NIST Smart Interoperability Framework 4.0 Presentation to Midwest Energy Solutions

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National Institute of Standards and Technology

U.S. Department of Commerce

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

Energy Independence and Security Act (2007)

"It is the policy of the United States to support the modernization of the Nation's electricity transmission and distribution system."

NIST has *"primary responsibility to* ***coordinate*** *development of a* ***framework*** *that includes protocols and model standards for information management to achieve* ***interoperability*** *of smart grid devices and systems…"*

Interoperability Frameworks to date

NIST Special Publication 1108

NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0

Office of the National Coordinator for Smart Grid Interoperability

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

2010

NIST Special Publication 1108R2

NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0

Office of the National Coordinator for Smart Grid Interoperability,
Engineering Laboratory
in collaboration with
Physical Measurement Laboratory
and
Information Technology Laboratory

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

2012

This publication is available free of charge from http://dx.doi.org/10.6028/NIST.SP.1108r3

NIST Special Publication 1108r3

NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 3.0

Smart Grid and Cyber-Physical Systems Program Office
and Energy and Environment Division,
Engineering Laboratory

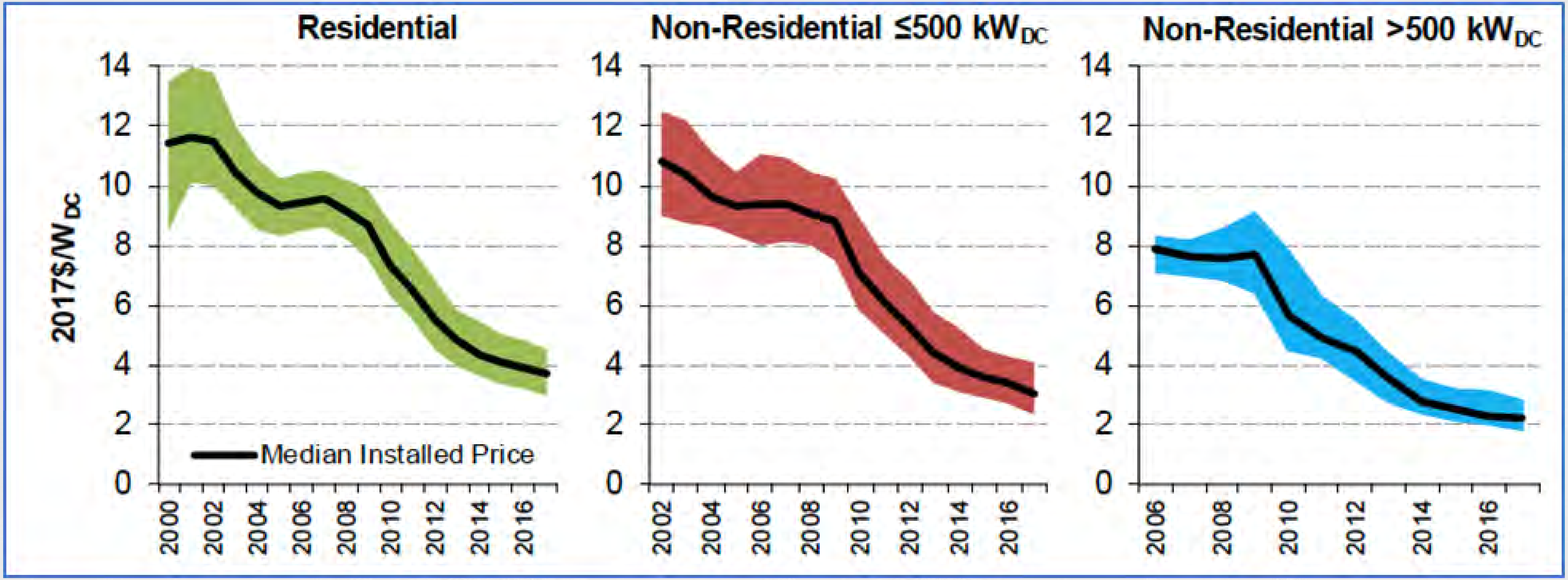
in collaboration with
Quantum Measurement Division,
Semiconductor and Dimensional Metrology Division,
and Electromagnetics Division,
Physical Measurement Laboratory
and
Advanced Network Technologies Division
and Computer Security Division,
Information Technology Laboratory

http://dx.doi.org/10.6028/NIST.SP.1108r3

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

2014

The Physical Context for our Grid is Changing



Source: Tracking the Sun: Installed Price Trends for Distributed Photovoltaic Systems in the United States-2018 edition

The Informational Context for our grid is changing

Figure 4.4 Unit costs of key emerging electricity technologies

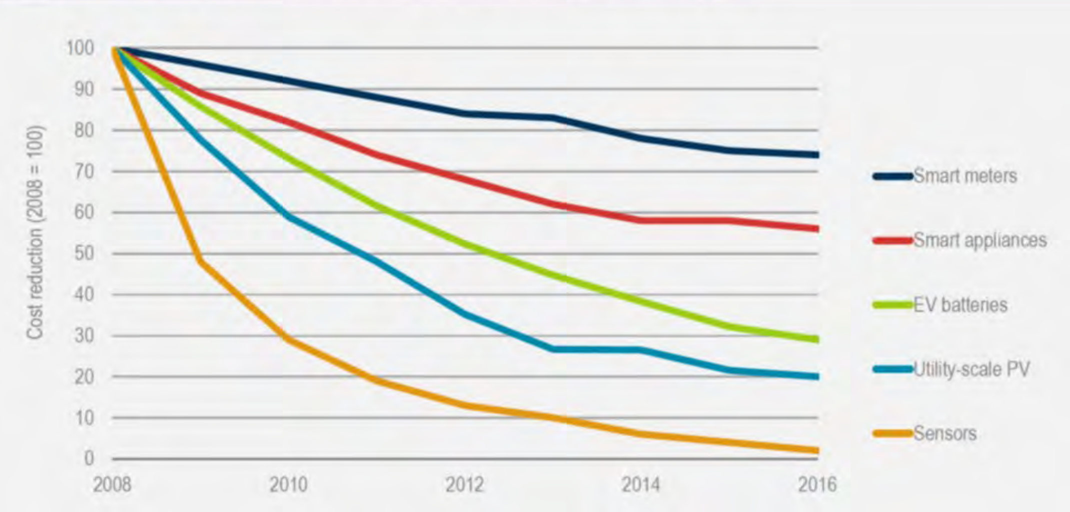


Figure 2.5 Household electricity consumption of appliances and other small plug loads

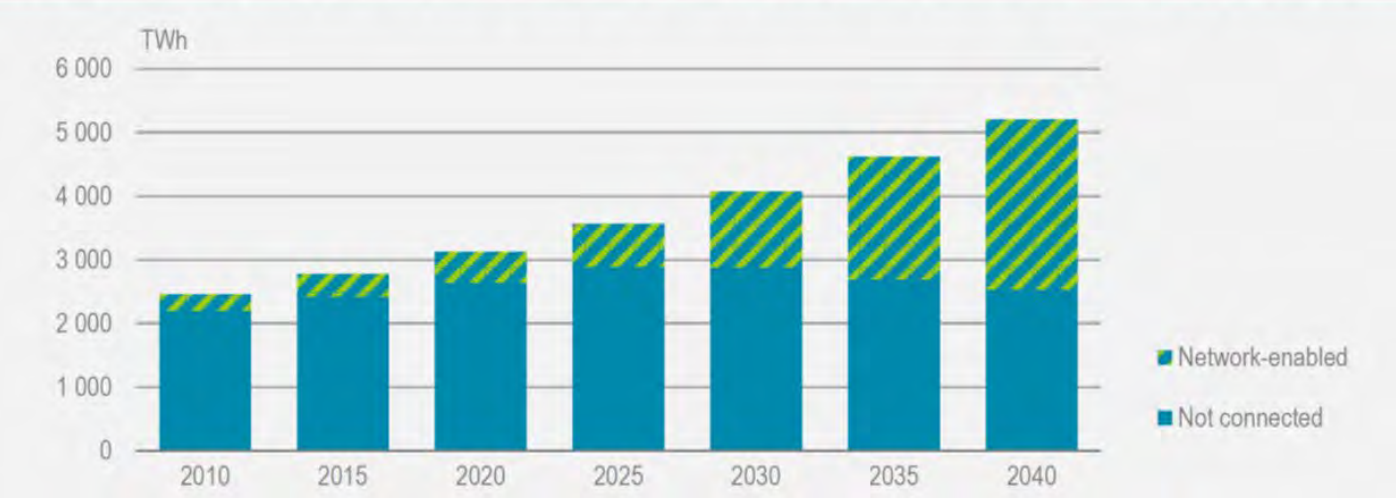


Figure 1.1 Global internet traffic

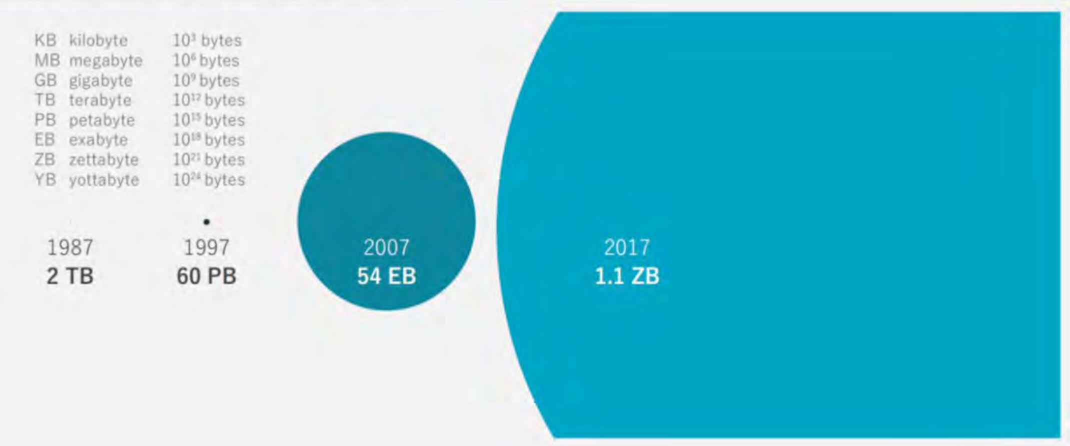
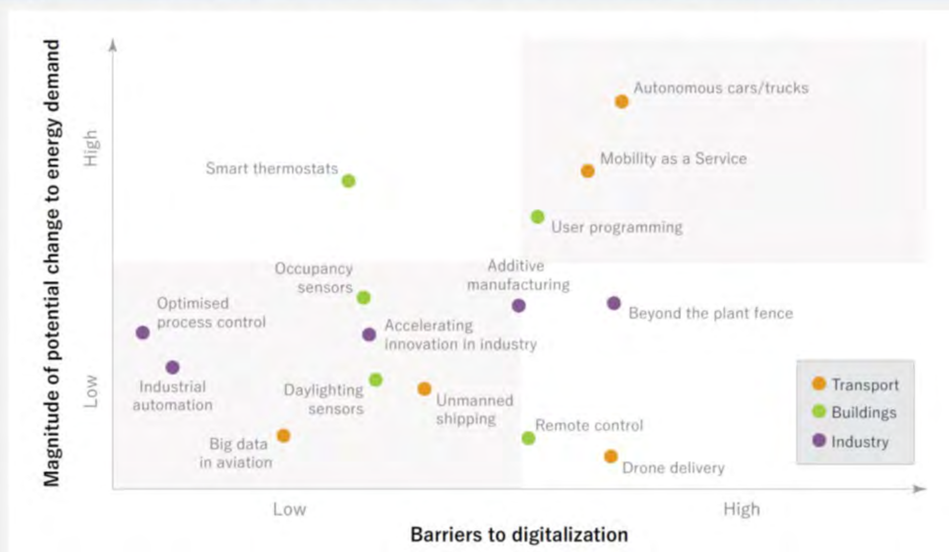


Figure 2.1 Digitalization's potential impact on transport, buildings, and industry



Source (all): IEA 2017, Digitalization & Energy

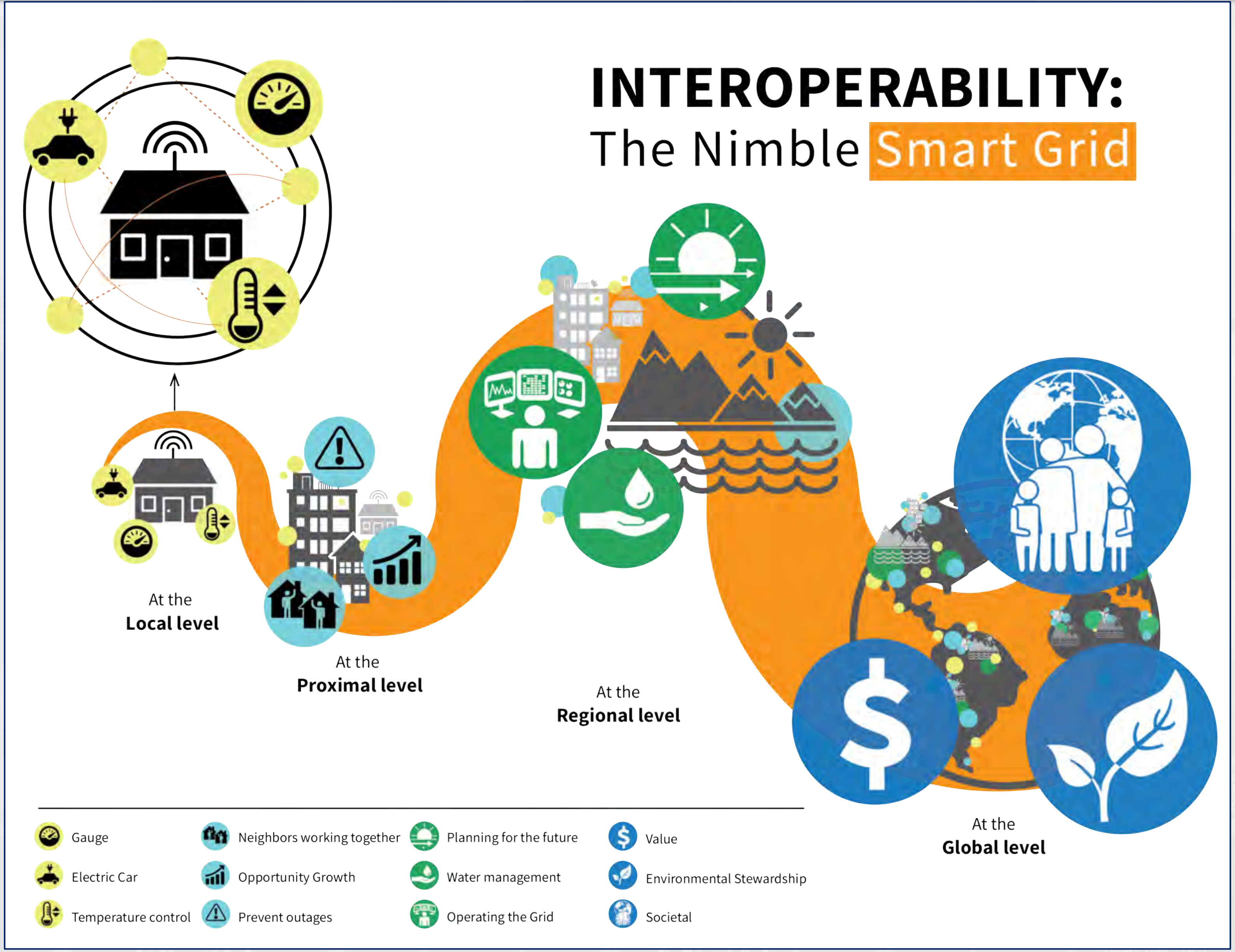
Interoperability requirements are changing

We need to understand the relationships between:

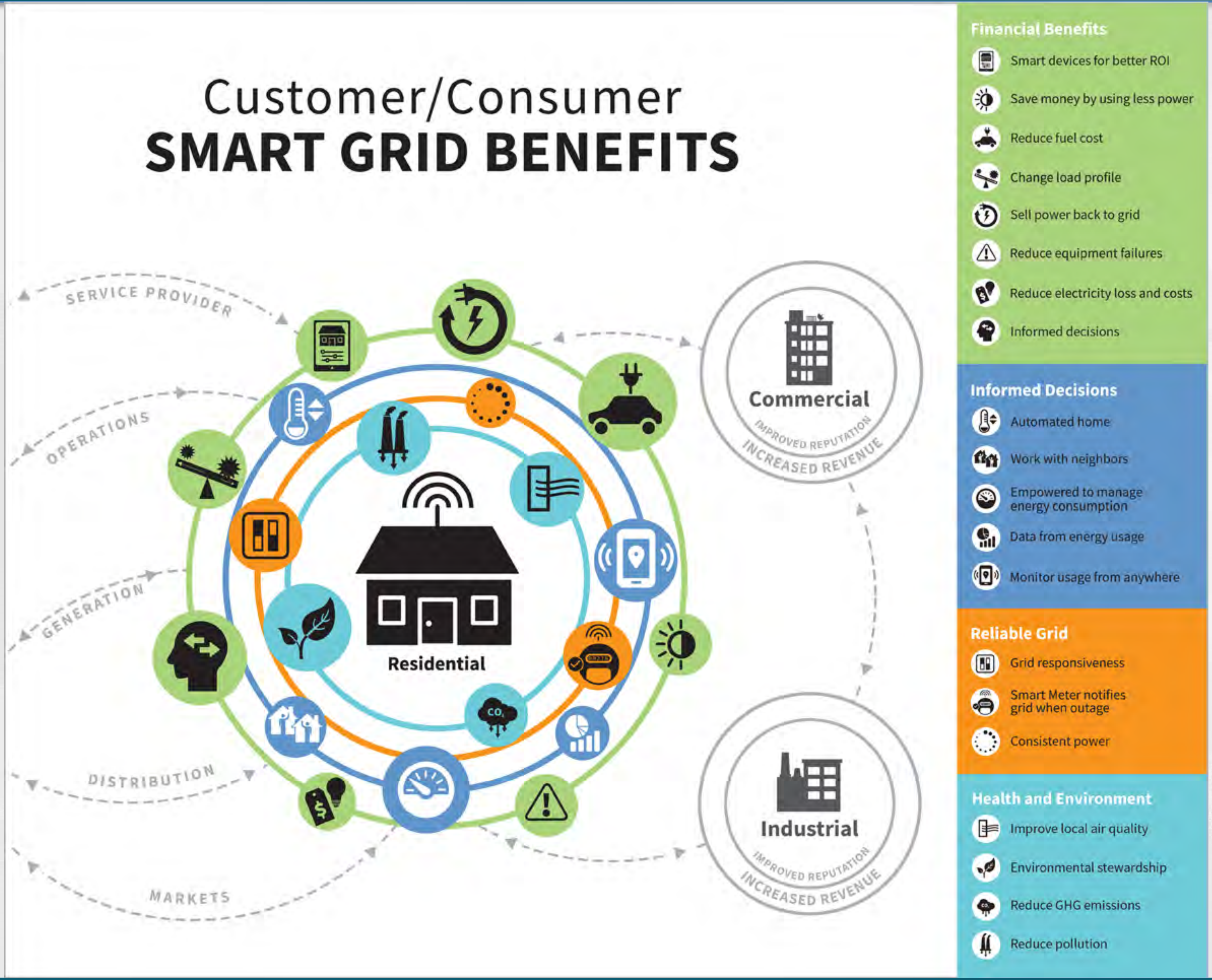
- Physical interoperability and conventional interoperability
- Interoperability and emerging economic opportunities
- Interoperability and cybersecurity
- Standards and interoperability
- Device heterogeneity and interoperability

