2012 Smart Grid R&D Program
Peer Review Meeting

Smart Grid Standards and Conformance Testing

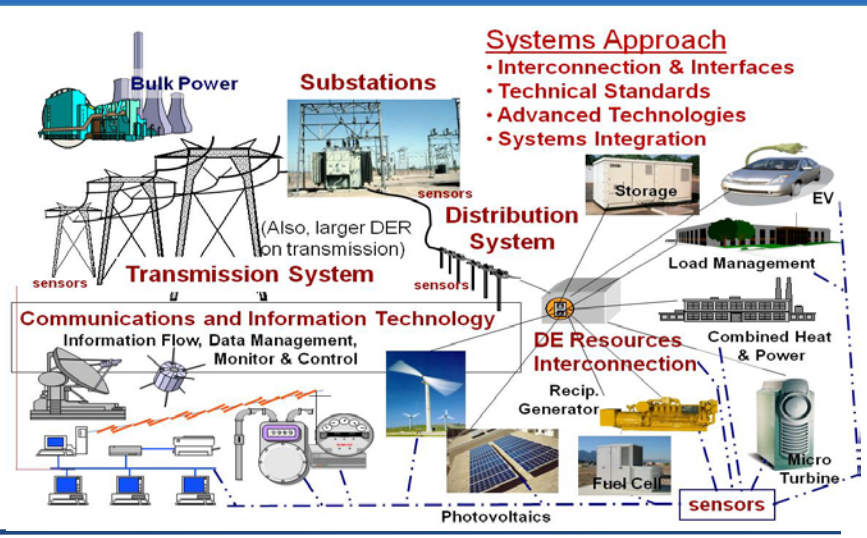
Tom Basso, *NREL*

(June 7, 2012)

Smart Grid Standards and Testing

Objective

Support the evolution of the electric power system infrastructure to an interoperable system that modernizes the grid, enhances its security and reliability, facilitates recovery from disruptions, provides for customer participation and choice in load management.



Life-cycle Funding Summary ($K)

FY11, authorized	FY12, authorized	FY13, requested	Out-year(s) (FY 14-FY15)
1,000	1,100	1,100	2,300

Technical Scope

National and international standards and best practices, and, conformance testing for: two-way communications and power flow; operating practices; interconnection, integration, and interoperability of power, communications and information technologies; and, for end-use applications and loads.

Significance and Impact

The significance and impact of standards and best practices for end-to-end interoperability, is that they provide foundational/crosscutting requirements for achieving the OE Smart Grid (SG) Program vision (e.g., pg 12 MYPP "…Standards and Best Practices cross-cuts the *Five Value Streams of the Smart Grid* - Figure 1.2). Additionally, testing provides similar foundational/cross-cutting requisites for SG success.

There are not MYPP quantitative and performance targets, nor are there trendable metrics relating standards and testing to the MYPP 2020 targets of (i) 20% SAIDI reduction in distribution outages, (ii) >98% reduction in outage time of required loads, and (iii) 20% load-factor improvement.

The next slide shows needs and challenges addressed by this project, and the slide after that states some significance and benefits in regards to standards and testing development and conformance.

Significance: Needs and Challenges

- Lack of common understanding and knowledge base for SG interconnection and interoperability terminology, systems integration, and testing among power, information and communications technologies, stakeholders, and roles
- Incomplete set of standards, guidelines and best practices
- Lack of standards and testing coordination and harmonization;
- Untested or non-validated technology, operations, and tests;
- Technology and testing: non-uniformity, non-interoperability, quality assurance, and acceptance practices;
- Improved DER integration and proven, agreed upon advanced operating strategies;
- Lack of standardized interfaces – hardware and software, operational, and informational.
- Lack of uniform, agreed upon implementation protocols

Significance and Impact

Smart Grid Standards and Testing also supports evaluation & demonstrations, including new technologies and methods that are in need of evaluation in terms of performance and conformance with emerging standards & best practices and interoperability requirements.

Significance of this addresses:
- Identifying gaps related to smart grid functionality or gaps in existing technologies and processes that could limit successful, cost-effective roll-out of smart grid systems.
- Developing protocols and methods for testing and evaluating new components and systems.
- Evaluating current industry, laboratory, and government testing capabilities.

Smart Grid Standards and Testing Approach*

* e.g., OE Multi-Year Program Plan 2010-2014

NIST *Smart Grid Standards Roadmap & Interoperability Framework* - NIST established *Framework* documents (SP1108r1); uses the Smart Grid Interoperability Panel (SGIP), Priority Action Plans (PAPs), Domain Expert Working Groups (DEWGs), SG Testing and Certification Committee (SGTCC), etc.

National Consensus Standards Development – IEEE standards via industry-driven partnerships with balanced stakeholder participation and open & impartial leadership (e.g., NREL R. DeBlasio: IEEE Standards Board of Governors, IEEE Standards liaison to DOE, SCC21 Chair).

IEEE Standards Coordinating Committee 21 (IEEE SCC21) - *Fuel Cells, Photovoltaics (PV), Dispersed Generation and Energy Storage* – sponsors and develops 1547 interconnection & 2030 interoperability series of standards, & PV standards. NREL provides SCC21 leadership (R. DeBlasio SCC21 Chair; T. Basso Vice Chair).

Harmonization of national and international standards -- IEEE SCC21 and IEC/TC8 -- International Electro-technical Commission/TC8 *System Aspects of Electrical Energy Supply* -- NREL manages IEC US/Technical Advisory Group/TC8; US/TAG/TC8 Technical Advisors: T. Basso and J. Koepfinger (IEEE Standards Board Emeritus member); in 2011, IEEE 1547 Std published as IEC/IEEE dual logo Publically Available Specification (PAS); in 2012 SG interconnection/interfaces project started by China (CEPRI).

