Call to Order and Welcome

Chris Greer

Director, Smart Grid and Cyber-Physical Systems Program Office
Engineering Laboratory, NIST

NIST Smart Grid Advisory Committee Virtual Meeting

April 2, 2019

Agenda

11:05 AM	Opening Remarks – Paul Centolella
11:10 AM	Engagement Subcommittee Report Out – Paul Centolella
11:20 AM	Technical Subcommittee Report Out – John McDonald
11:30 AM	NIST Smart Grid Framework Update – Avi Gopstein
12:05 PM	Proposed 2020 Budget for NIST – Jason Boehm
12:15 PM	Discussion – All
12:35 PM	Planning for June Face to Face Meeting - All
12:45 PM	Public Comments
1:00 PM	Adjourn

Technical Subcommittee Report Out

John McDonald
NIST Smart Grid Advisory Committee Member

April 2, 2019

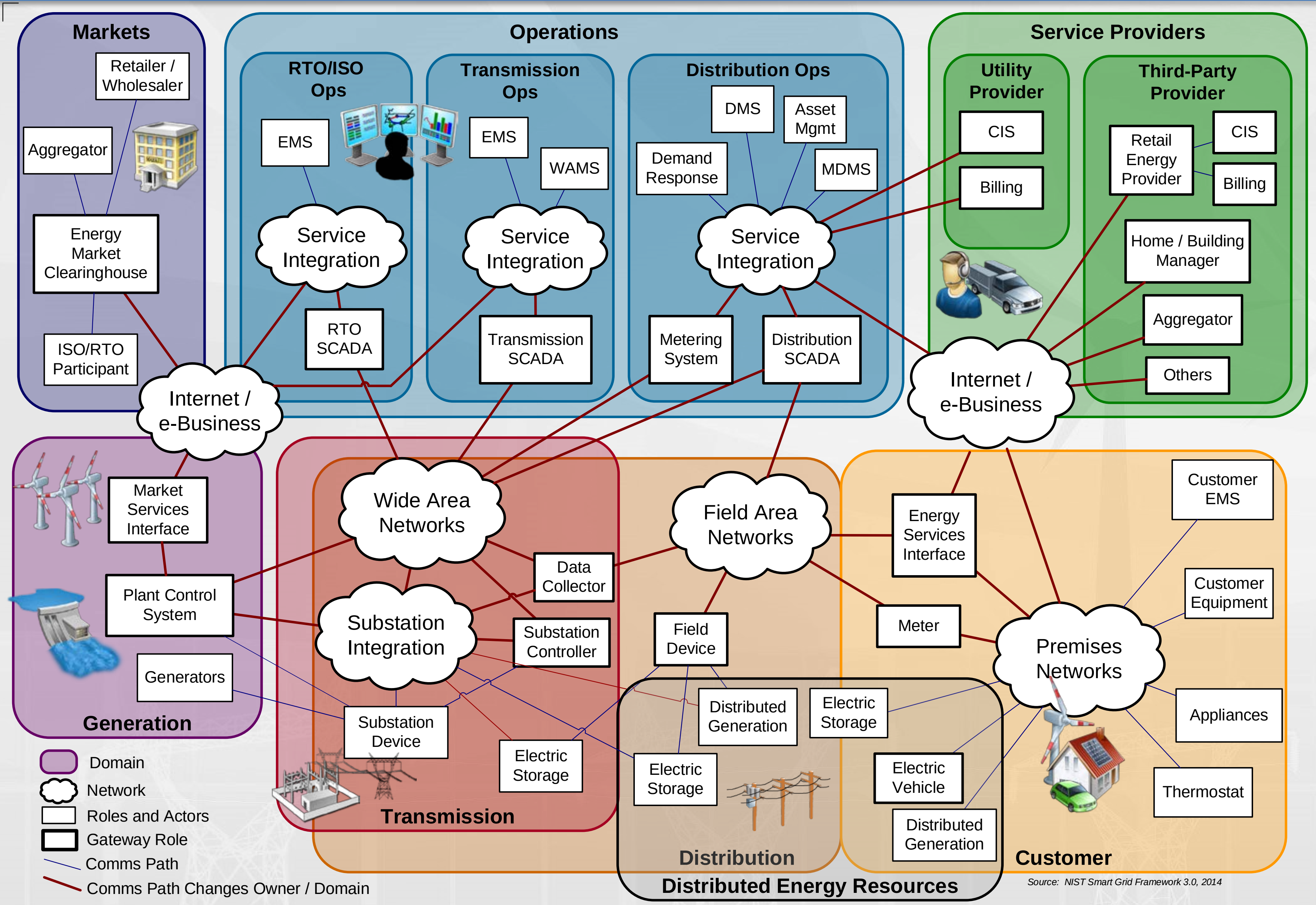
Technical Subcommittee

Chair: John McDonald

Members: Heather Donaldson, Santiago Grijalva, Audrey Lee, Paul Centolella, Debbie Gracio, Jason Handley, Kevin Cosgriff

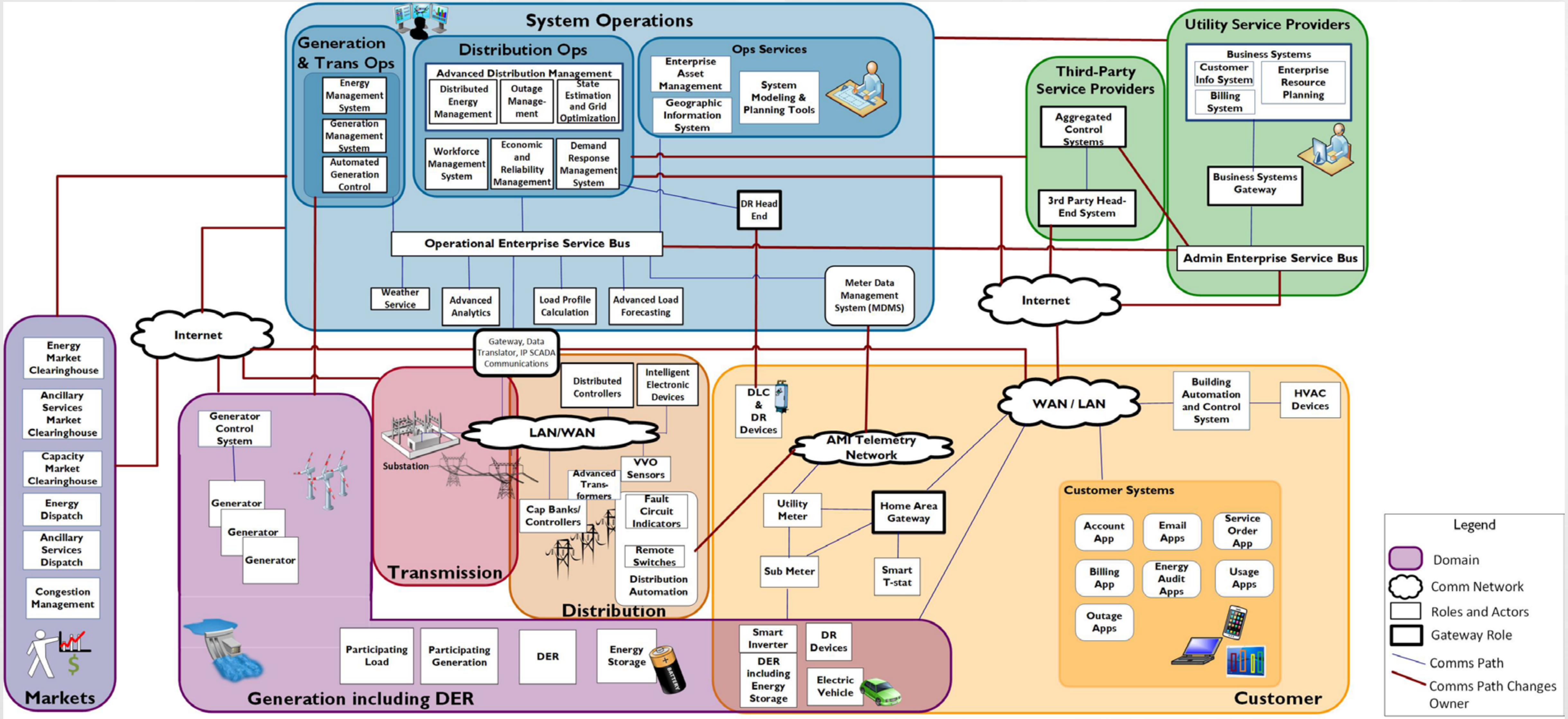
The goal of the technical subcommittee was to review and provide feedback to NIST on draft materials including Communications Pathways Scenarios, Domain Models and CPS Concerns and Smart Grid Matrix that were developed as part of the update to the NIST Framework and Roadmap for Smart Grid Interoperability Standards, version 4.

