

# Smart Grid Maturity Model

**Austin Montgomery**

Software Engineering Institute

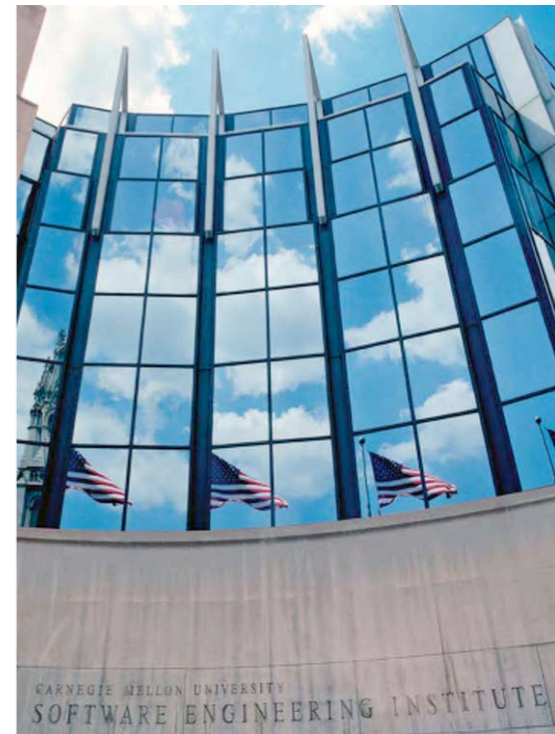
Carnegie Mellon University

# Software Engineering Institute Carnegie Mellon University

SEI is a federally-funded research and development center at Carnegie Mellon University, a global university recognized worldwide for its energy and environmental research initiatives.

A trusted, objective source of best practices, methods and tools, SEI is a global leader in software and systems engineering, process improvement and security best practices – all critical elements of smart grid success.

SEI collaborates in public-private partnership with government and industry on important cyber security, architecture, and interoperability challenges of the grid modernization.