NIST Conceptual Models for Interoperability and the smart grid must evolve

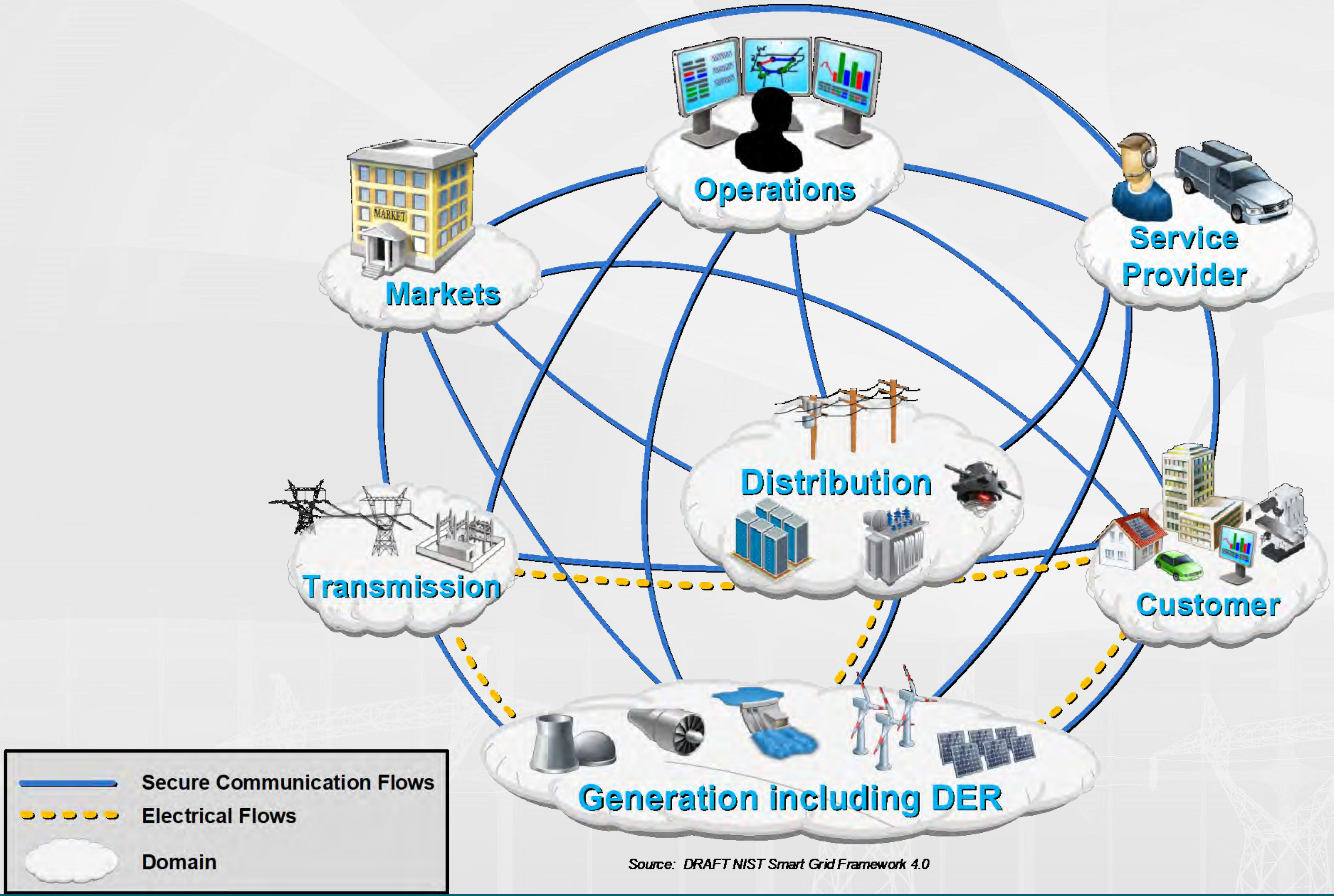
The Interoperability Value Proposition



The Customer Value Proposition



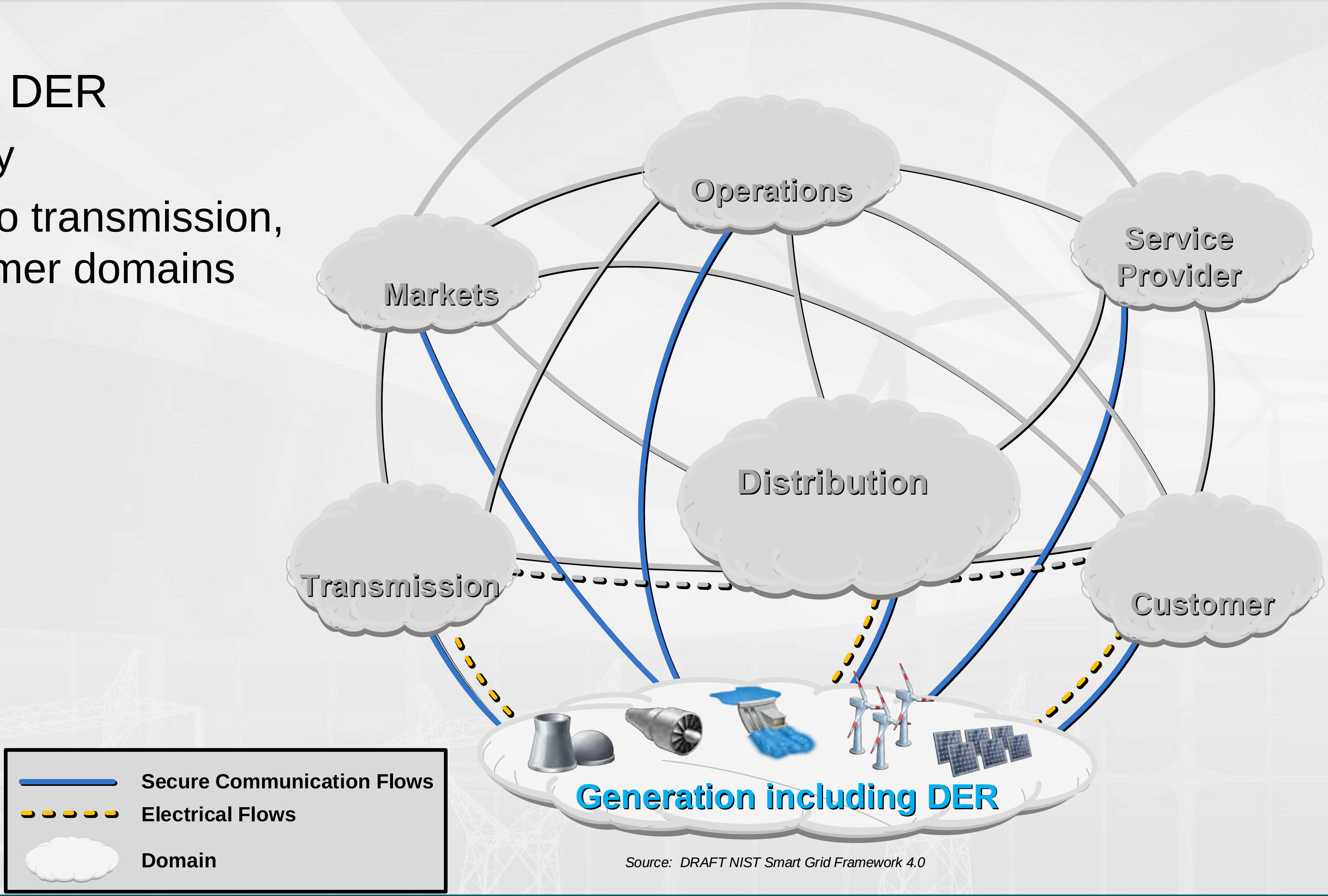
Smart Grid Conceptual Model (DRAFT V4)



Source: DRAFT NIST Smart Grid Framework 4.0

Smart Grid Conceptual Model (DRAFT V4)

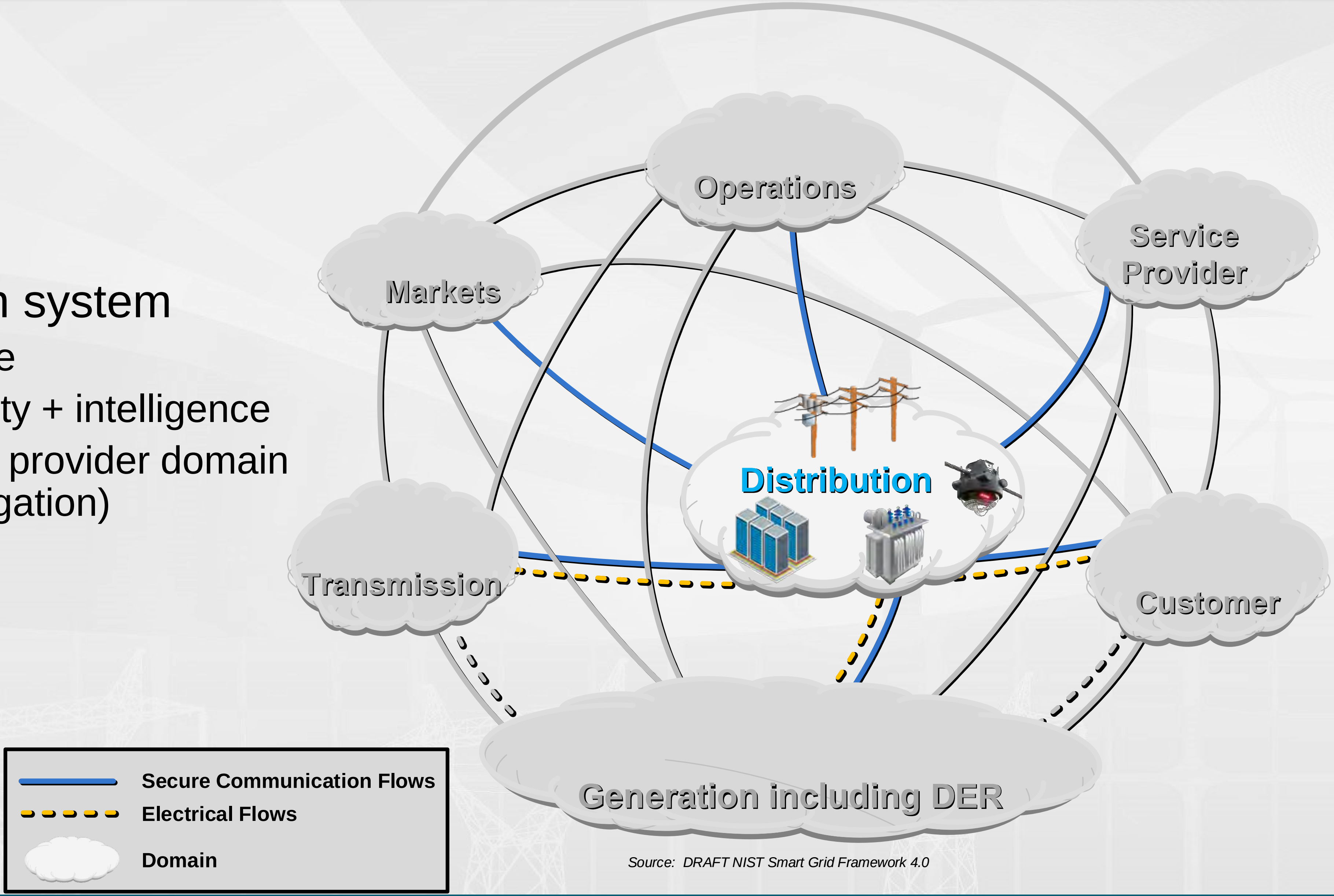
- Generation including DER
  - Technology diversity
  - Physical proximity to transmission, distribution + customer domains



Source: DRAFT NIST Smart Grid Framework 4.0

Smart Grid Conceptual Model (DRAFT V4)

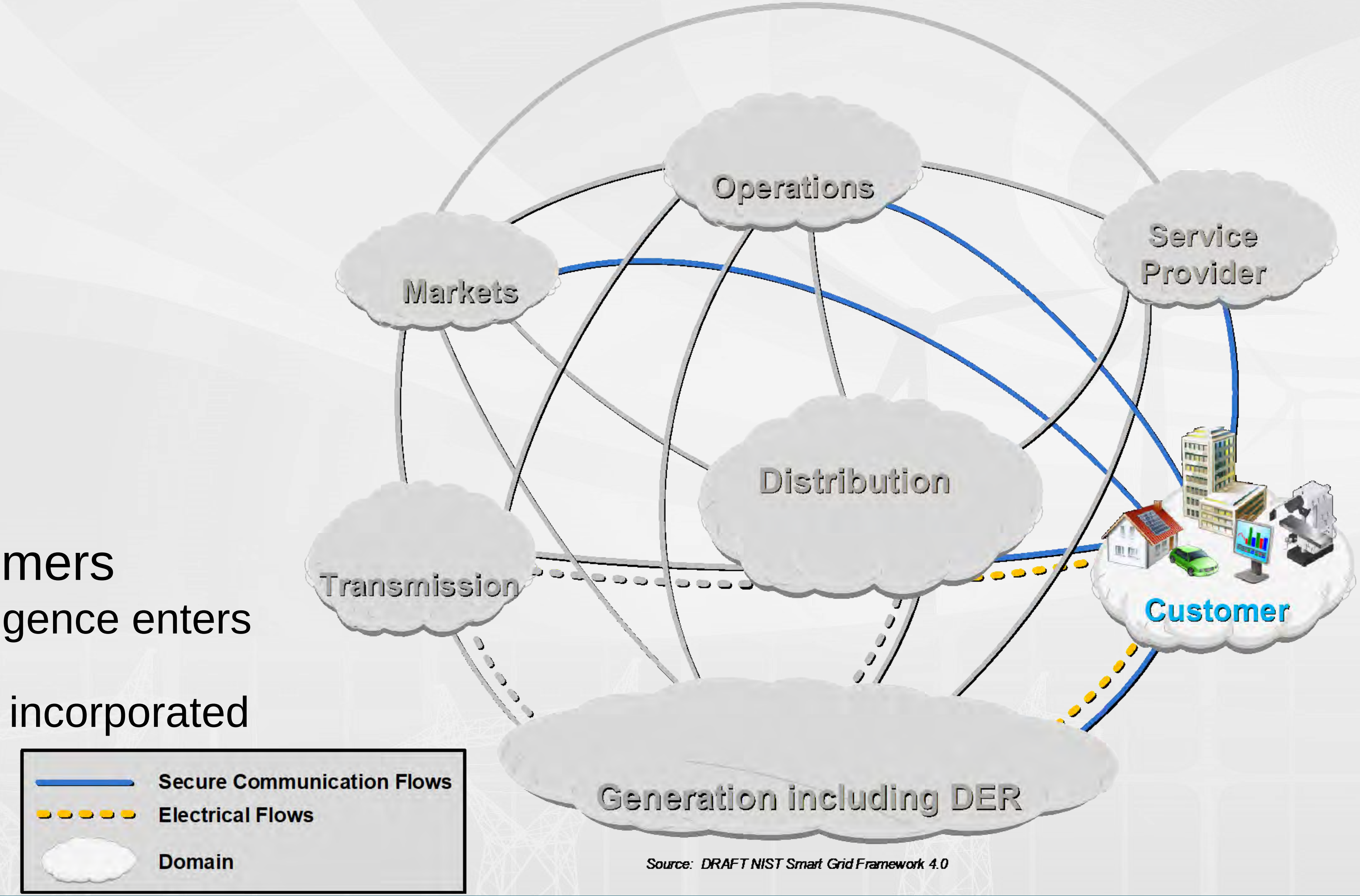
- Intelligent distribution system
  - Increasing importance
  - Improved controllability + intelligence
  - Connected to service provider domain (e.g., congestion mitigation)



Source: *DRAFT NIST Smart Grid Framework 4.0*

Smart Grid Conceptual Model (DRAFT V4)

- Empowered consumers
  - Operations & intelligence enters customer domain
  - Customer diversity incorporated



Source: DRAFT NIST Smart Grid Framework 4.0

Smart Grid Conceptual Model (DRAFT V4)

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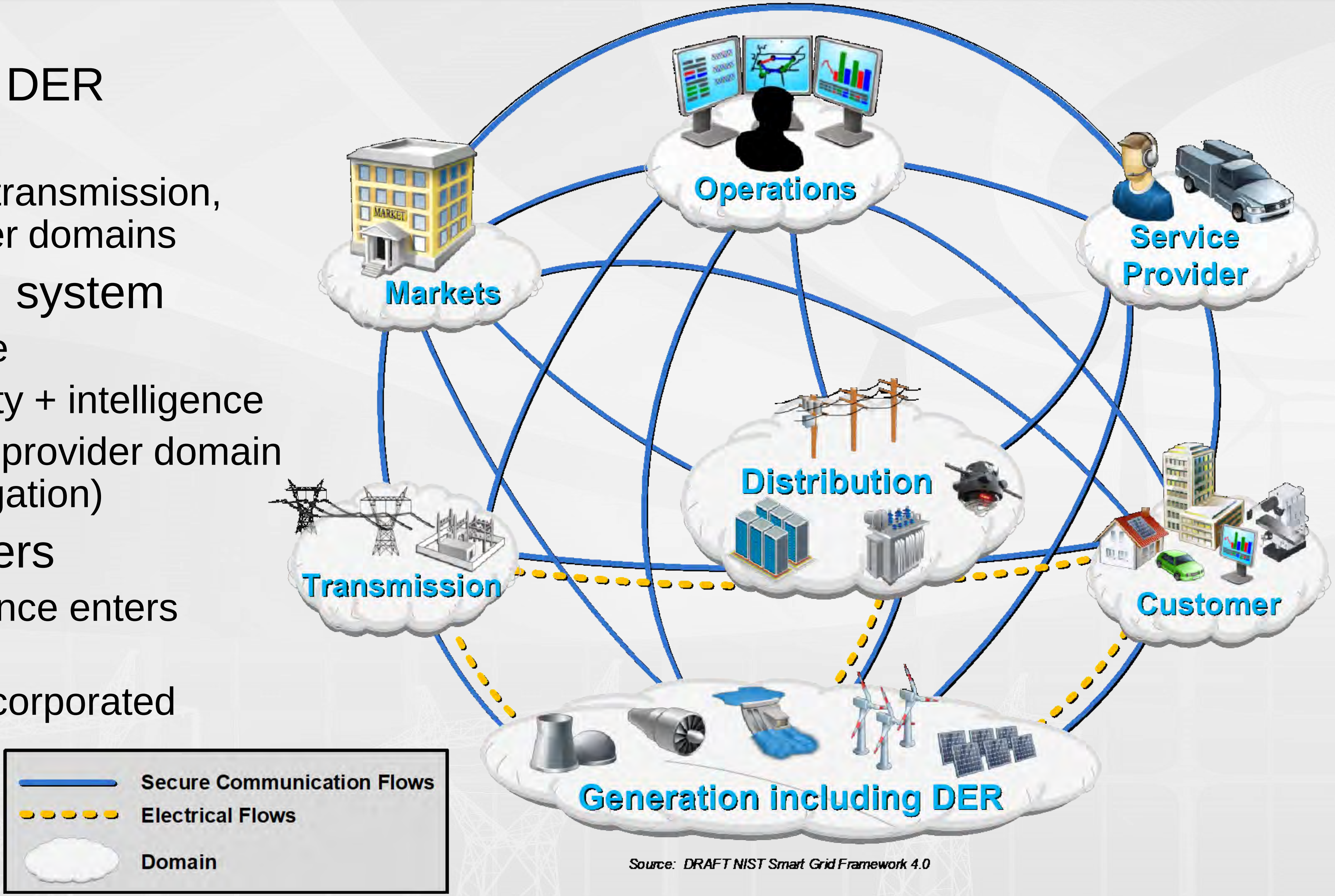
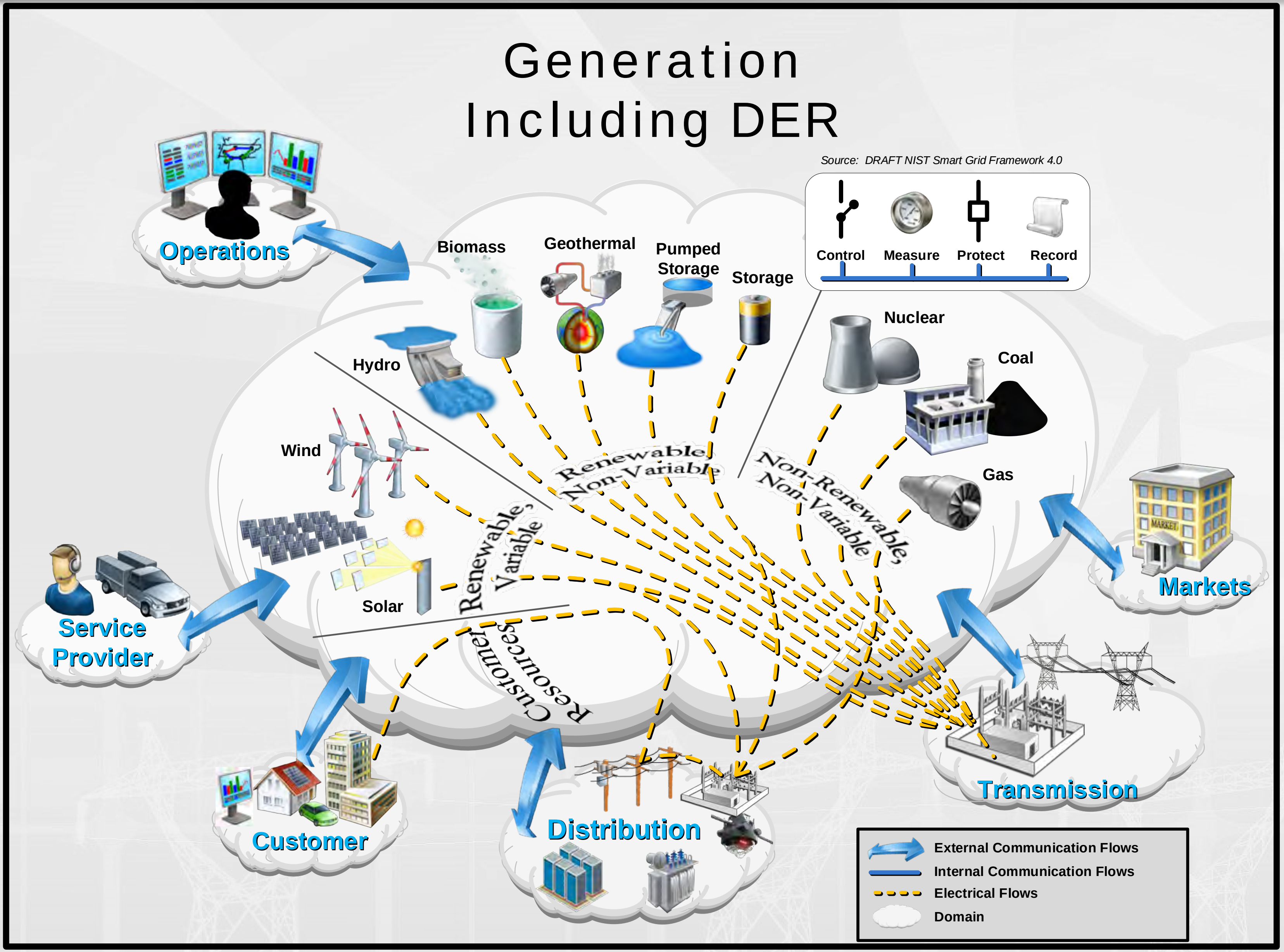
- Empowered consumers
  - Operations & intelligence enters customer domain
  - Customer diversity incorporated
- Emerging Markets
  - Platforms



