-4.2 Smart grid is a core competency throughout the organization.
When smart grid becomes a core competency throughout an organization, it becomes fundamental to the way in which everyone in the organization works. It is an organizational expertise.

SMR-4.3 Smart grid strategy is shared and revised collaboratively with external stakeholders, excluding some sensitive aspects.

Informative Characteristics

- The organization is willing to explore, engage, and invest in new business arrangements such as joint ventures and intellectual property sharing to execute smart grid strategy.
- Opportunities are enabled for enhanced market-driven funding and innovative regulatory funding schemes possibly including knowledge sharing on investment priorities, regulatory strategies, and pooling of resources to support consultations that will benefit the larger group.
- New external business partnerships emerge to improve intracompany optimization.
- Processes for mergers and acquisitions that include more favorable regulatory treatment are developed.
- The opportunities for taking advantage of scale to reduce the per capita cost of smart grid investments are identified.
- The organization is engaged in exploring new business ventures or coinvestments with other stakeholders to optimize strategy for operating a modern grid.

SMR-5: Pioneering

All stakeholders, internal and external, are involved in all relevant aspects of the business and have a goal of innovation.

Expected Characteristics

SMR-5.1 Smart grid strategy capitalizes on smart grid as a foundation for the introduction of new services and product offerings.
The overall strategy is built to act on insights gained through smart grid deployment and operational experience.

SMR-5.2 Smart grid business activities provide sufficient financial resources to enable continued investment in smart grid sustainment and expansion.
In general, this means that there is investment funding available through either positive ROI on smart grid applications themselves, or through cost recovery or other business or financial justification. For example, optimized rate design can ensure costs are recovered or a regulatory policy can result in beneficial treatment for investments made and risks taken.

SMR-5.3 New business model opportunities are implemented as a result of smart grid capabilities.
The organization is able to propose and take advantage of new business opportunities that emerge based on smart grid capabilities. Examples of new business models could include new revenue streams from new areas such as providing cable or phone servic-

es through BPL (broadband over power line) or offering building management services.

5 Organization and Structure (OS)

The Organization and Structure (OS) domain represents the organizational capabilities and characteristics that enable an organization to align and operate as required to achieve its desired smart grid transformation. The domain focuses on changes in communications, culture, structure, training and education, and knowledge management within the organization. For grid modernization efforts to be successful, the organizational structure must promote and reward cross-functional planning, design, and operations. The organization must align its structure to take advantage of opportunities that a smart grid will provide.

Maturity within this domain reflects an increasing capability for the organization to move beyond reactive and compartmentalized decision making to planned, fact-based, and nimble decision making to achieve its smart grid goals. It also reflects an organizational workforce whose competencies and skill sets are aligned with achieving the organization's smart grid vision.

OS-1: Initiating

The organization recognizes the need to achieve a smart grid transformation and takes initial steps to begin building the necessary competencies.

Expected Characteristics

OS-1.1 The organization has articulated its need to build smart grid competencies in its workforce.

OS-1.2 Organizational leadership has demonstrated a commitment to change the organization in support of achieving smart grid.
This often begins with public statements regarding a commitment to change. Stronger demonstrations of commitment would include actions such as assigning resources and budget.

OS-1.3 The organization has initiated smart grid awareness efforts to inform the workforce of smart grid activities.
Examples of "awareness efforts" could be internal memos, training sessions, or smart grid demonstrations. These efforts may be compartmentalized and may not necessarily align to organizational goals. For example, operational units are aware of grid modernization efforts that might directly impact them, but they are not necessarily aware of broader efforts or goals.

Informative Characteristic

It may be the case that a small group of individuals from within the organization initially champions the smart grid cause.

OS-2: Enabling

The organization works across functional units to enable the realization of its smart grid vision. The organization is overcoming barriers related to the workforce through active engagement. Long-term organizational impacts with respect to smart grid are recognized and proactively addressed. An example would be in the area of maintenance and work management. This task area needs coordination of the GIS system, outage notification, parts and inventory, asset management, work management, maintenance management, and transportation. These functions should be aligned organizationally so they work well together.

Expected Characteristics

OS-2.1 A new vision for a smart grid begins to drive change and affect related priorities like addressing the need for an adequately skilled workforce in a smart grid environment.
Ideally the vision looks beyond merely technological aspirations to address the benefits to each stakeholder group, and it must be communicated to all potential stakeholders beyond the team responsible for developing the smart grid vision and strategy. An organization defines its smart grid vision at SMR-1.1.

OS-2.2 The organization has aligned most operations around end-to-end processes (e.g., meter through distribution).
The necessary connections, collaborations, and transparencies among the various activities have been provided. For example, the area of maintenance and work management requires the coordination of the GIS system, outage notification, parts and inventory, asset management, work management, maintenance management, and transportation. These functions should be aligned organizationally so that they are able to work together.

OS-2.3 Most smart grid implementation and deployment teams include participants from all functions and lines of business that the deployment will impact.
Typically this means that matrix teams for planning and design of smart grid initiatives across lines of business (LOBs) begin collaborating (e.g., IT, engineering, operations, etc). There is organizational recognition of the need to invest in a smart grid transformation, but balanced by the need to leverage creativity and initiative with a more controlled investment strategy and reporting structure. There is an emphasis on individual initiative, but working within the concept of a team and a chain of command.

OS-2.4 Education and training to develop smart grid competencies have been identified and are available.
Significant portions of current grid operations personnel are likely to be leaving the workforce in the next decade. Organizations need to consider how they will address the loss of institutional knowledge and ensure that new personnel have an adequate skill set to address smart grid challenges.

OS-2.5 The linking of performance and compensation plans to the achievement of smart grid strategy milestones is in progress.
Plans should incent and reward smart grid efforts as part of an organizational culture transformation; however, this does not necessarily mean across the entire organization. For this characteristic it would be sufficient if there are parts of the organization that have linked performance and compensation plans to smart grid strategy miles-

tones for at least the members responsible for smart grid. Smart grid implementation milestones could be the installation of smart meters or implementing a consistent communications architecture.

OS-3: Integrating

The smart grid vision is being integrated into the organization's structure, and functions and LOBs are aligned. The smart grid vision affects the strategic priorities and fundamental aspects of the organization, such as culture, structure, role definition, performance evaluation, and compensation.

Expected Characteristics

OS-3.1 The smart grid vision and strategy is driving change across multiple lines of business and/or functions.
Emphasis should be placed on using smart grid capabilities to rethink service delivery as a tool to address concerns such as the adequacy of workforce competencies.

OS-3.2 Smart grid measures are incorporated into the organization's measurement system.
This can be accomplished via a balanced scorecard system. As the smart grid vision is realized, there is often investment in the redesign of processes that are able to take advantage of the smart grid capabilities. Measures and metrics should be developed and included on the balanced scorecard to ensure that redesigned processes align with operational goals and are reported in a similar fashion.

OS-3.3 Performance evaluation and/or compensation are linked to smart grid success.
Collaborative successes should be rewarded. Enterprise and cross-LOB accountability may need to be more valued than individual LOB and unit performance. Performance measures should address organizational behavior such as the satisfaction of team building requirements and the continued development of a smart grid workforce competency.

OS-3.4 Leadership is consistent in both its communication about and actions toward achieving its smart grid vision and strategy.

OS-3.5 A matrix or overlay structure to support smart grid goals is being evaluated, and steps toward changes are being documented or implemented.
It may be the case that a matrix or overlay structure is unnecessary for a given organization. Smart grid will introduce new cross-LOB interaction and interdependencies that take advantage of increased observability and control. Organizational structures will need to adapt to properly take advantage of the new capabilities. Examples of an overlay structure could be a steering committee, a cross-functional team, or interlocking governance structures.

OS-3.6 Education and training programs are aligned to exploit smart grid capabilities.

OS-4: Optimizing

The organization is structured to achieve its smart grid vision. Operational visibility extends across the organization, enabling the desired cultural and organizational transformation.

Expected Characteristics

OS-4.1 Management systems and organizational structure are capable of taking wide-spread advantage of the increased visibility and control capabilities provided through smart grid.

OS-4.2 Organization has end-to-end grid observability that can be leveraged by internal and external stakeholders.
This includes increased data sharing between internal lines of business and external stakeholders, which opens opportunities for organizational collaboration. Knowledge flows easily across the enterprise. Data and knowledge flows across the organization have been defined and refined, and they are now leveraged as part of cross-LOB business processes.

OS-4.3 As a result of an efficient organizational structure and the increased availability of information due to smart grid, decision making occurs at the closest point of need.
Decentralized real-time decision-making, real-time corrections, and other capabilities are now available. Roles, responsibilities, and well-defined work processes are in place to guide daily activities across LOBs. The authority for decisions is clear and required interactions for coordination are documented and followed. With automation and control enhancements, decision making will occur at the lowest empowered level, thus reducing the overall length of the command structure and allowing for greater efficiencies.

OS-5: Pioneering

Stakeholders are involved in most aspects of the business, and the organization is concentrating on innovation.

Expected Characteristics

OS-5.1 The organizational structure enables collaboration with other grid stakeholders to optimize overall grid operation and health.
Features such as increasingly integrated operations, novel collaborative strategies, extensive external information sharing (e.g., sharing of grid health data), and leadership in community-wide responses to security issues are appearing.

OS-5.2 The organization and its structure readily adapts to support new ventures, products, and services that emerge as a result of smart grid.
The willingness and capability for organizational change in support of smart grid goals enables technical and business leadership to adapt to emerging smart grid markets and business opportunities.

OS-5.3 Channels are in place to harvest ideas, develop them, and reward those who help shape future advances in process, workforce competencies, and technology.
Innovative thought extends beyond leaders and decision makers down to individuals across the organization.

6 Grid Operations (GO)

The Grid Operations (GO) domain represents the organizational capabilities and characteristics that support the reliable, secure, safe, and efficient operation of the electrical grid. Increasing maturity within this domain reflects an evolution from relatively inflexible, manually intensive operations with limited visibility into the health of the grid to automated operations with significant flexibility and a high degree of situational awareness at local, regional, and national levels. Organizations that have achieved a high level of maturity within this domain have an increased capability to utilize automation and information available from the deployment of smart grid technologies. They have the capability to manage power flows so that power losses are minimized and the usage of lowest-cost generation resources are maximized. They have increased levels of automation and the ability to see key aspects of "the whole grid," decreased response times for communications and control, and a reduced likelihood of cascading system failures. These capabilities support not only the goals of increasing grid reliability, security, efficiency, and safety but also broader grid modernization objectives such as delivering high-quality power, supporting multiple generation options, optimizing usage of grid assets, and operating efficiently.

GO-1: Initiating

The organization evaluates potential opportunities for automation in grid operations and explores process optimization capabilities that a smart grid will enable. This exploration contributes to the formulation of an overall smart grid vision.

Expected Characteristics

GO-1.1 Business cases for new equipment and systems related to smart grid are approved in at least one business function.

Business cases are approved by senior management, at least at a business function level, but are typically not integrated across the organization.

GO-1.2 New sensors, switches, and communications technologies are being evaluated for grid monitoring and control.

Evaluation criteria should include safety, security, and interoperability requirements. The evaluation may involve research and development and not just piloting and testing of equipment.

GO-1.3 Proof-of-concept projects and/or component testing for grid monitoring and control are underway.

Examples of proof of concepts and component testing for grid monitoring could be ASR (Automated Sectionalization and Restoration), transformer monitoring, and smart relays.

GO-1.4 Outage and distribution management systems linked to substation automation are being explored and evaluated (beyond SCADA).

This exploration may include distribution and substation automation pilots. Evaluation criteria should include careful consideration of the safety, security (both cyber and physical), and interoperability aspects of these systems. These criteria should apply to any use of the substation automation data, not just by the distribution utility *(e.g., to schedule or balance energy level and flow on a transmission grid). Having Supervisory Control and Data Acquisition (SCADA) (monitoring) to the substation is not considered substation automation.*

GO-1.5 Safety and security (physical and cyber) requirements are considered in all grid operations initiatives.
The safety and security requirements for smart grid capabilities should be identified and documented during exploration, evaluation, testing, and piloting.

GO-2: Enabling

The organization starts to deploy initial grid monitoring and control features that are tied to the smart grid vision. There is an emphasis on communications in support of grid automation.

Expected Characteristics

GO-2.1 Initial distribution to substation automation projects are underway.
Distribution to substation automation is bi-directional and includes capabilities such as advanced disturbance and event recording to aid in detailed electrical fault analyses, remote switching and advanced supervisory control over the power network, and advanced automation functions such as intelligent load shedding.

GO-2.2 Advanced outage restoration schemes are being implemented, which automatically resolve (self-heal) or reduce the magnitude of unplanned outages.
An example of an "advanced outage restoration scheme" is ASR (Automated Sectional Restoration). By "advanced," we mean employing the use of sensing resources to know what is happening and data analytics for automatically making corrections, or providing recommendations regarding corrections that can be made by an operator.

GO-2.3 Aside from SCADA, piloting of remote asset monitoring of key grid assets to support manual decision making is underway.
Data collection drives asset modeling and allows for more informed manual planning and maintenance decisions. Transformer monitoring is an example. Two way communications and monitoring by a systems application, rather than an operator, are some of the differentiating factors from normal SCADA.

GO-2.4 Investment in and expansion of data communications networks in support of grid operations is underway.
Examples of "expanded data communications" can include internet protocol (IP) networks over fiber, communications on a public carrier, or broadband over power lines. Security requirements are understood and are taken into account as part of the investment and expansion decision making process. Digital communications may be necessary to support the full capability of smart grid operations, but a blend of analog and digital communications will most likely be in place. Rural areas may lag behind urban in moving to digital.

GO-3: Integrating

Analytics, automation, and control operate across multiple systems and organizational functions.

Expected Characteristics

GO-3.1 Enabled by the deployment of smart grid capabilities, information to support analysis and decision making for grid operations is available across multiple systems and organizational functions.

Examples of "smart grid information" can include customer usage data, outage, or load information and transformer monitoring. This may lead to new processes being defined due to increased automation and observability and should reduce information latency across functions within the organization.

GO-3.2 Control analytics have been implemented and are used to improve cross-LOB decision making.

This means that a critical mass of data, equipment, and technologies are integrated with analytics for improved decision support. An example of this might be the integration of real time weather information into grid planning activities. Examples of "cross line of business" can include transmission to distribution, or engineering to customer support. An example of control analytics can include actions taken by ASR systems

GO-3.3 Grid operations' planning is now fact-based planning using grid data made available by deployed smart grid capabilities.