Legacy Communication Pathways Scenario (Unchanged)

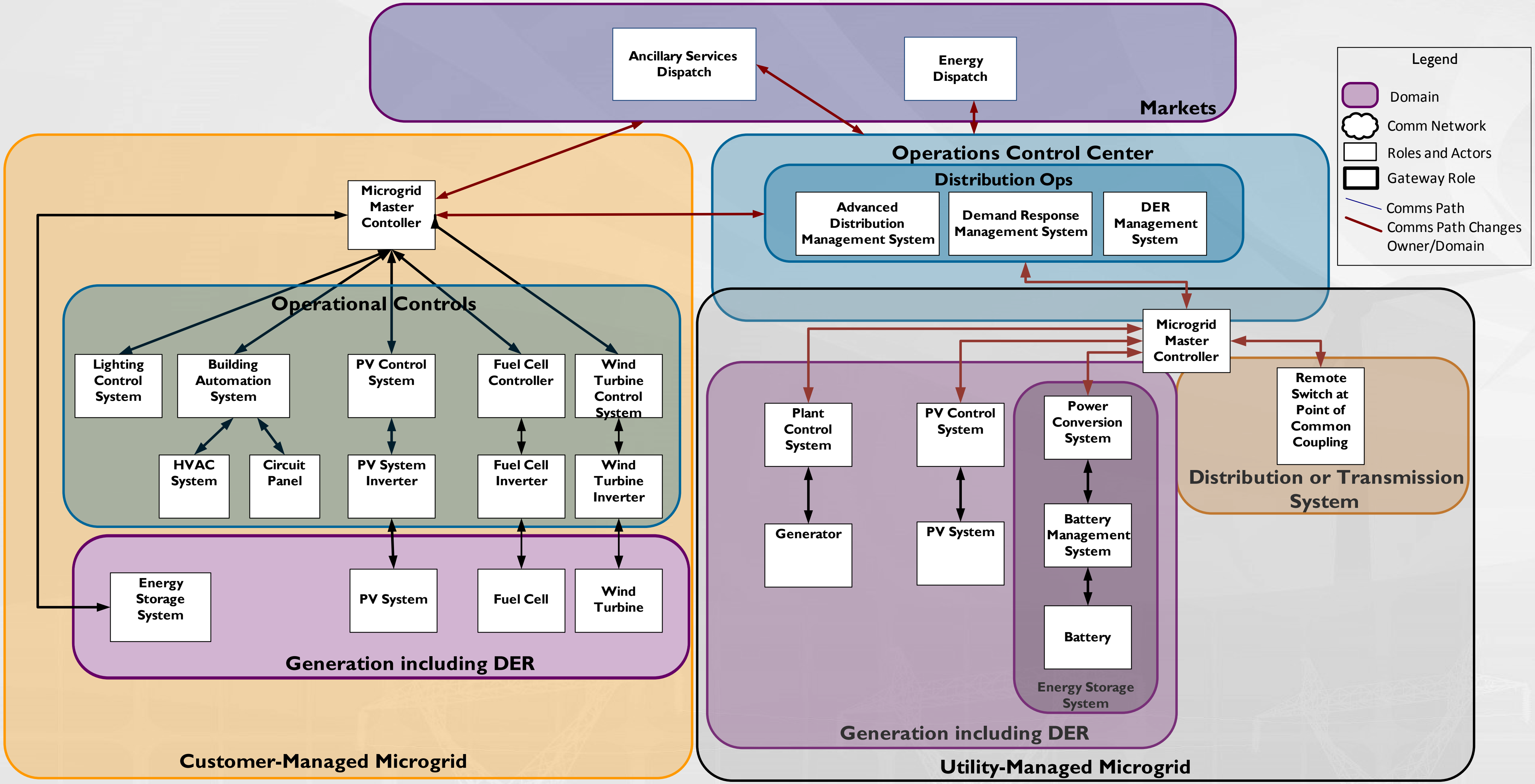


Source: *NIST Smart Grid Framework 3.0, 2014*

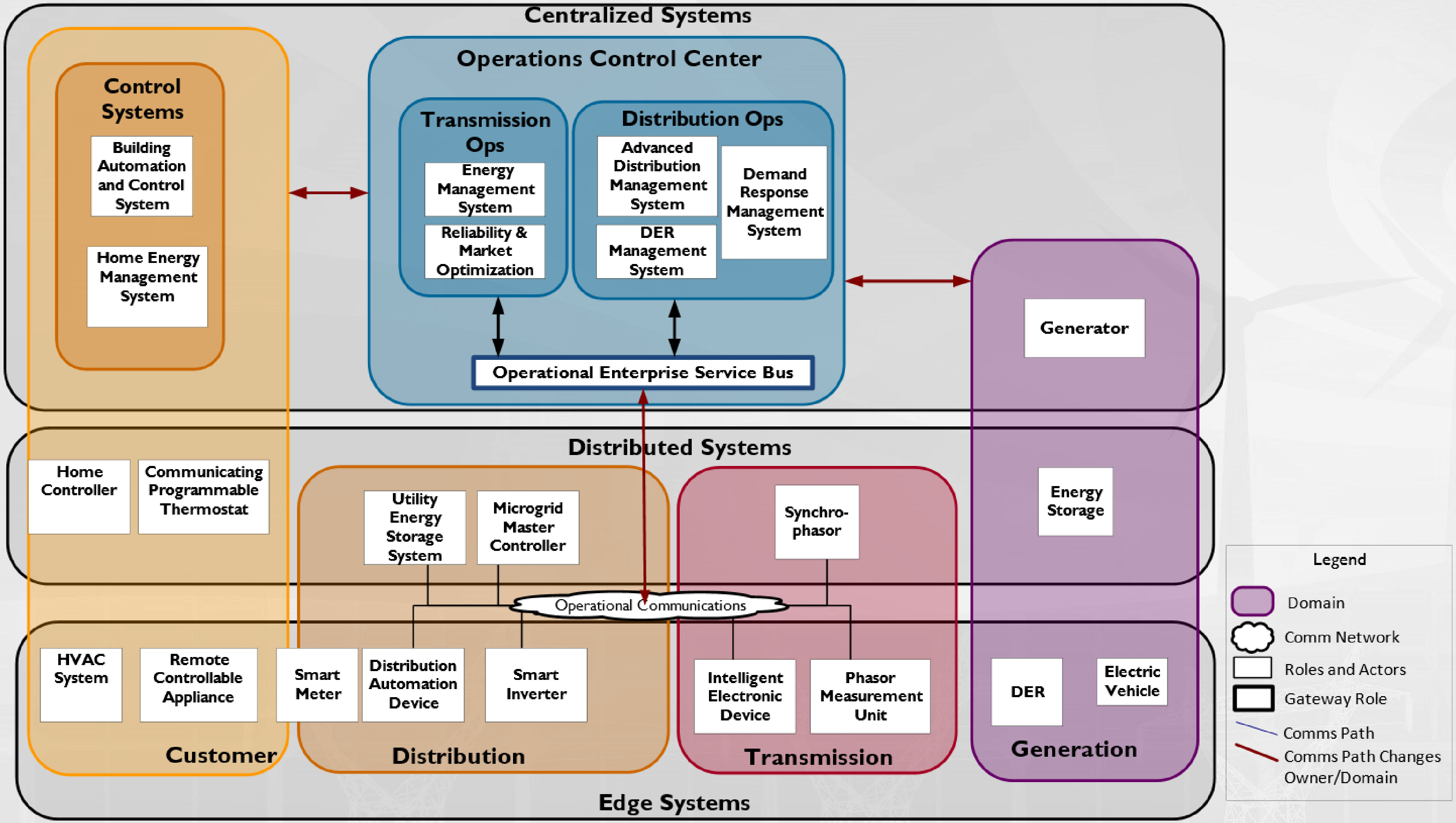
Scenario: High-DER Communications



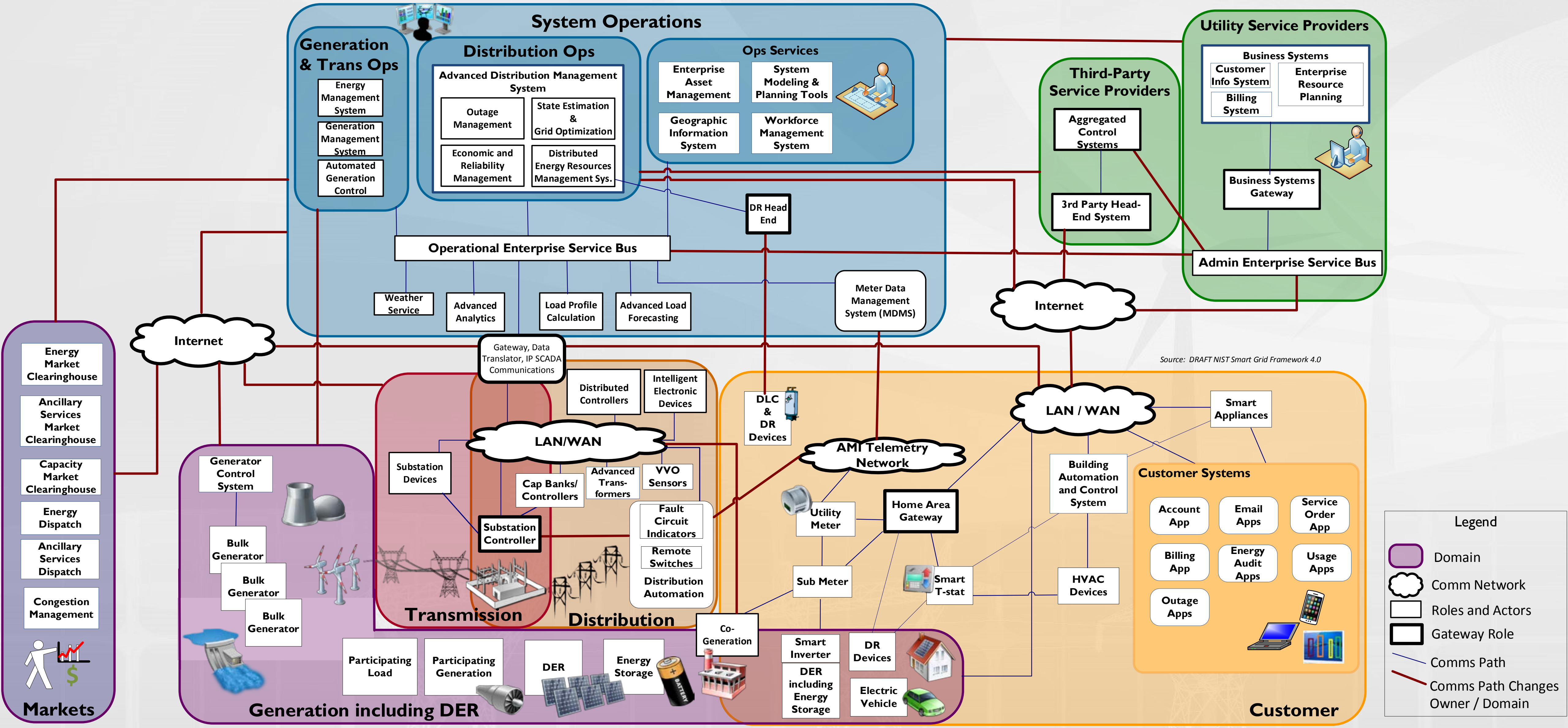
Scenario: Microgrid Communications



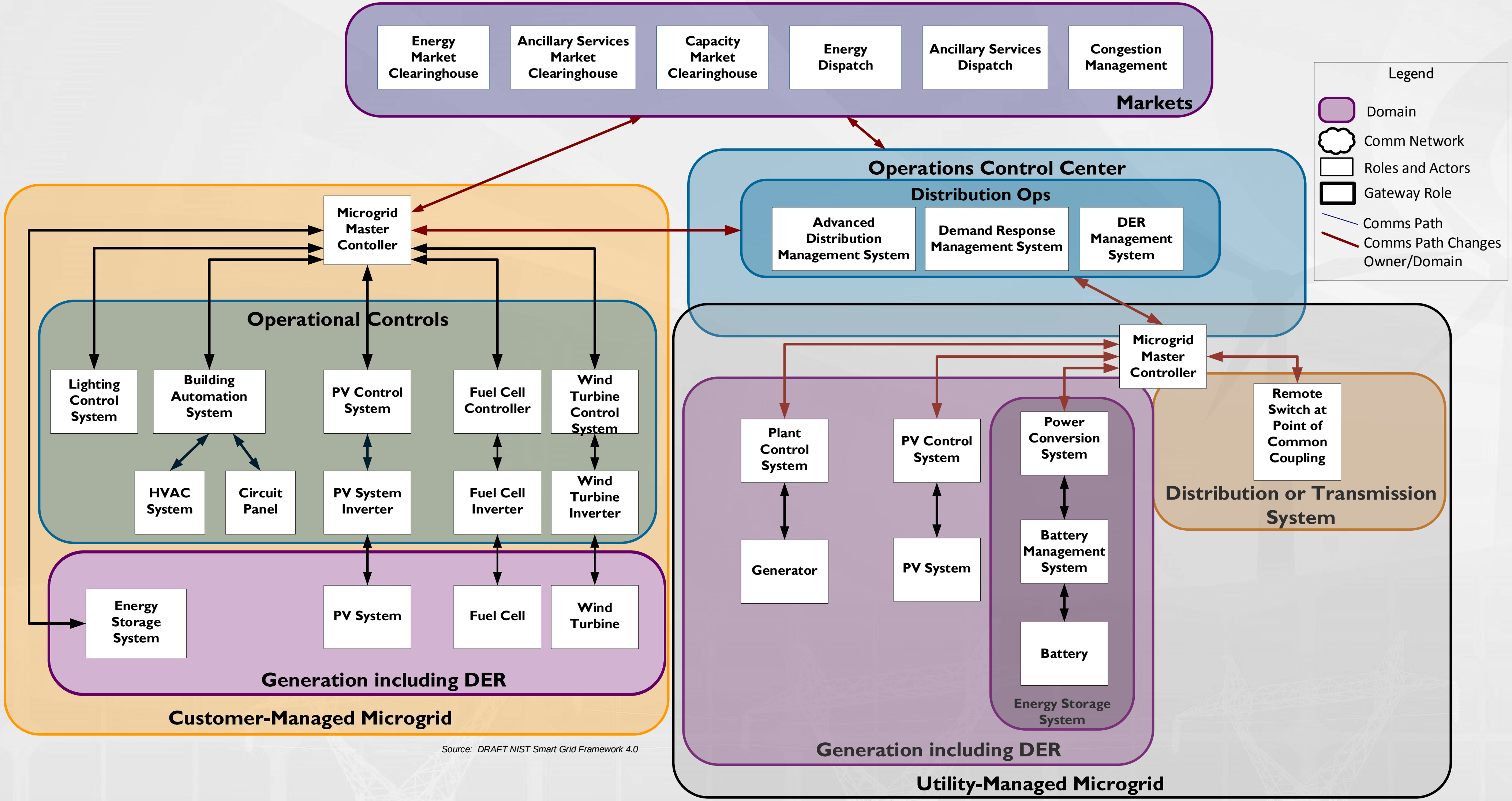