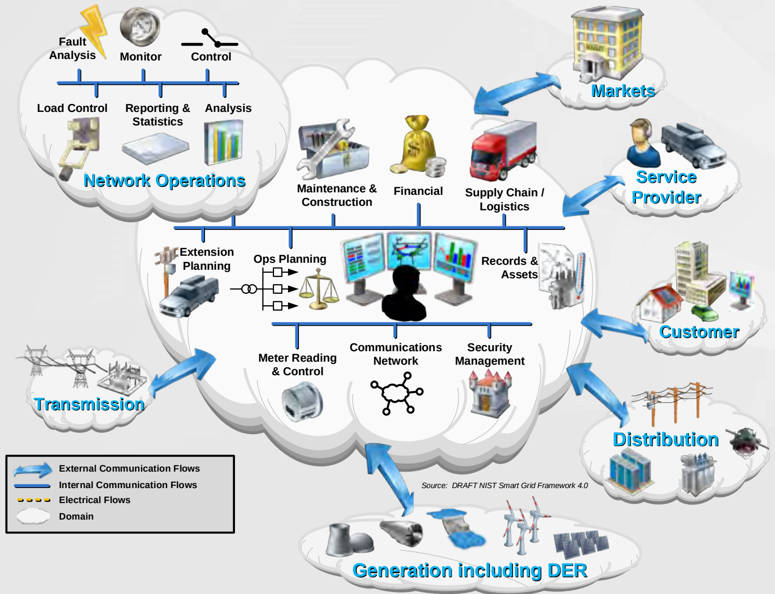
Source: *DRAFT NIST Smart Grid Framework 4.0*

The Conceptual Model: Generation Including DER

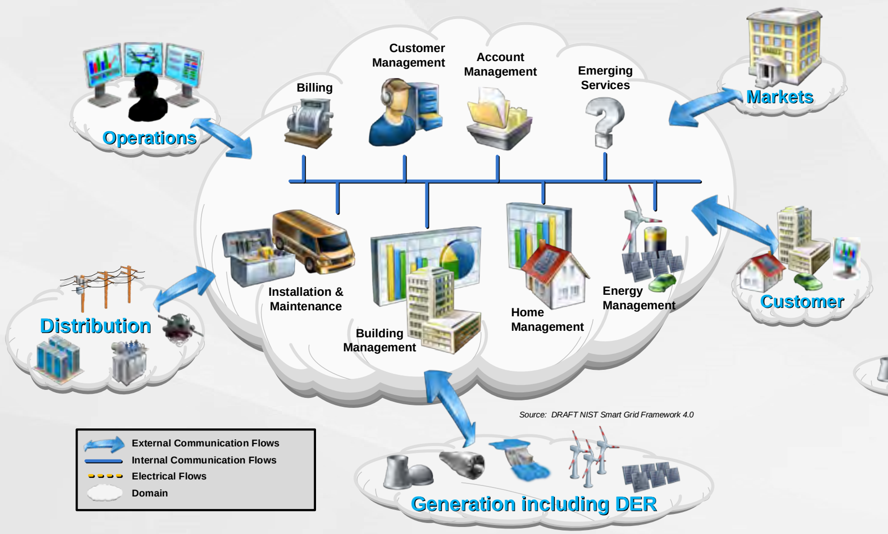


Updated Conceptual Model Domains

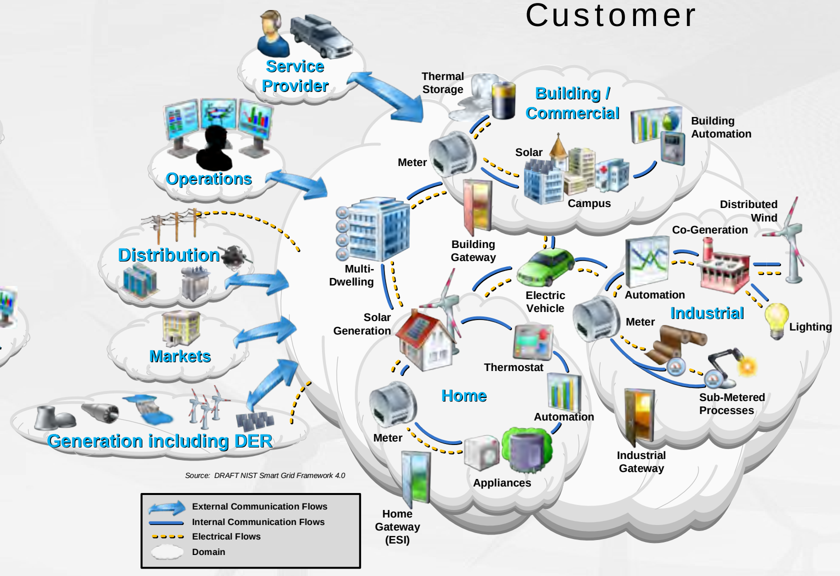
Operations



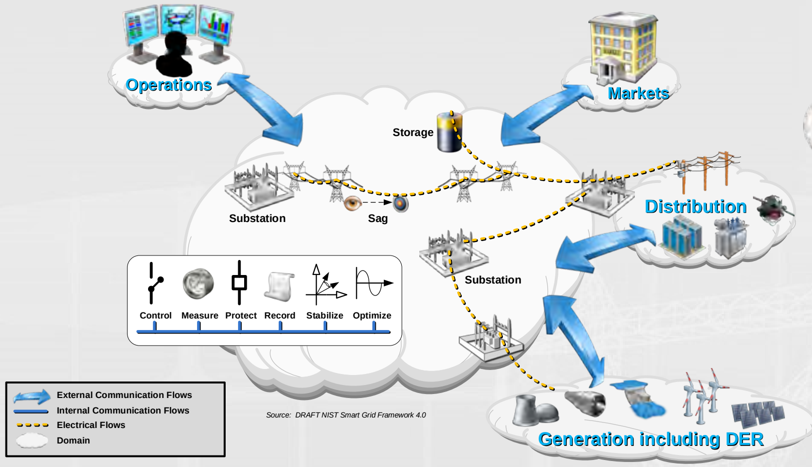
Service Provider



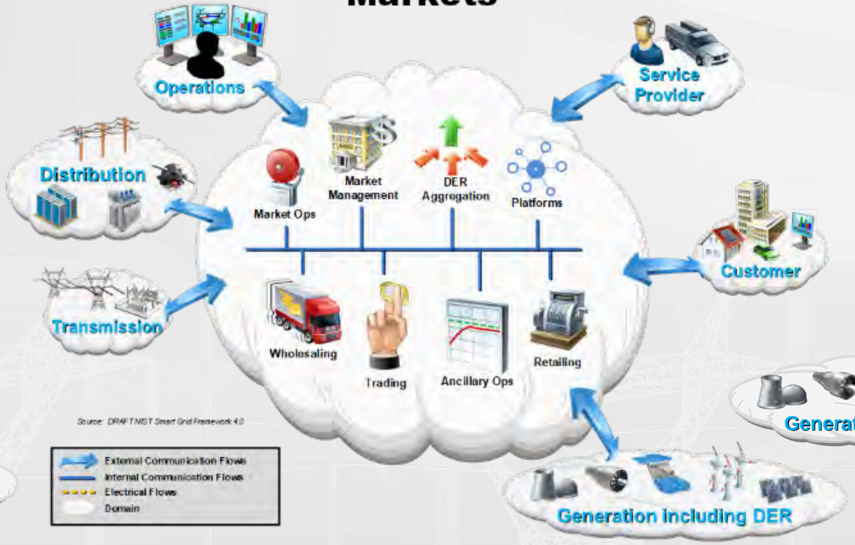
Customer



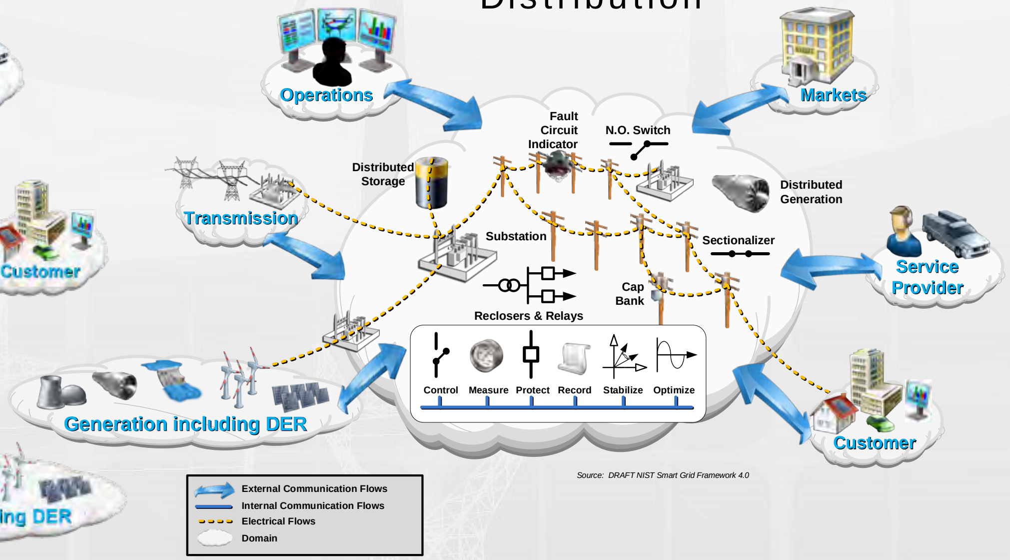
Transmission



Markets



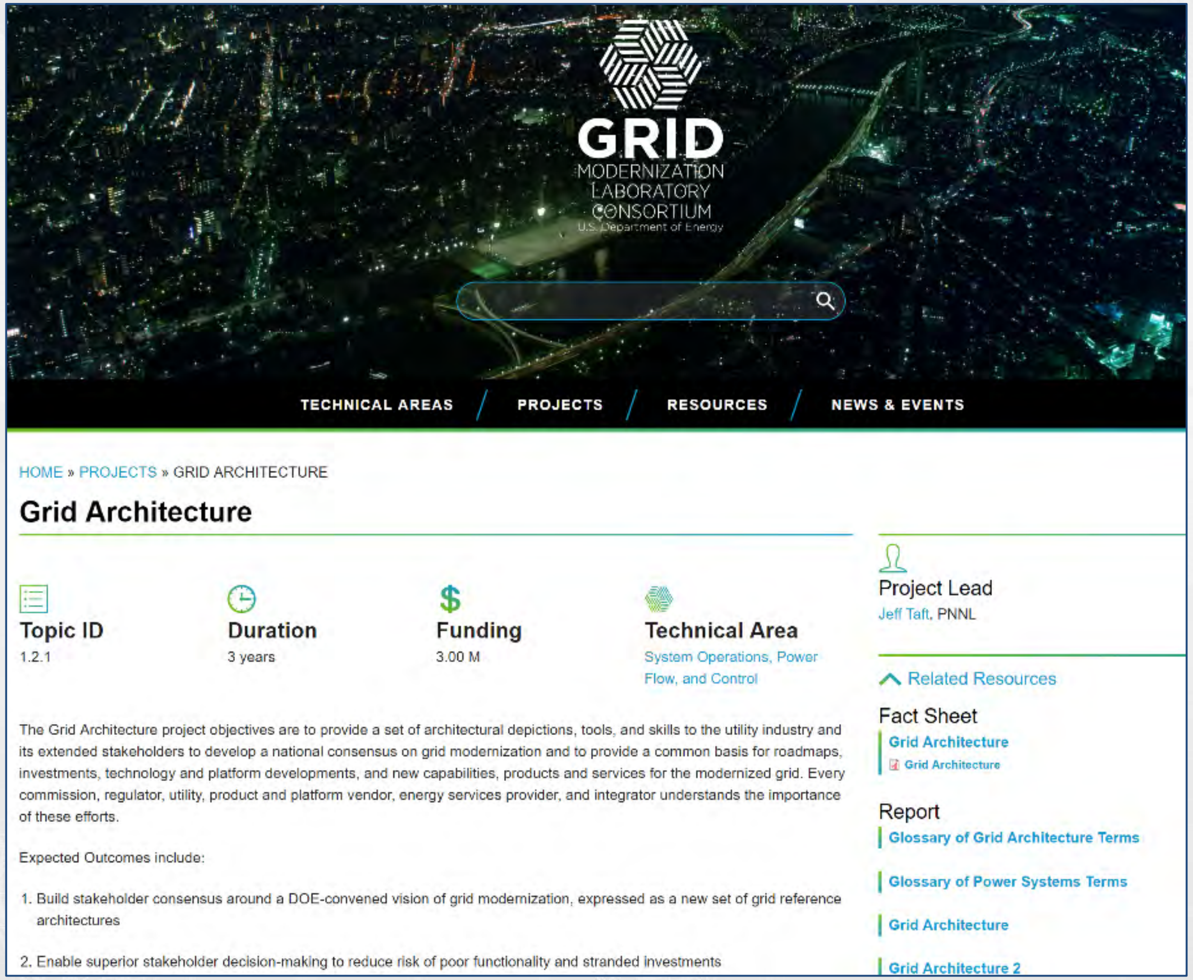
Distribution



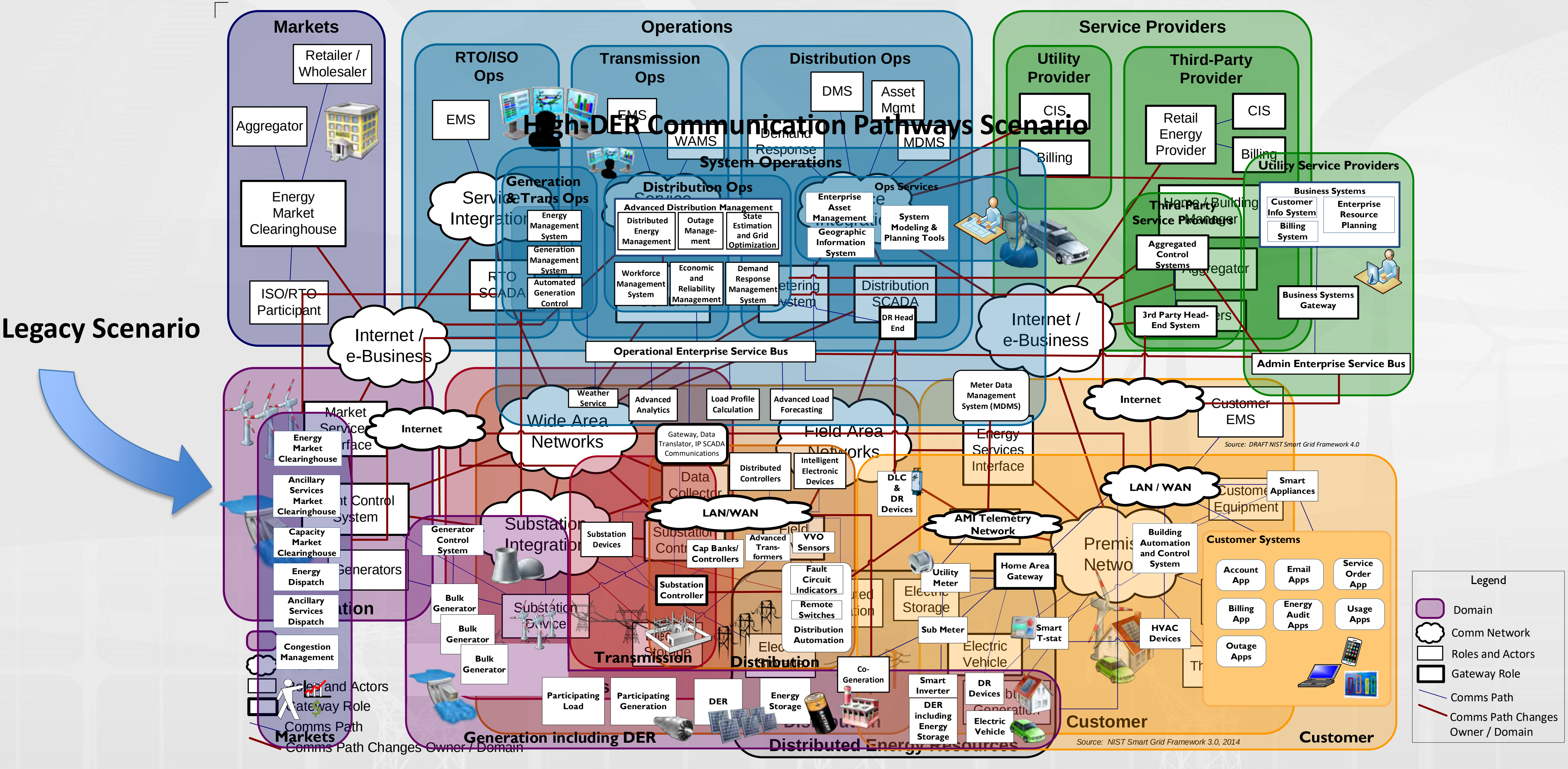
Each of described in depth in your pre-read (Appendix A)

NIST perspective

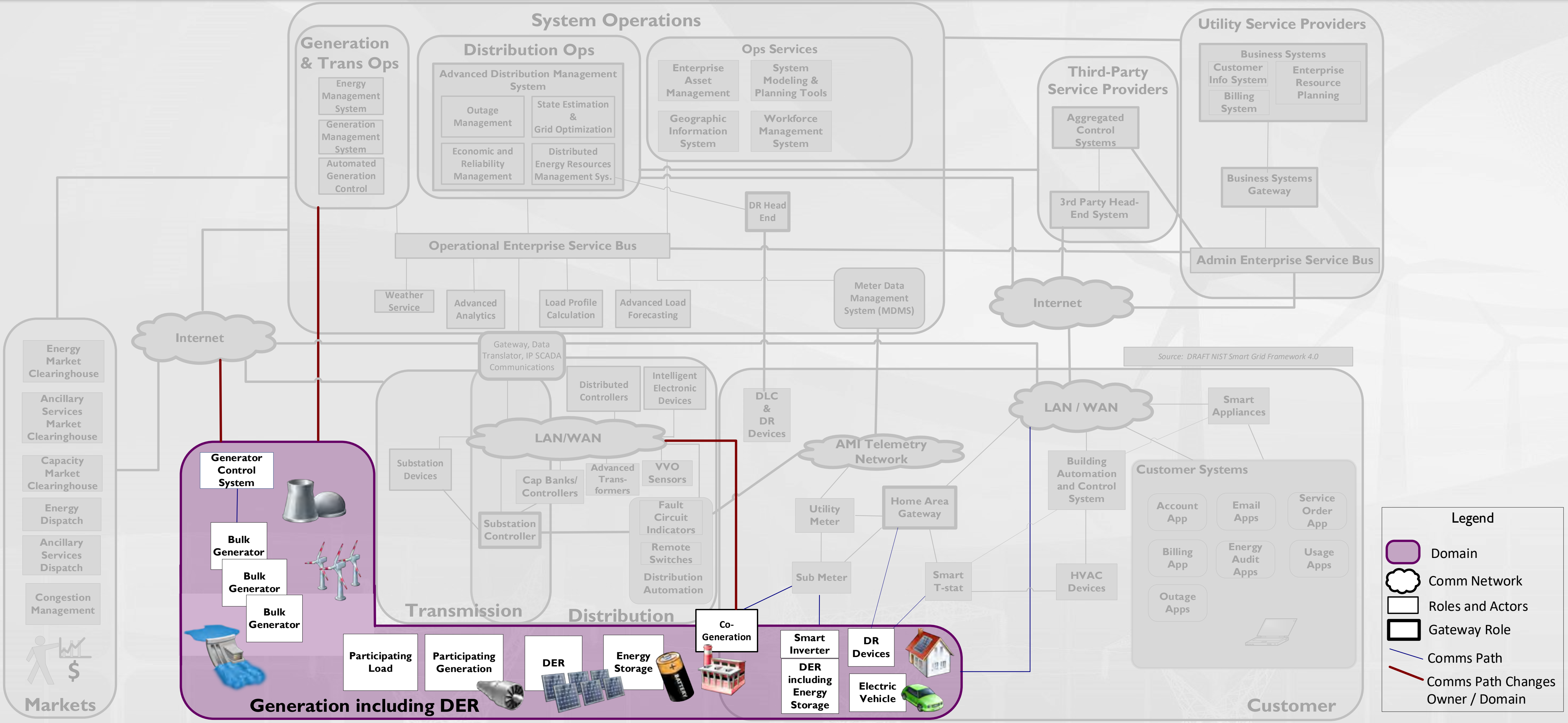
- Grid architectures are changing
  - Driven by technology and policy
- Changes will impact
  - Operations
  - Economics
  - Cybersecurity
  - Testing & Certification
- No single architecture is “correct”
- NIST are not architects