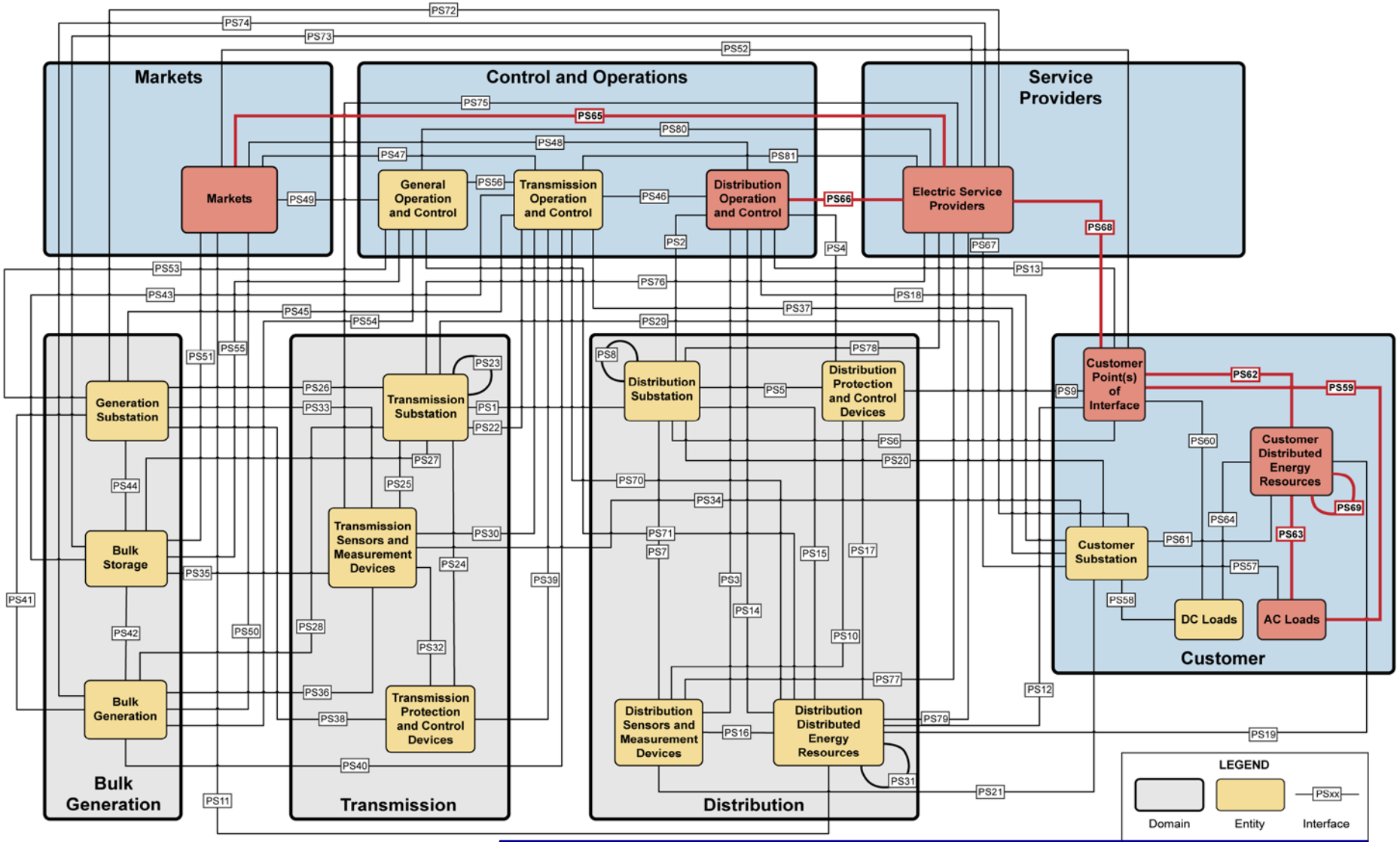
Testing and Conformance – NREL establishing report on testing; coordinating with other test labs and stakeholders; participating in ongoing test activities; may establish industry-driven consensus standard for testing (e.g., North America grid focus).

Technical Approach Addresses:

- Interoperability standards and testing for Smart Grid components and the overall system, e.g., interconnection, interoperability and integration for distributed energy resources (DER) including generation, storage, electric vehicles, microgrids, grid components, operations, loads, etc.
- Smart grid architecture & interoperability cyber security related requirements
- Exploratory and conformance test procedures related to Smart Grid interconnections, integration, interoperability, and cyber security requirements
- Smart grid interfaces among distribution & transmission systems, loads, markets, and operations including architectures and interoperability pertinent to customers, end use applications, including demand response
- Distribution system protection and operations, including automation practices
- Improved reliability & ancillary service definitions based on systems analysis
- Market systems clarification (e.g., technical needs) & uniformity among regions/states
- Identification of gaps and conflicts within existing standards, e.g., NERC, FERC, regional, international and IEEE standards.
- Providing technical support to authorities having jurisdiction for adopting and referencing smart grid interconnection and interoperability standards, best practices, and testing, e.g., states, regional, and federal entities such as NERC and ISOs/RTOs.

IEEE 2030 -- First/Only Consensus, SG System Architecture Standard:

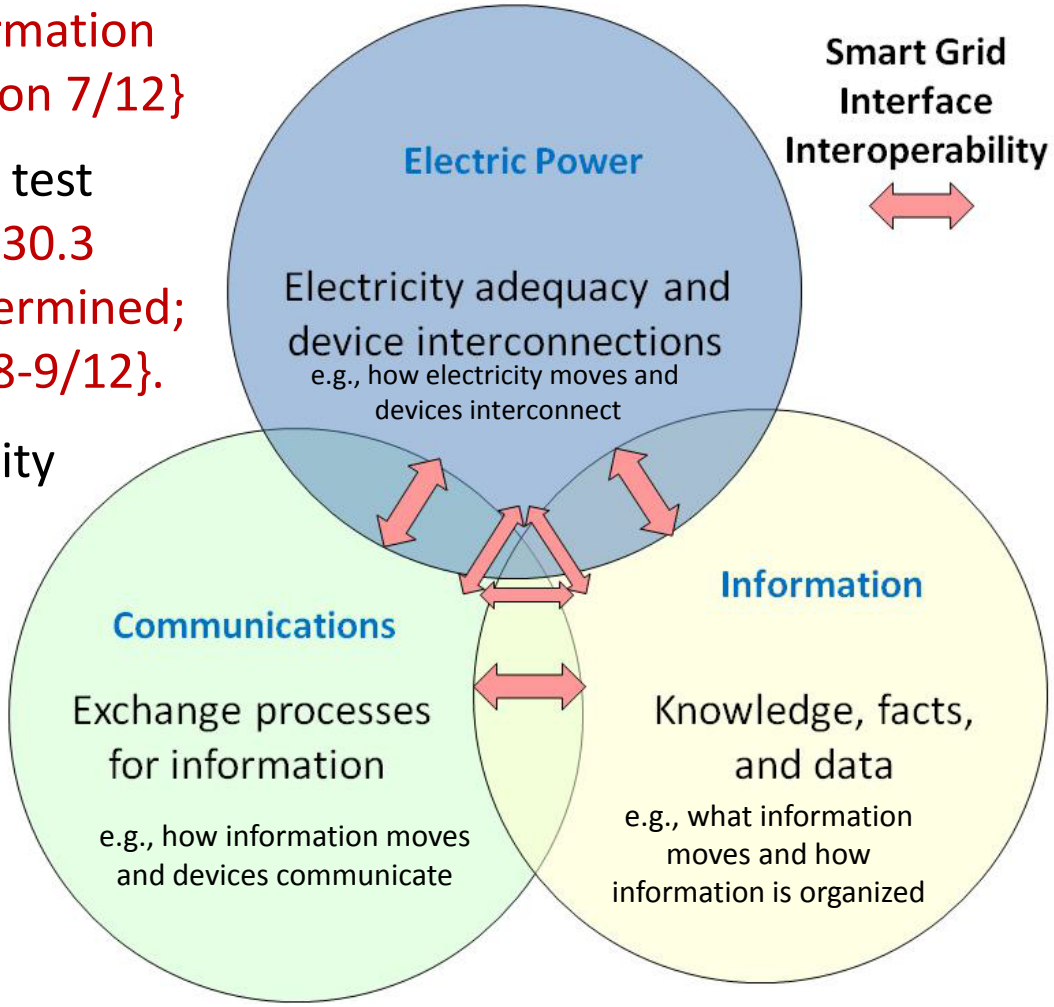
Simplified* Example: Service Provider Controls Customer DG, Community Energy Storage and Controllable Loads