Scenario: Hybrid Communications



High-DER Communication Pathways Scenario (updated)

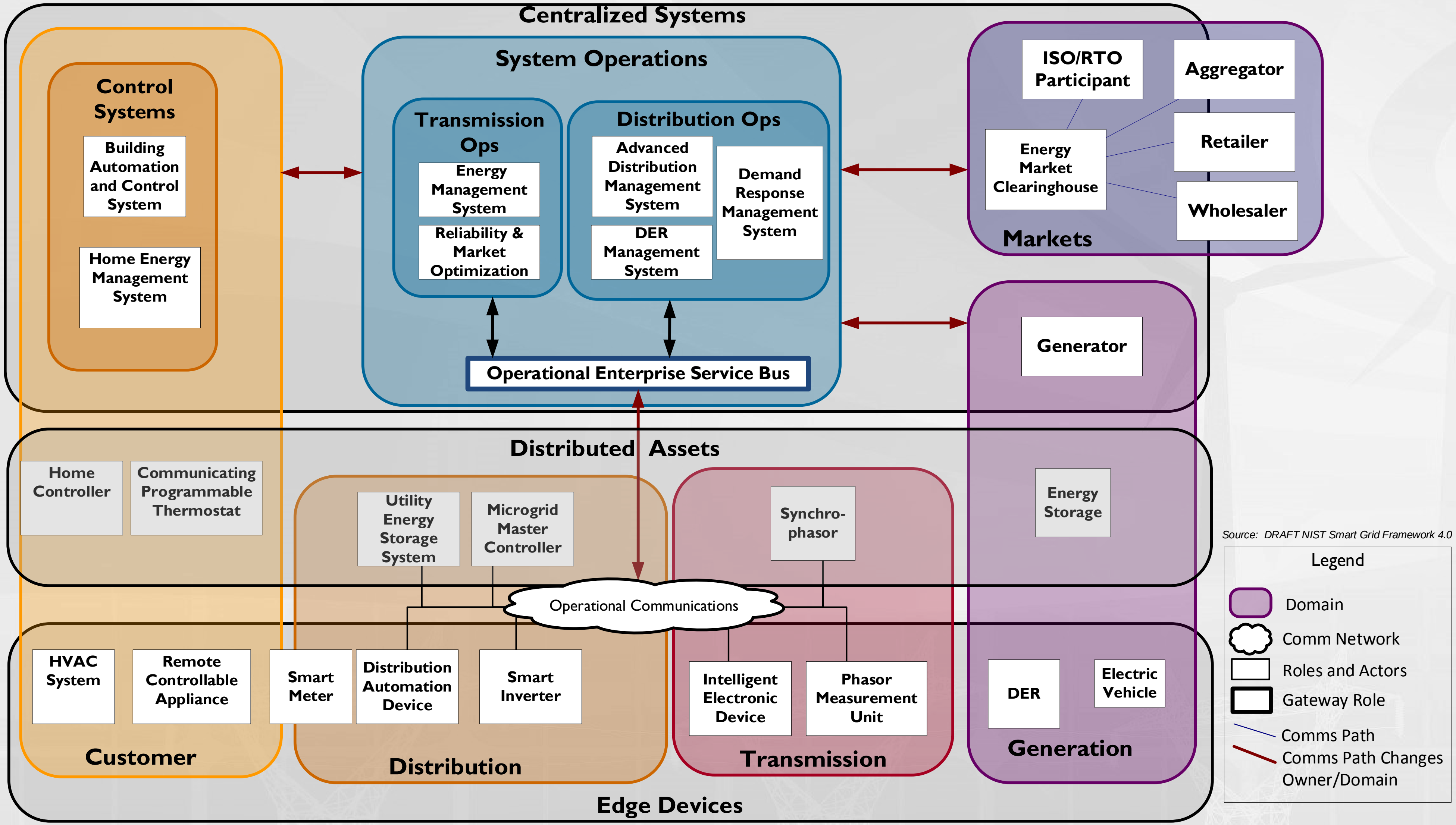


Microgrid Communications Pathway Scenario (updated)



Source: *DRAFT NIST Smart Grid Framework 4.0*

Hybrid Utility Communications Pathway Scenario (updated)



Functional Requirements Discussion

To complement the architecture in the prior Releases and analyze future requirements, this memo suggests a forward looking functional perspective. A functional architecture would start by focusing on what will be needed to integrate new technology and meet new challenges and how to do so efficiently so as to create net value.