New Communication Pathways Scenarios



High-DER Communication Pathways Scenario



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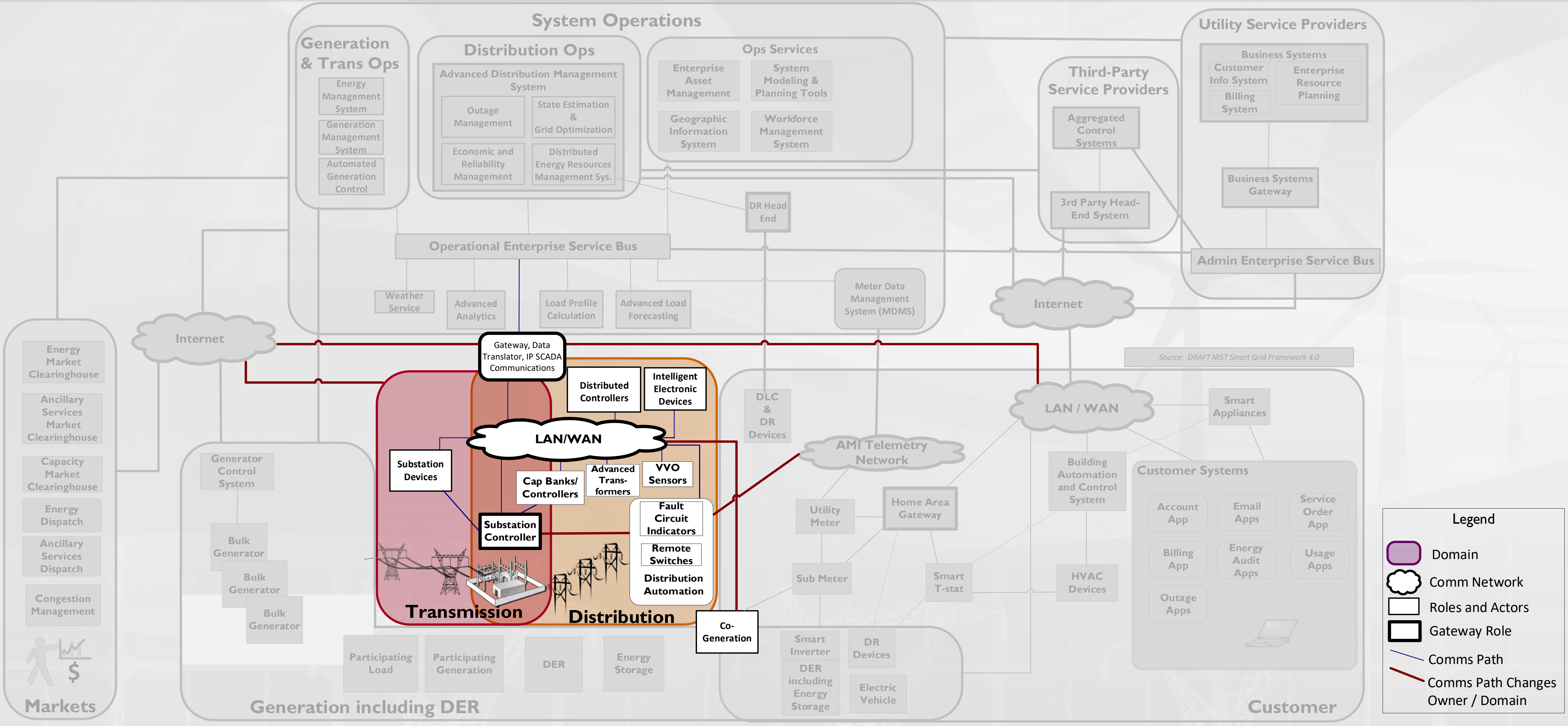
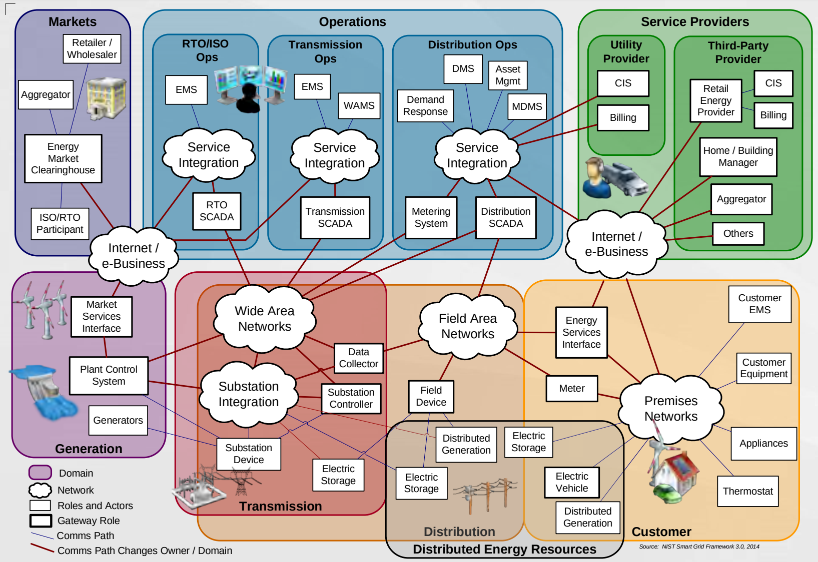
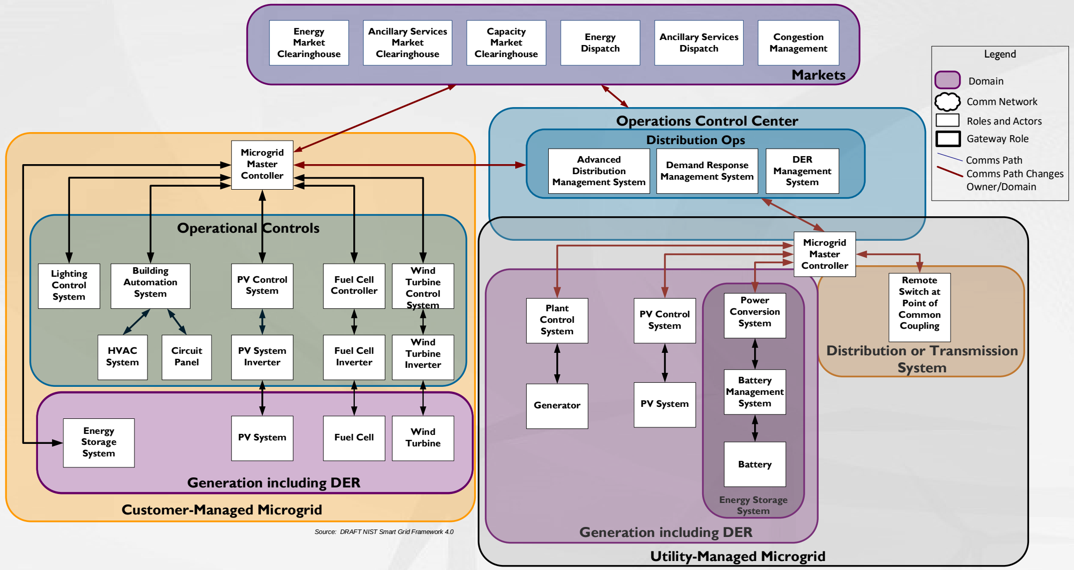


Four Communication Pathways Scenarios

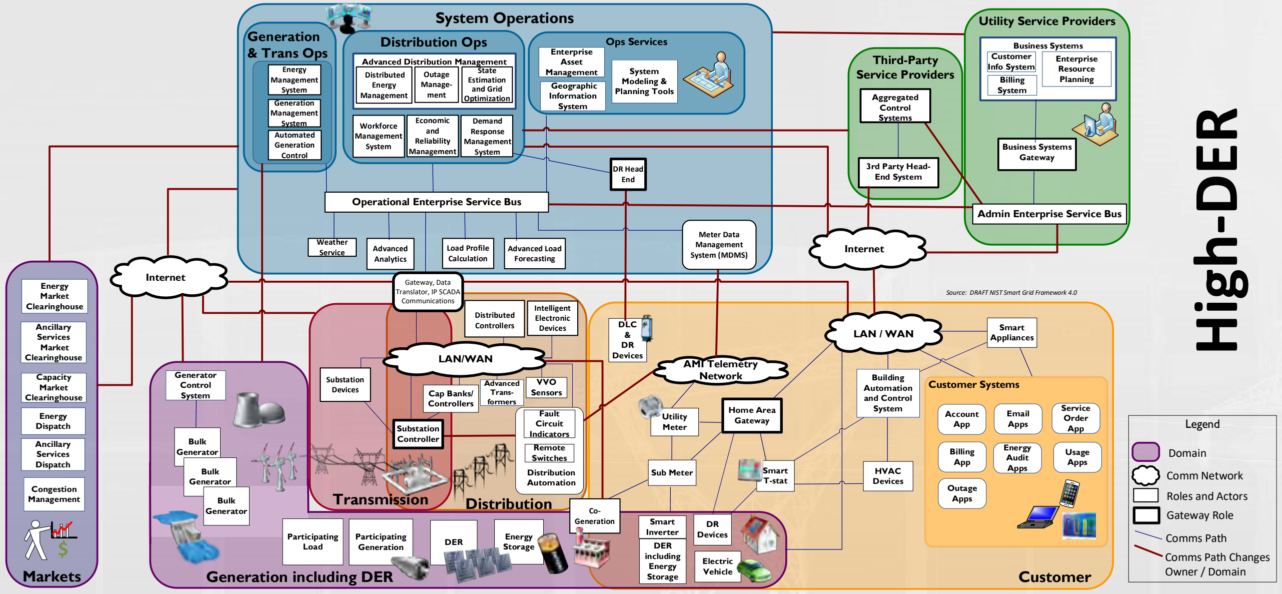


Legacy

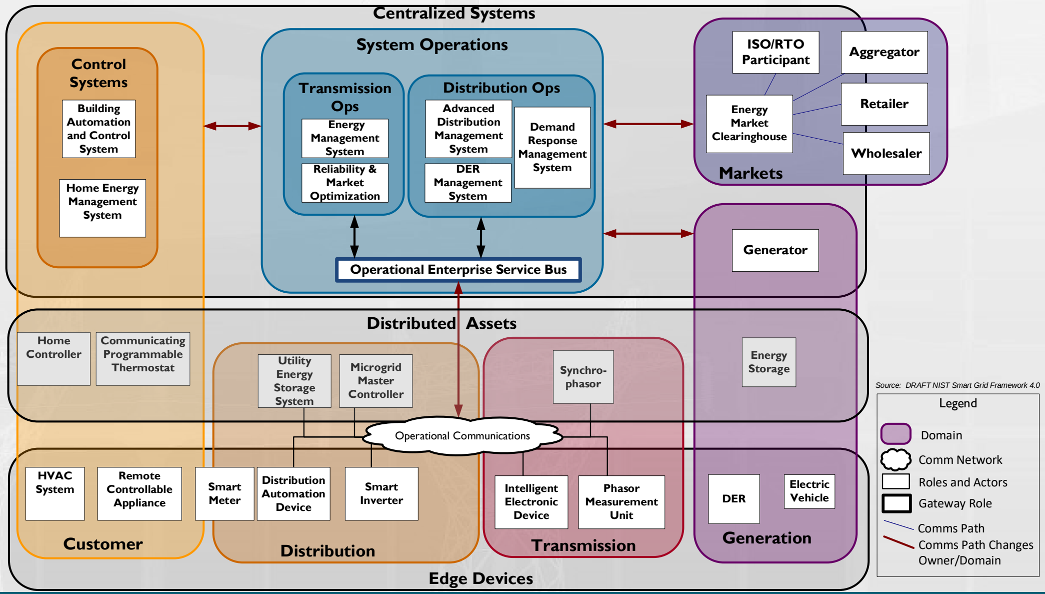
Microgrid



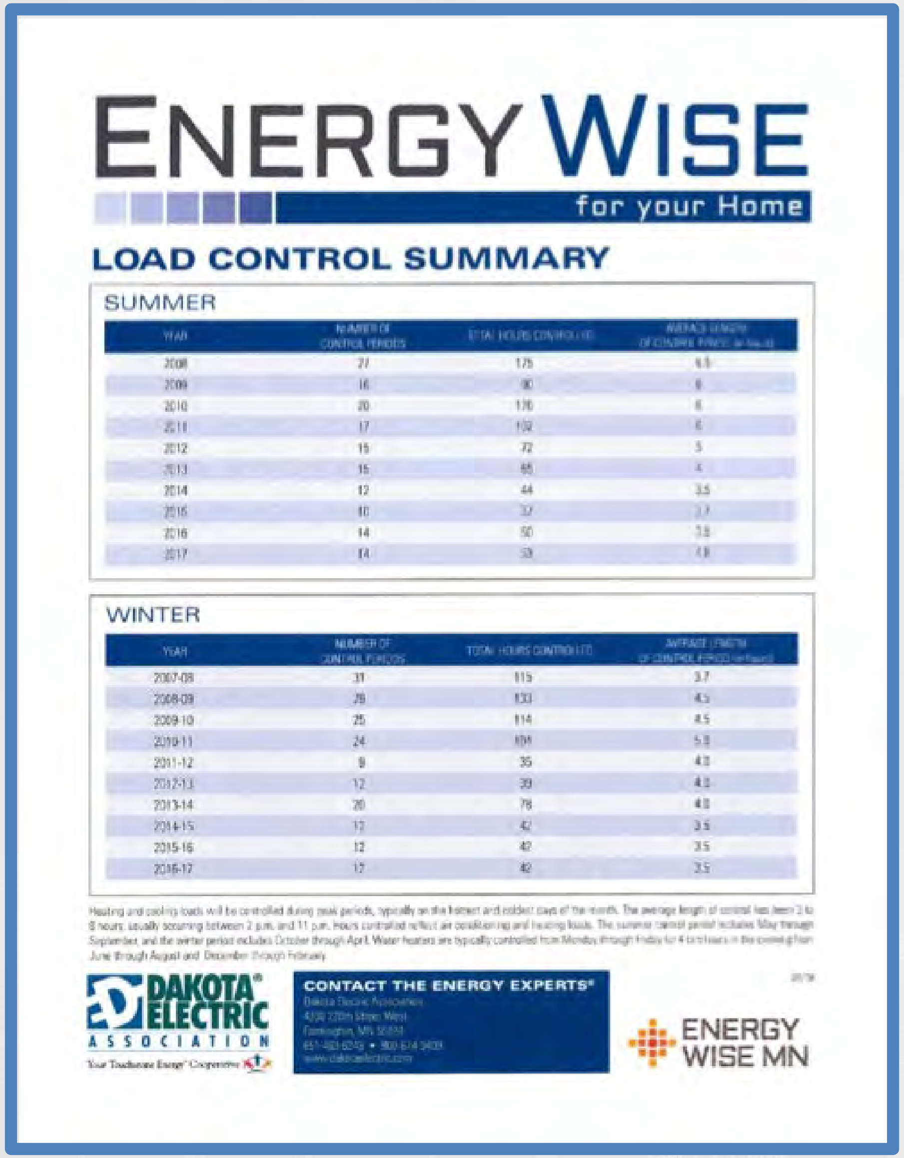
High-DER



Hybrid



Scenarios are not mutually exclusive



ENERGY WISE for your Home

LOAD CONTROL SUMMARY

SUMMER

YEAR	NUMBER OF CONTROL PERIODS	TOTAL HOURS CONTROLLED	AVERAGE LENGTH OF CONTROL PERIOD (in hours)
2008	27	175	6.5
2009	16	90	6
2010	20	170	6
2011	17	102	6
2012	15	72	5
2013	15	65	4
2014	12	44	3.5
2015	10	37	3.7
2016	14	50	3.5
2017	14	53	3.8

WINTER

YEAR	NUMBER OF CONTROL PERIODS	TOTAL HOURS CONTROLLED	AVERAGE LENGTH OF CONTROL PERIOD (in hours)
2007-08	31	115	3.7
2008-09	29	133	4.5
2009-10	25	114	4.5
2010-11	24	109	5.0
2011-12	8	35	4.3
2012-13	12	39	4.3
2013-14	20	78	4.0
2014-15	12	42	3.5
2015-16	12	42	3.5
2016-17	12	42	3.5

Heating and cooling loads will be controlled during peak periods, typically on the hottest and coldest days of the month. The average length of control has been 3 to 8 hours, usually occurring between 2 p.m. and 11 p.m. Hours controlled reflect air conditioning and heating loads. The summer control period includes May through September, and the winter period includes October through April. Water heaters are typically controlled from Monday through Friday for 4 to 6 hours in the evening from June through August and December through February.

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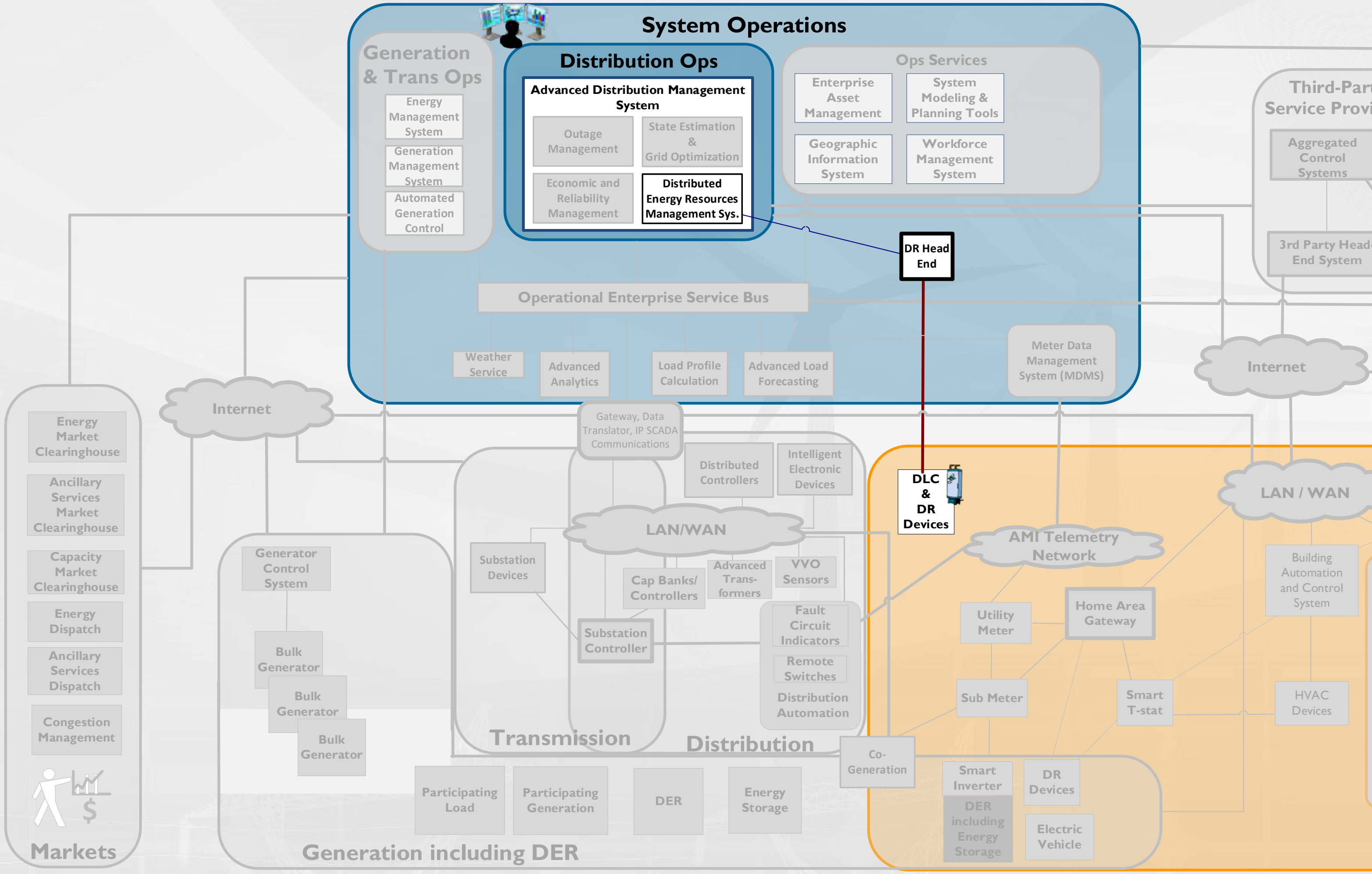
ENERGY WISE MN