* Protection, security, communications, testing, etc. not highlighted

Smart Grid Conformance Testing {status in parentheses}

- Identify interoperability test standards, requirements, and gaps {initial information compiled 4/12, additional information 7/12}
- Initiate consensus-based standard test protocols that are gaps {started P2030.3 [storage]; other protocols to be determined; recommend/initiate priority topics 8-9/12}.
- Determine needs for interoperability test beds, equipment, and practices {ongoing– status due summer '12}
- Develop interoperability conformance & evaluation metrics, e.g., establish criteria, test the tests among subset of interfaces and devices {ongoing, due 9/12}



FY 2011- 2012 Progress

(Selected Examples – see backup slides for details and more)

- Held IEEE 1547 Workshop for technical changes discussion and rationale for revision to IEEE Std 1547– May 2012, R. DeBlasio SCC21 & 1547 Chair, T. Basso SCC21 Vice Chair (65 participants); also, led or represented sessions on 1547 stakeholder feedback, e.g., DOE-EPRI-SEPA Workshop; PJM-EPRI-NREL workshop; & UVIG Meeting (Utility Variable-generation Integration Group).
- Represented US on IEC/TC8 Smart Grid Interface/Interconnection standard development led by China; Apr 2012 and Dec 2012 telecons.
- Published IEEE 2030 Guide for Smart Grid Interoperability (R. DeBlasio Chair, T. Basso Secretary, 500 participants) – Sept 2011 (459 balloters)
- Published IEEE Std 1547.6 Recommended Practice for DR on distribution secondary networks (J. Koepfinger, Chair; J. Bzura [US National Grid] Vice Chair, T. Basso Secretary; 185 participants) – Sept. 2011 (250 balloters)
- Published IEEE Std 1547.4 Guide for micro-grids (planned islands; Ben Kroposki Chair, T. Basso Secretary; 130 participants) – July 2011 (220 balloters)
- Published IEEE Std 1547.1 Standard Conformance Test Procedures for Interconnection Equipment – reaffirmed 2011 by 190 balloters (T. Basso)

Out-year Planned Progress & Milestones

- Publish IEEE 1547.7 (DR impacts – includes modeling and simulation) document (2013).
- Publish P1547.8 (extended use of 1547) in 2013 (e.g., NIST PAP 7 topic).
- Establish SG testing protocols, test beds, and best practices, and, publish reports for advanced technologies validation examples (test protocols, test beds, and practices in 2013, and reports 2013-2015).
- Initiate IEEE Std 1547 technical changes standard and related 1547.1 test procedures drafts and validation (2013) and publish (2014).
- Initiate, hold meetings for, and publish IEEE P2030.x Smart Grid Interoperability Testing (2013 and publish in 2015)
- Ballot and publish IEEE P2030.1 (EV *Infrastructure); P2030.2 (energy storage interoperability); P2030.3 energy storage testing* (ballot 2013-2014 and publish 2014-2015)
- Provide state-of-the-art SG testing capabilities and partnering for OE.
- Provide ongoing coordination/liaison support for DOE SG R&D, e.g., EERE, NIST, FERC/NERC, ISOs/RTOs, states,

SG Standards and Testing Leverage

- NREL-facilitated standards development was exceeded by industry commitment of 4-5 times DOE commitment (1547 and 2030 stats).
- NREL leverages participants expertise and commitment: participants vote top items to tackle; writing teams draft targeted inputs; working group reviews and recommends revisions; writing group establishes recommendations for ballot document; working group reviews and recommends ballot readiness - e.g.,. P1547.8 has ongoing 75 volunteers with 2100 yrs experience!
- NREL subject matter experts establish/conduct/contribute technical analyses, test-the-tests, provide impartial open venues for technical advancements and consensus building, partner with stakeholders (including utilities, manufacturers, integrators), esatablish reports, workshops, technically support authorities having jurisdiction, etc.

Interactions & Collaborations

- NRECA , e.g., R. Saint P1547.7 Chair
- PPL, e.g., D. Bassett P1547.8 Co-chair
- PJM , e.g., member on their SG work group
- GA Power, member, hosted SCC21 meetings
- MADRI, e.g., member on their SG subgroup
- EEI - SCC21 WG members
- NERC, e.g., member on their SG Task Force; and they liaison with IEEE SCC21

- NIST SGIP, NIST PAP7, SGTCC member
- DOE EERE Solar codes & standards coordination
- SNL, e.g., SCC21 WG members
- ORNL, e.g., SCC21 WG members

- INTEL - 2030 Task Force Chair; hosted 2030 meeting
- IBM – 2030 Task Force Chair; hosted 2030 meeting
- DTE/Detroit Edison Co., co-hosted 2030 meeting; members on SCC21 WGs;
- Kohler, e.g., Mark Siira 2030.2 Chair

- SAE, e.g., co-hosted 2030 meeting; liaison with SCC21 WGs; and members on SCC21 WGs;
- NEMA , e.g., member on their Energy Storage Council
- IEC, e.g., TC8 (manage US members; Technical Advisor for US/TC8 group; coordinate with TC57, TC82 member.