The remote asset monitoring capabilities piloted at Level 2 enable this. Through increased data availability, the organization transitions from scheduled-based to condition-based maintenance.

GO-3.4 Smart meters are important grid management sensors within the organization's network.

This requires timely availability of meter data at the grid control level and the ability to retrieve, analyze, and incorporate the data in grid management decisions.

GO-3.5 Grid data is used by an organization's physical and cyber security functions to support situational awareness and diagnostic activities.

An example could be a smart meter that can send a signal that it is being tampered with or having the capability to correlate anomalous grid activities with anomalous network and device activities.

GO-3.6 There is automated decision making within protection schemes (i.e., leveraging increased analytic capabilities and context).

Real data supports real-time modeling and simulations.

GO-4: Optimizing

Grid operations are integrated into and drive enterprise processes. This enables a transition from people-based decision making to automated decision making.

Expected Characteristics

GO-4.1 Operational data from smart grid deployments is being used to optimize processes across the organization.
An example of an optimized process could be remote meter disconnects. This supports more accurate planning and design.

GO-4.2 Grid operational management is based on near real-time data (i.e. dynamic grid management).
Management is targeted and focused on high-priority tasks and includes recognition of both reliability and security risks. The organization is transitioning from estimation to grid management based on live data, to provide dynamic grid management for load balancing, Volt/Volt-Ampere reactive (VAR) control, power factor management, circuit efficiency, peak management, etc. Dynamic grid management is beyond SCADA going to an operator in a control room. Examples could include a real-time optimization scheme or a system using artificial intelligence to improve the analytical understanding of grid activity cause and effect.

GO-4.3 Operational forecasts are based on data gathered through smart grid capabilities.
Forecasts could be for any time period including the next day, or the next year. Tactical and actionable forecasts rely on more frequent data being available.

GO-4.4 Grid operations information has been made available across functions and lines of business.
This means that there is end-to-end observability.

GO-4.5 There is automated decision making within protection schemes that is based on wide area monitoring.
With automated decision making, the organization is monitoring beyond its operational boundaries by using a computerized system that is programmed to make decisions based on analytics and act on a pre-set group of criteria and actions. For example, the system could monitor the heat index and be set to automatically redistribute load when the index hits a critical point to protect the integrity of the grid. Protection schemes should be considered in two ways: in this example, it first considers the heat index, but it must also consider the customer base. This protection scheme could monitor for heat index and take into consideration premises with elderly inhabitants, thus not shutting down power to specific premises on the grid.

GO-5: Pioneering

The increased observability and control in grid operations is now driving innovation within the organization. Ubiquitous system-wide dynamic control of the grid is now the goal, and the organization is discovering new opportunities as a result of the integrated view of customers, assets, and operations. Reliability is increased not only for operations directly under the control of the utility, but also extends to regional and national levels.

Expected Characteristics

GO-5.1 Self-healing capabilities are present.
Self-healing operations are an expansion of the self-healing grid concept that encompasses people, processes, communications, etc. A recloser is not what is being considered here. A self-healing grid is capable of automatically anticipating and responding to power system disturbances, including the isolation of failed sections and components, while optimizing the performance and service of the grid to customers.

GO-5.2 System-wide analytics-based and automated grid decision making (i.e. applying proven analytics-based control) is in place.
This capability is dependent on the full observability and trust that was established in Level 4. Decisions on whether centralized or distributed control is more appropriate are addressed within the strategy and blueprinting efforts of each organization.

7 Work and Asset Management (WAM)

The Work and Asset Management (WAM) domain represents the organizational capabilities and characteristics that support the optimal management of assets and workforce resources (i.e., people and equipment) that are central to meeting smart grid goals. Increasing levels of maturity for this domain reflect an increasing capability of an organization to utilize information made available from the deployment of smart grid technologies to

- reduce unnecessary maintenance and downtime
- track causes of failures
- diagnose faults and recommend corrective actions
- detect failure conditions in advance of actual failure
- reduce time between problem identification and resolution
- more efficiently deploy workforce resources
- improve capacity planning performance

For example, a utility that is mature in WAM bases its equipment operation and maintenance decisions on up-to-date, fact-based performance data instead of on generic industry best practices or broad, nonspecific, historical precedents. Increasing maturity within this domain also reflects an evolution from preventative and reactive usage and deployment of resources to predictive and planned management. This supports not only the goals of increasing grid reliability, security, efficiency, and safety but also enhances the organization's operational efficiency.

WAM-1: Initiating

The organization is exploring ways to enhance its asset and workforce management capability by utilizing smart grid implementation features. For example, the organization may explore ways to detect precursors to equipment failure in advance of an actual failure by leveraging data provided by sensors deployed for grid status monitoring.

Expected Characteristics

WAM-1.1 Enhancements to work and asset management to be achieved via smart grid implementation have been built into approved business cases at least at a business function level.
Enhancements to workforce and asset management capabilities are both proactive and predictive. Cases demonstrate value beyond reducing fault maintenance and speak to the capability to optimize costs across the life cycle and ensure availability. Business cases are not necessarily integrated across the organization.

WAM-1.2 Potential uses of remote asset monitoring are being evaluated.
Remote asset monitoring goes beyond the basic monitoring performed by typical SCADA. It implies two-way real time communication and provides insights into an asset's current health based on its past performance, corrective-action support, and contextual information on asset criticality to operations.

WAM-1.3 Asset and workforce management equipment and systems are being evaluated for their potential alignment with and contribution to the smart grid vision.

This likely includes consideration of geospatial information systems (GIS) to connect assets and geographic locations. An example is a mobile workforce and crew communication system that is integrated with remote asset monitoring to enable the optimization of work tasks and parts utilization.

WAM-2: Enabling

The organization is making investments in technologies to support asset monitoring and workforce deployment and has started piloting activities. It also continues to refine its work and asset management strategies.

Expected Characteristics

WAM-2.1 An approach for using smart grid capabilities to create inventories, maintain event histories, and track assets is in development.

The development of asset histories includes asset trend and profile information that is based on real asset data.

WAM-2.2 An integrated view of GIS and asset monitoring for increased operational visibility based on location, status, and interconnectivity has been developed. Pilot activities are taking place.

This might include using radio-frequency identification (RFID) technology to link assets to an inventory database that connects GIS and other asset management information.

WAM-2.3 An organization-wide mobile workforce strategy is in development.

This implies that the organization has recognized the need to optimally deploy mobile workforce assets and has identified specific performance objectives to be achieved by a corresponding strategy. Ideally the mobile workforce strategy would be connected to the smart grid strategy, but establishing that connection is not required at this level of maturity. Other activities related to this characteristic might include conducting pilots for enhancements to crew scheduling.

WAM-3: Integrating

The organization is now connecting its smart grid technologies and its workforce and asset management systems to take advantage of the wealth of available information. The interconnected systems are being used to support work and asset management processes. Optimization opportunities are beginning to be exploited to achieve efficiencies in asset maintenance and workforce deployments.

Expected Characteristics

WAM-3.1 Performance, trend analysis, and event audit data are available for individual components of the organization’s cyber and physical systems.

The systems in this case are both the cyber (e.g., SCADA and remote terminal units [RTUs]) and physical systems (e.g. switches and transformers) that support the generation, transmission, and distribution of energy. Examples of components could include switches, transformers, and meters.

WAM-3.2 Condition-based maintenance (CBM) programs for key components are in place.
CBM uses real data from the organization's remote asset monitoring capability to drive maintenance and replacement decisions. One of the efficiency gains that the CBM program might realize is the ability to begin to predictively repair or retire equipment. Examples could include systems to monitor transformers, breakers, and other substation or high value equipment.

WAM-3.3 Remote asset monitoring capabilities are integrated with asset management for at least one asset class.
An example asset class could be transformers.

WAM-3.4 The integration of remote asset monitoring with mobile workforce systems to automate work order creation is underway and in place for at least one asset class.
This might include skill-based routing of work tasks. An example could be when a monitored switch issue would trigger a work order with switch characteristics and list of recommended parts needed for repair.

WAM-3.5 An integrated view of GIS and asset monitoring for increased operational visibility is in place for at least one asset class.
The monitoring is based on location, status, and interconnectivity. This might also include the development of a proximity awareness capability for mobile assets and their interrelation to one another and to fixed assets.

WAM-3.6 Asset inventory is tracked using automation from sourcing to utilization.
An example of sourcing to utilization is from supplier to installed location. Tracking includes location information for an asset (i.e., whether put into use, pulled from use, in staging, warehoused, etc.). Automation might include workers entering the data via keyboard or barcode reader at the warehouse, or something more advanced like using RFID tags.

WAM-3.7 Modeling of asset investments for key components is underway.
The asset performance and management modeling is based on real smart grid data.

WAM-4: Optimizing

The organization is fully leveraging connections between its smart grid deployment and its work and asset management processes. Work and asset management processes are fully integrated into enterprise business processes. Grid reliability, security, efficiency, and safety are increasing, and the organization's own operational efficiency is measurably enhanced.

Expected Characteristics

WAM-4.1 A complete view of asset classes (including location and interrelationships) based on status (including security state), connectivity, and proximity is available to the organization.
Systems may not be tightly integrated, but access to a complete view of the data is enabled across the enterprise (i.e., a federated view of assets). Assets in this case implies more than operational equipment; it includes people and information.

WAM-4.2 Asset models are based on real (both current and historical) performance and monitoring data.
Asset models ideally include financial analysis by asset.

WAM-4.3 Performance and usage of assets (from procurement through retirement) is optimized in consideration of the entire asset fleet and across asset classes.
This includes such things as optimizing crews and equipment and optimizing the way grid operations use assets. It also includes efficient inventory management, utilizing real asset status and modeling information. An example of this would be maintaining an inventory for spares based on current asset status in order to maximize return on investment.

WAM-4.4 Service life for key grid components is managed through the performance of condition-based and predictive maintenance, and is based on real and current asset data.
Key grid components are assets that are required for generation, transmission, and distribution operations (e.g., relays, switches, generators, and transformers). This minimizes outages, minimizes maintenance, maximizes productivity, maximizes useful life, and maximizes potential financial return.

WAM-5: Pioneering

The organization seeks to tune the use of assets across the entire supply chain and drives strategic investment decisions based on the best asset ownership and utilization model.

Expected Characteristics

WAM-5.1 The use of assets between and across supply chain participants is optimized with processes defined and executed across supply chain participants.
Examples could include sharing machine data in real time with suppliers and customers, and they with the organization, in order to optimize both the organization's equipment and theirs.

WAM-5.2 Assets are leveraged to maximize utilization, including just-in-time asset retirement, based on smart grid data and systems.
An example could include running equipment at its maximum capacity and length of service, and staying just below a threshold that could cause failure.

8 Technology (TECH)

The Technology (TECH) domain represents the organizational capabilities and characteristics that enable effective strategic technology planning for smart grid capabilities and the establishment of rigorous engineering and business processes for the evaluation, acquisition, integration, and testing of new smart grid technology. The engineering and business processes should be based on the quality attributes necessary for achieving success and reducing risk (e.g., interoperability, upgradability, security, safety, cost, and performance). Organizational capabilities and characteristics in the Technology domain also reflect adherence to relevant industry and government standards, and integration throughout the enterprise of optimized, data-rich smart grid applications and analytics (with extensive data sharing across lines of business and among industry partners). Use of the organization's smart grid IT infrastructure as a platform for the creation and support of innovative business services not only contributes to the success of the organization but can also open new markets for the industry as a whole.

Achieving the organizational and national benefits of a smart grid transformation involves far more than having vendors produce and utilities (and their customers) acquire advanced smart grid technology. Technology can either contribute to or detract from an organization's ability to meet smart grid goals for itself and for society at large. Smart grid technology supports two-way digital communications, wide-area situational awareness (based on advanced sensor networks), and fine-grained control (e.g., of customer load using smart meters and smart-grid-aware appliances). Nonetheless a cohesive technology strategy, based on sound engineering principles and judicious enterprise-wide business management, is necessary to connect and support the innumerable data sources (including sensors), control elements, and users that make up a smart grid, today and into the future.

TECH-1: Initiating

The organization explores standardized but flexible IT systems that can be used as a solid technical foundation on which to build a robust smart grid information infrastructure.

Expected Characteristics

TECH-1.1 An enterprise IT architecture exists or is under development.
An existing enterprise IT architecture does not have to include specific provisions for smart grid applications. The knowledge and experience gained by designing and implementing an enterprise IT architecture, as well as the related operational experience, will be useful as the smart grid is designed and deployed.

TECH-1.2 The organization evaluates its existing or proposed IT architecture for quality attributes (e.g., interoperability, security, modifiability, etc.) that would support smart grid applications.

TECH-1.3 A change control process is used for applications and IT infrastructure (e.g., for additions, upgrades, and patches).
This characteristic refers to both traditional IT infrastructure and OT (operational technology) such as firmware in the meter.

TECH-1.4 Opportunities are identified to use technology to improve functional departmental performance.

For example, the organization can identify how technology can be used to reduce cost, improve workflow, simplify complex activities, automate repetitive tasks, reduce risk, or improve flexibility and adaptability.

TECH-1.5 There is a process to evaluate and select technologies in alignment with the organization's smart grid vision and/or strategies.

Informative Characteristics

- There is a plan for complying with industry standards relating to smart grid technologies.
- The organization is engaged in the evaluation of off-the-shelf and near-term smart grid technologies, such as AMI meters.
- Analytics are in use (automation not required).
- Functions are automated but may not be well linked (e.g., financial analysis should eventually be linked to operational analysis—data is captured but not flowing between functions or being used).
- Data sharing or interoperability may typically be accomplished through "point-to-point" (i.e., customized) interfaces between systems.

TECH-2: Enabling

The organization has a defined technology strategy for achieving smart grid goals that recognizes the interdependencies across the LOBs. Early deployments of technology to support smart grid pilots and applications are underway.

Expected Characteristics

TECH-2.1 Organization aligns tactical IT investments to an enterprise IT architecture (for providing smart grid services) within an LOB.

The organization develops an IT investment plan that is aligned with the strategic directions needed to gain the benefits of the smart grid.

TECH-2.2 Changes to the enterprise IT architecture that enable smart grid are being deployed.

TECH-2.3 Standards that support the smart grid strategy within the organization's IT architecture are selected.

At a minimum, internal standards must be defined along with a plan to adopt and adapt industry standards where applicable within the architecture. Standards will include areas such as communications, software development, change management, safety and security, and installation and maintenance. The organization applies its standards at least within independently managed IT infrastructure silos.