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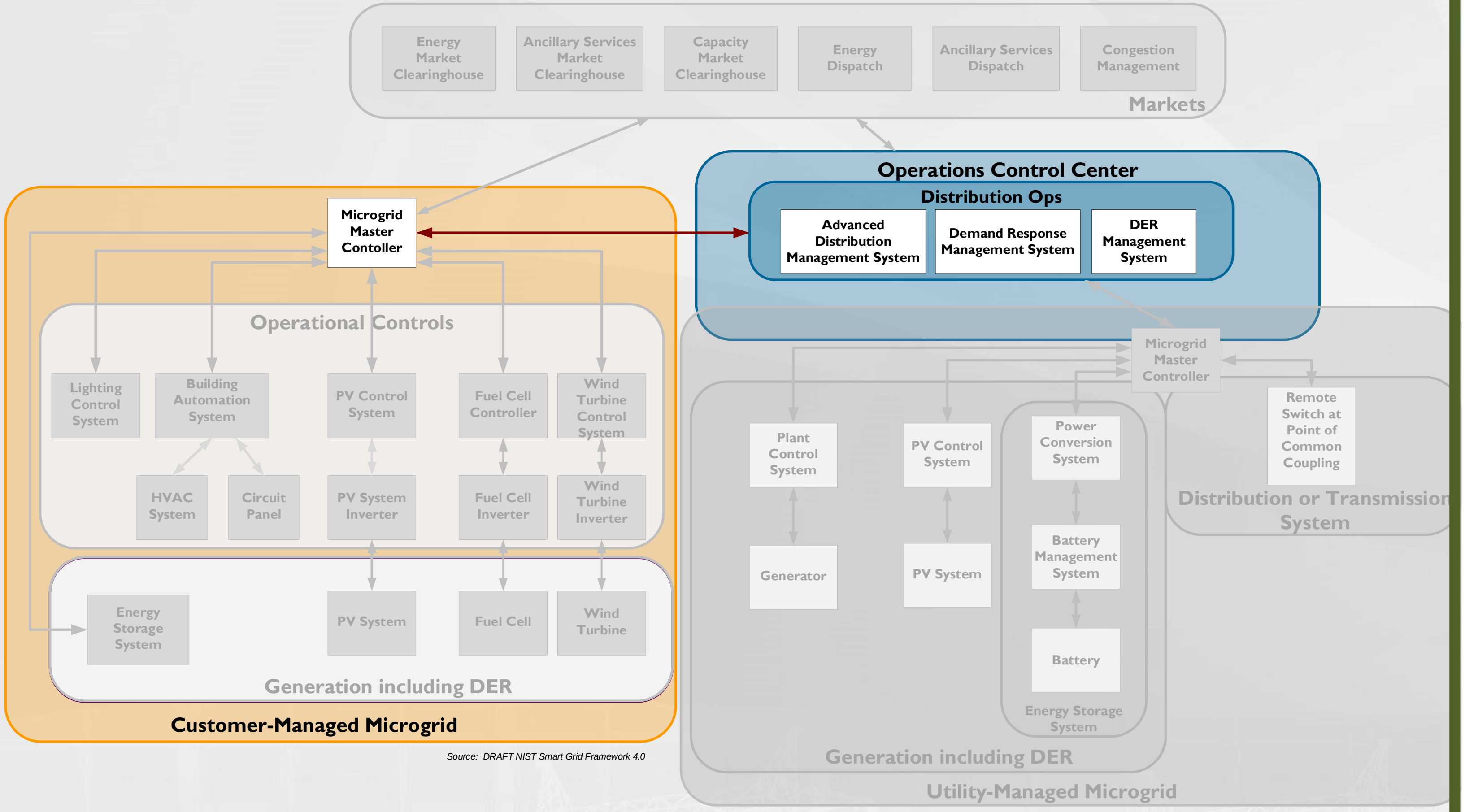
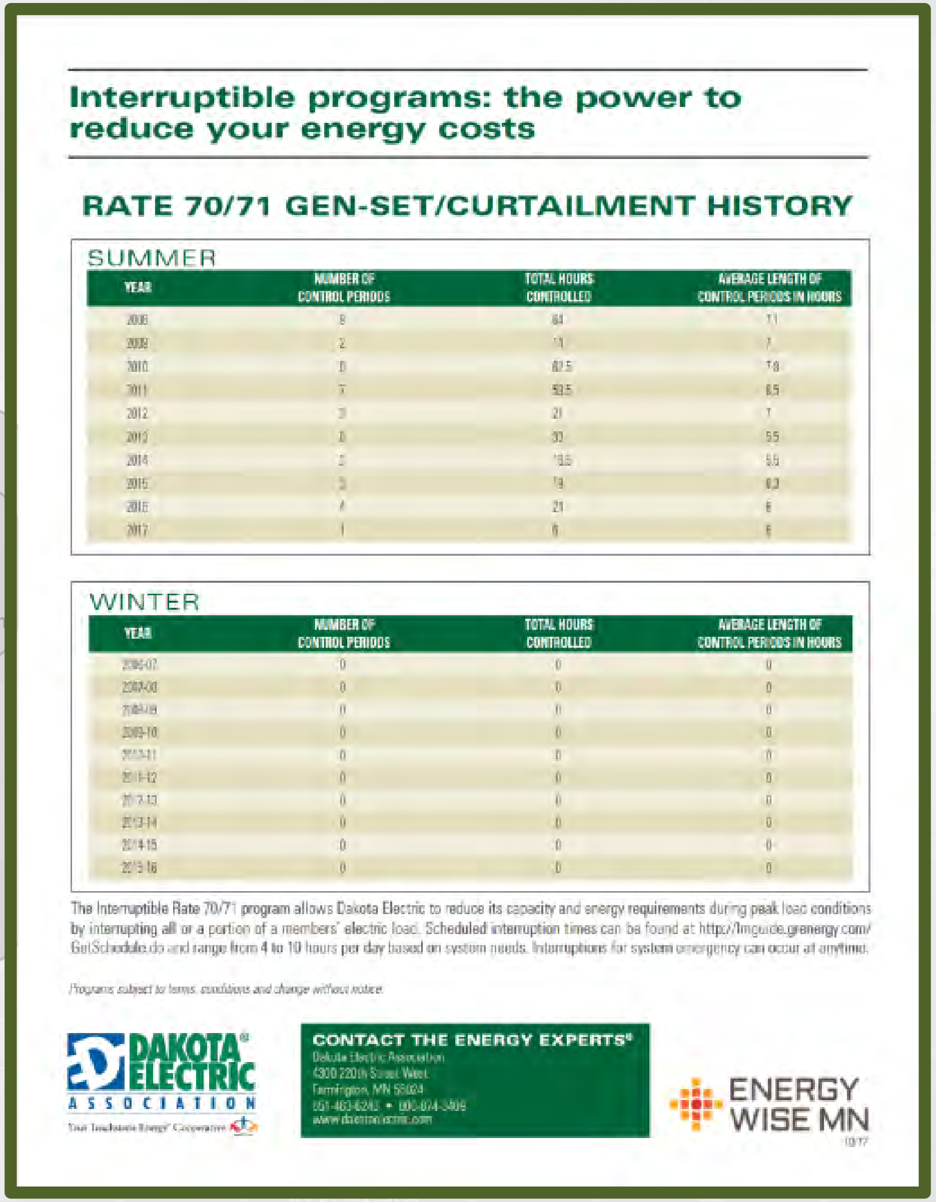


Source: DRAFT NIST Smart Grid Framework 4.0



Interruptible programs: the power to reduce your energy costs

RATE 70/71 GEN-SET/CURTAILMENT HISTORY

SUMMER

YEAR	NUMBER OF CONTROL PERIODS	TOTAL HOURS CONTROLLED	AVERAGE LENGTH OF CONTROL PERIODS IN HOURS
2008	9	64	7.1
2009	2	14	7
2010	11	87.5	7.9
2011	7	59.5	8.5
2012	3	21	7
2013	6	33	5.5
2014	3	16.5	5.5
2015	3	19	6.3
2016	4	21	5
2017	1	6	6

WINTER

YEAR	NUMBER OF CONTROL PERIODS	TOTAL HOURS CONTROLLED	AVERAGE LENGTH OF CONTROL PERIODS IN HOURS
2006-07	0	0	0
2007-08	0	0	0
2008-09	0	0	0
2009-10	0	0	0
2010-11	0	0	0
2011-12	0	0	0
2012-13	0	0	0
2013-14	0	0	0
2014-15	0	0	0
2015-16	0	0	0

The Interruptible Rate 70/71 program allows Dakota Electric to reduce its capacity and energy requirements during peak load conditions by interrupting all or a portion of a members' electric load. Scheduled interruption times can be found at http://lmguide.grenergy.com/GetSchedule.do and range from 4 to 10 hours per day based on system needs. Interruptions for system emergency can occur at anytime.

Programs subject to terms, conditions and change without notice.

DAKOTA ELECTRIC ASSOCIATION

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Farmington, MN 55024
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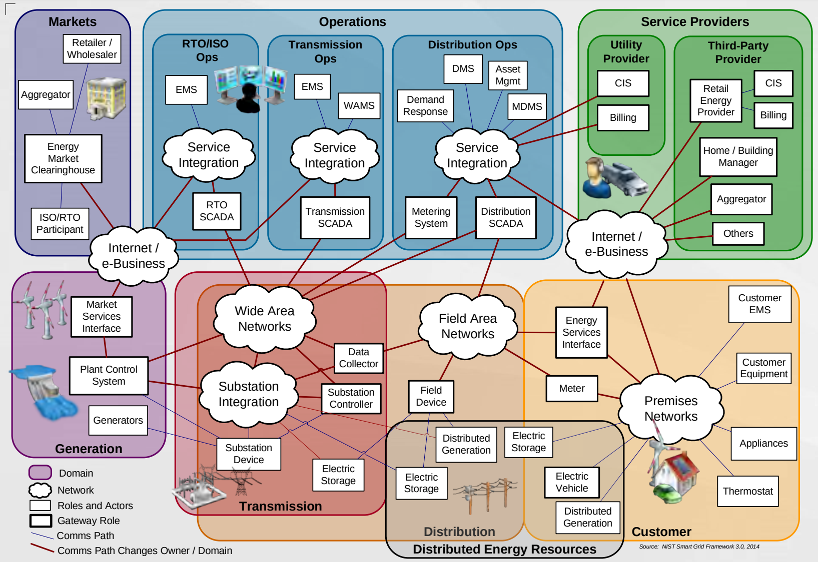
www.dakotaelectric.com

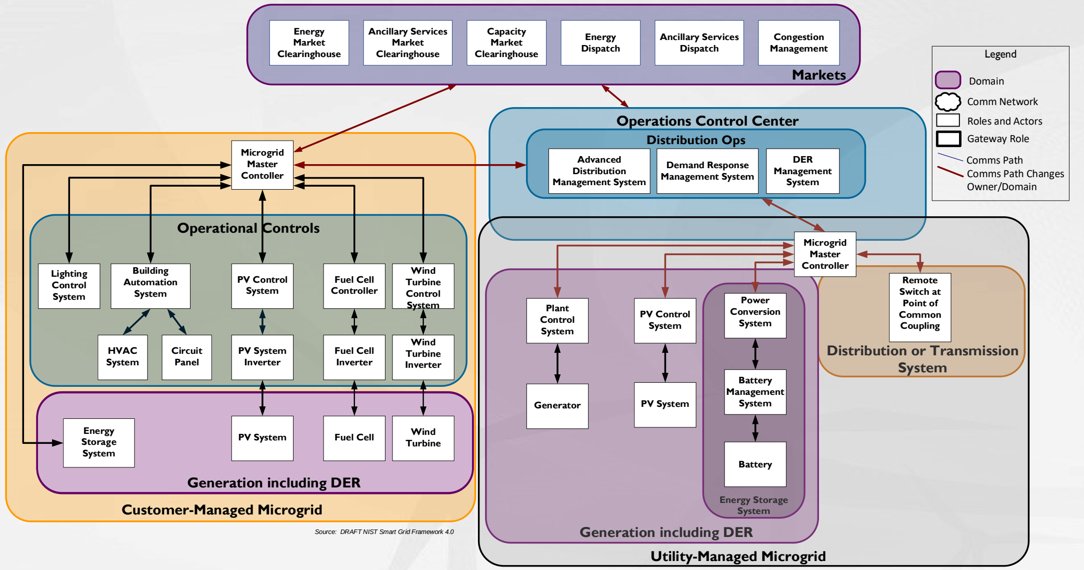
ENERGY WISE MN

Four Communication Pathways Scenarios

Legacy



Microgrid



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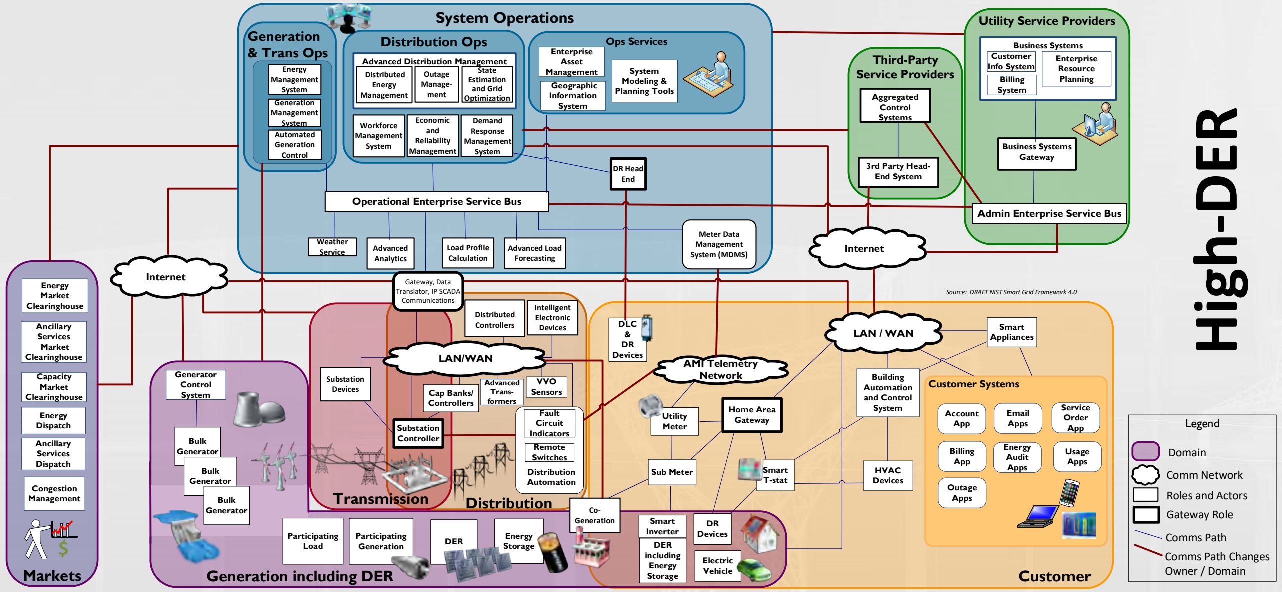
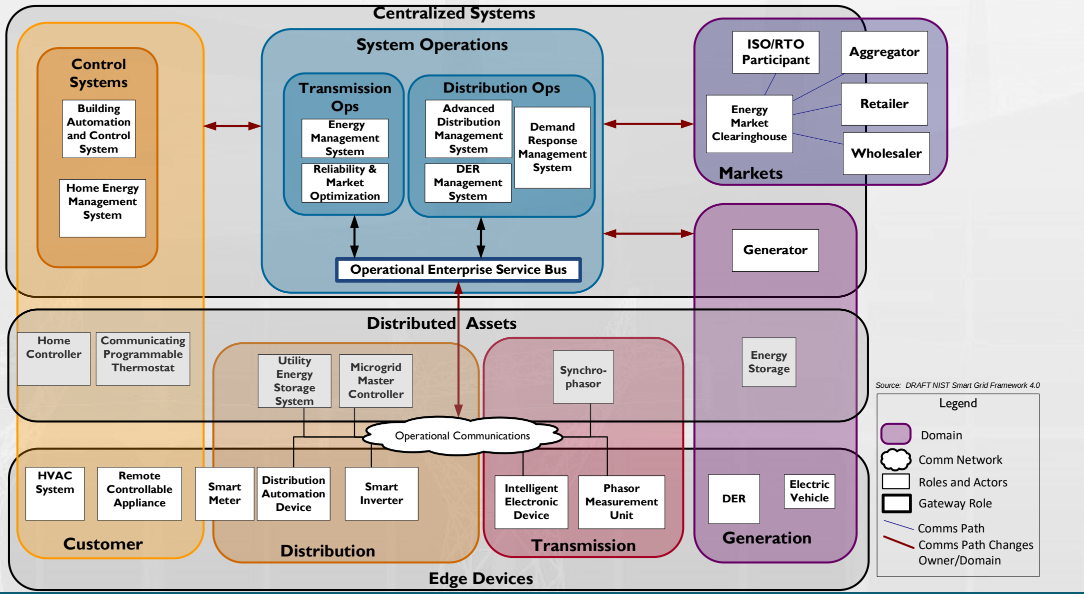


Hybrid



New Framework Model for Language

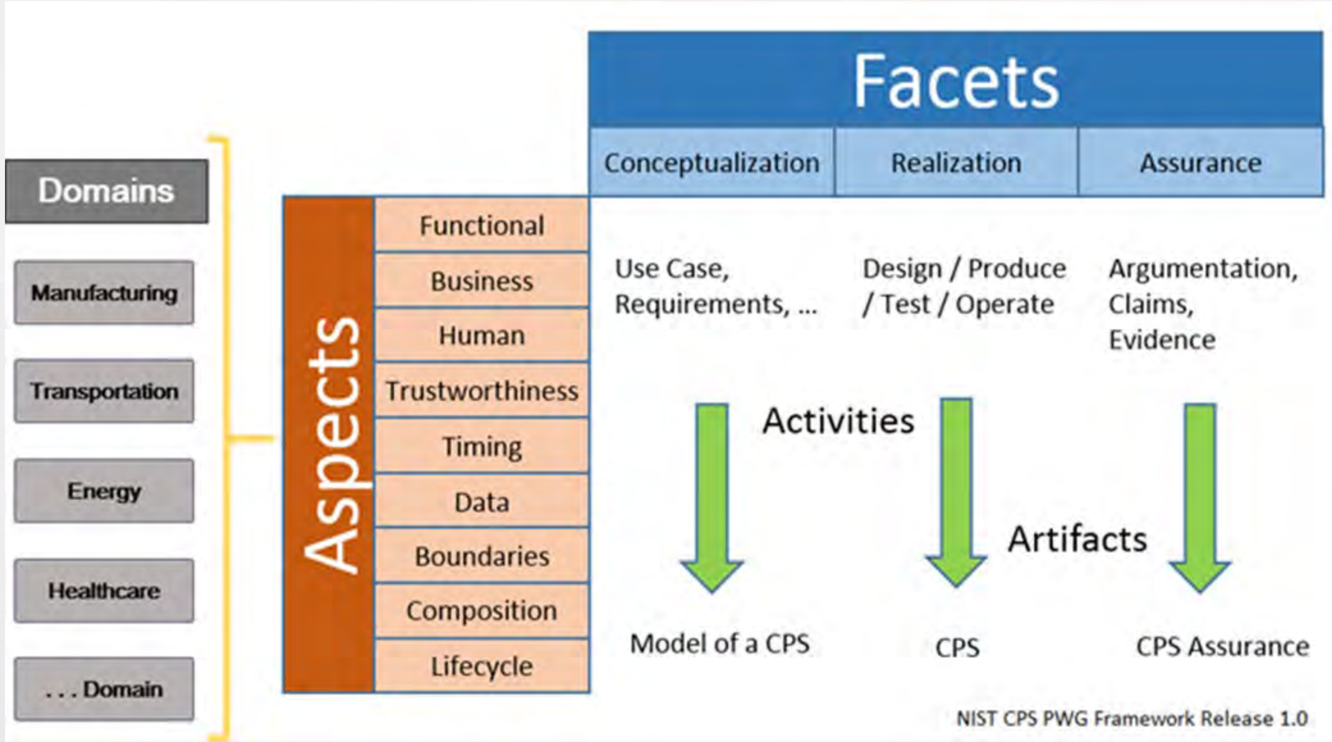
As the electrical grid becomes more complex, the language used to describe the electrical grid must become commensurately more precise.

This requires a model ontology for the grid

The CPS Framework—A Tool to Understand the Smart Grid

Jargon surrounds the electrical grid:

- *Intelligence moving to the edge*
- *Data tsunami*
- *Grid architecture*
- *Cloud / fog computing*
- *Smart grid*
- *Microgrid vs backup power*



The cyber-physical systems (CPS) framework provides a vocabulary of energy sector semantics, or ontology, through evaluation of CPS framework aspects and concerns

CPS Aspects and Concerns

- **Functional**
  - Actuation
  - Communication
  - Controllability
  - Functionality
  - Manageability
  - Measurability
  - Monitorability
  - Performance
  - Physical
  - Physical Context
  - Sensing
  - States
  - Uncertainty
- **Timing**
  - Logical Time
  - Synchronization
  - Time Awareness
  - Time Interval & Latency
- **Business**
  - Cost
  - Enterprise
  - Environment
  - Policy
  - Quality
  - Regulatory
  - Time to Market
  - Utility
- **Human**
  - Human Factors
  - Usability
- **Boundaries**
  - Behavioral
  - Networkability
  - Responsibility
- **Trustworthiness**
  - Privacy
  - Reliability
  - Resilience
  - Safety
  - Security
- **Composition**
  - Adaptability
  - Complexity
  - Constructivity
  - Discoverability
- **Data**
  - Data Semantics
  - Identity
  - Operations on Data
  - Relationship between Data
  - Data Velocity
  - Data Volume
- **Lifecycle**
  - Deployability
  - Disposability
  - Engineerability
  - Maintainability
  - Operability
  - Procureability
  - Producibility

INTELLIGENCE

(Illustrative relationships only)

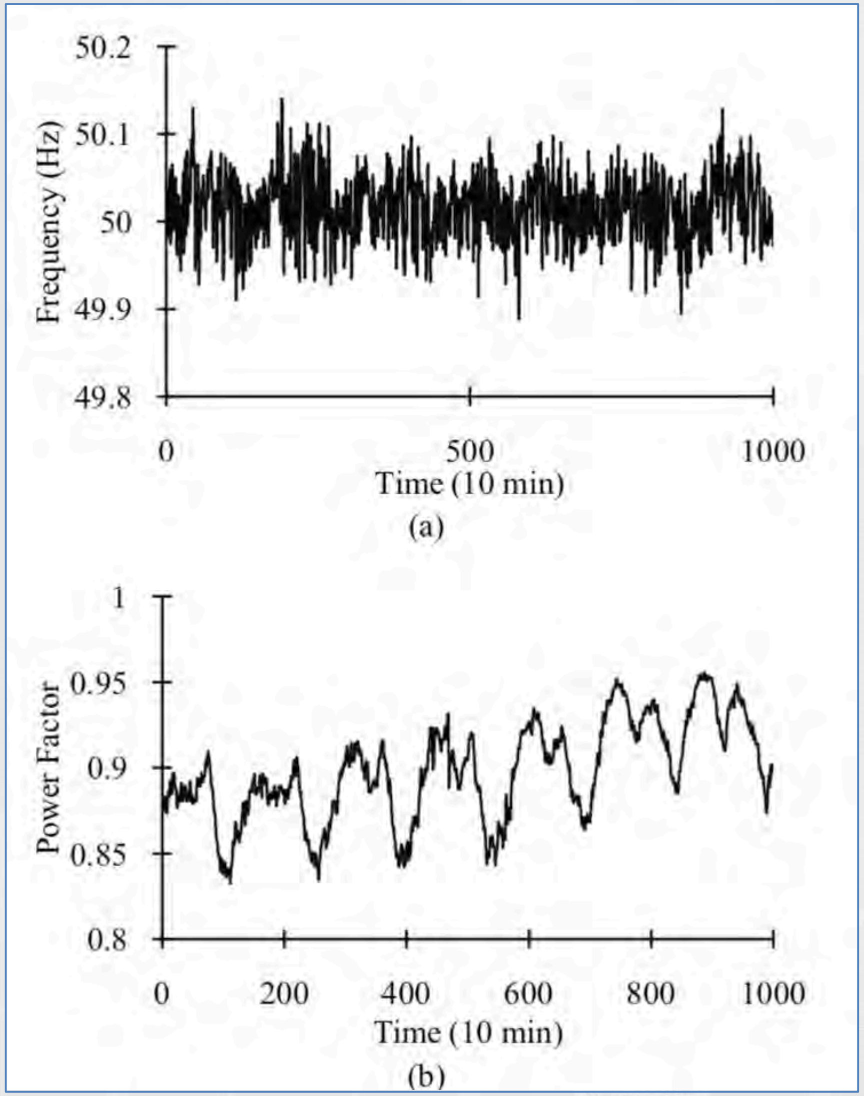
An Ontology for the Smart Grid

Aspect	Concern	Description	Grid Context for CPS Concern	Grid CPS Concern Description	Architecture Significance
Functional	**Controllability**	Ability of a CPS to control a property of a physical thing. There are many challenges to implementing control systems with CPS including the non-determinism of cyber systems, the uncertainty of location, time and observations or actions, their reliability and security, and complexity. Concerns related to the ability to modify a CPS or its function, if necessary.	• Controllability requires the condonation of sensing, processing and acting • Multiple inputs are needed to make control decisions • Most grid control systems and hardware were not designed to accommodate large numbers of DERs. • More dynamic monitoring and control to respond to the dynamic network	• Ability to control grid properties (sense, process and change); e.g., intentionally change a phenomenon / property	• Coordination of sensing and processing functions to produce accurate control signals. • Architectures needs to support control applications that input and evaluate multiple optimization factors including carbon usage and market prices • Architecture needs to support use of group commands (e.g. DNP3 settings groups) and third-party aggregator control of DERs • Architecture support of faster input of sensor data from traditional SCADA devices and newer devices including phasor measurement units (PMUs)
Functional	**Functionality**	Concerns related to the function that a CPS provides	• The constant evolution of the power system creates new grid functions. • Grid control functionality has expanded to include management of generation assets which require different functionality e.g. diverse generation assets require additional control functionality including distributed assets.	• Ability to provide grid functions e.g. control functions, sensing functions, service-related functions.	• Innovative grid technology needed to facilitate Power Markets, DERs, Microgrids, Electric Vehicles, etc. • Architecture needs to support management of DERs constraints that differ from older types of generation.
Functional	**Manageability**	Concerns related to the management of CPS function.	• Need the ability to manage change across multiple devices at different grid levels.	• Ability to manage change internally and externally to the grid at the cyber-physical boundary e.g. digital equipment and actuators affected by EMC	• Communication topology views and key externally visible properties for multi-tier distribution communications needed for system control, substations, field operations, and Transmission/Distribution integration[74]