- UL, e.g., SCC21 Committee
- TUV/ASU (test lab) SC21 WG member
- CSA (test lab) SCC WG member

- Satcon (inverter mfgr) WG member
- A123 Batteries - WG member
- Altair Nano (batteries) – WG Member

…. Hundreds more stakeholders in IEEE SCC21 standards working groups as consensus volunteers, e.g., GE, Westinghouse, Siemens, Eaton, KEMA, Cooper Power, …

THANK YOU!

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National Renewable Energy Laboratory – NREL http://www.nrel.gov

Distributed Energy Systems Integration Group

Electricity, Resources and Building Systems Integration Center

SCC21 (Standards Coordinating Committee 21): *Fuel Cells, Photovoltaics, Dispersed Generation, & Energy Storage*

http://grouper.ieee.org/groups/scc21/

IEEE 1547 series of Smart Grid Interconnection and

IEEE 2030 series of Smart Grid interoperability standards and

IEEE PV standards.

Tom Basso: SCC21 Representative and Vice Chair for IEEE SCC21, and, Chairman and Technical Advisor for IEC US Technical Advisory Group TC8 *Electrical Energy Supply Systems*

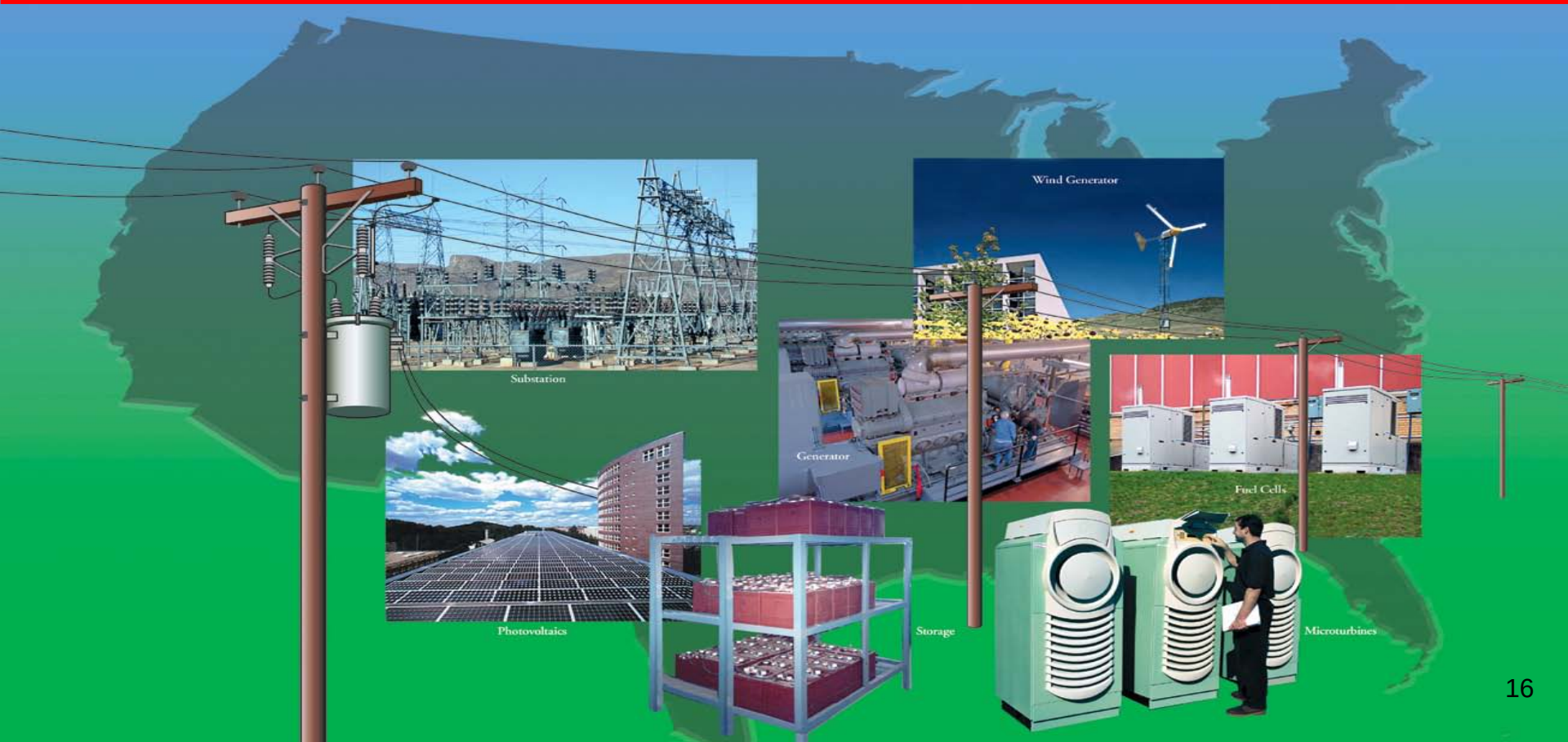
Smart Grid Standards and Testing

(Back-up Slides follow - all can be posted)

Significance and Impact: additional slides follow

- Energy Policy Act (2005) Cites and requires consideration of IEEE 1547 Standards and Best Practices for Interconnection.
- Energy Independence and Security Act (2007) Established NIST as Lead to Coordinate Framework and Roadmap for Smart Grid Interoperability Standards and Protocols; IEEE also stated as a standards development organization partner.
- Federal ARRA (2009): Smart Grid and High Penetration DER projects.

- NREL ESIF (Energy Systems Integration Facility, fall 2012) Multi-MW and High Performance Computing R&D & Test Facility.