TECH-2.4 A common technology evaluation and selection process is applied for all smart grid activities.

This process includes vendor and external source selection.

TECH-2.5 The organization has a data communications strategy for the grid.

A data communication strategy at the conceptual level has been defined to guide pilots and planning activities.

TECH-2.6 Pilots based on connectivity to distributed intelligent electronic devices (IEDs) are underway.

These pilots are for business unit applications such as power quality monitoring, protection, and control for substation automation and distribution automation.

TECH-2.7 Information security considerations are built into all smart grid initiatives from the outset.

The term "initiatives" implies not only deployments, but also plans, proposals, pilots, procurements (e.g., requests for proposals [RFPs]), education, and training. Information security includes an incident response (and vulnerability reporting) capability and is a critical part of business continuity planning.

Informative Characteristics

- An architecture implementation plan has been initiated that includes smart grid support.
- Analytics are deployed online.
- The organization promotes the industry adoption of open standards (e.g., for interoperability and security).
- The organization is active in industry-specific workshops and conferences on smart grid technology issues (including reliability, resiliency, interoperability, safety, and security).

TECH-3: Integrating

The organization implements its technology strategy for smart grid and integrates its organizational systems.

Expected Characteristics

TECH-3.1 Smart-grid-impacted business processes are aligned with the organization's enterprise IT architecture across LOBs.

The organization has a robust concept of a portfolio of smart grid services and a clear direction in implementing strategic applications capable of supporting the smart grid portfolio.

TECH-3.2 The organization's systems adhere to an enterprise IT architectural framework for smart grid.

For example, IEC 61850 (a standard for substation automation), Security Profile for Advanced Metering Infrastructure Version 1.0 (recommended security controls and guidance for protecting AMI systems), and CIM (the Common Information Model) may be used across smart grid functions and LOBs. The National Institute of Standards and Technology (NIST) Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0 (January 2010), identifies approximately 80 existing standards that can be applied to smart grid design and implementation efforts, and also identifies gap areas where further standards development is needed. The enterprise IT architectural framework can also be defined internally.

TECH-3.3 Smart-grid-specific technology has been implemented to improve cross-LOB performance.

For example, smart-grid-specific technology can improve peak demand management, *fault detection, and integrated Volt/VAR optimization (VVO). The organization may be evaluating further enterprise-wide opportunities for improvement.*

TECH-3.4 The use of advanced distributed intelligence and analytical capabilities are enabled through smart grid technology.

An example of distributed intelligence would be decentralized deployment of ASR systems.

TECH-3.5 The organization has an advanced sensor plan.

Advanced sensor plans could focus on situational awareness or near real-time control and include the use of phasor measurement units (PMUs) or other sophisticated sensors. Effective assessment of the dynamic performance of power systems requires wide-area situational awareness based on information from properly distributed PMUs.

TECH-3.6 The organization has a detailed data communication strategy and corresponding tactics in place that cross functions and LOBs.

A detailed data communications strategy includes decisions on types of physical communications infrastructure (e.g., broadband over power line or wireless), protocol(s) (e.g., IP), and data or other standards (e.g., for security or interoperability) that will be used. Corresponding tactics in place that cross functions and LOBs could include a means of governance for selecting interconnections, thus allowing all systems to operate together, regardless of the origin or final destination of the data.

Informative Characteristic

The technology strategy includes the application of open standards and the use of evolving off-the-shelf technologies.

TECH-4: Optimizing

Organizational systems are interconnected through a strategic, enterprise-wide IT architecture that has been optimized for the support of smart grid services. Visibility extends across lines of business and business functions throughout the organization. Security, privacy, and performance issues have been considered and addressed in the IT implementations across the enterprise.

Expected Characteristics

TECH-4.1 Data flows end to end, for example from customer to generation.

This applies where permitted by security, privacy, and performance requirements. An example could be a residential customer having the ability to review cost fluctuations affecting the electricity supplier so that informed decisions could be made with regard to the selection of generation sources.

TECH-4.2 Business processes are optimized by leveraging the organization's enterprise IT architecture.

Performance improvement techniques (e.g., lean six sigma) are applied to cross-LOB processes to achieve the greater efficiencies possible with increased observability and control across the enterprise IT architecture. These optimizations are applied throughout the organization's suite of strategic applications that support the portfolio of smart grid services.

TECH-4.3 Systems have sufficient wide area situational awareness to enable real-time monitoring/control/mitigation in response to complex events (e.g., natural disasters, severe weather, extreme demand fluctuations, etc.).
World-aware systems drive complex event processing, monitoring, and control.

TECH-4.4 Predictive modeling and/or near real-time simulation are used to optimize support processes.
For example, analytics drive optimization of decision support processes for power management and equipment maintenance. The application of new analytic capabilities is folded into cross-LOB business processes to enable increased efficiencies based upon real data and business rules. An example could be an Outage Management System (OMS) enhanced by predictive modeling.

TECH-4.5 Performance is improved by using sophisticated systems that are informed by smart grid data (e.g., business intelligence and knowledge management systems).

TECH-4.6 Security strategy and tactics continually evolve based on changes in the operational environment and lessons learned.

Informative Characteristic

The organization works with vendors to develop new and innovative technology solutions to meet the organization's smart grid needs.

TECH-5: Pioneering

Advanced technology helps the organization adapt quickly and serves as a foundation for future innovation. Organizational systems and processes have the ability to adapt to internal and external influences with sufficient speed and agility to (1) continue to meet smart grid goals despite a rapid onset of adverse circumstances and (2) take advantage of new entrepreneurial opportunities that arise as a consequence of the organization's smart grid capabilities.

Expected Characteristics

TECH-5.1 Autonomic computing using machine learning is implemented.
In a self-managing (i.e., autonomic) system with machine learning capabilities, the human operator takes on a new role by defining general policies and rules that serve as an input for the self-management process, which is managed in real time by the computational system. An example could be an outage management system that gets better at prediction outages as time goes on, through collection and consideration of date collected from previous outages.

TECH-5.2 The enterprise information infrastructure can automatically identify, mitigate, and recover from cyber incidents.
This involves recognizing and rapidly responding to cyber security incidents, preventing or mitigating (and/or recovering from) adverse impacts, and broadly sharing relevant incident data in a timely manner to help protect the community at large from potential industry-wide cyber security impacts. In some cases the infrastructure can recognize precursors to a cyber security incident and take protective measures to prevent negative impacts.

Informative Characteristics

- The organization is a recognized industry leader and wields a strong influence in conferences, workshops, technical societies, industry consortia, the cyber security incident response community, and so forth (e.g., DistribuTECH, IEEE Power & Energy Society, GridWise, IntelliGrid, DOE smart grid workshops, etc.).
- Leading-edge grid stability systems are deployed and utilized.
- Business processes automatically re-optimize as conditions dictate through advanced technology solutions.
- The organization partners with vendors to develop new and innovative technology solutions (e.g., advanced storage technology) to meet smart grid needs across the industry.
- The organization is monitoring and actively engaged in community efforts to develop and evolve industry standards for the smart grid (e.g., emerging technology standards for interoperability and security). The organization is well qualified to engage in developing standards given its experience in deployment of smart grid technology through Level 4.

9 Customer (CUST)

The Customer (CUST) domain represents the organizational capabilities and characteristics that enable customer participation toward achieving the benefits of the smart grid transformation. Customer participation may be passive (e.g., allowing the utility to manage customer load and the selection of energy sources) or active (e.g., giving customers the advanced visibility and control needed to automatically manage their own load and choose among alternative energy sources, in response to pricing signals and available market options).

Utilities that demonstrate high levels of maturity in the CUST domain fully empower their customers to make and execute their own choices regarding the use, source, and cost of energy, while protecting the security of the grid and customer privacy. At the same time, a high level of maturity in the CUST domain demonstrates organizational capabilities and characteristics that would help an organization to meet utility, regional, and national goals with respect to grid stability and resiliency, energy efficiency, reduction of peak load, conservation, increased use of green energy sources via distributed generation, and reduced reliance on foreign energy sources (e.g., through innovative uses of the smart grid such as providing a customer management infrastructure and interface for plug-in electric vehicles).

CUST-1: Initiating

The organization explores new ways to enable customer participation toward achieving smart grid goals and enhancing customer experiences.

Expected Characteristics

CUST-1.1 Research is being conducted on how to use smart grid technologies to enhance the customer's experience, benefits, and participation.
The purpose of the research is to determine the best way to (1) enable customer participation in achieving smart grid benefits for the utility and the customer (2) balance customer (end-use consumer) benefits versus utility benefits, and (3) reshape the customer experience (leveraging customer satisfaction surveys, focus groups, and other techniques). These investigations can be through public research via media, conferences, or industry consortia.

CUST-1.2 Security and privacy implications of the new technologies and business functions that enable customer participation in the smart grid are being investigated.

CUST-1.3 A vision of the future grid is being communicated to customers (e.g., by explaining smart grid benefits and describing potential use case scenarios).

CUST-1.4 The utility consults with public utility commissions and/or other government organizations concerning the impact on customers of the utility's smart grid strategies and anticipated implementation schedule.

Informative Characteristics

- "Drive-by" or "walk-by" Automated Meter Reading (AMR) may be implemented for some or all customers.

- Smart grid planning and anticipated benefits may be categorized according to broad customer segmentation (e.g., geography and demographics).
- Remote load control/management for commercial and industrial customers may be operational on a limited basis.
- Reactive utility interactions with the customer are the norm. Other than paying bills, customers interact with the utility primarily by initiating phone calls (e.g., for outage notifications, move in, move out, and billing questions) to which the utility reacts. Interactions with the utility's website may be limited to bill paying.

CUST-2: Enabling

The organization begins to undertake significant piloting and investment in smart grid technologies to enable customer participation, improve the customer experience, and enhance business efficiency.

Expected Characteristics

CUST-2.1 Pilots of remote Advanced Metering Infrastructure and/or Automated Meter Reading (AMI/AMR) are being conducted or have been deployed.
These pilots are specifically directed toward residential customers (non-commercial and non-industrial).

CUST-2.2 The organization has frequent (more than monthly) knowledge of residential customer usage.
Increased data gathering and analytics are initiated to better understand customers and their usage patterns. Analysis of customer usage patterns informs planning and operations in transmission and distribution.

CUST-2.3 The organization is modeling the reliability of grid equipment.
Modeling of reliability issues informs investments for improvements. Examples of investments that may improve reliability include purchase of new grid equipment and better training for operators.

CUST-2.4 Remote connect/disconnect is being piloted (or has been piloted) for residential customers.

CUST-2.5 The organization is assessing the impact on the customer of new services and delivery processes.
These include services and delivery options such as home area networks (HAN), smart meter installs, dynamic pricing, and/or turning power on or off remotely. This also includes pricing schemes and other innovative offerings to residential, commercial, and/or industrial customers.

CUST-2.6 Security and privacy requirements for customer protection are specified for smart-grid-related pilot projects and requests for proposals (RFPs) from vendors.

Informative Characteristics

- The utility is evaluating new customer relationship models, such as consumer-based generation in addition to utility-based distribution.
- The customer has the ability to specify and purchase green power.

CUST-3: Integrating

Integrated business systems and processes increase efficiency and interaction to improve customer satisfaction and provide new services that enhance customer participation.

Expected Characteristics

CUST-3.1 The organization tailors programs to specific customer segments.
The organization understands its residential customers well enough to identify, and take actions based on, a high degree of customer segmentation (e.g., price conscious customers versus customers for whom the cost of green power is no object). For all defined segments of residential customers, the organization has associated action plans to leverage products and services to these segments.

CUST-3.2 Two-way meter communication has been deployed for a significant number of customers.

CUST-3.3 A remote connect and disconnect capability has been deployed for a significant number of customers.

CUST-3.4 Demand response and/or remote load control is available to residential customers.

CUST-3.5 There is automatic outage detection at the substation level.
Instead of being notified of outages by calls or online communications initiated by their customers, the utility receives reports of outages from smart meters or other power system devices that detect and report the outage (e.g., to an energy control center) and provide data that can be analyzed to determine the probable cause of the outage.

CUST-3.6 Residential customers have on-demand access to daily usage data.
Fine-grained and timely usage data enables customers to understand how their consumption patterns (e.g., time-of-day) affect their electricity costs. The data availability could be more frequent than daily.

CUST-3.7 A common experience has been implemented across two or more residential customer interface channels.
Common customer experience means a common look and feel along with a consistency of message to the consumer. Examples of customer interface channels could be customer support phone systems, internet information, and mailings.

CUST-3.8 The organization provides customer education on how to use smart grid services to curtail peak usage.

CUST-3.9 Customer products and services have built-in security and privacy controls that follow industry and government standards.
Security and privacy controls are built in from the outset rather than "bolted on" later. For example, security and privacy controls may be based on guidance and recommendations provided by the UCA International Users Group (UCAIug) Smart Grid Security Working Group and the NIST Smart Grid Interoperability Panel Cyber Security Working Group.

Informative Characteristics

- There are new interactive products and service offerings for pricing, control, conservation, customization, efficiency, etc.

- The customer experiences information-rich interactions with their utility. For example, the customer can receive (planned) outage notifications (including back-in-service estimations), detailed information on usage, new products and services, etc., through multiple channels.
- The utility may be piloting home device control via home area networks.

CUST-4: Optimizing

Increased observability (of the state of the power system to a fine-grained level of detail) and integrated control across the utility enables some tailoring of services (e.g., pricing programs and automated load management) for individual customers based upon their usage histories, profiles, and preferences.

Expected Characteristics

CUST-4.1 Support is provided to customers to help them analyze and compare their actual usage against all available pricing programs.

CUST-4.2 There is automatic outage detection and proactive notification at the circuit level.
A distribution circuit could be supplying electricity to a group of residences or an entire neighborhood.

CUST-4.3 Customers have access to near real-time data on their own usage.
This access is on-demand and up-to-the-minute.

CUST-4.4 Residential customers participate in demand response and/or utility-managed remote load control programs.
The organization is modeling and tracking customer participation.

CUST-4.5 The utility supports the capability for automatic response to pricing signals for major energy consuming devices within the customer's premise.
This support includes not only provisioning and operating the underlying technology but also providing customer education about the capability.

CUST-4.6 In-home net billing programs are enabled.
An example might be a program that pays customers (or credits their accounts) for customer-provided electricity such as from solar panels to the grid or electric vehicles to the grid.

CUST-4.7 A common residential customer experience has been integrated.
This experience is across all means of interfacing with residential customers for all services provided (e.g., leveraging common data sources).