**Carnegie  
Mellon  
University**

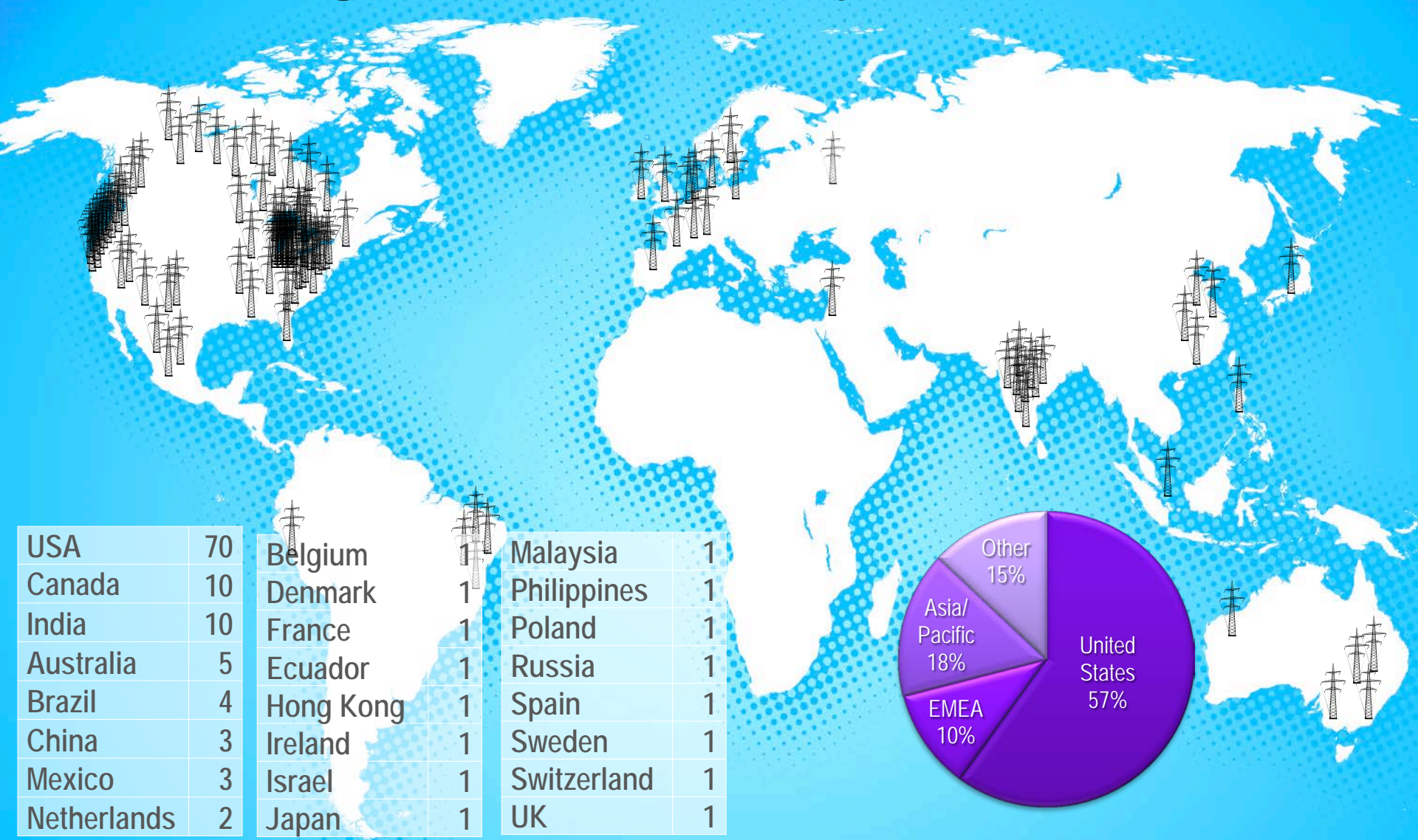
# The Smart Grid Maturity Model

*A management tool  
that provides a  
common language and framework  
for defining key elements of  
smart grid transformation  
and helping utilities develop a  
programmatically approach  
and track their progress*

# Stewardship on Behalf of the SGMM Community

- Provide **governance** working with multiple stakeholders
- Enable **widespread availability**, adoption, and use of the model for the benefit of the community
- **Evolve the model** based on stakeholder needs, market developments, user feedback, and interactions with domain experts
- Develop **transition** mechanisms—education, training, awareness, research collaboration—to support the model
- Grow the SGMM **community** of users worldwide