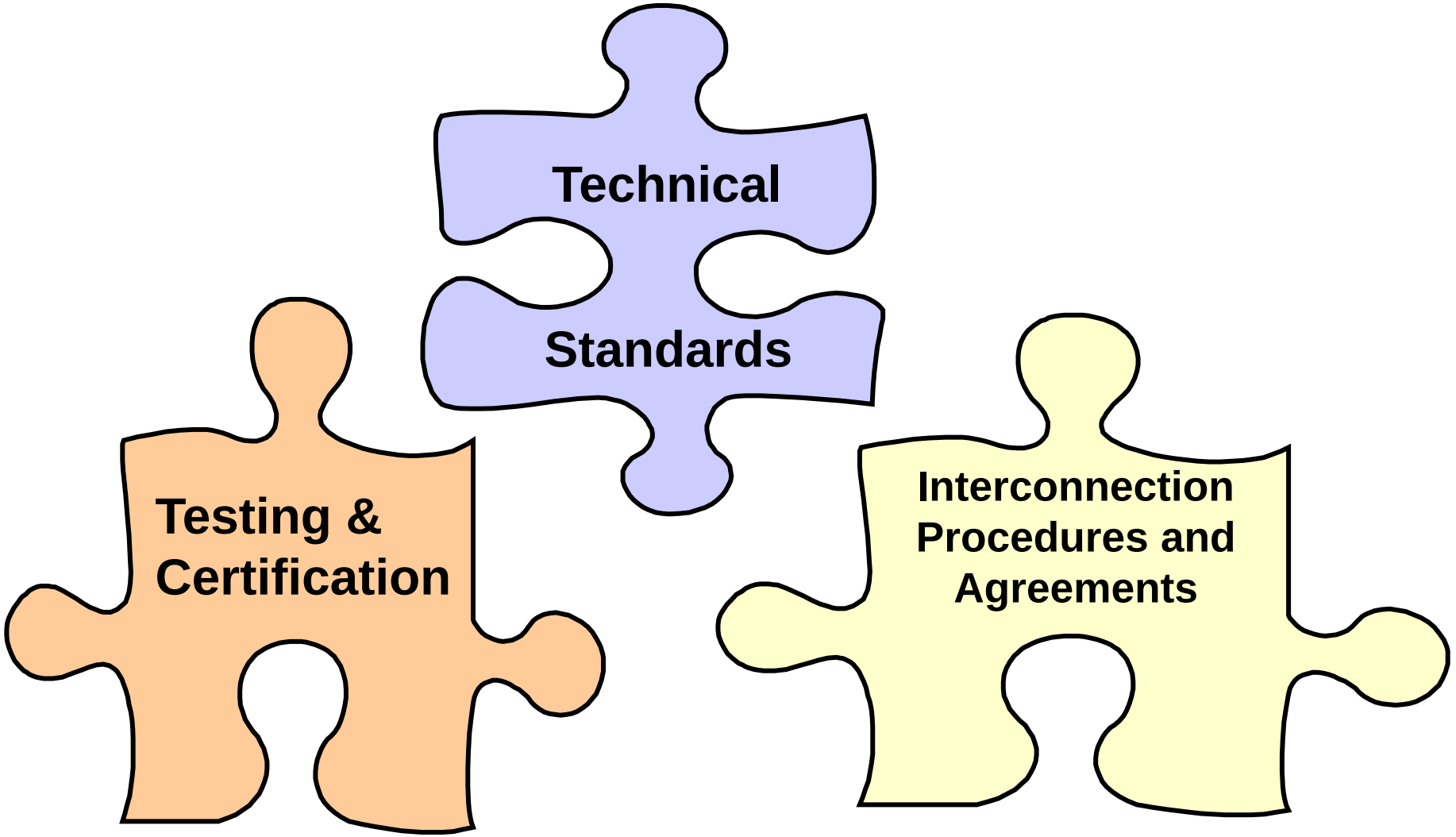


Significance and Benefits of Standards and Conformity Assessment/Testing

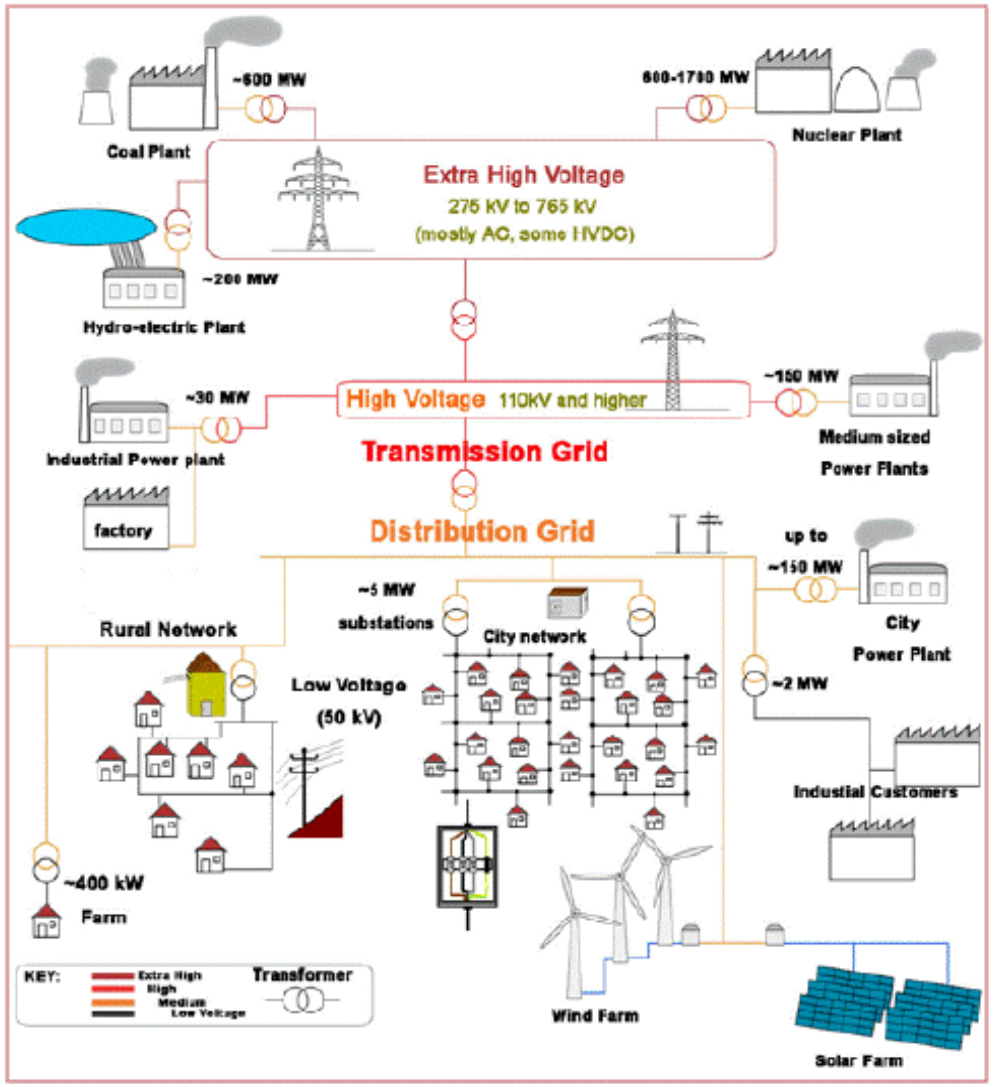
- Safeguards against hazards
- Fosters quality design and manufacture
- Increases competitiveness in industry
- Creates and expands markets
- Facilitates Trade and Commerce
- Assurance is provided when products meet quality standards, then users need not be concerned with redundant testing or evaluation of the product

- Accelerates engineering advances & implementation, interoperability, and installation
- Assists increased quality and reliability achievement
- Simplifies compliance to needs, permitting, & rules
- Promotes advanced communications; software platforms interchangeability
- Enables enhanced DE systems and grid intelligence
- Lower cost and quicker deployment for projects.