Informative Characteristics

- Behavior modeling augments customer segmentation for creating customer profiles.
- New customer service models are enabled, such as customized and personalized contracts or service level agreements (SLAs) covering pricing, availability, connects, disconnects, and load control.
- Customer accounts are managed through home device control and the home area network.
- There is predictive modeling of customer needs, including peak power demands.

CUST-5: Pioneering

The organization's products and services can be specifically and extensively tailored at a fine-grained level to individual customer profiles and desires.

Expected Characteristics

CUST-5.1 Customers can manage their end-to-end energy supply and usage level (i.e., energy sources and mix).
This means being able to at least specify their preferences profile and, at the extreme, would allow for active management.

CUST-5.2 There is automatic outage detection at the premise or device level.
This assumes capability for monitoring individual devices (e.g., appliances) has been deployed.

CUST-5.3 Plug-and-play customer-based generation (e.g., wind and solar) is supported.
This includes the necessary infrastructure, such as metering equipment that supports net billing. A good example of "plug and play" would be when a device is plugged into a computer, the operating system detects what it is and makes the necessary updates. Customers should be able to add any device (e.g., wind or solar) to the grid, and it should respond appropriately.

CUST-5.4 The organization is able to assure security and privacy for all customer data stored, transmitted, or processed on the grid.
The organization provides compelling evidence of assurance, which may include design reviews, penetration test results, third-party certifications, certifications of programmer training in secure coding, code reviews, third-party reviews of security and privacy policies, etc.

CUST-5.5 The organization plays a leadership role in industry-wide information sharing and standards development efforts for smart grid.
Information sharing and standards development efforts should consider customer security and privacy while also promoting customer choice and control. For example, employees of the organization are among the recognized leaders in government, industry, and/or professional society working groups that develop standards and best practices for smart grid security, privacy, and information sharing. The organization pioneers innovative programs to extend customer choice and control, which become widely adopted throughout the industry.

Informative Characteristics

- Innovative customer products may be available, such as appliance failure prediction and preventive maintenance programs.
- Consumption level by device is available, as are price-based time-of-use recommendations. This assumes capability for monitoring individual devices has been deployed.
- Green mobility (support for electric vehicles) and carbon emission programs may be available, including buying, selling, or trading carbon credits.

10 Value Chain Integration (VCI)

The Value Chain Integration (VCI) domain represents the organizational capabilities and characteristics that underlie an electric utility's ability to achieve its smart grid goals by successfully managing the utility's organizational interdependencies with both the supply chain for the production of electricity and the demand chain for its delivery. VCI enables dynamic supply and demand management based on near real-time information. Traditionally, electric utility companies were vertically integrated organizations typified by centralized decision making and bounded by political geography. Market pressures and regulatory changes transformed many utilities into new chains of organizations to produce and deliver electricity whereas in the past, one company monopolized the local market. As a result of environmental concerns and the need for increased efficiencies, market forces and regulatory bodies will again force the industry to change, providing new opportunities for organizations with smart grid competence and causing new value chains to emerge. Automation will extend beyond traditional boundaries and across the entire value chain to provide opportunities for innovation and efficiencies in load management, distributed generation, and market structure. As a utility matures, the cooperative planning, implementation, and management of electricity from sources of production to end-use consumption will optimize profitability and improve performance of the utility's value chain. Networked information technology and data sharing, aligned with value chain business units' requirements, are critical for success.

VCI-1: Initiating

The organization identifies the supply and distribution requirements for its products and services. Strategic plans address communication/information-sharing needs across the profit centers in the value chain.

Expected Characteristics

VCI-1.1 The organization identifies assets and programs necessary to facilitate load management.
Strategic planning to accomplish load management throughout the value chain incorporates asset identification, information sharing, and profitability analyses.

VCI-1.2 The organization has identified distributed generation sources and the capabilities needed to support them.
Strategic planning to accomplish distributed generation throughout the value chain incorporates asset identification, information sharing, and profitability analyses.

VCI-1.3 The organization has identified energy storage options and the capabilities needed to support them.

VCI-1.4 The organization has a strategy for developing, enabling, and managing a diverse resource portfolio (e.g., integration of new resources such as DR, DG).
The organization's resource portfolio is the set of energy sources (i.e., distributed generation, demand response, renewable, and storage, etc.) and includes ways to reduce/balance load in a holistic manner. To support the creation and management of a diverse resource portfolio, the organization determines the information and profitability needs of relevant decision makers along the value chain.

VCI-1.5 The security requirements to enable interaction with an expanded portfolio of value chain partners have been identified.
An example might be the organization has identified the security requirements necessary to protect sensitive communications with its potential partners.

Informative Characteristics

- The organization develops business cases and identifies benefits of implementing advanced metering infrastructure.
- The organization identifies costs, benefits, and needs for information sharing within its value chain.
- The utility has implemented simple peak demand programs (e.g., a/c load shedding).
- Contract vehicles are in place to accommodate distributed generation to large customers.

VCI-2: Enabling

Investments, decisions, and systems are implemented to enable benefits from a network of alternate generation sources managed for downstream load management.

Expected Characteristics

VCI-2.1 The organization provides support for energy management systems for its residential customers.
This might be accomplished via customer portals or in-home displays, for example.

VCI-2.2 The organization's value chain has been redefined based upon its smart grid capabilities.
This includes DG, micro-generation, energy storage, and other new customers and suppliers. An example of redefining the value chain could be relying less on finding alternative sources of generation to cover peaks, because of the ability to use demand response effectively.

VCI-2.3 The organization has conducted pilots to support a diverse resource portfolio.
This could include distributed generation, demand-side management, demand response, and energy storage, for example.

VCI-2.4 The organization has piloted secure interactions with an expanded portfolio of value chain partners.
For example, the organization may have piloted secure information sharing with multiple external partners. This would include the policies, procedures, and technology for communicating, storing, and accessing shared data in a manner that satisfies the business and security requirements of the organization and its partners.

Informative Characteristics

- Contract vehicles are in place to accommodate distributed generation for small- and mid-sized customers.
- The organization collaborates with suppliers and customers to identify new and innovative opportunities to automate and integrate processes that enable efficiency gains.
- The organization identifies opportunities to introduce new products and services.

VCI-3: Integrating

The organization's business systems are aligned and interconnected to promote dynamic management and profitability through network interaction with the value chain.

Expected Characteristics

VCI-3.1 An integrated resource plan is in place and includes new targeted resources and technologies (e.g., demand response, distributed generation, Volt/Volt-Ampere Reactive (VAR) management systems, etc.).

The integrated resource plan is a plan that seeks to establish an efficient balance among different types of generation and an efficient balance of supply and demand. Several major system components in distribution can affect the management of volts and VARs. These components include load tap changing (LTC) transformers, LTC line regulators, and capacitor bank controls (pole-top and substation step-bank), all of which can lend themselves to networked automation. Evaluation of a Volt/VAR management system requires all of these components to be considered individually and collectively to ascertain the most efficient, viable method of dynamic control.

VCI-3.2 Customer (commercial, industrial, and residential) premise energy management solutions with market and usage information are enabled.

The organization provides a secure information network to allow market and consumption information to be used by customer energy management systems (e.g., integrated smart thermostats communicate with AMI systems). Demand-side management (DSM) programs require utilities to plan, implement, and monitor activities that are designed to encourage consumers to modify their level and pattern of electricity usage.

VCI-3.3 Additional resources (e.g., PHVs, storage, DR) are available and deployed to provide substitutes for market products to support reliability or other objectives.

VCI-3.4 Security management and monitoring processes are deployed to protect the interactions with an expanded portfolio of value chain partners.

Informative Characteristics

- The organization participates in programs and associations to support value chain partners for load management and distributed generation (e.g., Rural Electric Associations, Retail Electric Providers, etc.).
- The organization adopts new models for trading energy efficiently given new sourcing capacity from customer-based management and distributed generation, new transmission and distribution connectivity and control, and innovative rate and pricing options. Deployment of energy trading mechanisms that leverage some of these features is underway.

VCI-4: Optimizing

The organization's business processes support the dynamic capture and utilization of information relevant to distributed generation and related load management activities.

Expected Characteristics

VCI-4.1 The organization's energy resources (including Volt/VAR, DG, and DR) are dispatchable and tradable.
Distributed generation and load management can be used to sell extra power. Another example is if an adjoining utility needs more power, the organization could use demand response to lower usage and assist in supplying power to the other utility.

VCI-4.2 The organization has implemented portfolio optimization models that encompass available resources and real-time markets.
Portfolio optimization models should encompass all available resources and real-time markets. Optimization models enable rapid response to dynamic market/supply conditions.

VCI-4.3 The organization provides secure two-way communications with Home Area Networks (HANs).

VCI-4.4 The organization has integrated visibility and potential control of residential customer's large-demand appliances (e.g., air conditioners, water heaters) to balance demand and supply.

Informative Characteristics

- The utility realizes opportunities for a value shift from generators to other organizations in the value chain so that they can share the gains from ancillary services (e.g., power on demand).
- The organization utilizes modeling of the entire generation and load management potential in real time, including the ability to scale distributed generation resources as needed.

VCI-5: Pioneering

The utility's dynamic management and automation of value chain assets realizes greater value and benefits, providing leadership in regional and national grid management capabilities.

Expected Characteristics

VCI-5.1 The optimization of energy assets is automated across the full value chain.
An example of optimization of energy assets across the full value chain could be turning up distributed generation capacity or draw (e.g., through residential customers capability such as PHVs) when the cost of centralized generation exceeds a certain threshold and distributed generation becomes more cost competitive.

VCI-5.2 Resources are adequately dispatchable and controllable so that the organization can take advantage of granular market options (e.g., locational marginal pricing).
For example, if an adjoining utility needs more power and is ready to pay higher prices for it, the organization could use demand response (DR) to lower usage and assist in supplying power to the other utility. The resulting monetary gain could be kept or

passed on to the DR customers. Successful participation in newly emerging markets can necessitate the introduction of new organizational roles and business models.

VCI-5.3 The organization’s automated control and resource optimization schemes consider and support regional and/or national grid optimization.

Informative Characteristics

- The organization’s control of its supply chain enables increased stability of supply and demand and enhances reliability of service.
- The organization’s capabilities extend optimization into regional/national grid operations and markets.
- The utility promotes a wider scope of information sharing at regional and national levels, which enables rapid management of events and price stability.

11 Societal and Environmental (SE)

The Societal and Environmental (SE) domain represents the organizational capabilities and characteristics that enable an organization to contribute to achieving societal goals regarding the reliability, safety, and security of our electric power infrastructure, the quantity and sources of the energy we use, and the impact of the infrastructure and our energy use on the environment and our quality of life. Societal and environmental issues compose a major focus of smart grid initiatives. A smarter grid can provide the ability for a utility and society to make better informed choices and leverage energy alternatives while improving environmental impacts. Utilities can promote conservation and green initiatives to mitigate capacity needs while developing the ability to integrate alternative and distributed energy sources. Effective implementation of these programs can enhance the organization's reputation and strengthen relationships with its customers, regulators, and the public at large.

Increased efficiencies in production and consumption made possible through a smarter grid not only reduce environmental impacts but can also sustain profitability. Organizations participating in smart grid deployments and operations can effectively address society's critical infrastructure protection concerns by incorporating security and resiliency solutions early on. The prevention, mitigation, and remediation of security risks and events will be an ongoing requirement for the utility and all participants of the smart grid.

SE-1: Initiating

The organization acknowledges the growing importance of societal and environmental issues and addresses them as an integral part of the organization's strategic planning for the smart grid.

Expected Characteristics

SE-1.1 The organization's smart grid strategy or vision addresses its role in societal and environmental issues.

The strategy addresses the utility's role in addressing cost increases, global warming, pollution issues, hazardous materials, spill control, "not in my backyard," etc., and identifies needed planning for related future development (e.g., renewable energy integration).

SE-1.2 The organization is publicly promoting the environmental benefits of its smart grid vision and strategy.

The organization is initiating conservation, efficiency, and "green" educational programs internally and externally. These efforts are publicized, and feedback is solicited. Educational materials concerning the utility's strategy and future developments are made available to promote a better-informed public dialogue.

SE-1.3 Records of the organization's environmental compliance performance are available for public inspection.

There is transparency with respect to the utility's regulated environmental compliance.

SE-1.4 The organization's smart grid vision or strategy specifies its role in protecting the nation's critical infrastructure.
Cyber and physical risks to networked energy systems are addressed at the earliest stages of smart grid planning, piloting, and implementation.

SE-2: Enabling

The organization is engaged in addressing societal and environmental issues by managing decisions, investments, and networks in a way that facilitates sustainable, efficient energy utilization.

Expected Characteristics

SE-2.1 The organization's smart grid strategies and work plans address societal and environmental issues.
These can include cost increases, global warming, pollution, hazardous materials, spill control, "not in my backyard," and other public concerns. For example, the organization may plan to monitor its carbon emissions and develop estimates of mitigation through application of smart grid technologies.

SE-2.2 The organization has established energy efficiency programs for its customers.
The organization is initiating conservation, efficiency, and "green" programs.

SE-2.3 The organization considers a "triple bottom line" view when making decisions.
The traditional reporting framework expands to take into account not only financial performance but environmental and social performance, a triple-bottom-line view.

SE-2.4 Environmental proof-of-concept projects (e.g., solar or wind generation connected to the grid) are underway that demonstrate smart grid benefits to the public and the environment.
The utility explores what their smart grid technologies and methods can address to benefit the public and the environment.

SE-2.5 Increasingly granular and more frequent consumption information is available to customers (including residential).
Detailed and timely energy usage information enables changes in consumption behavior.

Informative Characteristic

The organization can accommodate multiple energy sources, including intermittent renewable sources.

SE-3: Integrating

The organization's units share a common focus on societal and environmental issues.

Expected Characteristics

SE-3.1 The organization is implementing and measuring the performance of the societal and environmental programs included in its smart grid strategy and/or work plans, and the measures demonstrate effectiveness.
The organization has developed goals for its societal and environmental performance

and implemented the use of measurements to gauge its progress. An example could include reduction in miles travelled in support of grid maintenance.

SE-3.2 The organization makes available to customers (commercial, industrial, and residential) segmented and tailored information that includes environmental and societal benefits and costs.
For various categories of customers, the organization provides information that promotes a greater understanding of the customers' role in achieving societal and environmental goals. Commercial and industrial customers are provided with tailored analytics and advice.

SE-3.3 The organization has programs to encourage off-peak usage by customers.
The organization promotes a more balanced load profile by increased utilization of energy network troughs.