# A Growing Global Community





# SGMM at a glance

## 6 Maturity Levels: Defined sets of characteristics and outcomes

<p><b>5</b></p> <ul style="list-style-type: none"> <li>1 Smart grid strategy capitalizes on smart grid as a foundation for the introduction of new services and product offerings.</li> <li>2 Smart grid business activities provide sufficient financial resources to enable continued investment in smart grid sustainment and expansion.</li> <li>3 New business model opportunities emerge as a result of smart grid capabilities and are implemented.</li> </ul>	<ul style="list-style-type: none"> <li>1 The organizational structure enables collaboration with other grid stakeholders to optimize overall grid operation and health.</li> <li>2 The organization is able to readily adapt to support new ventures, products, and services that emerge as a result of smart grid.</li> <li>3 Channels are in place to harvest ideas, develop them, and regard those who help shape future advances in process, workforce complexities, and technology.</li> </ul>	<ul style="list-style-type: none"> <li>1 Self-healing capabilities are present.</li> <li>2 System-wide, analytics-based, and automated grid decision making is in place.</li> </ul>	<ul style="list-style-type: none"> <li>1 The use of assets between and across supply chain participants is optimized with processes defined and executed across the supply chain.</li> <li>2 Assets are leveraged to maximize utilization, including just-in-time asset retirement, based on smart grid data and systems.</li> </ul>	<ul style="list-style-type: none"> <li>1 Autonomic computing and machine learning are implemented.</li> <li>2 The enterprise information infrastructure can automatically identify, mitigate, and recover from cyber incidents.</li> </ul>	<ul style="list-style-type: none"> <li>1 Customers can manage their end-to-end energy supply and usage levels.</li> <li>2 There is automatic outage detection at premise or device level.</li> <li>3 Plug-and-play, customer-based generation is supported.</li> <li>4 Security and privacy for all customer data is assured.</li> <li>5 The organization plays a leadership role in industry-wide information sharing and standards development efforts for smart grid.</li> </ul>	<ul style="list-style-type: none"> <li>1 The optimization of energy assets is automated across the full value chain.</li> <li>2 Resources are adequately dispatchable and controllable so that the organization can take advantage of granular market options.</li> <li>3 The organization's automated control and resource optimization schemes consider and support regional and/or national grid optimization.</li> </ul>	<ul style="list-style-type: none"> <li>1 Triple bottom line goals align with local, regional, and national objectives.</li> <li>2 Customers control their energy-based environmental footprints through autonomic optimization of their end-to-end energy supply and usage level (energy source and mix).</li> <li>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.</li> </ul>
<p><b>4</b></p> <ul style="list-style-type: none"> <li>1 Smart grid vision and strategy drive the organization's strategy and direction.</li> <li>2 Smart grid is a core competency throughout the organization.</li> <li>3 Smart grid strategy is shared and revised collaboratively with external stakeholders.</li> </ul>	<ul style="list-style-type: none"> <li>1 Management systems and organizational structure are capable of taking advantage of the increased visibility and control provided through smart grid.</li> <li>2 There is end-to-end grid observability that can be leveraged by internal and external stakeholders.</li> <li>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.</li> </ul>	<ul style="list-style-type: none"> <li>1 Operational data from smart grid deployments is being used to optimize processes across the organization.</li> <li>2 Grid operational management is based on near real-time data.</li> <li>3 Operational forecasts are based on data gathered through smart grid.</li> <li>4 Grid operations information has been made available across functions and silos.</li> <li>5 There is automated decision-making within protection schemes that is based on wide-area monitoring.</li> </ul>	<ul style="list-style-type: none"> <li>1 A complete view of assets based on status, connectivity, and proximity is available to the organization.</li> <li>2 Asset models are based on real performance and monitoring data.</li> <li>3 Performance and usage of assets is optimized across the asset fleet and across asset classes.</li> <li>4 Service life for key grid components is managed through condition-based and predictive maintenance, and is based on real and current asset data.</li> </ul>	<ul style="list-style-type: none"> <li>1 Data flows end to end from customer to generation.</li> <li>2 Business processes are optimized by leveraging the enterprise IT architecture.</li> <li>3 Systems have sufficient wide-area situational awareness to enable real-time monitoring and control for complex events.</li> <li>4 Predictive modeling and near real-time simulation are used to optimize support processes.</li> <li>5 Performance is improved through sophisticated systems that are informed by smart grid data.</li> <li>6 Security strategy and tactics continually evolve based on changes in</li> </ul>	<ul style="list-style-type: none"> <li>1 Support is provided to customers to help analyze and compare usage against all available pricing programs.</li> <li>2 There is outage detection and proactive notification at the circuit level.</li> <li>3 Customers have access to near real-time data on their own usage.</li> <li>4 Residential customers participate in demand response and/or utility-managed remote load control programs.</li> <li>5 Autonomic response to pricing signals for devices within the customer's premise is supported.