Challenge: *Putting the Pieces Together*



Interconnection Standards, Rules, and Jurisdiction



Bulk System Guidelines
NERC, FERC
IEEE, ANSI, IEC
NESC

Plenty of technical and jurisdictional overlap, confusion, contradiction…

Distribution System Guidelines
IEEE 1547, PUC/PRC
IEEE, ANSI, IEC
NEC

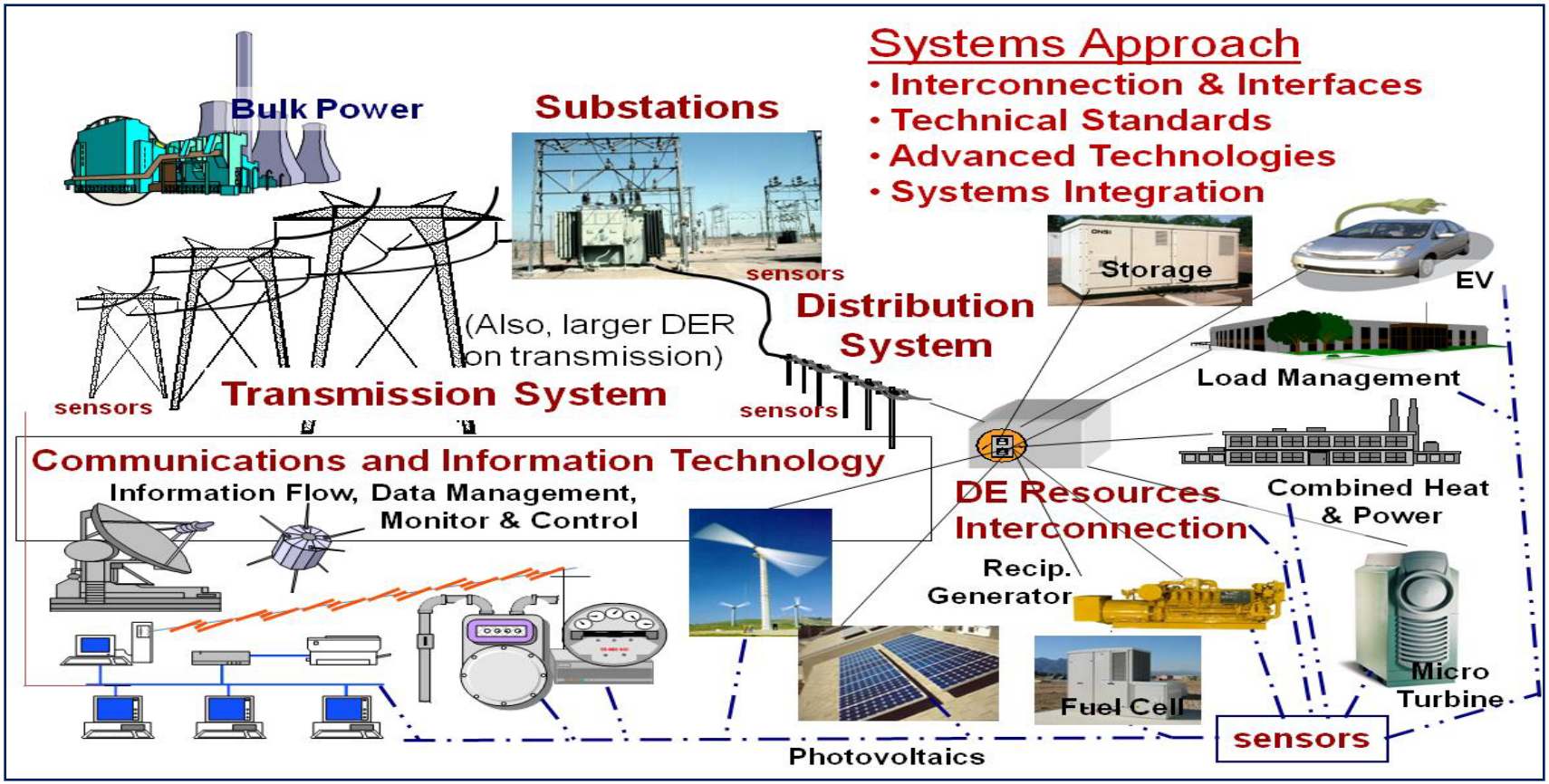
Smart Grid Standards and Testing

Technical Approach & Transformational R&D

additional slides follow

→System of Systems Approach ←

{e.g., see MYPP 2010-2014 Figure 1.1 Smart Grid Components}



OE defines the smart grid by seven performance-based functionalities:
1) customer participation, 2) integration of all generation and storage options, 3) new markets and operations, 4) power quality for the 21st Century, 5) asset optimization and operational efficiency, 6) self healing from disturbances, and 7) resiliency against attacks and disasters.

Technical Approach: Additional Activities

- Conduct 1547 revision workshops and standards development meetings consensus meetings.
- Lead or participate in SG testing activities/coordination focused on US/North America grid priorities.
- Provide state-of-the-art SG testing capabilities and partnering for OE.
- Initiate potential P2030.x *Draft Standard for … Conformance Test Procedures for Smart Grid Equipment*
- Coordination with DOE EERE solar program, NIST, FERC/NERC, etc.
- Support states, regions (e.g., ISOs/RTOs), and international interconnection and smart grid activities
- Support security and reliability smart grid activities
- Support DOE planning, subcontracting, etc.
- Publish updates/outreach on standards and testing
- Ongoing coordination among additional NREL, DOE and other stakeholders for accelerated standards and testing development and updates.