SE-3.4 The organization regularly reports on the sustainability and the societal and environmental impacts of its smart grid programs and technologies.
An example of regular reporting is an organization that makes environmental and societal scorecards that are updated on a quarterly basis available on its website.

Informative Characteristics

- The organization invests in ways to reduce or capture carbon emissions with a focus on energy efficiency and cost effectiveness.
- Programs are in place for commercial and industrial customers to manage their usage.

SE-4: Optimizing

The organization has implemented business processes that deliver an environmentally friendly energy network while minimizing costs and sustaining profitability. Collaboration with industry stakeholders in addressing societal and environmental issues is a key element of these processes.

Expected Characteristics

SE-4.1 The organization collaborates with external stakeholders to address environmental and societal issues.
Collaboration with a diverse set of external stakeholders (including environmental groups, investment community, etc.) is part of the organization's standard business processes.

SE-4.2 The organization maintains a public environmental and societal scorecard.

SE-4.3 Programs are in place to shave peak demand (e.g., demand response programs, dynamic pricing signals, and managed control of devices).

SE-4.4 End-user energy usage and devices are actively managed through the utility's network, where appropriate.

SE-4.5 The organization fulfills its critical infrastructure assurance goals for resiliency, and contributes to those of the region and the nation.

Informative Characteristics

- The utility has established load management programs to reduce its carbon footprint.
- The utility has the ability to scale distributed generation units as needed.

- Environmentally driven investments are aligned with the smart grid strategy.
- The organization provides leadership on relevant utility issues through public interaction and participation in industry associations.

SE-5: Pioneering

The organization extends and integrates technology, business processes, and assets to the regional and national grids to maximize societal value and environmental benefits.

Expected Characteristics

SE-5.1 Triple-bottom-line goals align with local, regional, and national objectives.
Solutions for societal and environmental issues previously resolved at the organizational level now extend to a regional or national scale. Major societal and environmental issues require large-scale collaboration and information sharing.

SE-5.2 Customers (commercial, industrial, and residential) control their energy-based environmental footprint through automatic optimization of their end-to-end energy supply and usage level (energy source and mix) based on their selected preferences.
A potential scenario would be customers who choose to purchase half of their electricity from solar generation and half from wind generation. If no wind generated power is available, then selected high energy devices in the home are automatically turned off.

SE-5.3 The organization is a leader in developing and promoting industry-wide resilience best practices and/or technologies for protection of the national critical infrastructure.

12 Using the SGMM

The previous sections of this document covered the details of the model. This final section provides a brief overview on how the model can be successfully used in an organization and points to some potential pitfalls that may lead to failure to derive benefits from the use of the model.

12.1 The SGMM and Strategic Planning

The SGMM was created to serve as a management support tool for electric utilities. The model provides a framework for understanding the current state of smart grid deployment and capability within an electric utility and provides a context for establishing future strategies and work plans. As such, it has a number of valid uses (both strategic and tactical) that are summarized in the table below.

Table 1: Using the SGMM

• To establish a shared picture of smart grid objectives • To communicate smart grid vision both internally and externally • To use as a strategic framework for identifying business and investment objectives • To benchmark and learn from others	• To use as a guide to identify a specific roadmap or waypoints • To assess and prioritize current opportunities and projects • To use as a decision making framework for investment purposes • To assess resource needs to move from one level to another in a domain • To measure progress

The most common way that the SGMM has been used to date has been as part of a strategic objectives identification process. The process begins with the organization performing an SGMM assessment. The assessment results establish a shared picture of the organization’s current state of smart grid deployment. The organization then uses its understanding of its current operating environment and planning horizon in conjunction with the model to establish a desired future state, including an SGMM-based maturity target profile that it wishes to achieve. The organization periodically re-assesses against the SGMM to understand its progress toward the objectives.

12.2 The SGMM and Benchmarking

An organization is rated in each domain of the model by taking the SGMM Compass. The compass is composed of both domain-specific and nonspecific compass questions. The rating for a specific domain is entirely based on the domain-specific questions for that domain. The Compass contains one domain-specific question for each expected characteristic in the model. To ease understanding, the domain-specific compass questions are numbered consistently with the characteristics in this document. An organization does not have to “completely” exhibit all expected characteristics of a given level of a domain to be rated at that level. Scoring criteria establish a level rating based on a composite of the responses to all domain-specific questions in that domain level. Higher ratings in a domain reflect a growing extent of smart grid implementation in an organization with respect to the subject of that domain. The result of an SGMM assessment is a maturity profile that includes maturity ratings for each of the eight SGMM domains (see

Figure 3).

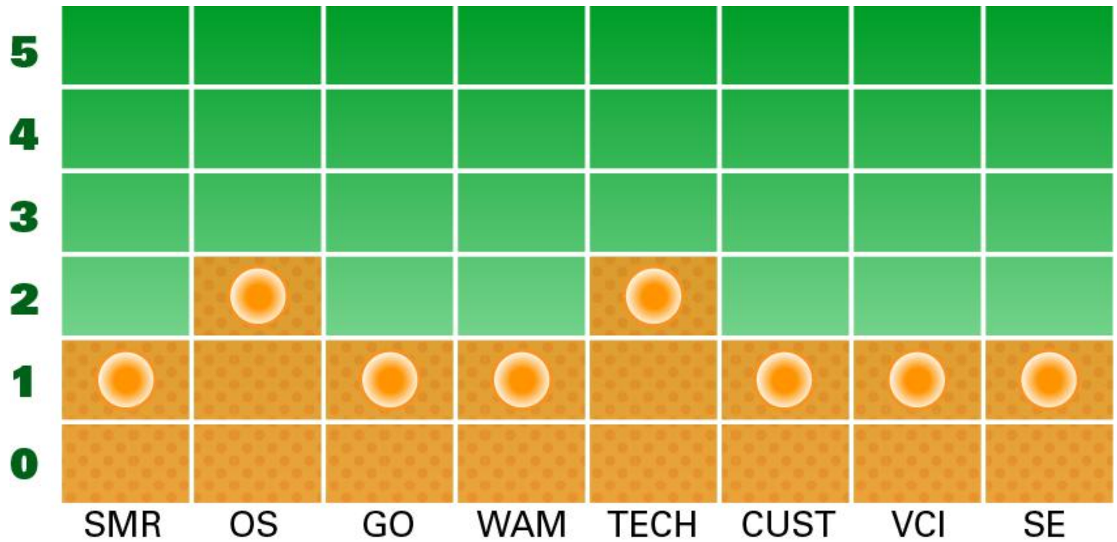

Figure 3: A Sample Maturity Profile

An organization's ratings are best and most appropriately used to compare the organization against itself over time (e.g., to understand the effectiveness and impact of ongoing efforts or planning exercises in the context of the SGMM). However, as with any model that provides a "score," there is often significant interest in comparing the scores of different organizations. While this might be an interesting exercise, it is important to be cautious when drawing conclusions from the results. There is a temptation to say that higher maturity scores within a domain are always better than lower scores. This, however, is a not a valid use of the model because it does not take into consideration the organization's business goals and operating environment.

There is significant diversity in the operating environments of the utility community. The maturity profile that is ideal for one utility at a particular point in time is going to be determined by a utility's size, its economic and regulatory profile, its ownership profile, and many other factors. It may be the case that some SGMM domains do not apply to a particular utility or that a utility's current regulatory environment prevents it from moving beyond a specific level of maturity within a domain. Making evaluations based strictly on an organization's SGMM ratings without a reasonably good understanding of the context will likely lead to invalid conclusions.

That being said, the results of an SGMM assessment can be used for some benchmarking. For example, it might be useful for an organization to compare its domain ratings against other utilities that have a similar demographic profile. If their ratings are significantly different, then it might be useful for the utility to explore why that difference exists. It may highlight some area of strategic importance that may have been overlooked or prompt the organization to explore how gains in an overlooked domain might increase its success. Differences in business goals and objectives can sometimes explain significant differences in objectives and ratings.

Nonspecific questions in the compass have no impact on an organization's maturity ratings, but are used to accumulate performance data from all utilities that participate in the compass. This data will be used to perform analyses to evaluate performance and demographic trends as they correlate to various patterns of maturity profiles. The findings from these analyses will be used to improve the model and will be provided in published reports so that the community can benefit from insights gained.

All utility-specific data collected through the compass process will be kept completely confidential by the SEI. Data summary reports and trends analyses may be published, but they will never reveal the identity of any specific utilities either directly or indirectly.

12.3 Performing an SGMM Assessment

To perform an assessment against the model, an organization needs to complete the Compass survey and then have it scored. More information on Compass scoring can be found at http://www.sei.cmu.edu/smartgrid.

Appendix A Model Architecture

This appendix describes the architecture of the SGMM. The architecture presents the fundamental elements of the model and the relationships among them. This material is provided to explain the structure of the model itself and the key properties of its design.

SGMM Metamodel

Figure 4 describes the SGMM metamodel (a model of a model) as a Unified Modeling Language (UML) class diagram. Each class represents an important element of the SGMM. Relationships show how the elements are related, including the multiplicities involved in those relationships. Each element is elaborated in the following sections.

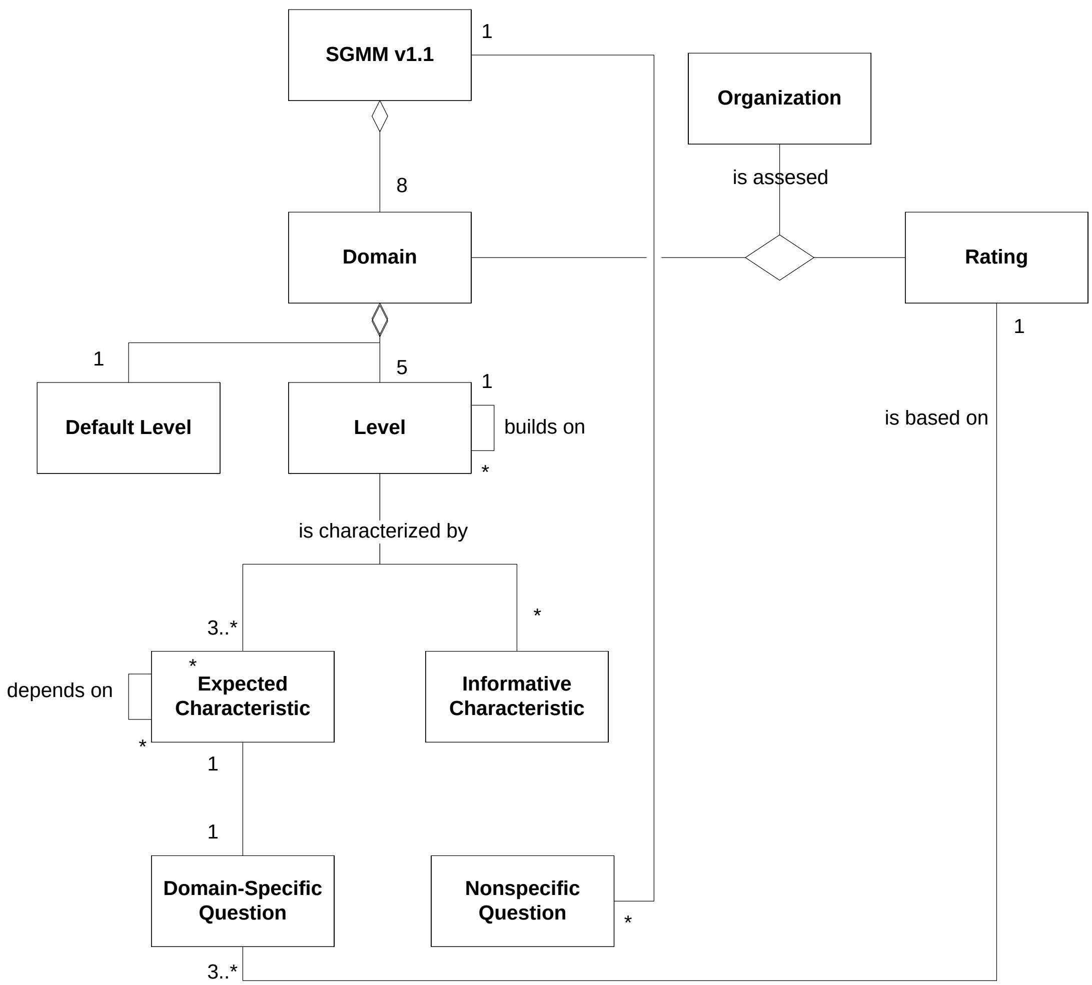

Figure 4: SGMM Metamodel in UML

SGMM v1.1

This element represents the current version of the SGMM as a whole. The SGMM provides a framework for understanding the current state of smart grid deployment and capability within an electric utility and a context for establishing future strategies and work plans.

This version of the SGMM is composed of eight domains, as defined in Section 3.

Domain

A domain is a logical grouping of smart-grid-related capabilities and characteristics in a focus area. There are eight domains in SGMM v1.1:

1. Strategy, Management, and Regulatory (SMR)
2. Organization and Structure (OS)
3. Grid Operations (GO)
4. Work and Asset Management (WAM)
5. Technology (TECH)
6. Customer (CUST)
7. Value Chain Integration (VCI)
8. Societal and Environmental (SE)

Though domains address related topics, each has a unique emphasis. The details of each domain are described through the characteristics of the levels of the domain. Each domain is composed of six levels—a single default level (Level 0) and five nonzero levels (Levels 1-5).

Each nonzero level defines a set of characteristics expressing the extent of smart grid deployment and capability one would expect to find in an organization operating at that level.

Levels are progressive in nature. As smart grid deployment grows in scope and capability in an organization, that organization would be assessed at increasingly higher levels. As the levels build on each other, it would be unusual for an organization to exhibit the expected characteristics of a level without also exhibiting the expected characteristics of lower levels in that domain.

Levels in one domain are independent of levels in other domains. An organization could exhibit the expected characteristics of a high level in one domain while exhibiting few expected characteristics of even a low level of another domain. While characteristics of different domains may be related (e.g., sharing a common dependency on a technology like AMI), each focuses on the aspects relevant to a single domain. This allows individual domains to be assessed independently.

Default Level

The default level of a domain (Level 0) is indicative of an organization that has not sufficiently exhibited the expected characteristics of Level 1. For example, in a period before or during the initial steps toward the adoption of smart grid technology, this would be normal for an organization. See Section 2.1 Level 0 - Default for more information.

Default levels are not described by characteristics. Any organization not satisfying Level 1 of a domain is at the default level for that domain, by definition.