</li> <li>6 In-home net billing programs are enabled.</li> <li>7 A common customer experience has been integrated.</li> </ul>	<ul style="list-style-type: none"> <li>1 Energy resources (including WinVAR, DG, and DER) are dispatchable and tradable.</li> <li>2 Portfolio optimization models that encompass available resources and real-time market are implemented.</li> <li>3 Secure two-way communications with Home Area Networks (HANs) are available.</li> <li>4 Visibility and potential control of customers' large-demand appliances to balance demand and supply is available.</li> </ul>	<ul style="list-style-type: none"> <li>1 The organization collaborates with external stakeholders to address environmental and societal issues.</li> <li>2 A public environmental and societal scorecard is maintained.</li> <li>3 Programs are in place to drive peak demand.</li> <li>4 End-user energy usage and devices are actively managed through the utility's network.</li> <li>5 The organization fulfills its critical infrastructure assurance goals for resiliency, and contributes to those of the region and the nation.</li> </ul>
<p><b>3</b></p> <ul style="list-style-type: none"> <li>1 The smart grid vision, strategy, and business case are incorporated into the vision and strategy.</li> <li>2 A smart grid governance model is established.</li> <li>3 Smart grid leaders with explicit authority across functions and lines of business are designated to ensure effective implementation of the smart grid strategy.</li> <li>4 Required authorizations for smart grid investments have been secured.</li> </ul>	<ul style="list-style-type: none"> <li>1 The smart grid vision and strategy are driving organizational change.</li> <li>2 Smart grid measures are incorporated into the measurement system.</li> <li>3 Performance and compensation are linked to smart grid success.</li> <li>4 Leadership is consistent in communication and actions regarding smart grid.</li> <li>5 A matrix or overlay structure is in place.</li> <li>6 Education and training are</li> </ul>	<ul style="list-style-type: none"> <li>1 Smart grid information is available across systems and organizational functions.</li> <li>2 Control analytics have been implemented and are used to improve cross-UB decision-making.</li> <li>3 Grid operations planning is now fact-based using grid data made</li> </ul>	<ul style="list-style-type: none"> <li>1 Performance, trend analysis, and event audit data are available for components of the organization's systems.</li> <li>2 CBM programs for key components are in place.</li> <li>3 Remote asset monitoring capabilities are integrated with asset management.</li> </ul>	<ul style="list-style-type: none"> <li>1 Smart grid-impacted business processes are aligned with the enterprise IT architecture across LOBs.</li> <li>2 Systems adhere to an enterprise IT architectural framework for smart grid.</li> <li>3 Smart grid-specific technology has been implemented to improve cross-UB operations.</li> </ul>	<ul style="list-style-type: none"> <li>1 The organization tailors programs to customer segments.</li> <li>2 Two-way meter communication has been deployed.</li> <li>3 A remote connect/disconnect capability is deployed.</li> <li>4 Demand response and/or remote load control is available to customers.</li> <li>5 There is automatic outage detection at the substation level.</li> </ul>	<ul style="list-style-type: none"> <li>1 An integrated resource plan is in place and includes new targeted resources and technologies.</li> <li>2 Customer premise energy management solutions with market and usage information are enabled.</li> <li>3 Additional resources are available and deployed to provide</li> </ul>	<ul style="list-style-type: none"> <li>1 Performance of societal and environmental programs are measured and effectiveness is demonstrated.</li> <li>2 Segmented and tailored information that includes environmental and societal benefits and costs is available to customers.</li> <li>3 Programs to encourage off-peak usage by customers are in place.</li> <li>4 The organization regularly reports on the sustainability and the societal and environmental impacts of its smart grid programs and technologies.</li> </ul>
<p><b>175 Characteristics: Features you would expect to see at each stage of the smart grid journey</b></p>							
<p><b>2</b></p> <ul style="list-style-type: none"> <li>1 An initial smart grid strategy and a business plan are approved by management.</li> <li>2 A common smart grid vision is accepted across the organization.</li> <li>3 Operational investment is explicitly aligned to the smart grid strategy.</li> <li>4 Budgets are established specifically for funding the implementation of the smart grid vision.</li> <li>5 There is collaboration with regulators and other stakeholders regarding implementation of the smart grid vision and strategy.</li> <li>6 There is support and funding for conducting proof-of-concept projects to evaluate feasibility and alignment.</li> </ul>	<ul style="list-style-type: none"> <li>1 A new vision for a smart grid is articulated in a smart grid environment.</li> <li>2 The organization has aligned most operations around end-to-end processes.</li> <li>3 Most smart grid implementation and deployment teams include participants from all functions and LOBs that the deployment will impact.</li> <li>4 Education and training to develop smart grid competencies have been identified and are available.</li> <li>5 The linking of performance and compensation plans to achieve smart grid milestones is in progress.</li> </ul>	<ul style="list-style-type: none"> <li>1 Which resource to reduce the response or optimize resources.</li> <li>2 Aside from SCADA, piloting of remote asset monitoring of key grid assets to support manual decision-making is underway.</li> <li>4 Investment in and expansion of data communications networks in support of grid operations is underway.