IEEE 2030 Series of Smart Grid Interoperability Standards

- IEEE Std 2030 – 2011 *Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System and End-Use Applications and Loads*
- IEEE P2030.1 Draft *Guide for Electric-Sourced Transportation Infrastructure*
- IEEE P2030.2 – Draft *Guide for Energy Storage Systems Interoperability with Electric Power Infrastructure*
- IEEE P2030.3 – Draft *Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications*
- Potential *P2030.x Draft Standard for … Conformance Test Procedures for Smart Grid Equipment*

1547 Series of Interconnection Standards

1547-2003 Standard for Interconnecting Distributed Resources (DR) with Electric Power Systems (EPS) - **Reaffirmed in 2008**

1547.1-2005 Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems – **Reaffirmed in 2011**

1547.2-2008 Application Guide for IEEE1547 Standard for Interconnecting Distributed Resources with Electric Power Systems

1547.3- 2007 Guide for Monitoring, Information Exchange and Control of DR

1547.4-2011 Guide for Design, Operation, and Integration of Distributed Resources Island Systems with Electric Power Systems ***{"Micro-grids"}***

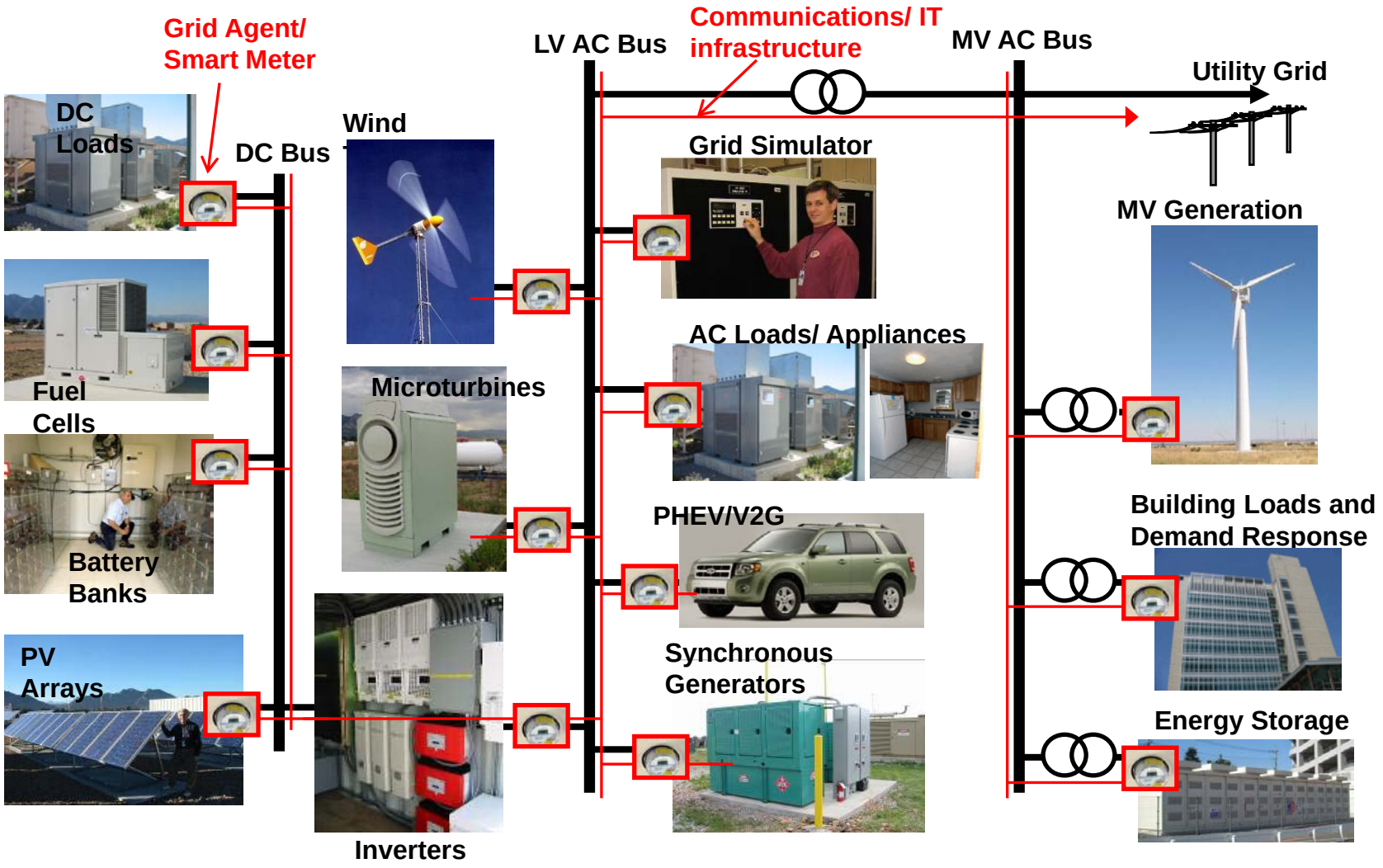
P1547.5 Draft Guidelines for Interconnection of Electric Power Sources Greater Than 10 MVA to the Power Transmission Grid *{Withdrawn December 2011}*

1547.6 -2011 Recommended Practice for Interconnecting Distributed Resources With Electric Power Systems Distribution Secondary Networks

P1547.7 Draft ***Guide to Conducting Distribution Impact Studies for DR Interconnection***

P1547.8 Draft ***Recommended Practice for Establishing Methods and Procedures that Provide Supplemental Support for Implementation Strategies for Expanded Use of IEEE Std 1547***

NREL Example Smart Grid Testing



IEEE 1547 Interconnection Standards Use – A Model for Smart Grid Standards and Testing

Federal, Regional, State and Local Authorities/Jurisdictions Standards Implementation

IEEE 1547
Interconnection System and Test Requirements

- Voltage Regulation
- Grounding
- Disconnects
- Monitoring
- Islanding
- etc.

IEEE 1547.1
Interconnection System Testing

- O/U Voltage and Frequency
- Synchronization
- EMI
- Surge Withstand
- DC injection
- Harmonics
- Islanding
- Reconnection

UL 1741*
Interconnection Equipment

- 1547.1 Tests
- Construction
- Protection against risks of injury to persons
- Rating, Marking
- Specific DR Tests for various technologies

NEC

Article 690 PV Systems;

Article 705: interconnection systems (shall be suitable per intended use per UL1741)

PJM Interconnection, Inc.
Small Generator Interconnection Standards
FERC approved
(0-to<10MW and 10-to-20 MW; incorporate 1547 and 1547.1)

* UL 1741 supplements and is to be used in conjunction with 1547 and 1547.1

PJM* Small Generator Interconnection Standards Summary Overview (Generators ≤ 10 MW, and, 10-20MW)

1547 Std technical requirements

1547 based test requirements
- Design Test (may be pre-certified)
- Production Test
- Installation Evaluation
- Commissioning Test
- Periodic Testing (per PJM tariff requirements)

PJM SCADA option available

Other Requirements
- e.g. PJM EPS owner voltage regulation
- e.g., PJM EPS metering
- e.g. other National / local codes