Comments SGAC Chair

A functional perspective could facilitate the analysis of complex issues and enable consistent identification of the interoperability requirements needed to meet system objectives. Although the Actors who perform an activity may vary, interoperability standards ideally should support multiple business and regulatory models and provide consistent definitions of function, the information to be exchanged, syntax and communications, and require physical components…

Comments from SGAC Chair

Function / Time Scale / Mode of Operation	**Supply and Demand Domains**		**Grid Domains**		**Control and Coordination Domains**	
	Supply	**Demand & Use**	**Transmission**	**Distribution** (including Microgrids)	**System Operations: Quantity Signals** ISO / TO DSO / Distribution Utility Microgrid Operator	**Markets: Value Signals** Organized Bulk Power (ISO) Markets, DLMP Markets, Microgrids
Sub-cycle (<60Hz)						
Stabilization of Real Power / Sub-cycle / Autonomous	AGC & Generator Inertia Flywheels, Capacitors	Experimental End Use Frequency Control			Qualifies Distributed Devices; Specifies Requirements to Ensure System Stability	Market / tariff needed to compensate any non-utility devices for Grid Stabilization Service
Stabilization of Reactive Power – Advanced Power Electronics Compress Voltage Volatility / Sub-cycle / Autonomous	Smart Inverters if integrated into a consistent, stable DSO / Utility architecture			Low Voltage VAr Controller	Specifies Standards ensuring Coordinated Operation of Devices; Sets Voltage Targets; May Compress Voltage to Low End of ANSI Std. for Energy/Demand Savings	Market mechanism needed to compensate non-utility Smart Inverters if Inverters provide Volt VAr Control Service
Power Flow Control / Sub-cycle / Autonomous			Power Electronics (e.g. Smart Wires) injects Impedance or Capacitance to direct Flows to Specified Lines	Power Electronics (e.g. Switched Source) injects Impedance or Capacitance to allocate Flows to specified feeders	Operator sets flow control targets & / or limits to optimize power transfers & avoid constraints	Markets recognize modified flows. Market potentially could treat flow control as a resource.
Microgrid Islanding & Fractal Distribution Reconfiguration / Potentially Sub-cycle / Autonomous or DSO or Distribution Utility Initiated to Maintain Service when Disruptive Event impacts other parts of the grid	Transitions to Separate Operation: Stabilizing Resources, Flexible Generation & Storage manage ramping during the transition.	Transitions to Separate Operation: Stabilizing Resources, Flexible Demand & Storage manage ramping during the transition.		Distribution Topology Modified	DSO or Distribution Utility sets Conditions and may Initiate Topology Change. Separate dispatch of resources balances load in islanded areas.	Microgrid or Islanded portion of Distribution may use a Local Distributed Market to Coordinate Supply and Demand.
Sub-Dispatch Interval (< 5 minute)						
Frequency Regulation / 2 to 4 seconds / Devices Follow Operator Signals	Fast Responding Generation & Storage	Flexible Demand could saturate Reg Market			Sends Regulation Signal to Qualified Participants	Market of Regulation Services

Table of functions:

- Sub-cycle
  - Automation
  - Reactive Power
  - Microgrid islanding
- 5-minute
  - Frequency regulation
  - Distributed dynamic markets for local optimization
  - Flexible intelligent demand
- 5- to 15-minute
  - Dynamic line/transformer ratings
  - Dynamic topology management
  - Reserve market for flexibility ramping
  - SCED
  - Bulk power real time energy + reserves markets
- 15-minute to Daily
  - Upstream V-VAR control
  - Security constrained unit commitment
  - Day ahead markets

Testing & Certification Landscape & Interoperability Profiles

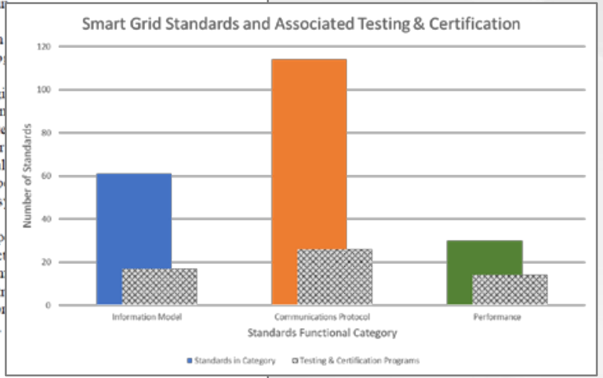
DRAFT Evaluation of Testing & Certification Landscape for Smart Grid Standards

Eugene Song, Cuong Nguyen, Avi Gopstein

Smart Grid and Cyber-Physical Systems Program
National Institute of Standards and Technolo

Smart grid standards play a key role in the adoption of new technologi
Standards encourage innovation, boost productivity, and enhance econ
reducing or eliminating technical barriers,[1] and those that advance inte
maximize operational benefits while minimizing deployment costs for
and certification (T&C) programs—which provide a mechanism for al
confidence that equipment function conforms to standards and will op
therefore important to realizing the benefits of a strong standards ecos

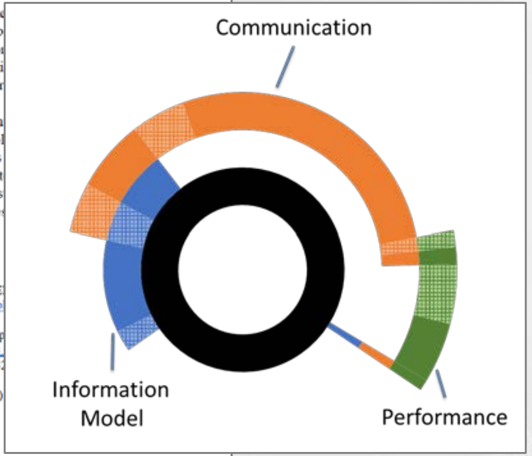
To gain an understanding of the T&C landscape for smart grid interop
representative list of smart grid standards (see *Included Standards* sec
the status of associated T&C programs. Because the complexity of sm
their applications has increased commensurately with that of the electr
the interoperability impact each standard—and any associated T&C pr
a functional perspective (see *Evaluation Methodology* section below).