</li> </ul>	<ul style="list-style-type: none"> <li>4 An enterprise-level tool to assist monitoring based on location, status, and interconnectivity (model) has been developed.</li> <li>3 An organization-wide mobile workforce strategy is in development.</li> </ul>	<ul style="list-style-type: none"> <li>4 Standards are selected to support the smart grid strategy within the enterprise IT architecture.</li> <li>4 A common technology evaluation and selection process is applied for all smart grid activities.</li> <li>5 There is a data communications strategy for the grid.</li> <li>6 Pilots based on connectivity to distributed EEs are underway.</li> <li>7 Security is built into all smart grid initiatives from the outset.</li> </ul>	<ul style="list-style-type: none"> <li>3 The organization is modeling the reliability of grid equipment.</li> <li>4 Remote connect/disconnect is being piloted for residential customer usage.</li> <li>5 The impact on the customer of new services and delivery processes is being assessed.</li> <li>6 Security and privacy requirements for customer protection are specified for smart grid-related pilot projects and RFPs.</li> </ul>	<ul style="list-style-type: none"> <li>4 The value chain is being modeled based on its smart grid capabilities.</li> <li>3 Pilots to support a diverse resource portfolio have been conducted.</li> <li>4 Secure interactions have been piloted with an expanded portfolio of value chain partners.</li> </ul>	<ul style="list-style-type: none"> <li>1 Smart-grid strategies and work plans address societal and environmental issues.</li> <li>2 Energy efficiency programs for customers have been established.</li> <li>3 The organization considers a "triple bottom line" view when making decisions.</li> <li>4 Environmental proof-of-concept projects are underway that demonstrate smart grid benefits.</li> <li>5 Increasingly granular and more frequent consumption information is available to customers.</li> </ul>
<p><b>1</b></p> <ul style="list-style-type: none"> <li>1 Smart grid vision is developed with a goal of operational improvement.</li> <li>2 Experimental implementations of smart grid concepts are supported.</li> <li>3 Discussions have been held with regulators about the organization's smart grid vision.</li> </ul>	<ul style="list-style-type: none"> <li>1 The organization has articulated its need to build smart grid competencies in its workforce.</li> <li>2 Leadership has demonstrated a commitment to change the organization in support of achieving smart grid.</li> <li>3 Smart grid awareness efforts to inform the workforce of smart grid activities have been initiated.</li> </ul>	<ul style="list-style-type: none"> <li>1 Business cases for new equipment and systems related to smart grid are approved.</li> <li>2 New sensors, switches, and communications technologies are evaluated for grid monitoring and control.</li> <li>3 Proof-of-concept projects and component testing for grid monitoring and control are underway.</li> <li>4 Storage and distribution management systems linked to substation automation are being explored and evaluated.</li> <li>5 Safety and security (physical and cyber) requirements are</li> </ul>	<ul style="list-style-type: none"> <li>1 Enhancements to work and asset management have been built into approved business cases.</li> <li>2 Potential uses of remote asset monitoring are being evaluated.</li> <li>3 Asset and workforce management equipment and systems are being evaluated for their potential alignment to the smart grid vision.</li> </ul>	<ul style="list-style-type: none"> <li>1 An enterprise IT architecture exists or is under development.</li> <li>2 Existing or proposed IT architectures have been evaluated for quality attributes that support smart grid applications.</li> <li>3 A change control process is used for applications and IT infrastructure.</li> <li>4 Opportunities are identified to use technology to improve departmental performance.</li> <li>5 There is a process to evaluate and select technologies in alignment with smart grid vision and strategies.</li> </ul>	<ul style="list-style-type: none"> <li>1 Research is being conducted on how to use smart grid technologies to enhance the customer's experience, benefits, and participation.</li> <li>2 Security and privacy implications of smart grid are being investigated.</li> <li>3 A vision of the future grid is being communicated to customers.</li> <li>4 The utility consults with public utility commissions and/or other government organizations concerning the impact on customers.</li> </ul>	<ul style="list-style-type: none"> <li>1 Assets and programs necessary to facilitate load management are identified.</li> <li>2 Distributed generation sources and the capabilities needed to support them are identified.</li> <li>3 Energy storage options and the capabilities needed to support them are identified.</li> <li>4 There is a strategy for creating and managing a diverse resource portfolio.</li> <li>5 Security requirements to enable interaction with an expanded portfolio of value chain partners have been identified.</li> </ul>	<ul style="list-style-type: none"> <li>1 The smart grid strategy addresses the organization's role in societal and environmental issues.</li> <li>2 The environmental benefits of the smart grid vision and strategy are publicly promoted.</li> <li>3 Environmental compliance performance records are available for public inspection.</li> <li>4 The smart grid vision or strategy specifies the organization's role in protecting the nation's critical infrastructure.</li> </ul>
<p><b>0</b></p> <p><b>SMR</b> Strategy, Management, &amp; Regulatory</p>	<p><b>OS</b> Organization &amp; Structure</p>	<p><b>GO</b> Grid Operations</p>	<p><b>WAM</b> Work &amp; Asset Management</p>	<p><b>TECH</b> Technology</p>	<p><b>CUST</b> Customer</p>	<p><b>VCI</b> Value Chain Integration</p>	<p><b>SE</b> Societal &amp; Environmental</p>