Level

The remaining levels of each domain are the nonzero levels (Levels 1-5). Each level is described by a set of characteristics indicative of organizations at this stage of smart grid deployment and capability. Two different kinds of characteristics are used to describe each nonzero level—expected characteristics and informative characteristics.

Characteristics are not shared across domains or levels. While characteristics may address related topics, each focuses on the aspect of the issue that is important at the domain and level at which it appears.

Each level of each domain has a unique abbreviation for reference. This abbreviation is the concatenation of the short string identifying the domain (see the parenthetical in the list in Section 0) with the level number (e.g., CUST-3 is Level 3 of the Customer domain).

The typical meaning of each nonzero level, regardless of domain, is described in Section 2.1 Level 0 - Default. Briefly, these are

Level 1	Initiating
Level 2	Enabling
Level 3	Integrating
Level 4	Optimizing
Level 5	Pioneering

Expected Characteristic

An expected characteristic describes a specific implementation feature that an organization is expected to exhibit at a given level of a domain. Each nonzero level of each domain must have at least three expected characteristics (with the exception of Level 5). Level 5 is about breaking new ground and advancing the state of the practice. As such, it is less specific and sometimes described by fewer characteristics.

Each expected characteristic within a level is numbered. This number is concatenated with the unique abbreviation for the level of the domain to create a unique abbreviation for each expected characteristic (e.g., CUST-3.2 is the second expected characteristic of Level 3 of the Customer domain).

Expected characteristics, like levels, often build on other expected characteristics. Typically they build on other expected characteristics of the same domain, but occasionally there is a dependency from a characteristic of one domain to a characteristic of another domain.

Informative Characteristic

An informative characteristic describes related implementation features that an organization may exhibit at a given level of a domain, but informative characteristics are not required. Each nonzero level of a domain may have any number of informative characteristics, including none.

Informative characteristics are not numbered, and so do not have unique abbreviations.

Domain-Specific Question

A domain-specific question is a question that is used to assess an organization's level rating in some domain. Each domain-specific question addresses a single expected characteristic and each expected characteristic has exactly one domain-specific question.

Nonspecific Question

A nonspecific question is a question that is not used to assess an organization's level rating in any domain (e.g., demographic questions). Nonspecific questions may relate to informative characteristics, but this is not required.

Organization

For the purposes of the SGMM, an organization is an electric utility or a subset of such a utility that uses the model to understand the current state of its smart grid deployment and capability. An organization is assessed against the SGMM to determine a series of level ratings (0-5), one per domain.

The SGMM is meant to be applied to a single utility or meaningful subset thereof, not across a collection of utilities. It has been defined with vertical utilities in mind, though with an emphasis on distribution technologies.

Rating

An organization is rated independently in each domain of the model. The rating for a specific domain is entirely based on the domain-specific questions for that domain. Nonspecific questions have no impact on an organization's ratings.

An organization does not have to "completely" exhibit all expected characteristics of a given level of a domain to be rated at that level. Scoring criteria are used to base a level rating on a composite of the responses to all scored questions of a level.

An organization's ratings are best and most appropriately used to compare the organization against itself over time (e.g., to understand the effectiveness and impact of ongoing efforts or planning exercises).

Higher ratings in a domain reflect a growing extent of smart grid implementation in an organization with respect to the subject of that domain.

SGMM as Communicated Across Different Documents

The full details of the SGMM are defined by two documents, the Model Definition Document and the Compass, each with its own emphasis. In this section, each document is related to the meta-model to explain its emphasis.

The *Smart Grid Maturity Model, v1.1: Definition* document (this document) defines the SGMM. As illustrated in Figure 5, this document defines the model itself, including domains, levels, and expected and informative characteristics. This document does not address the assessment process, except to define the material (the model itself) that is the subject of the assessment.

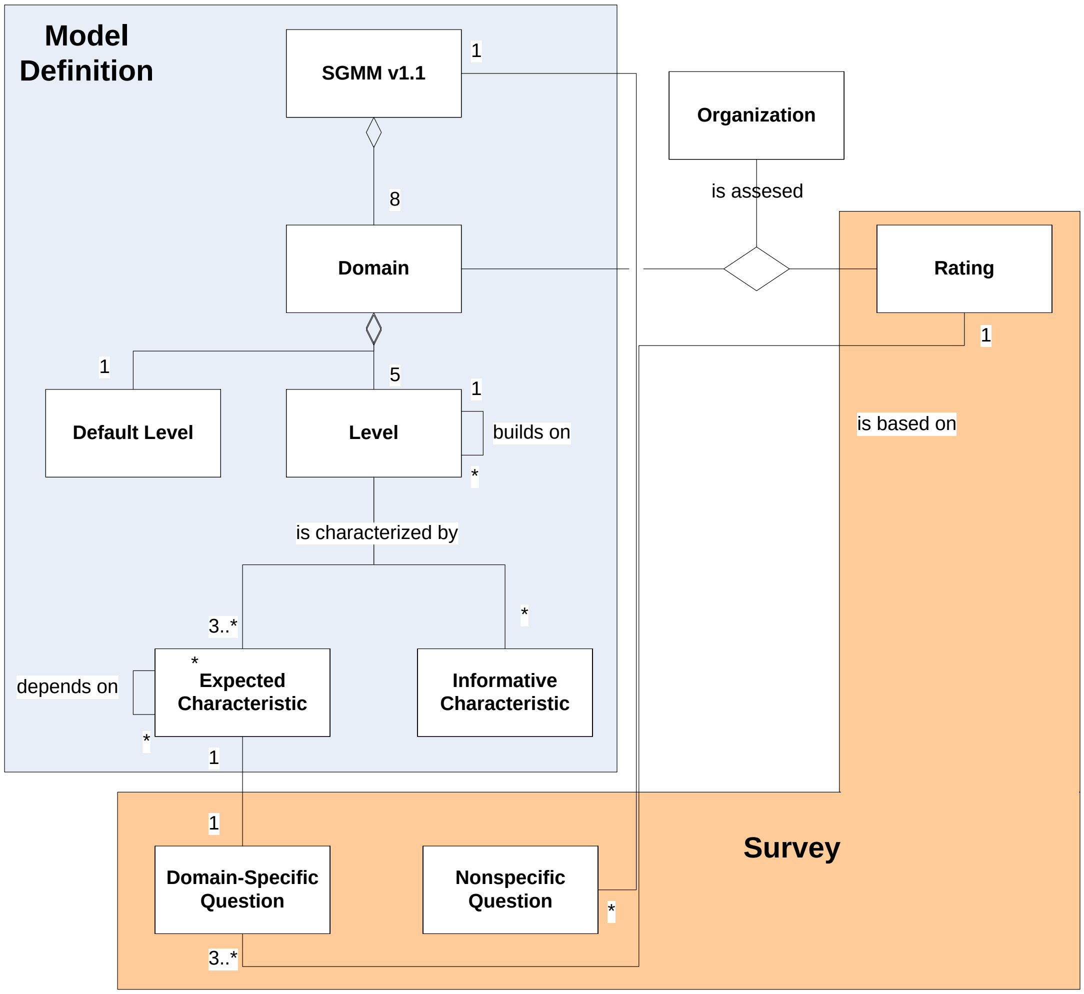

Figure 5: Material Addressed by the SGMM Model Defintion and Compass Assessment Survey

The *Smart Grid Maturity Model: Compass Assessment Survey* document can be used as a reference as it defines the questions that are used to assess an organization's ratings across the domains of the SGMM. It cannot be used for an assessment as it does not include scoring criteria.

Appendix B Smart Grid Maturity Model: Matrix

Smart Grid Maturity Model: Matrix

SGMM
Smart Grid Maturity Model

Level	Strategy, Management, and Regulatory (SMR) vision, planning, governance, stakeholder collaboration	Organization and Structure (OS) culture, structure, training, communications, knowledge management
5 PIONEERING	1 Smart grid strategy capitalizes on smart grid as a foundation for the introduction of new services and product offerings. 2 Smart grid business activities provide sufficient financial resources to enable continued investment in smart grid sustainment and expansion. 3 New business model opportunities emerge as a result of smart grid capabilities and are implemented.	1 The organizational structure enables collaboration with other grid stakeholders to optimize overall grid operation and health. 2 The organization is able to readily adapt to support new ventures, products, and services that emerge as a result of smart grid. 3 Channels are in place to harvest ideas, develop them, and reward those who help shape future advances in process, workforce competencies, and technology.
4 OPTIMIZING	1 Smart grid vision and strategy drive the organization's strategy and direction. 2 Smart grid is a core competency throughout the organization. 3 Smart grid strategy is shared and revised collaboratively with external stakeholders.	1 Management systems and organizational structure are capable of taking advantage of the increased visibility and control provided by smart grid. 2 There is end-to-end grid observability that can be leveraged by internal and external stakeholders. 3 Decision making occurs at the closest point of need as a result of an efficient organizational structure and the increased availability of information due to smart grid.
3 INTEGRATING	1 The smart grid vision, strategy, and business case are incorporated into the vision and strategy. 2 A smart grid governance model is established. 3 Smart grid leaders with explicit authority across functions and lines of business are designated to ensure effective implementation of the smart grid strategy. 4 Required authorizations for smart grid investments have been secured.	1 The smart grid vision and strategy are driving organizational change. 2 Smart grid measures are incorporated into the measurement system. 3 Performance and compensation are linked to smart grid success. 4 Leadership is consistent in communication and actions regarding smart grid. 5 A matrix or overlay structure to support smart grid activities is in place. 6 Education and training are aligned to exploit smart grid capabilities.
2 ENABLING	1 An initial smart grid strategy and a business plan are approved by management. 2 A common smart grid vision is accepted across the organization. 3 Operational investment is explicitly aligned to the smart grid strategy. 4 Budgets are established specifically for funding the implementation of the smart grid vision. 5 There is collaboration with regulators and other stakeholders regarding implementation of the smart grid vision and strategy. 6 There is support and funding for conducting proof-of-concept projects to evaluate feasibility and alignment.	1 A new vision for a smart grid begins to drive change and affect related priorities. 2 Most operations have been aligned around end-to-end processes. 3 Smart grid implementation and deployment teams include participants from all impacted functions and LOBs. 4 Education and training to develop smart grid competencies have been identified and are available. 5 The linking of performance and compensation plans to achieve smart grid milestones is in progress.
1 INITIATING	1 Smart grid vision is developed with a goal of operational improvement. 2 Experimental implementations of smart grid concepts are supported. 3 Discussions have been held with regulators about the organization's smart grid vision.	1 The organization has articulated its need to build smart grid competencies in its workforce. 2 Leadership has demonstrated a commitment to change the organization in support of achieving smart grid. 3 Smart grid awareness efforts to inform the workforce of smart grid activities have been initiated.
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Version 1.1

Smart Grid Maturity Model: Matrix

SGMM
Smart Grid Maturity Model

Level	**Grid Operations (GO)** reliability, efficiency, security, safety, observability, control	**Work and Asset Management (WAM)** asset monitoring, tracking and maintenance, mobile workforce
5 PIONEERING	1 Self-healing capabilities are present. 2 System-wide, analytics-based, and automated grid decision making is in place.	1 The use of assets between and across supply chain participants is optimized with processes defined and executed across the supply chain. 2 Assets are leveraged to maximize utilization, including just-in-time asset retirement, based on smart grid data and systems.
4 OPTIMIZING	1 Operational data from smart grid deployments is being used to optimize processes across the organization. 2 Grid operational management is based on near real-time data. 3 Operational forecasts are based on data gathered through smart grid. 4 Grid operations information has been made available across functions and LOBs. 5 There is automated decision-making within protection schemes that is based on wide-area monitoring.	1 A complete view of assets based on status, connectivity, and proximity is available to the organization. 2 Asset models are based on real performance and monitoring data. 3 Performance and usage of assets is optimized across the asset fleet and across asset classes. 4 Service life for key grid components is managed through condition-based and predictive maintenance, and is based on real and current asset data.
3 INTEGRATING	1 Smart grid information is available across systems and organizational functions. 2 Control analytics have been implemented and are used to improve cross-LOB decision-making. 3 Grid operations planning is now fact-based using grid data made available by smart grid capabilities. 4 Smart meters are important grid management sensors. 5 Grid data is used by an organization's security functions. 6 There is automated decision-making within protection schemes.	1 Performance, trend analysis, and event audit data are available for components of the organization's systems. 2 CBM programs for key components are in place. 3 Remote asset monitoring capabilities are integrated with asset management. 4 Integration of remote asset monitoring with mobile workforce systems, in order to automate work order creation, is underway. 5 An integrated view of GIS and asset monitoring is in place. 6 Asset inventory is being tracked using automation. 7 Modeling of asset investments for key components is underway.
2 ENABLING	1 Initial distribution to substation automation projects are underway. 2 Advanced outage restoration schemes are being implemented, which resolve or reduce the magnitude of unplanned outages. 3 Aside from SCADA, piloting of remote asset monitoring of key grid assets to support manual decision making is underway. 4 Investment in and expansion of data communications networks in support of grid operations is underway.	1 An approach to track, inventory, and maintain event histories of assets is in development. 2 An integrated view of GIS for asset monitoring based on location, status, and interconnectivity (nodal) has been developed. 3 An organization-wide mobile workforce strategy is in development.
1 INITIATING	1 Business cases for new equipment and systems related to smart grid are approved. 2 New sensors, switches, and communications technologies are evaluated for grid monitoring and control. 3 Proof-of-concept projects and component testing for grid monitoring and control are underway. 4 Outage and distribution management systems linked to substation automation are being explored and evaluated. 5 Safety and security (physical and cyber) requirements are considered.	1 Enhancements to work and asset management have been built into approved business cases. 2 Potential uses of remote asset monitoring are being evaluated. 3 Asset and workforce management equipment and systems are being evaluated for their potential alignment to the smart grid vision.
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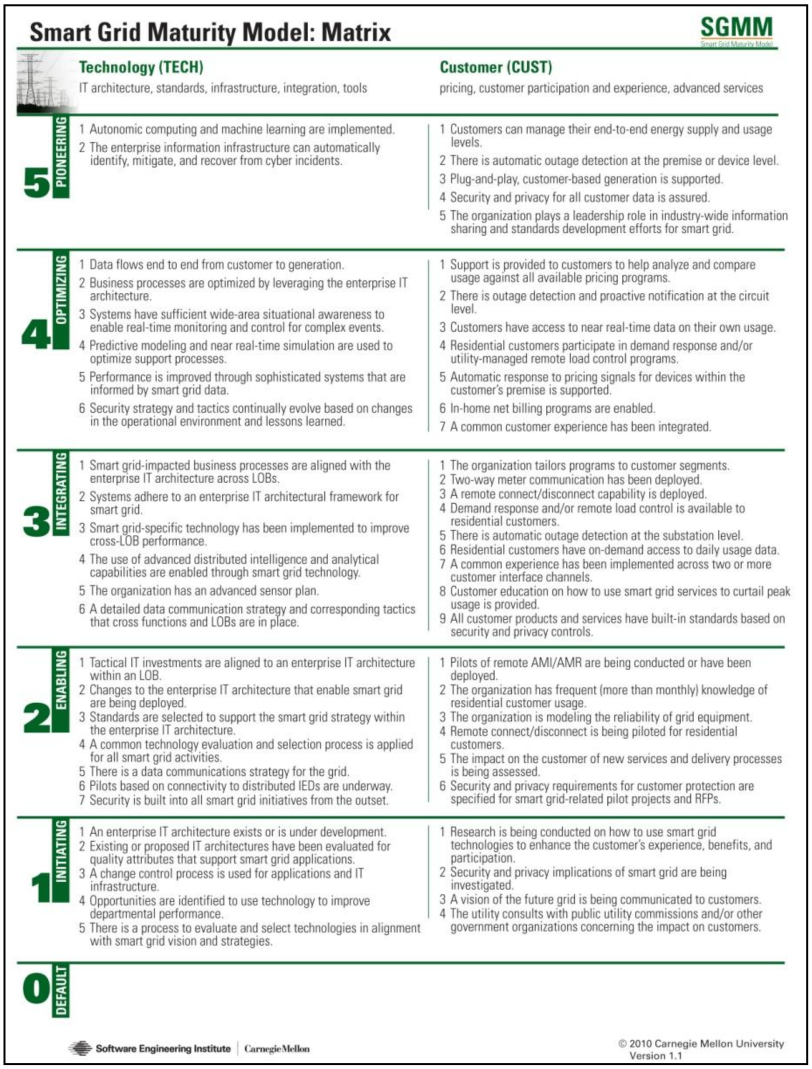