Evaluation Methodology

Applications for smart grid standards may span numerous dimensions of the
IEC 61850 has applications in each of the NIST Smart Grid Conceptual Mo
including generation, transmission, distribution, customer, market, operati
provider. Compounding the complexity inherent to this breadth of applicati
smart grid standards are likely to have different use cases in each domain or

To simplify the evaluation process for identifying those standards that migh
interoperability, NIST employed a functional classification system to compl
architectural view of standards applications. Standards were categorized as
information models and model mapping, communication protocols and prot
physical performance specifications, test methodologies, guidelines and bes
cybersecurity. Those standards that belong to the first three function classes
relevant to smart grid interoperability.



[1] Distribution System Operator (DSO) Priorities For Smart Grid Standardization- A EURE
Smart Grid joint position paper https://www.edsoforsmartgrids.eu/wp-content/uploads/pub
Gird-Standardisation.pdf
[2] NIST Special Publication 1108r3, NIST Framework and Roadmap for Smart Grid Interop
Release 3.0 (2014), https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1108r3.
[3] See, for example: Public Utilities Commission of the State of California Resolution E-452
http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M029/K624/29624509.PDF
[4] Interoperability function classes include: (1) Information models and model mapping; (2)
and protocol mapping; and (3) physical performance specifications.

1

DRAFT Interoperability Profile Description

Information exchanges and coordinated actions across devices, actors and systems are required to maximize the operational and economic value of the smart grid.[1] The interoperability required to enable this optimization is best achieved through the use of open standards to define interface performance requirements.[2] Testing and certification programs provide a mechanism to ensure that equipment function conforms to standards and will operate as intended when deployed. NIST research reveals a limited availability of testing and certification programs for smart gird interoperability standards,[3] and this paper proposes an approach to developing interoperability profiles to help accelerate the development of testing and certification programs.

Testing and Certification—Context

Testing and certification programs provide common and acceptable processes that are used to demonstrate conformance with a standard and support interoperability between devices and systems.[4] Completing the program allows vendors to offer products certified to that standard, and affords customers a level of trust that products will work as intended when deployed. Standardized interface performance requirements are required for modernizing the grid as new technology integrates with legacy grid systems,[5] and the value of certification programs increases as the number of devices, range of technologies, and operational paradigms on the grid continues to grow.

The testing and certification value proposition benefits all grid stakeholders. Customers benefit by ensuring that standards and performance requirements are implemented appropriately and consistently across procured equipment, which eases integration of new products and services with existing infrastructure and operations.[6] Testing and certification also reduces vendor and manufacturer implementation costs for new standards by establishing clear performance requirements and ensuring product certifications occur in a neutral environment, which can facilitate market access.[7] State legislators and regulators have also recognized the importance of interoperability testing and certification as a means to maximize the benefits of new grid technology investments.[5,7]

Testing and certification programs help achieve interoperability across smart grid devices and systems,[8] an important component of NIST's mandate in this space.[9] Yet despite the substantial

[1] NIST Special Publication 1108r3, NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 3.0 (2014), https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1108r3.pdf
[2] European Commission Smart Grids Task Force, *Interoperability, Standards and Functionalities applied in the large scale roll out of smart metering* (2015). Available here.
[3] See companion document: *DRAFT Evaluation of Testing & Certification Landscape for Smart Grid Standards*. Available here.
[4] ANSI/NEMA Smart Grid Interoperability Process Reference Manual (ANSI/NEMA SG-IPRM 1-2016). Available here.
[5] Illinois Statute 220 ILCS 5/16-108.6. Available here; California Code - PUC § 8360. Available here.
[6] Ahmadi, M. *The Need for Security Testing and Conformance Standards in the Smart Grid*. Grid-Interop Forum, 2011. Available here.
[7] Public Utilities Commission of the State of California, RESOLUTION E-4527 (2012). Available here.
[8] SEPA. *Interoperability Process Reference Manual—User's Guide* (2017). Available here.
[9] Energy Independence and Security Act of 2007 (Public Law 110-140, available here).

1

https://www.nist.gov/sites/default/files/documents/2018/06/25/draft_tc_landscape_evaluation_final.pdf

https://www.nist.gov/sites/default/files/documents/2018/06/25/draft_interoperability_profile_description_final.pdf

Questions?

Update on Interoperability Framework 4.0

Avi Gopstein

Smart Grid Program Manager

April 2, 2019

National Institute of Standards and Technology
U.S. Department of Commerce

Activities since last SGFAC Meeting (April 2018)

Stakeholder engagement and feedback at the heart of our process:

Public Events:

- June 6: Launch Webinar
- July 9: Testing & Certification Workshop
- September 12: Georgia Public Service Commission Workshop
- September 27: Indiana Utility Regulatory Commission Workshop
- October 16: California Public Utilities Commission Workshop
- November 13-14: Smart Grid Interoperability Framework & Cybersecurity Workshop
- November 29: Rhode Island Public Utilities Commission Workshop

Significant and **Diverse Participation:**

- 275 unique participants (261 non-NIST; 233 in-person)
- Regulators & state government, standards organizations, equipment manufacturers, technology providers, utilities, ISO/RTO, service providers, T&C laboratories, FFRDCs, National Laboratories, NGOs, consultants, foreign governments, citizens/energy users.

Many evolving pre-publication **documents**

https://www.nist.gov/engineering-laboratory/smart-grid/smart-grid-framework

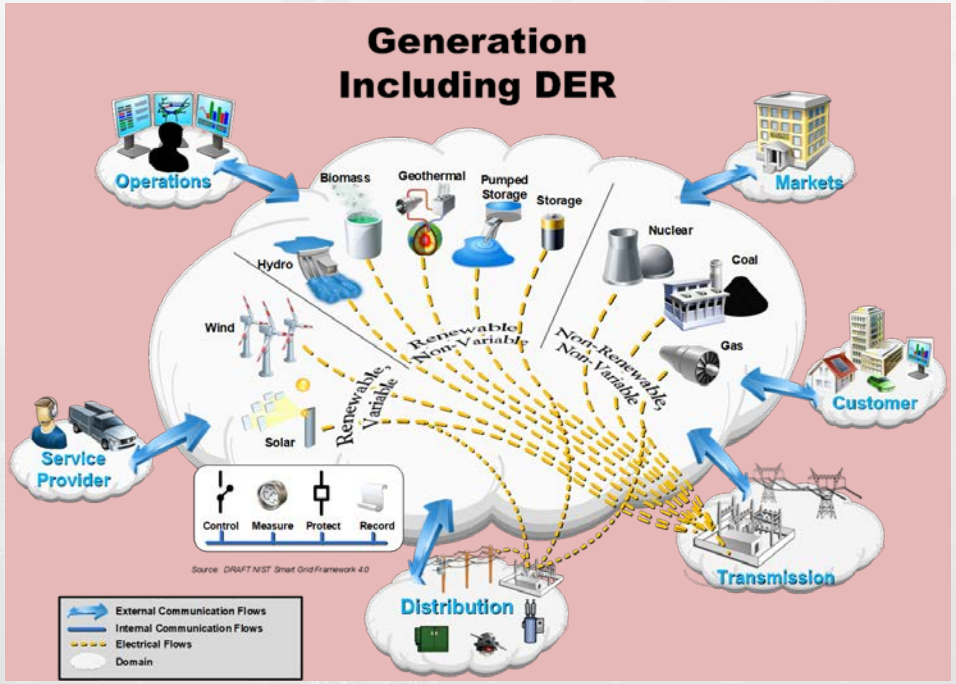
Launch Webinar (June 6, 2018)