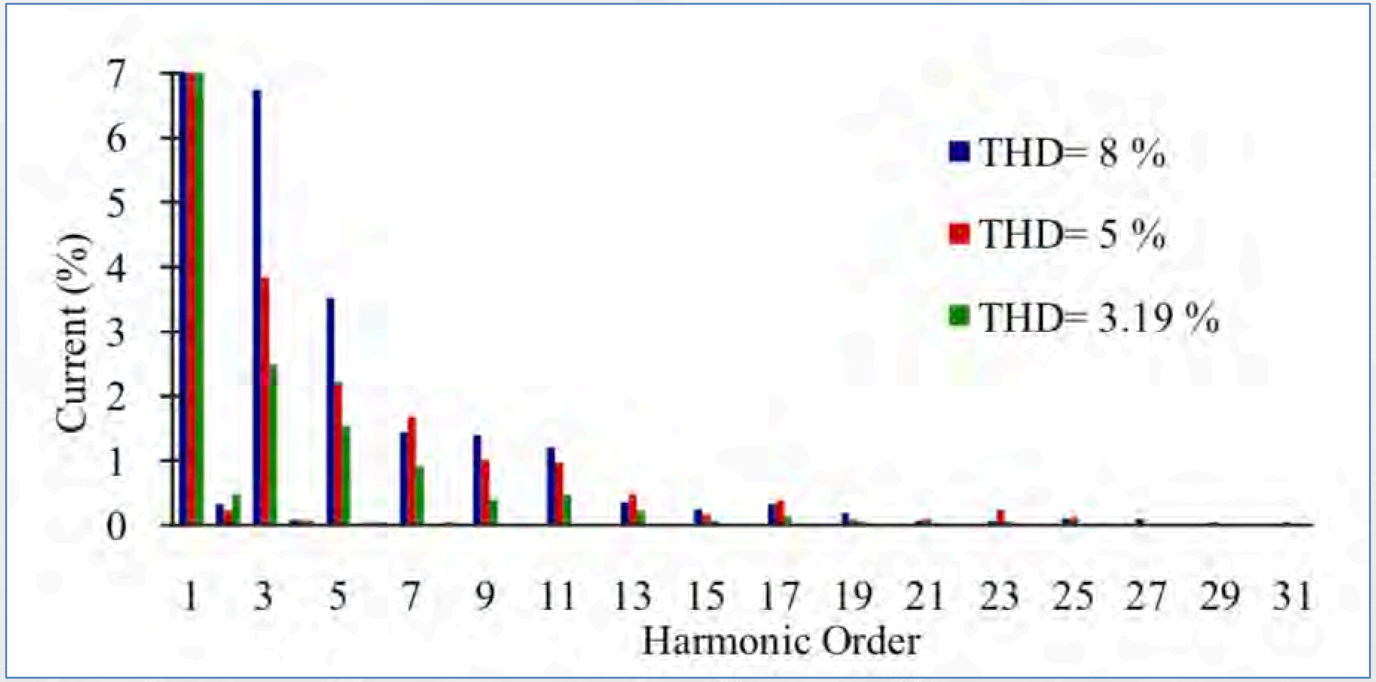
Operations Key Interoperability Issues

- Physical and Conventional Interoperability
  - Observability requirements
  - Controllability requirements
- Deriving Interoperability Requirements
- Priority Interoperability interfaces

Operations: Physics is changing at the grid edge

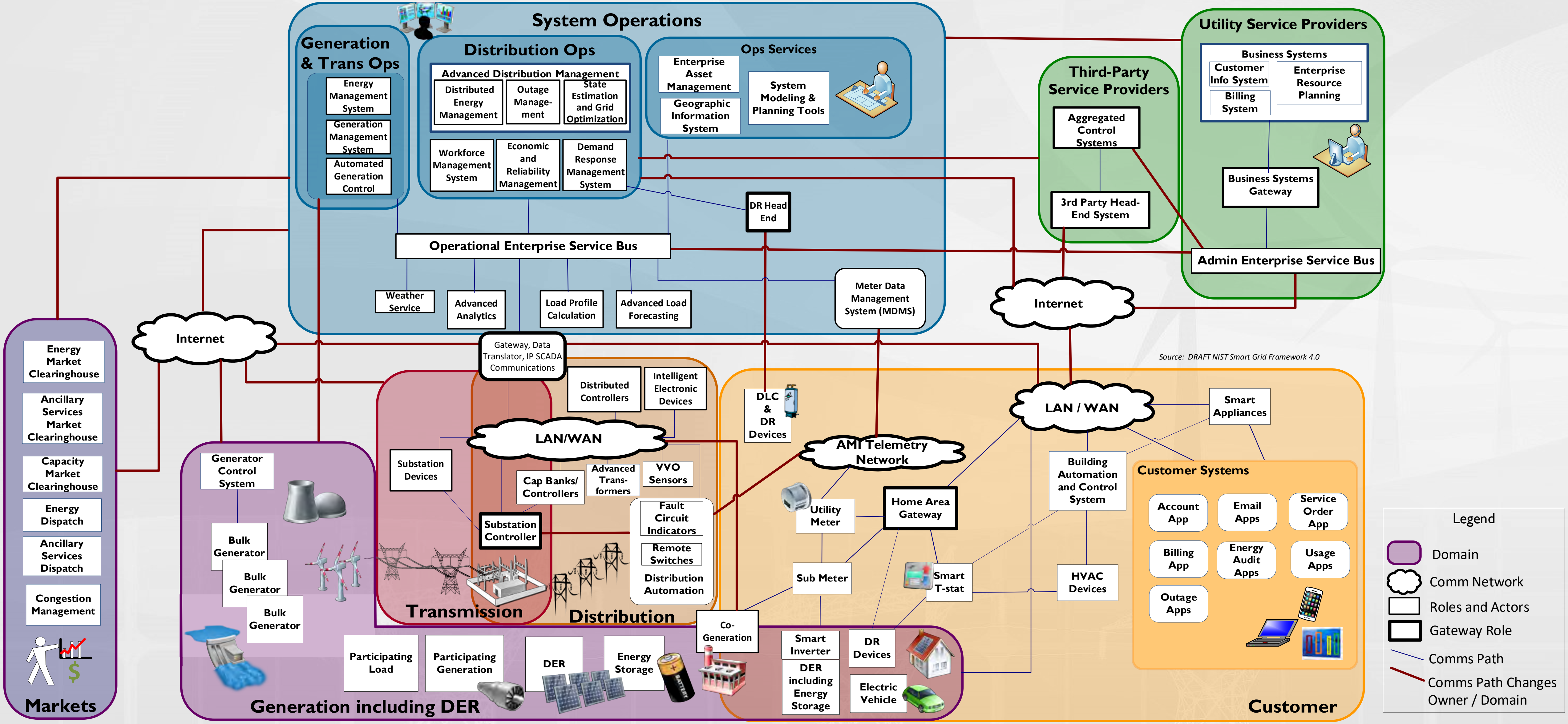


Observed frequency regulation and power factor issues at a distribution center, and observed current harmonic spectrum at the first transformer.



Source: Rad, et al. *Analysis of the grid harmonics and their impacts on distribution transformers*. (2012) https://doi.org/10.1109/PECI.2012.6184593

Operational dynamics – what's going on?



What role do new(er) resources have in this?

New DER and Inverter Functions
(Regulatory Requirements from IEEE 1547 and Rule 21)

#	DER Functions	Description and Key Parameters
	Mandatory DER Functions (Regulatory Requirements from IEEE 1547 and California's Rule 21)	
1.	**Disconnect/Connect Function** Disconnect or connect the DER from the grid at its ECP	The disconnect command initiates the galvanic separation (usually via switches or breakers) of the DER at its ECP or at the PCC. There may be a time delay between receiving the command and the actual disconnect. The connect command initiates or allows the reconnection of the DER at its ECP or at the PCC. A permission to reconnect may also be issued.
2.	**Cease to Energize and Return to Service** The DER ceases all active power output. Allow active power output at the PCC	"Cease to energize" is a different function from disconnect/connect. The (draft) definition is "the DER shall not export active power during steady-state or transient conditions. Reactive power exchange (absorb or supply) shall be less than x% (maybe 10%?) of nameplate DER rating and shall exclusively result from passive devices." There may be a time delay between receiving the command and the actual cease to energize. "Return to service" allows current flow at the PCC. A permission to return to service may also be issued.
3.	**High/Low Voltage Ride-Through Mode** The DER rides throu… fluctuations in voltag…	The DER follows the utility-specified voltage ride-through
4.	**High/Low Frequen… Mode** The DER rides throu… fluctuations in freque…	
5.	**Dynamic Reactive… Mode** The DER reacts agai… changes (spikes and… dynamic system stab… dV/dt	

#	DER Functions	Description and Key Parameters
6.	**Frequency-Watt Mode** The DER responds to large frequency excursions during abnormal events at a Referenced ECP by changing its production or consumption rate	The DER is provided with frequency-watt curves that define the changes in its watt output based on frequencies around the nominal frequency during abnormal events. When the emergency frequency-watt mode is enabled, the DER monitors the frequency and adjusts its production or consumption rate to follow the specified emergency frequency-watt curve parameters.
7.	**Volt-Watt Mode** The DER responds to changes in the voltage at the Referenced ECP by changing its production or consumption rate	The DER is provided with voltage-watt curves that define the changes in its watt output based on voltage deviations from nominal, as a means for countering those voltage deviations. When the volt-watt mode is enabled, the DER receives the voltage measurement from a meter (or other source) at the Referenced ECP. The DER adjusts its production or consumption rate to follow the specified volt-watt curve parameters.
8.	**Fixed (Constant) Power Factor Mode** The DER power factor is set to a fixed value.	The DER power factor is set to the specified power factor. A leading power factor is positive and a lagging power factor is negative, as defined by the IEEE or IEC sign conventions.
9.	**Fixed (Constant) Reactive Power Mode** The DER is requested to provide a fixed amount of reactive power	The DER is requested to provide a fixed amount of reactive power
10.	**Volt-VAr Control Mode** …ER responds to c… at the Referenc… ing or absorbing… in the desired vo…	The DER is provided with voltage-VAr curves that define the VArs
	…VAr Mode …ER responds to c… at the Referenc… ng its VArs	
	…PF Mode …ER responds to c… at the Referenc… ng its power fac…	
	…tive Power Mo… …DER to generat… as a percentage… …ity	

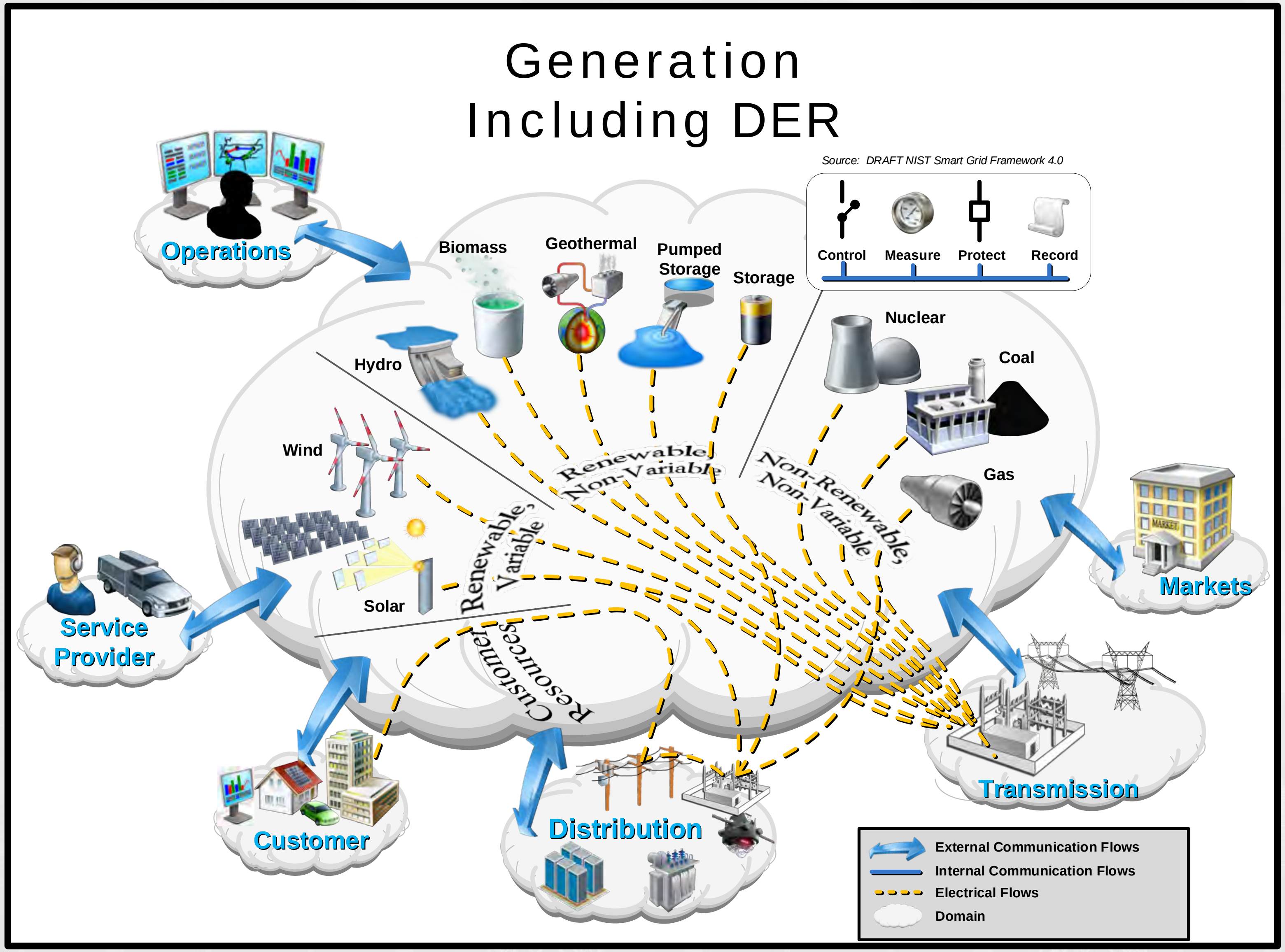
#	DER Functions	Description and Key Parameters
14.	**Limit Active Power Production or Consumption Mode** Limits the production and/or consumption level of the DER based on the Referenced ECP	The production and/or consumption of the DER is limited at the Referenced ECP, indicated as absolute watts values. Separate parameters are provided for production or consumption limits to permit these to be different.
15.	**Low Frequency-Watt Emergency Mode** for demand side management (fast load shedding)	Enable automatic « low frequency » disconnection of a specified proportion of their demand (in stages) in a given time frame
16.	**Low Voltage-Watt Emergency Mode** for demand side management	Provide capabilities to … enable automatic or manual load tap changer blocking and automatic « low voltage » disconnection.
17.	**Monitoring Function** The DER provides nameplate, configuration, status, measurements, and other requested data	The DER provides status, measurements, alarms, logs, and other data as authorized and requested by users. Examples include connect status, updated capacities, real and reactive power output/consumption, state of charge, voltage, and other measurements. Also of interest are forecast statuses and expected measurements.
18.	**Scheduling of Power Settings and Modes**	The DER follows the schedule which consists of a time offset (specified as a number of seconds) from the start of the schedule and is associated with: • a power system setting • the enabling/disabling of a function • a price signal
	…R Functions	
	…ng Mode …load at the …er it exceeds a …er level	The active power output of the DER limits the load at the Referenced ECP if it starts to exceed a target power level, thus limiting import power. The production output is a percentage of the excess load over the target power level. The target power level is specified in absolute watts.
	…ode …s the load by a …ferenced ECP, …ed a threshold	The active power output of the DER follows and counteracts the load at the Referenced ECP if it starts to exceed a target power level, thus resulting in a flat power profile. The production output is a percentage of the excess load over the target power level. The target power level is specified in absolute watts.
	…ing Mode …d/or production of …generation power …CP.	The consumption and/or production of the DER follows and counteracts the generation measured at the Referenced ECP if it starts to exceed a target power level. The consumption and/or production output is a percentage of the excess generation watts over the target power level. The target power level is specified in absolute watts.

#	DER Functions	Description and Key Parameters
22.	**Dynamic Active Power Smoothing Mode** The DER produces or absorbs active power in order to smooth the changes in the power level at the Referenced ECP. Rate of change of power – dW/dt	The DER follows the specified smoothing gradient which is a signed quantity that establishes the ratio of smoothing active power to the real-time delta-watts of the load or generation at the Referenced ECP. When the power smoothing mode is enabled, the DER receives the watt measurements from a meter (or other source) at the Referenced ECP. New data points are provided multiple times per second.
23.	**Frequency-Watt Primary Control mode** The DER changes its watt output or input to provide frequency support to maintain frequency within normal limits	The DER changes its watt output or input based on parameters or curves, to provide primary frequency control with the purpose of maintaining frequency within the normal frequency limits
24.	**Automatic Generation Control (AGC) Mode** The DER responds to raise and lower power level requests to provide frequency regulation support	When AGC mode is enabled, the DER responds to signals to increase or decrease the rate of consumption or production every 4 to 10 seconds, with the purpose of managing frequency.
25.	**Operating Reserve (Spinning Reserve) mode** The DER provides operating reserve	The DER can provide reserve power available within about 10 minutes
26.	**Dynamic Frequency-Watt Mode** The DER responds to the rate of change of frequency (ROCOF) by changing its watt output or input to minimize spikes and sags	The DER responds to the rate of change of frequency (ROCOF) by changing its watt output or input to minimize spikes and sags
27.	**Coordinated Charge/Discharge Management Mode** The DER determines when and how fast to charge or discharge so long as it meets its target state of charge level obligation by the specified time *(focus is on Electric Vehicle consumption)*	The DER is provided with a target state of charge and a time by which that SOC is to be reached. This allows the DER to determine when to charge or discharge based on price. The DER takes into account not only the duration at maximum consumption / production rate, but also other factors, such as that at high SOC the maximum consumption rate may not be able to be sustained, and vice versa, at low SOC, the maximum discharge rate may not be able to be sustained

#	DER Functions	Description and Key Parameters
28.	**Frequency-Watt Smoothing Mode** The DER responds to changes in frequency at the Referenced ECP by changing its consumption or production rate based on frequency deviations from nominal, as a means for countering those frequency deviations. df/dt	The DER is provided with frequency-watt curves that define the changes in its watt output based on frequency deviations from nominal, as a means for countering those frequency deviations and smoothing the frequency. When the frequency-watt mode is enabled, the DER monitors the frequency and adjusts its production or consumption rate to follow the specified frequency-watt curve parameters. New data points are provided multiple times per second.
29.	**Power Factor Limiting (Correcting) Mode** The DER supplies or absorbs VArs to hold the power factor at the Referenced ECP within the PF limit	When the PF limiting (correcting) mode is enabled, the DER is provided with the target PF. The DER supplies or absorbs VArs in order to maintain the PF at the Referenced ECP within the limits of the target PF.
30.	**Delta Power Control Function** Decrease active power output to ensure there remains spinning reserve amount that was bid into the market	Decrease active power output to ensure there remains spinning reserve amount that was bid into the market
31.	**Power Rate Control** The power is limited by the maximum ramp rate.	Manage active power ramp time, when the activ… the required power level by the end of the ramp… the required power level earlier, but not later.
32.	**Dynamic Volt-Watt Function** Dynamically absorb or produce additional watts in proportion to the instantaneous difference from a moving average of the measured voltage	Dynamically absorb or produce additional watt… instantaneous difference from a moving average… voltage. This function utilizes the same basic co… the Dynamic Reactive Current function but uses… output rather than reactive current.
	Non-Operational Requirements	
33.	**Collect and Provide Historical Information** Collect and provide detailed measurement and performance data which may be valuable to record in an operational historian	Collect and provide detailed measurement and p… which may be used to assess the real-time respo… events, control commands, and autonomous fun… could also be used to determine actual capabilit… compliance, and other characteristics of DER sy…

#	DER Functions	Description and Key Parameters
	Capabilities Not Yet Defined by Regulations, EPRI, or IEC 61850	
34.	**Microgrid Separation Control (Intentional Islanding)** Process for normal separation, emergency separation, and reconnection of microgrids	Process for normal separation, emergency separation, and reconnection of microgrids. These microgrids could be individual facilities or could be multiple facilities using Area EPS grid equipment between these facilities.
35.	**Provide Black Start Capability** Support the reestablishment of power after an outage	Ability to start without grid power, and the ability to add significant load in segmented groups.
36.	**Provide Backup Power (Often implemented, but not standardized)** Ability to provide power to local loads when not connected to the grid	Ability to provide power to local loads behind a PCC when the facility is not connected to the grid, either during an outage or due to intentional or unintentional islanding.