Smart Grid Maturity Model: Matrix

SGMM
Smart Grid Maturity Model

Level	Technology (TECH) IT architecture, standards, infrastructure, integration, tools	Customer (CUST) pricing, customer participation and experience, advanced services
5 PIONEERING	1 Autonomic computing and machine learning are implemented. 2 The enterprise information infrastructure can automatically identify, mitigate, and recover from cyber incidents.	1 Customers can manage their end-to-end energy supply and usage levels. 2 There is automatic outage detection at the premise or device level. 3 Plug-and-play, customer-based generation is supported. 4 Security and privacy for all customer data is assured. 5 The organization plays a leadership role in industry-wide information sharing and standards development efforts for smart grid.
4 OPTIMIZING	1 Data flows end to end from customer to generation. 2 Business processes are optimized by leveraging the enterprise IT architecture. 3 Systems have sufficient wide-area situational awareness to enable real-time monitoring and control for complex events. 4 Predictive modeling and near real-time simulation are used to optimize support processes. 5 Performance is improved through sophisticated systems that are informed by smart grid data. 6 Security strategy and tactics continually evolve based on changes in the operational environment and lessons learned.	1 Support is provided to customers to help analyze and compare usage against all available pricing programs. 2 There is outage detection and proactive notification at the circuit level. 3 Customers have access to near real-time data on their own usage. 4 Residential customers participate in demand response and/or utility-managed remote load control programs. 5 Automatic response to pricing signals for devices within the customer's premise is supported. 6 In-home net billing programs are enabled. 7 A common customer experience has been integrated.
3 INTEGRATING	1 Smart grid-impacted business processes are aligned with the enterprise IT architecture across LOBs. 2 Systems adhere to an enterprise IT architectural framework for smart grid. 3 Smart grid-specific technology has been implemented to improve cross-LOB performance. 4 The use of advanced distributed intelligence and analytical capabilities are enabled through smart grid technology. 5 The organization has an advanced sensor plan. 6 A detailed data communication strategy and corresponding tactics that cross functions and LOBs are in place.	1 The organization tailors programs to customer segments. 2 Two-way meter communication has been deployed. 3 A remote connect/disconnect capability is deployed. 4 Demand response and/or remote load control is available to residential customers. 5 There is automatic outage detection at the substation level. 6 Residential customers have on-demand access to daily usage data. 7 A common experience has been implemented across two or more customer interface channels. 8 Customer education on how to use smart grid services to curtail peak usage is provided. 9 All customer products and services have built-in standards based on security and privacy controls.
2 ENABLING	1 Tactical IT investments are aligned to an enterprise IT architecture within an LOB. 2 Changes to the enterprise IT architecture that enable smart grid are being deployed. 3 Standards are selected to support the smart grid strategy within the enterprise IT architecture. 4 A common technology evaluation and selection process is applied for all smart grid activities. 5 There is a data communications strategy for the grid. 6 Pilots based on connectivity to distributed IEDs are underway. 7 Security is built into all smart grid initiatives from the outset.	1 Pilots of remote AMI/AMR are being conducted or have been deployed. 2 The organization has frequent (more than monthly) knowledge of residential customer usage. 3 The organization is modeling the reliability of grid equipment. 4 Remote connect/disconnect is being piloted for residential customers. 5 The impact on the customer of new services and delivery processes is being assessed. 6 Security and privacy requirements for customer protection are specified for smart grid-related pilot projects and RFPs.
1 INITIATING	1 An enterprise IT architecture exists or is under development. 2 Existing or proposed IT architectures have been evaluated for quality attributes that support smart grid applications. 3 A change control process is used for applications and IT infrastructure. 4 Opportunities are identified to use technology to improve departmental performance. 5 There is a process to evaluate and select technologies in alignment with smart grid vision and strategies.	1 Research is being conducted on how to use smart grid technologies to enhance the customer's experience, benefits, and participation. 2 Security and privacy implications of smart grid are being investigated. 3 A vision of the future grid is being communicated to customers. 4 The utility consults with public utility commissions and/or other government organizations concerning the impact on customers.
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Smart Grid Maturity Model: Matrix

SGMM
Smart Grid Maturity Model

Level	Value Chain Integration (VCI) demand and supply management, leveraging market opportunities	Societal and Environmental (SE) responsibility, sustainability, critical infrastructure, efficiency
5 PIONEERING	1 The optimization of energy assets is automated across the full value chain. 2 Resources are adequately dispatchable and controllable so that the organization can take advantage of granular market options. 3 Automated control and resource optimization schemes consider and support regional and/or national grid optimization.	1 Triple bottom line goals align with local, regional, and national objectives. 2 Customers control their energy-based environmental footprints through automatic optimization of their end-to-end energy supply and usage level (energy source and mix). 3 The organization is a leader in developing and promoting industry-wide resilience best practices and/or technologies for protection of the national critical infrastructure.
4 OPTIMIZING	1 Energy resources (including Volt/VAR, DG, and DR) are dispatchable and tradable. 2 Portfolio optimization models that encompass available resources and real-time markets are implemented. 3 Secure two-way communications with Home Area Networks (HANs) are available. 4 Visibility and potential control of customers' large-demand appliances to balance demand and supply is available.	1 The organization collaborates with external stakeholders to address environmental and societal issues. 2 A public environmental and societal scorecard is maintained. 3 Programs are in place to shave peak demand. 4 End-user energy usage and devices are actively managed through the utility's network. 5 The organization fulfills its critical infrastructure assurance goals for resiliency, and contributes to those of the region and the nation.
3 INTEGRATING	1 An integrated resource plan is in place and includes new targeted resources and technologies. 2 Customer premise energy management solutions with market and usage information are enabled. 3 Additional resources are available and deployed to provide substitutes for market products to support reliability or other objectives. 4 Security management and monitoring processes are deployed to protect the interactions with an expanded portfolio of value chain partners.	1 Performance of societal and environmental programs are measured and effectiveness is demonstrated. 2 Segmented and tailored information that includes environmental and societal benefits and costs is available to customers. 3 Programs to encourage off-peak usage by customers are in place. 4 The organization regularly reports on the sustainability and the societal and environmental impacts of its smart grid programs and technologies.
2 ENABLING	1 Support is provided for energy management systems for residential customers. 2 The value chain has been redefined based on its smart grid capabilities. 3 Pilots to support a diverse resource portfolio have been conducted. 4 Secure interactions have been piloted with an expanded portfolio of value chain partners.	1 Smart-grid strategies and work plans address societal and environmental issues. 2 Energy efficiency programs for customers have been established. 3 The organization considers a "triple bottom line" view when making decisions. 4 Environmental proof-of-concept projects are underway that demonstrate smart grid benefits. 5 Increasingly granular and more frequent consumption information is available to customers.
1 INITIATING	1 Assets and programs necessary to facilitate load management are identified. 2 Distributed generation sources and the capabilities needed to support them are identified. 3 Energy storage options and the capabilities needed to support them are identified. 4 There is a strategy for creating and managing a diverse resource portfolio. 5 Security requirements to enable interaction with an expanded portfolio of value chain partners have been identified.	1 The smart grid strategy addresses the organization's role in societal and environmental issues. 2 The environmental benefits of the smart grid vision and strategy are publicly promoted. 3 Environmental compliance performance records are available for public inspection. 4 The smart grid vision or strategy specifies the organization's role in protecting the nation's critical infrastructure.
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Appendix C Glossary

Advanced Metering Infrastructure (AMI)

Advanced Metering Infrastructure refers to systems that measure, collect, and analyze energy usage, from advanced devices such as electricity meters, gas meters, and/or water meters, through various communication media on request or on a pre-defined schedule.

Advanced outage restoration schemes

Advanced capabilities to restore power after an unplanned outage. In this context, "advanced" means employing the use of sensing resources to know what is happening and data analytics for automatically making corrections, or providing recommendations regarding corrections that can be made by an operator. An example of an "advanced outage restoration scheme" is Automated Sectional Restoration.

Analytics-based control

Analytics-based control employs the use of sensing and other resources to gather data on situational awareness. Then the results of analysis or modeling based on that data are used to automatically make control decisions, or to provide recommendations regarding control actions that can be made by an operator.

Automated Meter Reading (AMR)

Automated Meter Reading is the technology of automatically collecting consumption data from metering devices (water, gas, or electric) and transferring that data to a central database for billing, troubleshooting, and analyzing. AMR is generally considered less sophisticated than Advanced Metering Infrastructure (AMI). A common form of AMR used today is drive-by meter reading.

Automated outage detection

In contrast to being notified of outages by calls or online communications initiated by their customers, the utility receives reports of outages from smart meters or other power system devices that detect and report the outage (e.g., to an energy control center) and provide data that can be analyzed to determine the probable cause of the outage.

Circuit level

The last stage (i.e., the lowest level) of distribution before electricity is delivered to a meter. For residential customers, circuit level represents distribution down to the transformer that delivers electricity to a group of residences. In the U.S. a final transformer typically supplies eight houses, whereas in Europe the number is typically 25 houses per transformer.

Condition-based maintenance

Performing maintenance on equipment when measures of the health of the equipment indicate that maintenance activities should be carried out. To support condition-based maintenance, equipment may be instrumented to provide data for health analysis and modeling. Alternatively, or as a supplementary activity, periodic maintenance inspections may be performed to collect health data using a variety of tools and technologies. Condition-based maintenance is also known as *predictive maintenance* since the goal to predict when maintenance activities will be most cost effective based on the projected condition of the equipment over time. In contrast, see “Schedule-based maintenance.”

Core competency

The combination of technology and production skills that creates an organization’s products and services and provides its competitive advantage in the marketplace. One or more workforce competencies must be present in the workforce so that they can execute a core competency of the organization. A workforce competency is a cluster of knowledge, skills, and process abilities that an individual should develop to perform a particular type of work in the organization [Adapted from P-CMM 2009].

Customer

A residential, commercial, or industrial end user of electric power supplied by a utility.

Customer (CUST) domain

The Customer domain represents the organizational capabilities and characteristics that enable customer participation toward achieving the benefits of the smart grid transformation. Customer participation may be passive (e.g., allowing the utility to manage customer load and the selection of energy sources) or active (e.g., giving customers the advanced visibility and control needed to automatically manage their own load and choose among alternative energy sources, in response to pricing signals and available market options).

Default level

The default level of a domain (Level 0) is indicative of an organization that has not sufficiently exhibited the expected characteristics of Level 1.

Distributed Generation (DG)

In contrast to large-scale central generation facilities, distributed generation refers to decentralized, typically small-scale, energy sources that are located relatively close to (often on the premises of) the consumers of the electricity being provided. These energy sources include photovoltaic cells, fuel cells, wind turbines, microturbines, gas turbines, reciprocating engines, and diesel-fired generators, and can be owned by the consumer or the utility. Distributed generation can be used to supplement (or partially replace) the power provided by a central generation facility (e.g., by generating the extra power needed to meet peak loads) or in some cases could be used to meet all of a consumer’s electricity needs, as well as feed excess power back to the grid.

Domain

A domain is a logical grouping of smart-grid-related capabilities and characteristics.

Domain-specific question

A domain-specific question is a question that is used to assess an organization’s level rating in some domain. There is exactly one domain-specific question for every expected characteristic in the model.

End-to-end grid observability

This term can be defined from both an organizational perspective and from a grid-wide perspective. End-to-end observability within an organization means that grid operations information is made available to all functions and lines of business. End-to-end observability across the grid means end-to-end data flow from generation to customer and from customer to generation, where permitted by security, privacy, and other requirements. An example could be a residential customer having the ability to go online and review cost fluctuations affecting the electricity supplier so that informed decisions could be made with regard to the selection of generation sources.

End-to-end process

A structured set of automated and/or manual activities and tasks that fulfills some aspect of an organization's mission and encompasses a business flow extending from the provider of a service to the consumer of that service.

Energy network troughs

Periods of particularly low off-peak energy usage. Utilities can create a more balanced load profile by encouraging customer usage during such periods through time-differentiated pricing (based on expected load profiles for different times of day) or by using pricing signals to offer lower prices in an automated, dynamic fashion based on near-real-time recognition of low-load conditions.

Enterprise

The largest (i.e., highest level) organizational entity to which the organization participating in the SGMM Compass belongs. For some participants, the organization taking the compass is the enterprise itself. The organization is the focus of the SGMM and is assessed against the model to determine their current state of smart grid deployment and capability. See "Organization."