## 8 Domains: Logical groupings of smart grid related characteristics



# SGMM Levels

  
**5**

Breaking new ground; industry-leading innovation

  
**4**

Optimizing smart grid to benefit entire organization; may reach beyond organization; increased automation

  
**3**

Integrating smart grid deployments across the organization, realizing measurably improved performance

  
**2**

Investing based on clear strategy, implementing first projects to enable smart grid (may be compartmentalized)

  
**1**

Taking the first steps, exploring options, conducting experiments, developing smart grid vision

  
**0**

Default level (status quo)

# SGMM Domains

SMR

Strategy, Mgmt & Regulatory

*Vision, planning, governance, stakeholder collaboration*

OS

Organization and Structure

*Culture, structure, training, communications, knowledge mgmt*

GO

Grid Operations

*Reliability, efficiency, security, safety, observability, control*

WAM

Work & Asset Management

*Asset monitoring, tracking & maintenance, mobile workforce*

TECH

Technology

*IT architecture, standards, infrastructure, integration, tools*

CUST

Customer

*Pricing, customer participation & experience, advanced services*

VCI

Value Chain Integration

*Demand & supply management, leveraging market opportunities*

SE

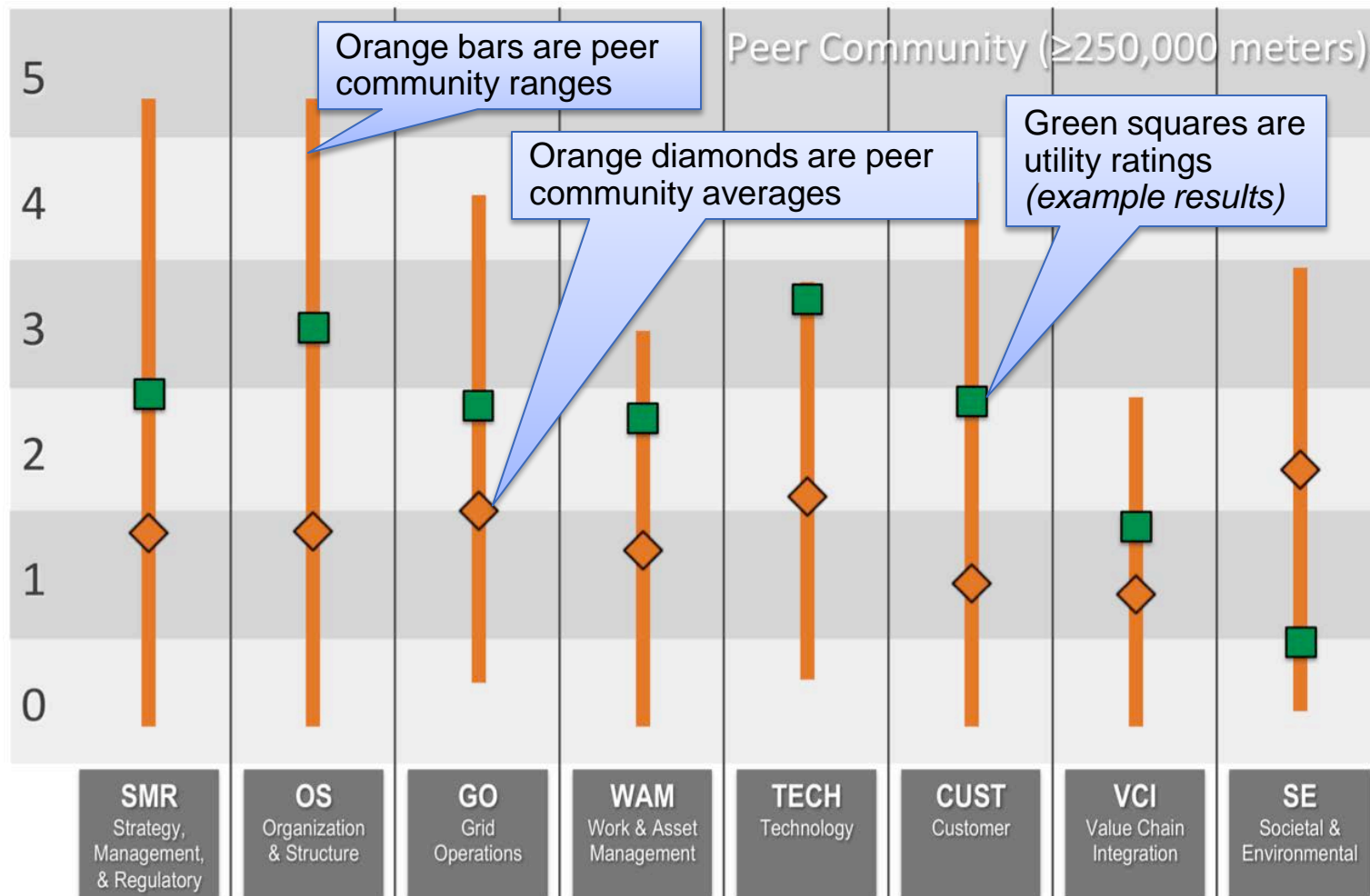
Societal & Environmental

*Responsibility, sustainability, critical infrastructure, efficiency*



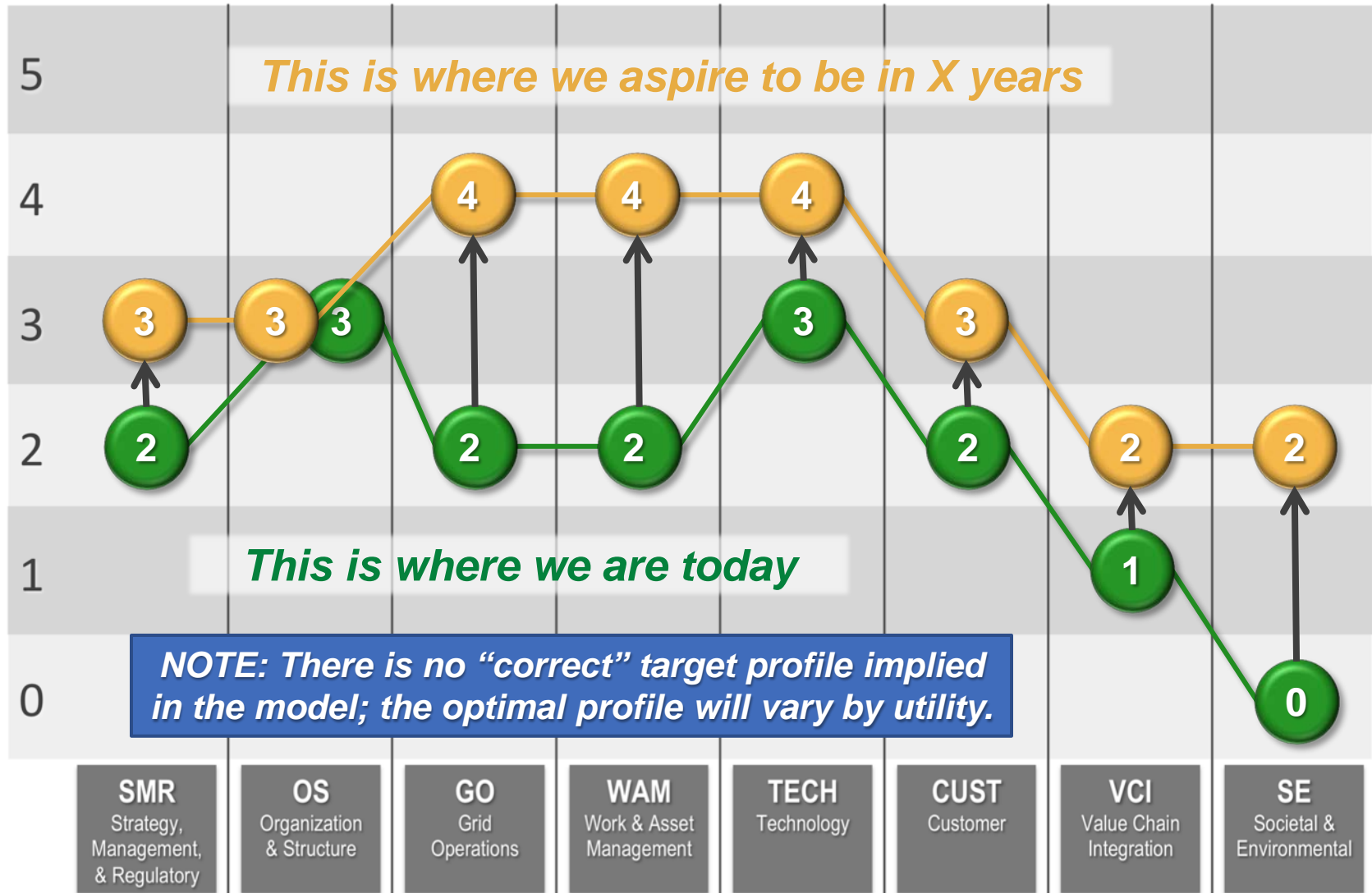
# Compass Results: peer community comparison