The Conceptual Model: Generation Including DER

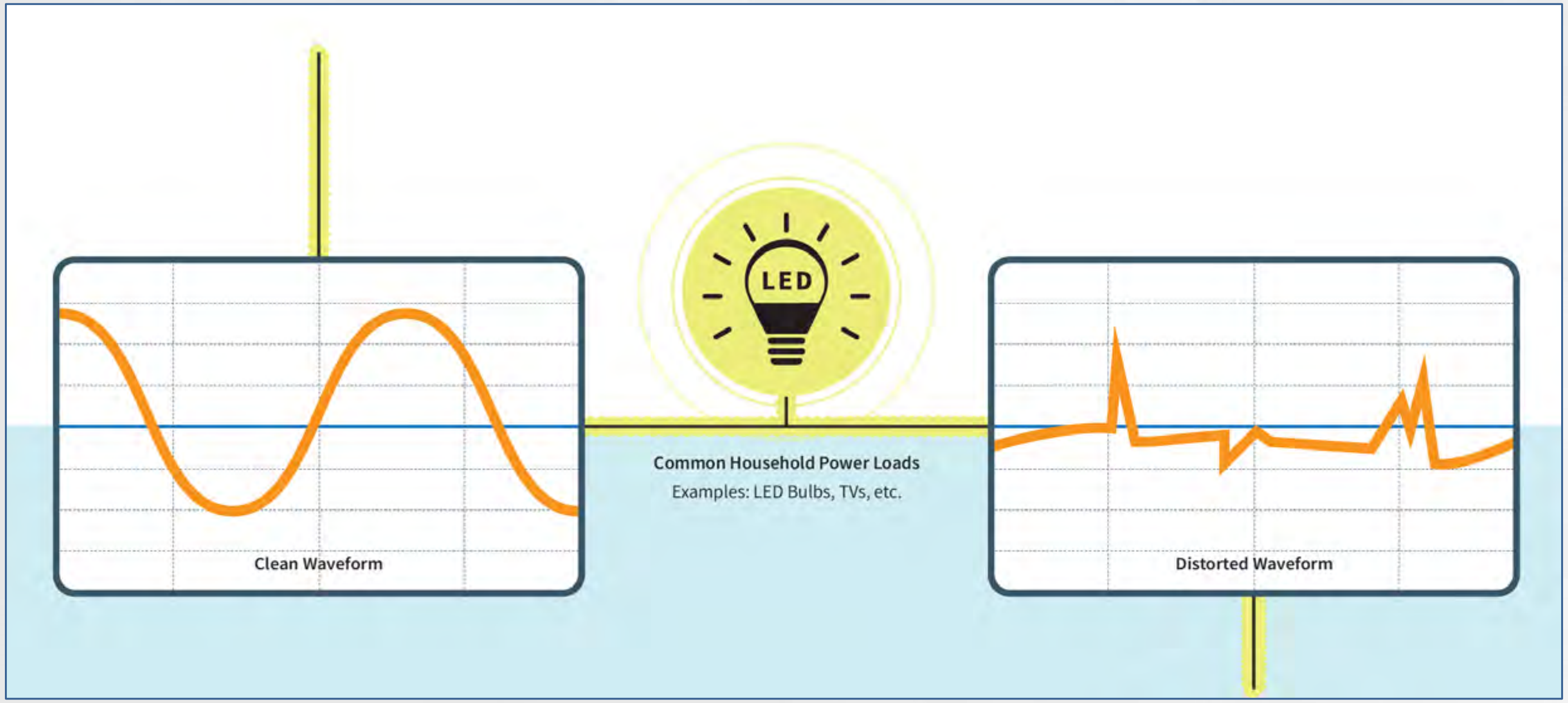


In 2018:

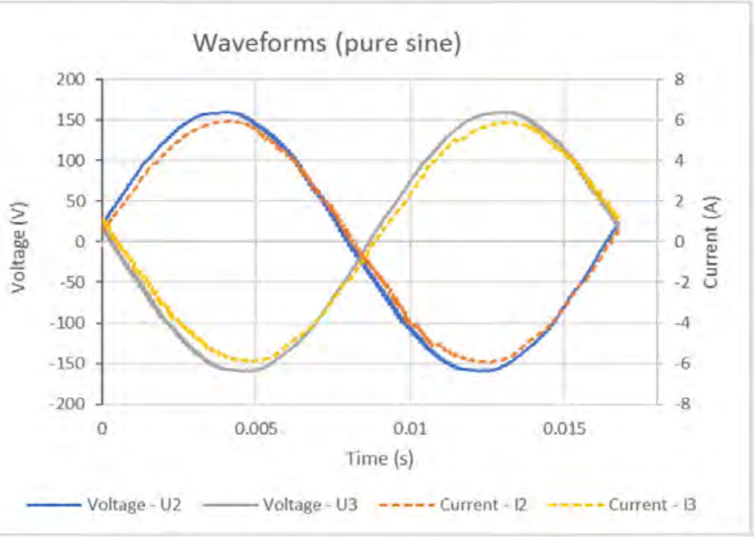
- Utility-scale solar =1.6% net generation
- Distributed solar = 0.7% net generation

Source: EIA Monthly Energy Review tables 7.2b and 10.6

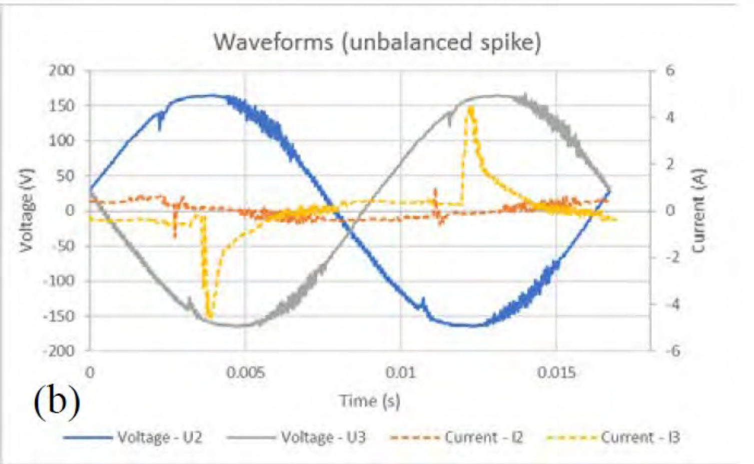
What are the other drivers?



Incandescent Bulbs

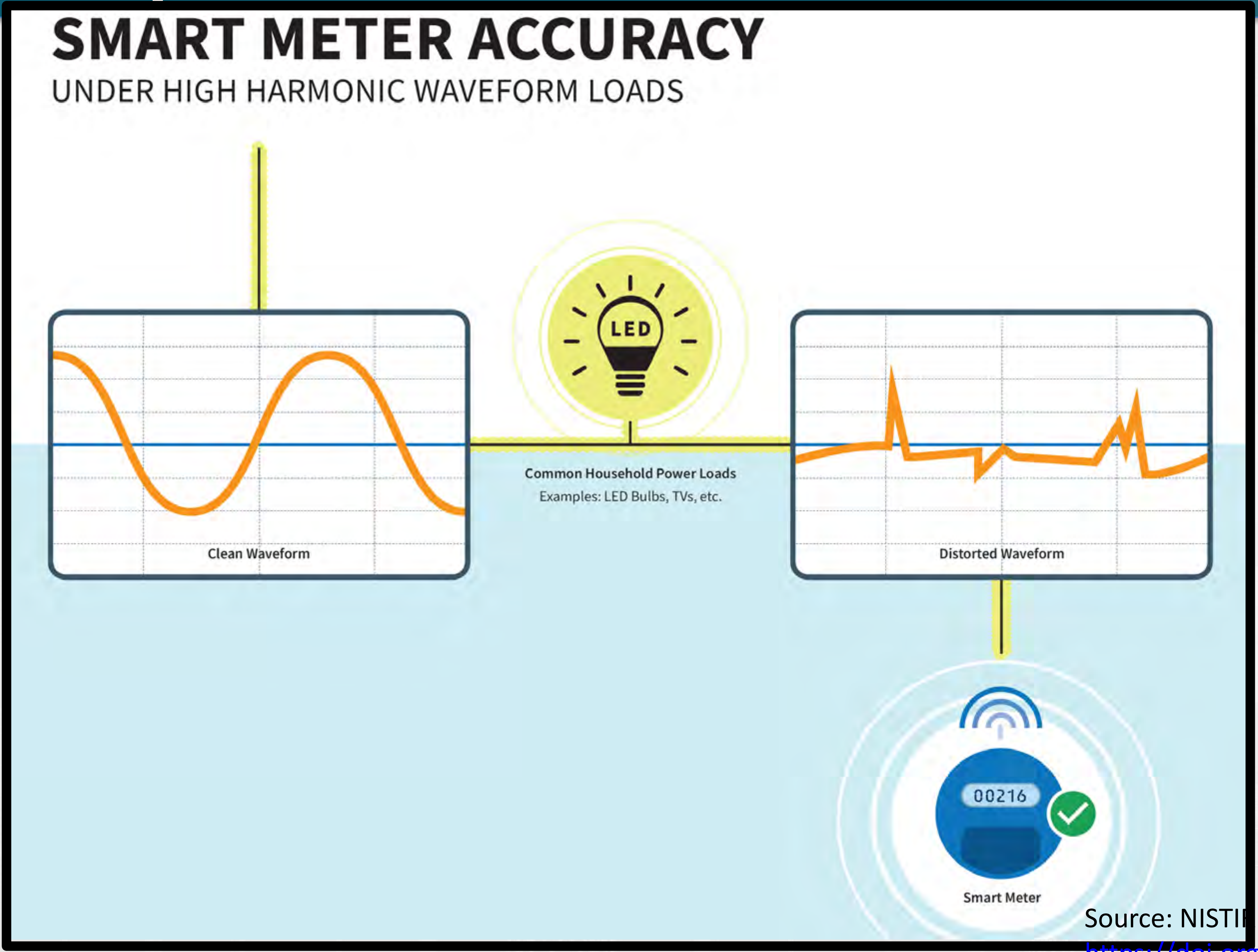


LED Bulbs



Source: NISTIR 8428
https://doi.org/10.6028/NIST.IR.8248

Impacts are minimal when controlled for



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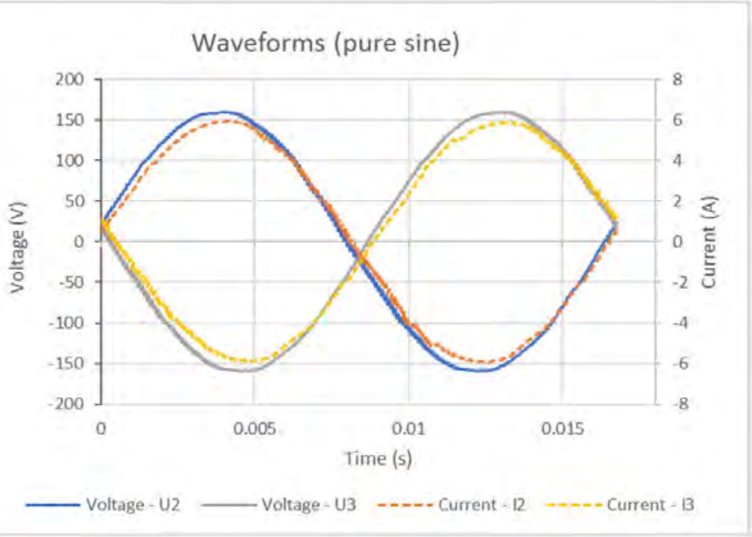
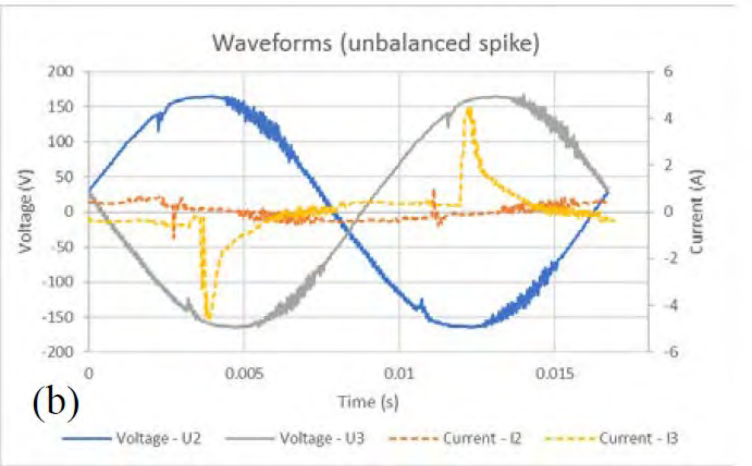


LED Bulbs



Source: NISTIR 8428
https://doi.org/10.6028/NIST.IR.8248

Economics of Interoperability - Introduction

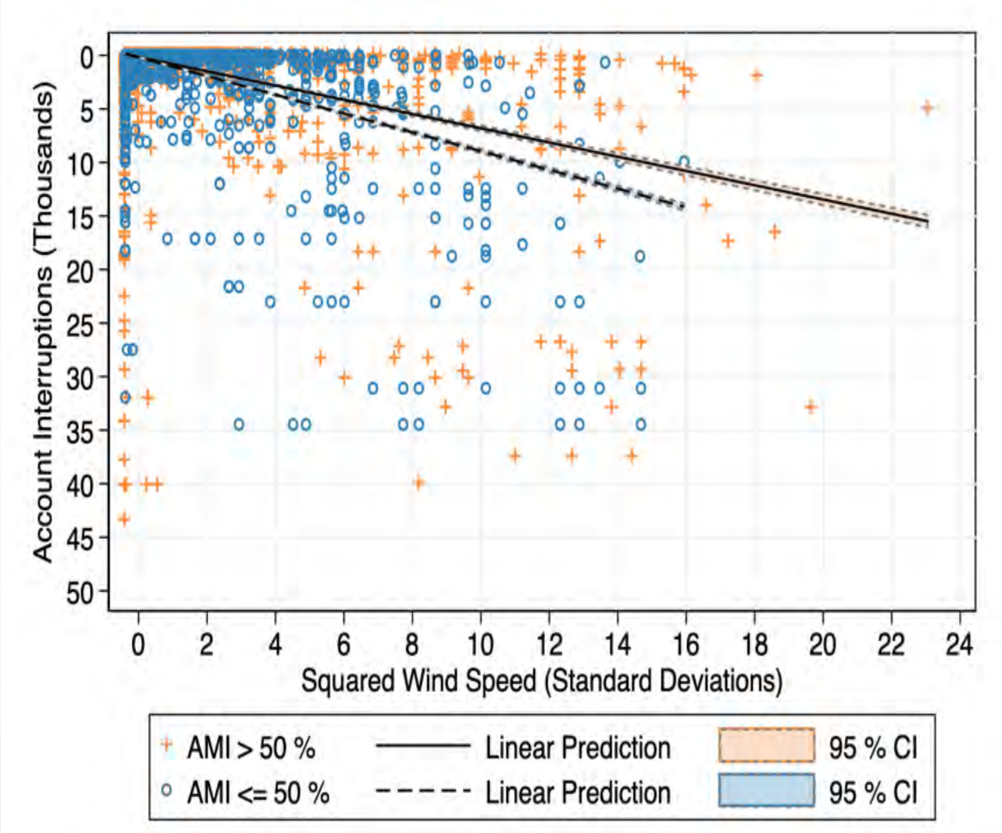
- **Expectations** of and within the electric power sector are changing rapidly.

- Increasing technical and organizational **modularity** within the sector have opened opportunities for innovation by incumbents and new entrants.

- **Combinatorial Innovation**
- Recent developments are consistent with past historical experiences in which a
  - ***"set of technologies, comes along that offers a rich set of components that can be combined and recombined to create new products"***
  - (Economics of Information Technology, Varian 2001)

- Interoperability benefits are much more than integration costs

Hurricane Irma Resilience Case Study



Economics of Interoperability – Key Messages

1. **Interoperability can help overcome the barriers** of device specificity and support the development of new grid services.

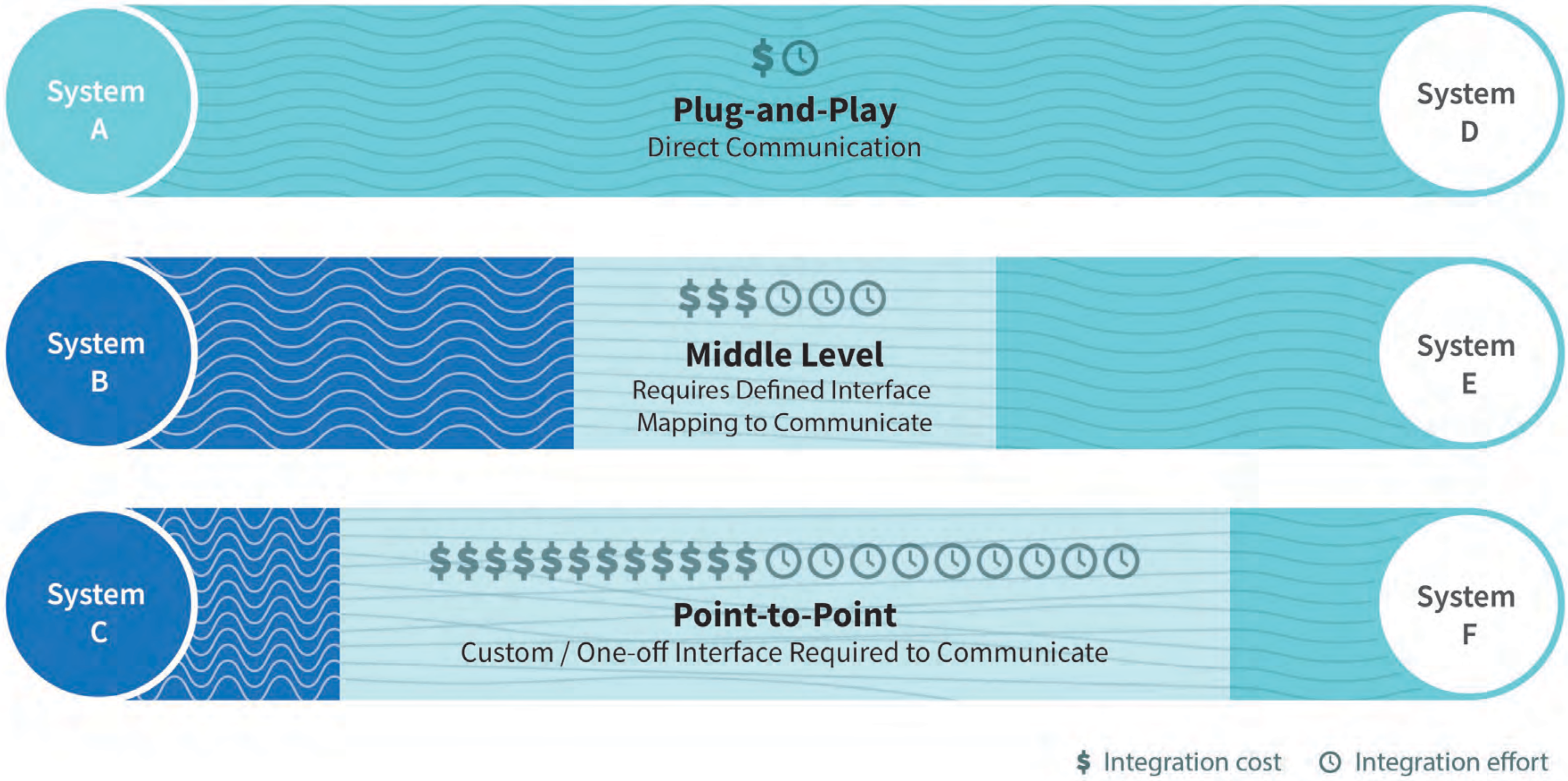
2. **Interoperability is crucial to customer empowerment.**

3. Interoperability can counter rising transaction and production costs associated with increasing complexity of interaction among diverse organizations of varying regulatory status.

4. Interoperability requirements relate directly to trustworthiness

5. Testing and Certification regimes improve the economics of interoperability by ensuring that devices, systems, and components perform as expected and are fit for purpose.