- 55 participants
  - 27% of whom attended later events in person
- Unveil updated Smart Grid Conceptual Model
- Describe “new” Generation Including DER domain
- Communication Pathways Scenarios
- Discuss Cybersecurity Risk Profile

Important Takeaway:

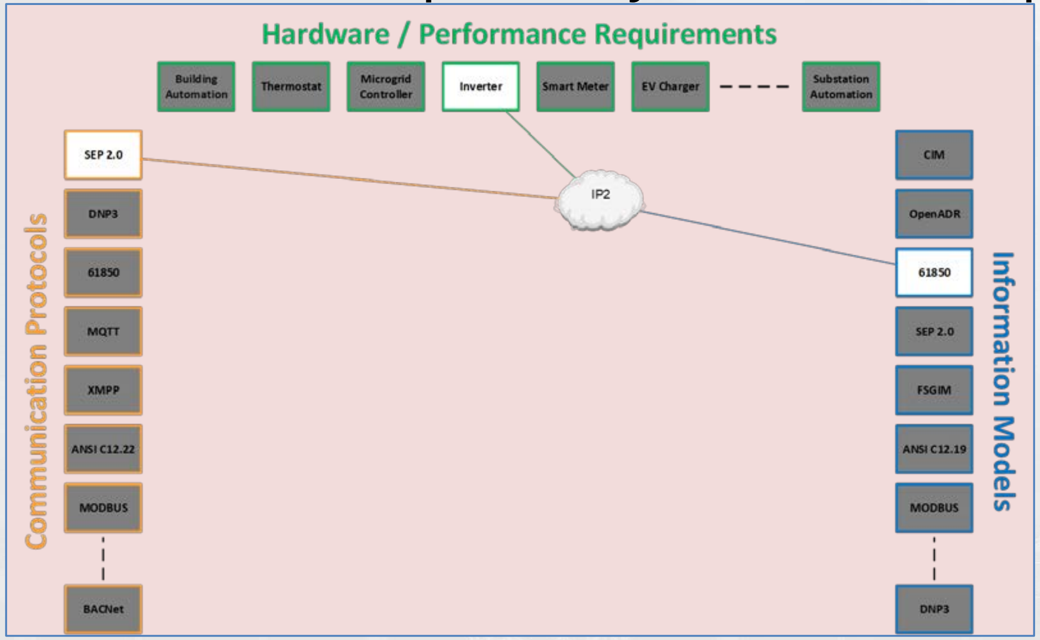
Questions surround the inclusion of DR as a supply resource.

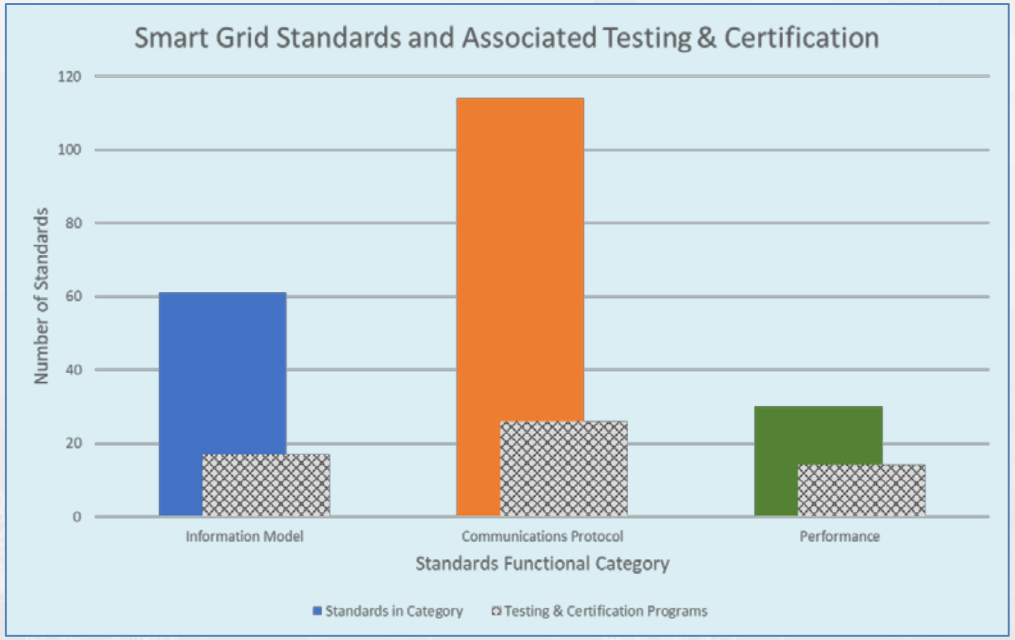
Archival Domain Image from Webinar



Testing & Certification Workshop (July 9, 2018)

- Sponsored by IEEE-SA and SEPA
- 48 attendees
- Two draft documents:
  - DRAFT Evaluation of Testing & Certification Landscape for Smart Grid Standards
  - DRAFT Interoperability Profile Description





Archival Interoperability Profile and Standards T&C Landscape Assessment Figures from Workshop

Testing & Certification Workshop (July 9, 2018)

Important Takeaways

- Lack of interoperability is already costing companies $Millions
- Lack of interoperability limits where data can be used
- Broad support for the idea of an interoperability profile
  - Mix of physical performance, communications, and data model is the right approach
  - Profiles should lead to specific interoperability testing requirements
  - Questions over which profiles are most important, and how specific
- Standards landscape assessment confirmed and quantified known issue
- Open-source requirements and test harnesses would be revolutionary

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Actions:

- Near-term: publish landscape analysis
- Medium-term: develop stakeholder community for profile development
- Longer-term: publish profiles, develop open-source test harnesses

Atlanta Workshop (September 12, 2018)

- Sponsored by NARUC, hosted by the Georgia PSC
- 23 participants
  - Limited by Hurricane Florence response
- Provided complete draft update of Smart Grid Conceptual Model

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Important Takeaways:

- The grid is switching from capacity to resource (fuel) based reliability models
  - Interoperability is key to utilizing dynamic ratings for conventional assets
- The business case for interoperability isn’t clear to decision makers:
  - Need to improve understanding of interoperability economic benefits
- Unanticipated benefits of interoperability are significant
  - Industry representatives believe most benefits accrue to customers
- Demand response must be included as a generation asset
- Microgrid controller to operations center is key interoperability profile interface
  - The difference between sunny day and resilience operations

Indianapolis Workshop (September 27, 2018)

- Sponsored by NARUC, hosted by the Indiana URC
- 28 participants
- Updated conceptual model (again)
- Updated communication pathways models

Important Takeaways:

- Key Gap: Value metrics for interoperability (especially AMI)
- Key Interfaces: Focused on the customer
  - Electric vehicles
  - Customer storage (battery, water heater)
  - Human interface (proxies are customer devices for automation, or AMI)
- Key Graphic: Cloud model
  - Useful for customer interface
  - Communication and education (will benefit utilities)

San Francisco Workshop (October 16, 2018)

- Sponsored by NARUC, hosted by California Public Utilities Commission
- 37 participants
- Two new draft documents:
  - Update of NIST Smart Grid Conceptual Model – Second Discussion DRAFT
  - Developing an Ontology for the Smart Grid – Discussion DRAFT

Important Takeaways:

- The idea of a common language (ontology) is important
- Timeline for change is accelerating
- Trustworthiness is an issue of growing concern
  - Trustworthiness, resource location, system topology could drive interoperability requirements
- Data sharing is an important part of interoperability
  - The need depends on what you are trying to accomplish
  - Data format is a big concern
- Benefits quantification remains an underserved issue
- Questions about whether interoperability can facilitate planned obsolescence
  - The ability to plan for new capabilities through legacy asset retirement and replacement

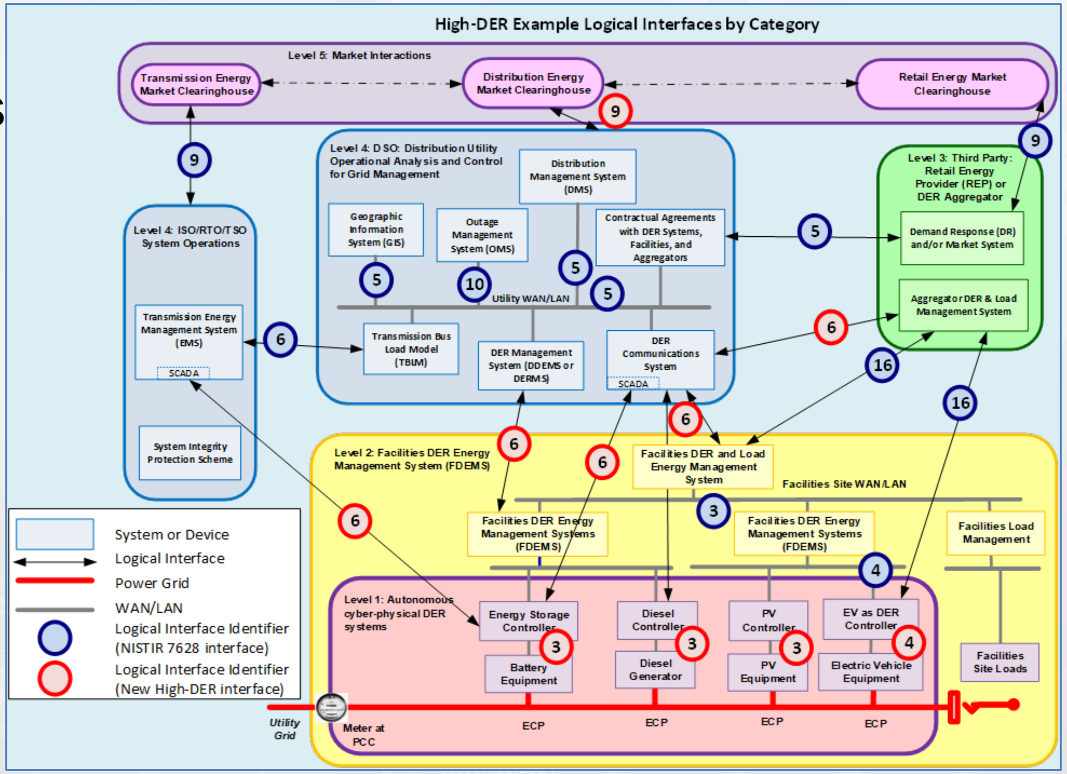
Interoperability Framework & Cybersecurity Workshop

- November 13-14, 2018; 109 attendees
- Provided five draft documents
  - Draft update to NIST's Smart Grid Conceptual Model (Version 3)
  - Draft introduction of a smart grid ontology (Version 2)
  - Draft description of a smart grid cybersecurity risk profile
  - Draft assessment of smart grid interface categories
  - Draft overview of publish/subscribe communications

Table 2 IDENTIFY Smart Grid Profile

Category		Maintain Safety	Maintain Reliability+E13	Maintain Resilience	Support Grid Modernization	Considerations for Power System Owners/Operators
		Subcategories				
ID	Asset Management	ID.AM-1	ID.AM-1	ID.AM-1	ID.AM-1	Knowing hardware assets is critical for maintaining safety, reliability, and resilience, as well as facilitating the transition to the modern grid. Legacy and modernized assets need to be known and understood. As modernized grids become more distributed, power system owners/operators need to be accountable for all distributed assets that they own.
		ID.AM-2	ID.AM-2	ID.AM-2	ID.AM-2	Knowing software assets is critical for maintaining reliability, and resilience, as well as facilitating the transition to the modern grid. Legacy and modernized assets need to be known and understood. This especially applies to modernized assets because the sophisticated logic that they execute is driven by software.

Snapshot of Smart Grid Risk Profile



Logical Interface Categories for High-DER Scenario

Important Takeaways:

- Complexity is a driving feature
  - Utility's historic approach doesn't work anymore, increases threats
- Cybersecurity and trustworthiness tradeoffs need to be explored
  - Identity management & full trust versus micro-segmentation and zero trust
  - In a CPS with abstracted layers of autonomous function, trustworthiness also involves the physical function and control decisions
- The use of scenarios to explore the different diagrams / models / requirements is very helpful
- Interest in exploring the relationship between the logical interface categories with the cybersecurity risk profile
- Question: If the spaghetti diagram is an inherently hierarchical set of interfaces, do we need to create a new LIC for peer-to-peer communications?

Providence Workshop (November 29, 2018)

- Sponsored by NARUC, hosted by Rhode Island PUC
- 33 participants

Important Takeaways:

- A better approach to understanding the value of interoperability is needed
  - Interoperability is a hedge against forced obsolescence, but the value of that hedge is uncertain.
- Regulators want to know what questions they should be asking about interoperability when vetting proposals
- The Northeast region would benefit from technical exchanges and working groups that are bigger than individual states
  - Would help avoid balkanization of markets, requirements, and technologies
- Interoperability requirements must be better described to facilitate improved tests
  - A standard is only as good as the test it is verified against
- Changes are accelerating:
  - NEISO has had days where midday loads are lower than nighttime minimums
  - Question: Future load curves will look like flat horizons—which interoperability interfaces will enable that?

Next Steps – Document and Publish

- NIST Tech Notes:
  - T&C Workshop Report
  - Regional Workshops Report
  - Interoperability Framework & Cybersecurity Workshop Report
  - Smart Grid Standards Testing & Certification Landscape Assessment
  - Cybersecurity Risk Profile for the Smart Grid
- NIST Special Publication:
  - Smart Grid Interoperability Framework 4.0