*example results*



# Navigation Results: consensus aspirations

*example results*



# Customer Domain: Sample Characteristics

- 5.1** Customers can manage their end-to-end energy supply and usage level.
- 4.5** The utility supports the capability for automatic response to pricing signals for major energy consuming devices within the customer premises.
- 3.6** Residential customers have on-demand access to daily usage data.
- 2.5** The organization is assessing the impact on the customer of new services and delivery processes.
- 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).

# Contact Information

Austin Montgomery  
Smart Grid Program Lead  
[amontgom@sei.cmu.edu](mailto:amontgom@sei.cmu.edu)  
703.908.1110

[www.sei.cmu.edu/smartgrid](http://www.sei.cmu.edu/smartgrid)  
[info@sei.cmu.edu](mailto:info@sei.cmu.edu)

# Notices

- © 2012 Carnegie Mellon University
- NO WARRANTY
- THIS CARNEGIE MELLON UNIVERSITY AND SOFTWARE ENGINEERING INSTITUTE MATERIAL IS FURNISHED ON AN "AS-IS" BASIS. CARNEGIE MELLON UNIVERSITY MAKES NO WARRANTIES OF ANY KIND, EITHER EXPRESSED OR IMPLIED, AS TO ANY MATTER INCLUDING, BUT NOT LIMITED TO, WARRANTY OF FITNESS FOR PURPOSE OR MERCHANTABILITY, EXCLUSIVITY, OR RESULTS OBTAINED FROM USE OF THE MATERIAL. CARNEGIE MELLON UNIVERSITY DOES NOT MAKE ANY WARRANTY OF ANY KIND WITH RESPECT TO FREEDOM FROM PATENT, TRADEMARK, OR COPYRIGHT INFRINGEMENT.
- Use of any trademarks in this presentation is not intended in any way to infringe on the rights of the trademark holder.
- This Presentation may be reproduced in its entirety, without modification, and freely distributed in written or electronic form without requesting formal permission. Permission is required for any other use. Requests for permission should be directed to the Software Engineering Institute at [permission@sei.cmu.edu](mailto:permission@sei.cmu.edu).
- This work was created in the performance of Federal Government Contract Number FA8721-05-C-0003 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center. The Government of the United States has a royalty-free government-purpose license to use, duplicate, or disclose the work, in whole or in part and in any manner, and to have or permit others to do so, for government purposes pursuant to the copyright license under the clause at 252.227-7013.