Interoperability Levels



Interoperability Levels and Standards Testing

- Considerable time/effort goes into standards-making
- Purchasers want “interoperable” products
- How is “interoperability” determined?
- Testing provides the facts to support claims of “interoperability”

Standards T&C landscape analysis

NIST Technical Note 2042

Review of Smart Grid Standards for Testing and Certification Landscape Analysis

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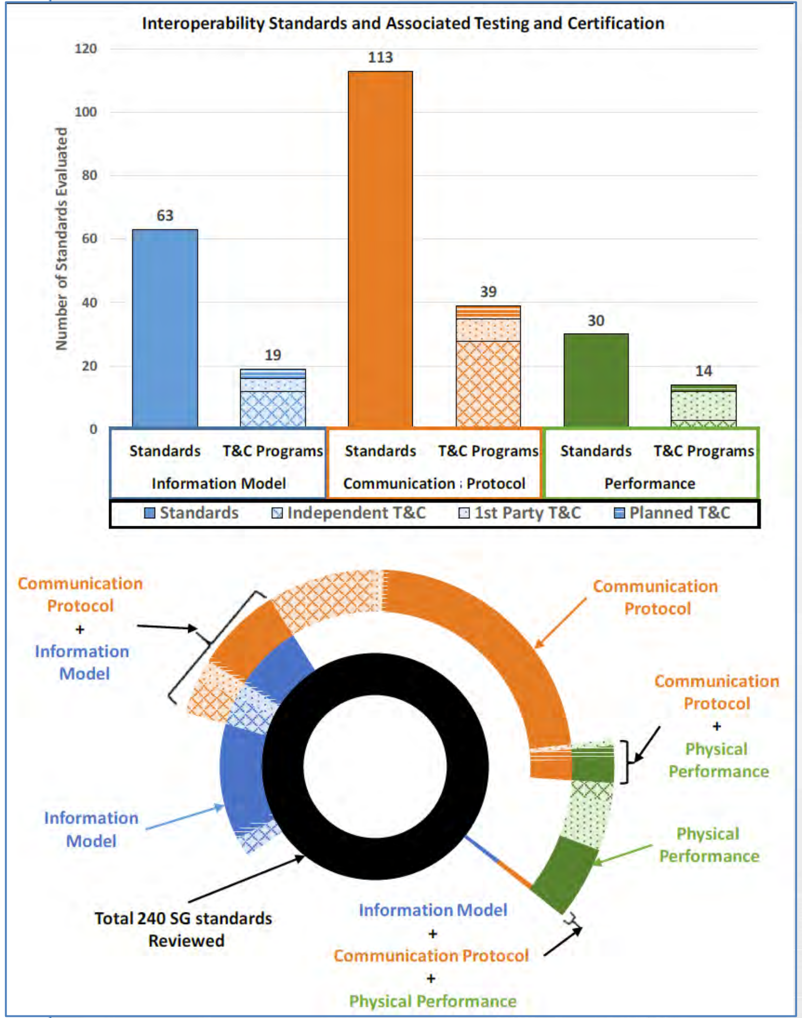


Table 1. Standard Category and Number of Standards Evaluated.

Standard Category	Number of Standards Evaluated			
	Total No. of Standards	*with T&C Programs of type:* ITCA[2]	1st Party	Planned
Information Model	34	5	0	2
Information Model & Communication Protocol	28	7	4	1
Communication Protocol	77	21	2	1
Communication Protocol & Physical Performance	7	0	1	2
Physical Performance	22	3	8	0
Information Model + Communication Protocol + Physical Performance	1	0	0	0
Total	*169*	*36*	*15*	*6*

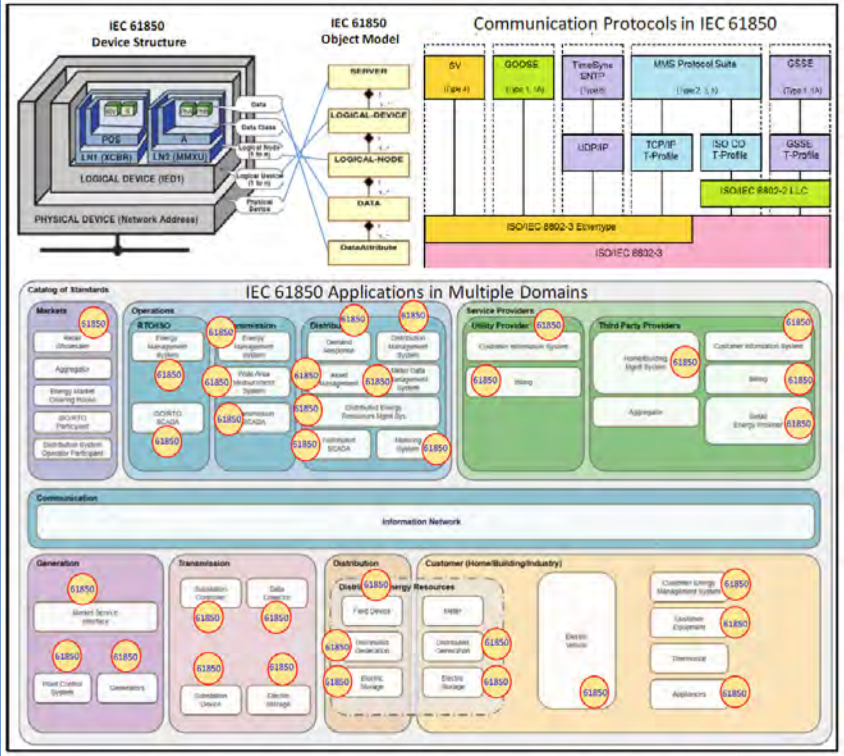
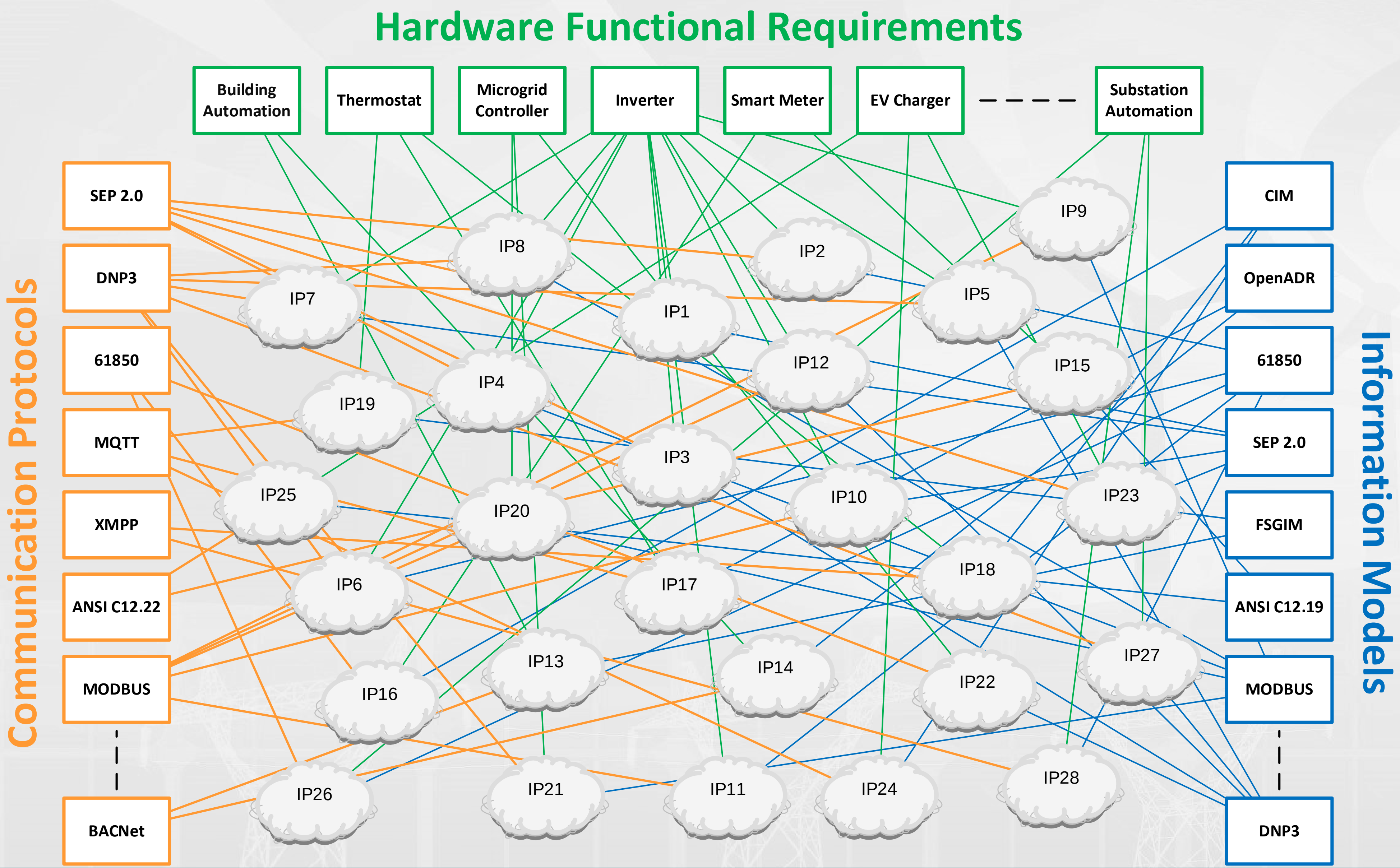
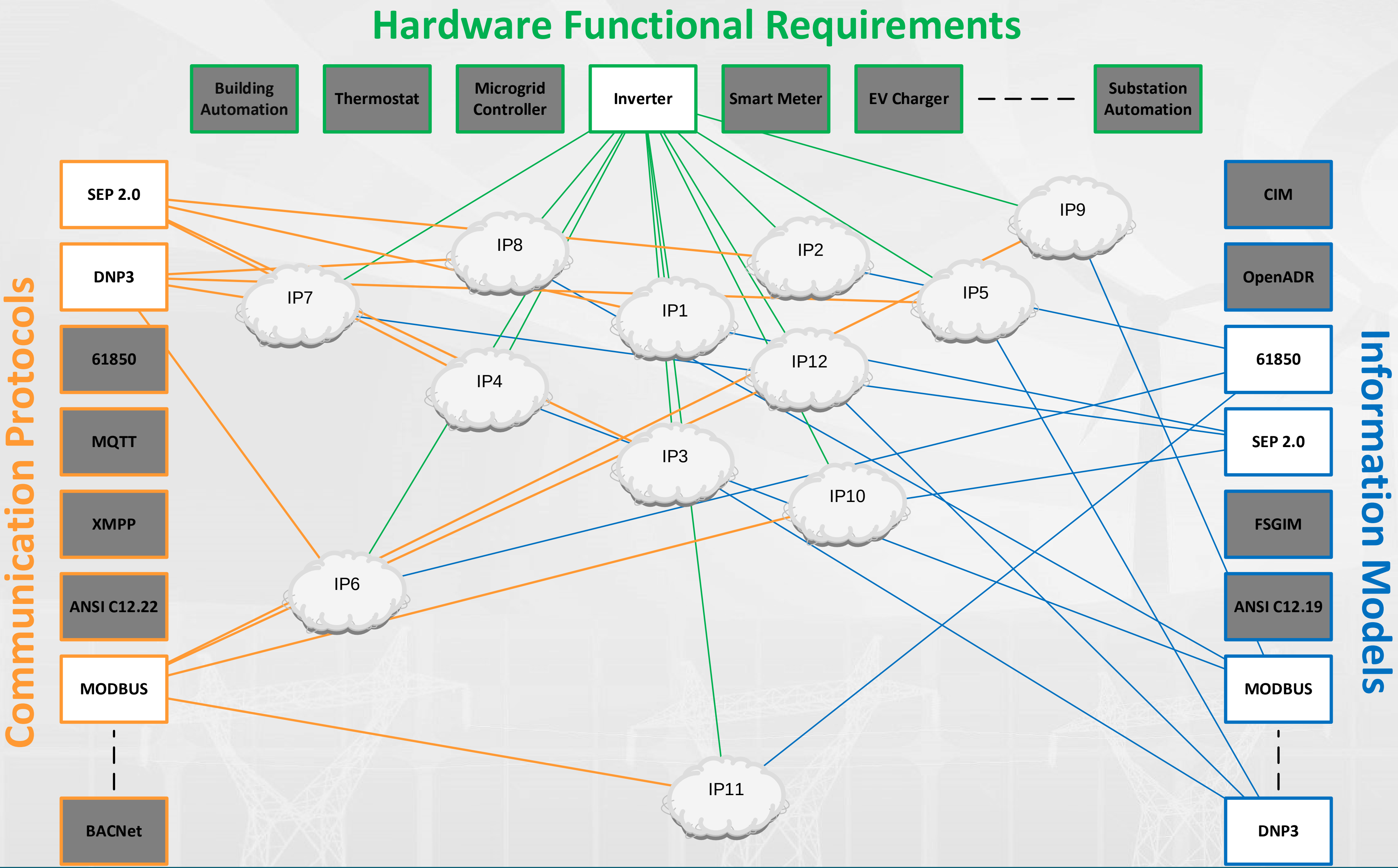


Figure 1. IEC 61850 functionality and applications in multiple domains[1].

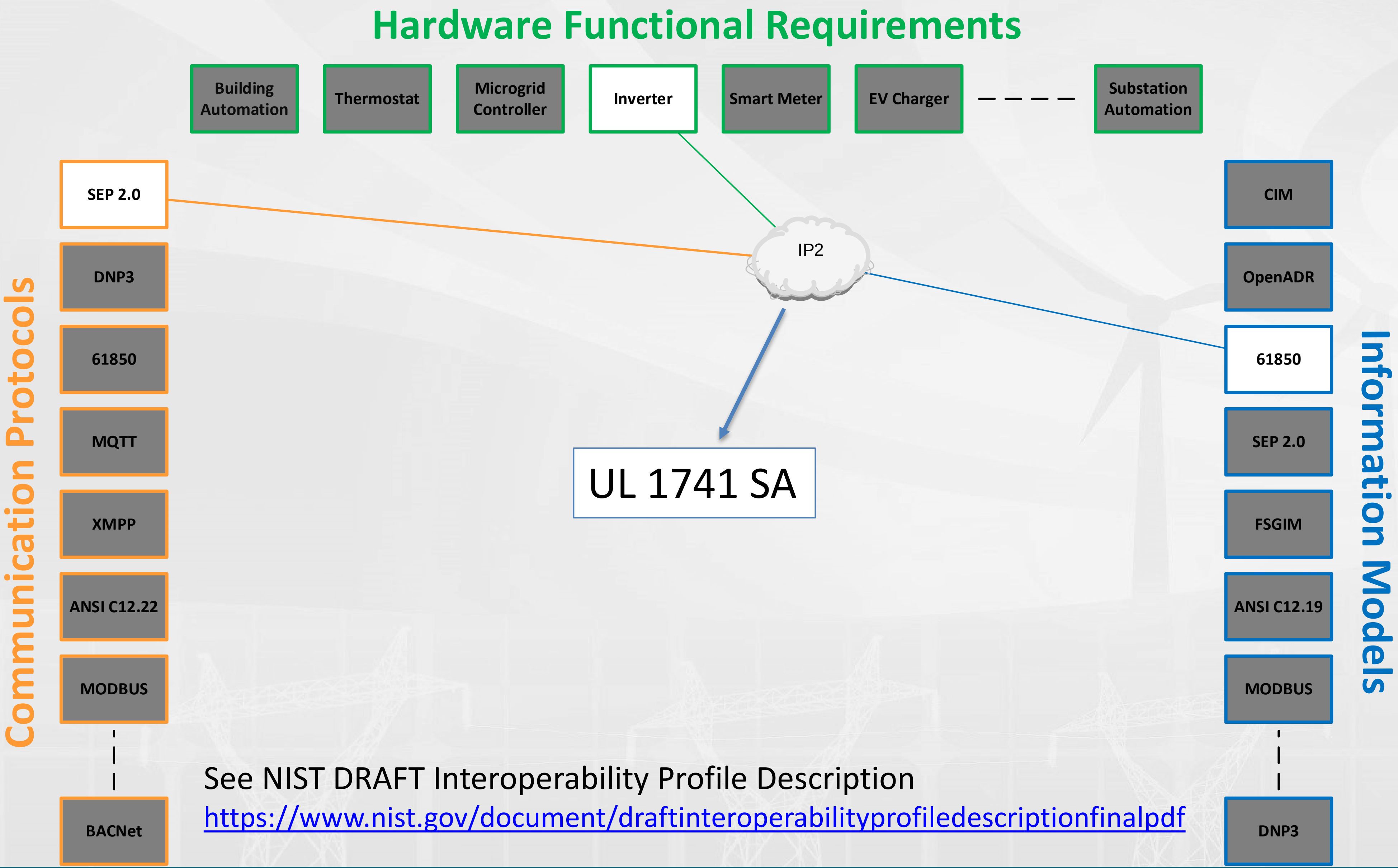
Interoperability Profile: Illustrative Landscape



Interoperability Profile: IEEE 1547 Case Study



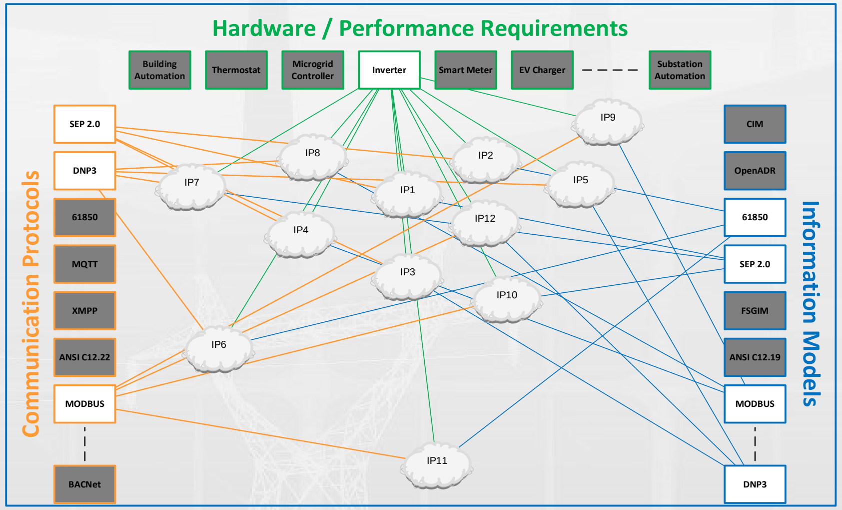
Interoperability Profile: California Rule 21 Case Study



See NIST DRAFT Interoperability Profile Description
https://www.nist.gov/document/draftinteroperabilityprofiledescriptionfinalpdf

Interoperability Profile

- A profile is a description of a well-defined subset of the standard that has been agreed upon by a user community, testing authority or standards body.
- The specification and use of profiles allows the interoperability gap to be narrowed by reducing the degrees of freedom of implementation flexibility in the context of interest by the device supplier, implementer and system owner.
- Basic set of elements for a profile include:
  - Physical performance specifications
  - Communication protocol
  - Information model



What we're doing about it (Please join us!)

Smart Electric Power Alliance

Why You Should Care About Interoperability Profiles

Interoperability Profiles for Smart Grid Modernization

Background

Industry standards for smart grid may support interoperability; however, the standards may also allow for configurations that are not interoperable or may restrict other desired features. To address this gap, the industry needs additional detail for each standard's requirements. Interoperability profiles provide this detail while saving vendors and utilities time and effort, reducing integration expenses, and improving the deployment of devices and systems.

Interoperability Profiles

An interoperability profile specifies standards-based requirements for interfaces or applications accepted by a user-community, testing authorities, and standards bodies. It contains specific configuration options within a standard's requirements sufficient to deliver the desired level of interoperability and functionality.

Communication Requirements	Data Requirements	Functional Requirements
Hardware Requirements	Integration Requirements	Interoperability Requirements
Operational Limits	Performance Requirements	Other elements as applicable

Table 1: Example Interoperability Profile Requirements and Elements

Interested stakeholders typically develop Interoperability profiles. This requires the participation of utilities, vendors, manufacturers, system integrators, standards development organizations and test laboratories.

Interoperability Profile Selection and Development

End device users (e.g. utilities), with feedback from stakeholders, prioritize the profiles to be developed and advise on the requirements. Industry consensus drives the selection of interoperability profiles based on the following criteria:

1. The level of interest
2. Potential to solve a current industry implementation and or interoperability concern
3. Technology maturity and usability of current implementations and standards
4. Level of interoperability required, as determined by usage
5. Existence of an ecosystem or body that will promote the adoption of the profiles.

For each device, system, or interface selected, the group will develop a consensus on the:

1. Key features and functionality
2. Performance requirements and operational limits
3. Communication and data requirements
4. Common system/device interactions

Smart Electric Power Alliance

Why You Should Care About Interoperability Profiles

5. Boundaries of use
6. Specific elements of applicable standards
7. Interoperability requirements

Interoperability Profile Candidates

The following non-prioritized list of candidates are examples of initial interfaces or applications.

Electric Vehicle Charging

The benefit of an interoperability profile for electric vehicle (EV) charging is the harmonization of the different charging protocols supporting the wider adoption of chargers. The profile will lower costs by providing manufacturers with fewer implementation requirements. EV standards include:

IEEE 2030.5	IEEE 2690	IEC 63110	ISO/IEC 15118	OpenADR 2.0	OSCPP 2.0

Table 2: Partial list of standards used in EV charging equipment

Energy Services Interface

The Energy Services Interface (ESI) is a bi-directional, service-oriented interface supporting the secure exchange of information between entities inside and outside of a customer boundary. ESI facilitates interactions between electrical loads, storage, and generation. Standards include:

CTA 2045-A	IEEE 2030.5	OpenADR 2.0 A/B

Table 3: ESI Standards

Transactive Energy

Transactive energy (TE) is the use of economic and control techniques to manage the flow of energy within an existing electric power system based on market values. TE standards include:

OASIS Energy Interoperation	OpenADR 2.0	PowerMatcher	TeMIX

Table 4: Transactive Energy Standards

Distributed Energy Resources

The distributed energy resource (DER) landscape includes physical performance, data, and communication requirements. Common DER standards include:

IEC 61850	IEEE 1547	IEEE 1815	IEEE 2030.5	Open Field Message Bus	SunSpec ModBus

Table 5: DER Standards

Join the team and steer the industry towards interoperability

Your input is critical to ensure that these profiles are practical, useful, and meet your needs. The expected commitment is no more than an hour a week, with most work being done via bi-weekly online meetings.

If you are interested in participating or for more information and access to additional resources, please contact membership@sepapower.org.

THANK YOU

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