Enterprise IT architecture

The architecture of a set of IT systems deployed throughout the enterprise. An enterprise IT architecture defines the hardware, software, network, and data elements of an IT system, their properties, and the relationships among them. An enterprise IT architecture is often described in terms of multiple, related views of the system (e.g., a communications architecture, a process architecture, and an information architecture). Note: This should not be confused with enterprise architecture, which is a broader concept that also includes enterprise goals and business processes.

Estimate of Restoration Time (ERT) accuracy

The percentage of actual restoration times (time from outage detection until service is restored to a customer, or actual clock time of restoration) that meet or beat the initial estimates of restoration time provided to customers.

External stakeholders

Individuals and groups external to a utility that can be affected by or can affect the utility's business behavior. External stakeholders include customers, voters, financial institutions, environmental groups, taxpayers, and regulatory bodies.

Expected Characteristic

An expected characteristic describes a specific implementation feature that an organization is expected to exhibit at a given level of a domain.

Field visit

An event where utility personnel go to a physical location to operate, maintain, or inspect some aspect of their grid.

Formal process

A documented, repeatable, structured set of automated and/or manual activities and tasks that fulfills some aspect of an organization's mission.

Grid Operations (GO) domain

The Grid Operations domain in the Smart Grid Maturity Model represents the organizational capabilities and characteristics that support the reliable, secure, safe, and efficient operation of the electrical grid. Increasing maturity within this domain reflects an evolution from relatively inflexible, manually-intensive operations with limited visibility into the health of the grid to automated operations with significant flexibility and a high degree of situational awareness at local, regional, and national levels.

Informative characteristic

An informative characteristic describes implementation features that an organization may exhibit at a given level of a domain, but informative characteristics are not required by the model.

Interruptible rate

"The lower rate offered to a customer (generally a large industrial or commercial entity) who agrees to have electric service interrupted, usually during a high demand period" [NARUC].

Load

"Any consumer of electrical energy; also, the amount of power (demand) used by a utility system, electrical device or consumer. Load can be manually or automatically curtailed or shed temporarily during times of high usage (customers have agreed beforehand to such actions) or managed to ensure a reliable electricity supply" [NARUC].

Load management

"In contrast to conservation strategies to reduce energy usage generally, load management tries to shift demand from peak generating periods to offpeak times. Many utilities encourage load management by offering customers a choice of service options with various price incentives. See interruptible rates" [NARUC].

Line losses

Energy waste (through heat and corona effects) resulting from the transmission of electrical energy across power lines.

Line of business (LOB)

A well-defined area of commercial activity focused on providing a particular type of product or service. A line of business typically corresponds to a specific organizational entity that is responsible for carrying out the related activity, often as part of a larger commercial enterprise. Examples of differing lines of business are generation vs. distribution, and power delivery vs. building automation services.

Maturity profile

A maturity profile is the set of scores that result from an organization taking an SGMM Compass, and comprises the organization's ratings (0-5) for each of the eight model domains. An organization is rated independently in each domain of the model. Higher ratings in a domain reflect a growing extent of smart grid implementation in an organization with respect to the subject of that domain. The organization's ratings can be used to compare the organization to itself over time (e.g., to understand the effectiveness and impact of ongoing improvement efforts or planning exercises in the context of the SGMM).

Net billing

Allows a customer to receive credit for customer-owned generation (e.g., wind or solar) that is fed onto the electricity grid. The customer's bill for electricity service from the utility is reduced by the price of the electricity the customer supplies to the grid. It is even possible for a customer to receive a net payment from the utility. If the metering equipment can keep a record of the separate electricity flows (rather than just the net amount of electricity used by the customer beyond the amount the customer generates), customer-supplied electricity may be valued at a different rate than electricity supplied by the utility.

Net metering

"Consumers of electricity can deduct the amount of electricity that they supply to the grid (via solar panels for example) with the use of a net metering device. The consumer receives a credit for the electricity conveyed on to the electricity grid ..." [ECO 2010].

Nonspecific question

A nonspecific question is a question that is no used to assess an organization's level rating in any domain and instead captures demographic and performance information.

Organization

For the purposes of the SGMM, an organization is an electric utility or a subset of such a utility that uses the model to understand their current state of smart grid deployment and capability. The organization is the focus of the SGMM and is assessed against the model to determine a set of level ratings, one rating per domain.

Organization and Structure (OS) domain

The Organization and Structure domain in the Smart Grid Maturity Model represents the organizational capabilities and characteristics that enable an organization to align and operate as required to achieve its desired smart grid transformation. The domain focuses on changes in communications, culture, structure, training and education, and knowledge management within the organization.

Outage duration

The time from first indication of outage to restoration of service to all impacted customers.

Outage frequency

Total number of customer interruptions divided by the total number of customers (typically for the period of a year). This reliability measure is also known as the "System Average Interruption Frequency Index (SAIFI)." This measure and other key measures used to quantify reliability are defined in IEEE Standard 1366-2003: *IEEE Guide for Electric Power Distribution Reliability Indices*. http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=1300984

Plug-and-play customer-based generation

Physical and logical support that simplifies the initial connection of customer-based generation equipment to the grid (e.g., by automating equipment discovery and configuration). This plug-and-play capability relies on a standards-based interoperable design specification for distribution grid interfaces and customer-based generation equipment.

Predictive maintenance
See condition-based maintenance.

Price elasticity model
An abstract representation of how the demand for electricity would change in response to changes in price and how that would affect a utility's revenue.

Rate design
"The type of prices used to signal consumers and recover costs. For example, these can involve block pricing, multipart prices, seasonal rates, time of use rates, and bundled services..." [NARUC].

Remote connect/disconnect
The ability to connect or disconnect service to a customer without sending a technician to the physical location.

Revenue
Total annual revenue is net proceeds generated from the sale of products or services. This should reflect the selling price less any allowances such as quantity, discounts, rebates, and returns. (Note: Business entity revenue needs to only include inter-company business segment revenue when the transactions between those business segments are intended to reflect an arm's length transfer price and would therefore meet the regulatory requirements for external revenue reporting.)

Schedule-based maintenance
Performing maintenance based on the average expected lifetime and service intervals for a given piece of equipment (based on factors such as its class, manufacturer's recommendations/repair data, and level of use). In contrast, see "Condition-based maintenance."

Self-healing capability
The ability to automatically anticipate and/or sense and recognize power system disturbances and automatically respond with the appropriate corrective action.

Situational awareness
Situational awareness denotes having a sufficiently accurate and up-to-date understanding of the past, current, and projected future state of a system, in the context of its environment, to support effective decision making with respect to activities that depend on and/or affect how well a system functions. It involves the collection of data (e.g., via sensor networks), data fusion, and data analysis (which may include modeling and simulation) to support automated and/or human decision making (for example, concerning smart grid control functions). Situational awareness also involves the presentation of the results of the data analysis in a form (e.g., using data visualization techniques, appropriate use of alarms) that allows human operators or other human decision makers to quickly grasp the key elements needed for good decision making.

Smart grid plan
A formal, detailed written technical and business plan for implementing an organization's smart grid strategy.

Smart grid strategy

A high-level description of the technical and business steps that will be taken to achieve the organization's smart grid vision, including the roles and responsibilities of the individuals and entities needed to carry out those steps. Progress toward achieving the organization's smart grid vision should be periodically assessed and the smart grid strategy should be adjusted accordingly.

Smart grid vision

A high-level description of an envisioned future state of the organization in which a set of desired goals of the organization and its stakeholders are being fulfilled through the implementation of smart grid technology.

Societal and Environmental (SE) domain

The Societal and Environmental domain in the Smart Grid Maturity Model represents the organizational capabilities and characteristics that enable an organization to contribute to achieving societal goals regarding the reliability, safety, security, and affordability of our electric power infrastructure, the quantity and sources of the energy we use, and the impact of the infrastructure and our energy use on the environment and our quality of life. Societal and environmental issues comprise a major focus of smart grid initiatives.

Strategy, Management, and Regulatory (SMR) domain

The Strategy, Management, and Regulatory (SMR) domain in the Smart Grid Maturity Model represents the capabilities and characteristics that enable an organization to successfully develop a smart grid vision and strategy, establish internal governance and management processes, and promote collaborative relationships with stakeholders to implement that strategy and vision. The integration, communication, and management of the mission, vision, and strategy guides the way through a successful smart grid transformation.

Substation automation

Substation automation goes beyond traditional SCADA to provide added capability and information that can further improve operations and maintenance, increase system and staff efficiencies, and leverage and defer major capital investments. Applications and data of interest may include remote access to intelligent electronic devices (IED0/relay configuration ports, waveforms, event data, diagnostic information, video for security or equipment status assessment, metering, switching, volt/VAR management, and others to maintain uninterrupted power services to the end users.

Sustainability

"The concept that economic development must take full account of the environmental consequences of economic activity. Sustainability of the environment is achieved through using resources so that they can be replaced or renewed and therefore are not depleted" [ECO 2010].

Technology (TECH) domain

The Technology domain in the Smart Grid Maturity Model represents the organizational capabilities and characteristics that enable effective strategic technology planning for smart grid capabilities and the establishment of rigorous engineering and business processes for the evaluation, acquisition, integration, and testing of new smart grid technology. The engineering and business processes should be based on the quality attributes necessary for achieving success and reducing risk (e.g., interoperability, upgradability, security, safety, cost, and performance).

Total customer count

Total number of customers, not meter count (since some customers may have multiple meters).

Triple bottom line

The three factors that compose the triple bottom line are commonly known as people, planet, and profit. Triple bottom line (TBL or 3BL) refers to measures of organizational success that include social and environmental impacts, in addition to economic factors (i.e., the traditional financial bottom line).

Value Chain Integration (VCI) domain

The Value Chain Integration domain in the Smart Grid Maturity Model represents the organizational capabilities and characteristics that underlie an electric utility's ability to achieve its smart grid goals by successfully managing the utility's organizational interdependencies with both the supply chain for the production of electricity and the demand chain for its delivery. Value Chain Integration enables dynamic supply and demand management based on near real-time information.

Vertical integration

"Ownership of all aspects of production, sale, and delivery for a product or service (often as a result of mergers of firms involved in different stages of production). Electric utilities have been vertically integrated historically, with a single firm owning assets and being responsible for generation, transmission, and distribution systems, as well as for the metering and billing activities (retail)" [NARUC].

Work and Asset Management (WAM) domain

The Work and Asset Management domain in the Smart Grid Maturity Model represents the organizational capabilities and characteristics that support the optimal management of assets and workforce resources (i.e. people and equipment) that are central to meeting smart grid goals. Increasing levels of maturity for this domain reflect an increasing capability of an organization to utilize information made available from the deployment of smart grid technologies.

Appendix D Acronym List

- AMI – Advanced Metering Infrastructure
- AMR – Automated Meter Reading
- AOBA – Apartment and Office Building Association
- ASR – Automated Sectionalization and Restoration
- BPL – Broadband Over Power Line
- CBM – Condition-Based Maintenance
- CIM – Common Information Model
- CUST – Customer
- DG – Distributed Generation
- DOE – United States Department of Energy
- DR – Demand Response
- GIS – Geospatial Information System
- GO – Grid Operations
- HAN – Home Area Network
- IEC – International Electrotechnical Commission
- IED – Intelligent Electronic Devices
- LOB – Line of Business
- LTC – Load Tap Changing
- NETL – National Energy Technology Laboratory
- NIST – National Institute of Standards and Technology
- OMS – Outage Management System
- OS – Organization and Structure
- PHV – Plug-in Hybrid Vehicle
- PMU – Phasor Measurement Unit
- RFID – Radio-Frequency Identification
- RFP – Request for Proposals
- ROI – Return on Investment
- RTU – Remote Terminal Unit
- SCADA – Supervisory Control and Data Acquisition
- SE – Societal and Environmental
- SEI – Software Engineering Institute
- SGMM – Smart Grid Maturity Model
- SLA – Service Level Agreements
- SMR – Strategy, Management, and Regulatory

- TECH – Technology
- VAR – Volt/Volt-Ampere Reactive (VAR)
- VCI – Value Chain Integration
- VVO – Volt/VAR Optimization
- WAM – Work and Asset Management

Appendix E History

Version 1.1 History:

Version 1.1 – Preview, Release April 5, 2010

Version 1.0 History:

In 2007, IBM formed the Global Intelligent Utility Network Coalition (GIUNC), a unique coalition of innovative utility companies from around the world collaborating with one another to accelerate the deployment of smart grid and move the electric power industry forward through this challenging transformation. The Coalition's first collaborative effort was to develop the Smart Grid Maturity Model, Version 1.0. The Coalition promoted the model as a business tool for use by utilities all over the globe to support their smart grid strategy development and progress monitoring.

Out of its commitment to make the model widely available to the electric power industry, the GIUNC determined that the SGMM should be transferred to a global body or institution for impartial delivery, stewardship, and growth. In March 2009, all rights to the SGMM were donated by the Coalition to Carnegie Mellon Software Engineering Institute (SEI). SEI's continued stewardship, improvement, and evolution of the model is made possible through the support of the U.S. Department of Energy out of its commitment to assist utilities with their smart grid transformation.

APQC, a non-profit member-based research organization, assisted the Coalition in the development of SGMM Version 1.0 and continues to assist SEI in the evolution and support of the model.

GIUNC Members:

- Alliander—The Netherlands
- CenterPoint Energy, Inc.—U.S.
- Country Energy—Australia
- CPFL Energia—Brazil
- DONG Energy—Denmark
- ERDF—France
- IBM—U.S.
- North Delhi Power Limited—India
- Oncor—U.S.
- Pepco Holdings, Inc.—U.S.
- Progress Energy—U.S.
- Sempra Energy—U.S.

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13. **ABSTRACT (MAXIMUM 200 WORDS)**

The Smart Grid Maturity Model (SGMM) is a business tool stewarded by the Software Engineering Institute at Carnegie Mellon University. It was originally developed by electric power utilities for use by electric power utilities. The model provides a framework for understanding the current extent of smart grid deployment and capability within an electric utility, a context for establishing strategic objectives and implementation plans in support of grid modernization, and a means to evaluate progress over time toward those objectives.

The SGMM is composed of eight domains and six maturity levels as detailed in this document, which contains the full definition and description of the model. Introductory material to aid in understanding the purpose and use of the SGMM is also provided.

The primary audiences for the SGMM, and for this document, are electric power utilities that are seeking guidance related to the modernization of their operations and practices for delivering electricity. The audience also includes any related stakeholders for such utilities. Currently, the model is better suited for utilities with transmission and distribution operations than for pure generation utilities.

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