Purpose for adopting PJM-wide technical standards based on 1547:
- Limit barriers to interconnection
- Provide transparency
- Allow for pre-certification and other means to expedite interconnection process

*PJM is a regional transmission organization with over 140 GW load; 165 GW generating capacity

Smart Grid Standards and Testing

Technical Accomplishments

additional slides follow

Smart Grid Standards OE Milestones

OE AOP: Smart Grid R&D -- FY 2012 Milestones	
Smart Grid Interconnection Standards Development {status notes}	**Date**
Oversee IEEE Std 2030 "Guide for Smart Grid Interoperability of Electric Power, Communications and Information Technologies with End-use Applications and Loads" (publication) {published Sept 2011; ballot pool of 459 participants}	Sept.- Oct. 2011
Establish IEEE P1547.8 (extended use of IEEE Std 1547) – P1547.8 Draft 2 {D2 feedback Jan 2012, D2.1 established at Feb 2012 meeting; D3 to be posted 6/12; stretch goal complete draft CY 2012; ballot in 2013}.	Nov. 2011 & Sept. 2012
Lead US participation for IEC-IEEE dual logo standard drafts (follow on beyond 1547 PAS) {dual logo voted down by TC8; TC8 project started - PT 62786-2 "Smart Grid User Interface - Part 2: Domain Side Energy Source Interconnection with the Grid" led by China, Basso & DeBlasio USA reps on that team}	spring and summer 2012

Smart Grid Standards OE Milestones

OE AOP: Smart Grid R&D -- FY 2012 Milestones	Date due
Smart Grid Interconnection Standards Development {status notes}	(planned)
Hold two meetings for IEEE P1547.8 and P1547.7 {Feb 2012, and planned Aug 2012}, and P2030.2 energy storage systems interoperability {Oct 2011 & Feb and May, and planned Aug 2012} (meetings and related documents)	Feb. 2012 & summer 2012
Complete IEEE P1547.7 "Guide for Conducting Distribution Impact Studies for Distributed Resource Interconnection" {ballot-draft planned Aug 2012 with IEEE ballot 10/2012}	Sept 2012
Provide coordination and liaison with related organizations and activities – summary of annual activities. {ongoing, e.g., participation, presentations and/or papers for: Grid-Interop 2011 Meeting 12/11; SGIP DEWG Distributed and Renewables Generation and Storage; SGIP Smart Grid Testing and Certification Committee; IEEE PES Innovative Smart Grid Technology Meeting 1/12; SGIP PAP energy storage meetings and teleconferences; IEEE PES T&D Conference 5/12 (supersession on microgrids); IEEE PES Annual Meeting 7/12 (supersession "Distributed energy resources grid integration performance requirements and emerging standards").	Sept. 2012

Smart Grid Testing: OE Milestones

OE AOP: Smart Grid R&D -- FY 2012 Milestones	Date due
Smart Grid Testing Development {status notes}	(planned)
Identify existing Smart Grid standards and requirements and determine interoperability testing areas and needs (letter report) {initial information drafted; expect report 6/2012}	3/2012
Establish consensus-based IEEE P2030.x testing practices - initiate project including international harmonization – dates to be determined {ongoing, expect late summer completion}	spring – summer 2012
Hold meeting/seminar on smart grid interoperability conformance testing {ongoing, expect late summer completion}	spring – summer 2012
Identify equipment needed to conduct interoperability testing {ongoing, expect mid-summer completion}	6/2012
Develop criteria and evaluation metrics to address Smart Grid conformance and interoperability testing {ongoing, expect late summer completion}	7/2012
Provide coordination and liaison with related organizations and activities – summary of annual activities {on schedule}	9/2012

FY 2011- 2012 Progress (expanded slide 1)

- Held IEEE 1547 Workshop for technical changes discussion and rationale for revision to IEEE Std 1547– May 2012, R. DeBlasio SCC21 and 1547 Chair, T. Basso SCC21 Vice Chair (65 participants)
- Led session on 1547 at DOE-EPRI-SEPA Workshop "High Penetration and Distributed PV Integration Efforts"; April 2012 (T. Basso)
- Represented 1547 at PJM-EPRI-NREL workshop "Inverter Based Generation Power System Performance Needs"; April 2012 (T. Basso)
- Represented 1547 at UVIG (Utility Variable-generation Integration Group) "Distributed Generation Users Group Meeting"; April 2012 (T. Basso).
- Panel member for Supersession "Microgrids, Islanding and Distributed Generation" at IEEE T&D meeting May 2012 (T. Basso).
- Presented and published paper on IEEE SCC21 1547 and 2030 Smart Grid standards update at the IEEE "Innovative Smart Grid Technologies" meeting Jan. 2012 (T. Basso, and J. Hambrick - presenter).
- Presented and published paper on IEEE Smart Grid standards update at the *GridInterop 2011* and the NIST PAP7 meetings; Dec. 2012 (T. Basso).
- Represented US TAG for IEC/TC8 SG interface/interconnection standards development (led by China).

FY 2011- 2012 Progress (expanded slide 2)

- Published IEEE 2030 Guide for Smart Grid Interoperability (R. DeBlasio Chair, T. Basso Secretary, 500 participants) – Sept 2011 (459 balloters)
- Published IEEE Std 1547.4 Guide for micro-grids (island systems; Ben Kroposki Chair, T. Basso Secretary; 130 participants) – July 2011 (220 balloters)
- Published IEEE Std 1547.6 Recommended Practice for DR on distribution secondary networks (J. Koepfinger, Chair; J. Bzura [US National Grid] Vice Chair, T. Basso Secretary; 185 participants) – Sept. 2011 (250 balloters)
- Published IEEE Std 1547.1 Standard Conformance Test Procedures for Interconnection Equipment – reaffirmed 2011 by 190 balloters (T. Basso)
- IEEE P1547.7 Guide for DR impact studies (R. Saint [NRECA] Chair; T.Basso Secretary; 125 participants) – established ballot-ready draft 7 (June 2012)
- IEEE P1547.8 Recommended Practice for extended use of IEEE 1547 standard; 4 meetings, 1st was Aug 2010; drafts 1-2-3 established (T. Basso and D. Bassett [PPL-retired] Co-Chairs; 95 participants)
- Held 5 IEEE SCC21/1547 series meetings (T. Basso, SCC21 Vice Chair)
- Held 6 P2030.2 Guide for storage systems interoperability meetings and four P2030 writing group meetings (M. Siira [Kohler – retired] Chair, T. Basso Secretary).

FY 2011-2012 Progress (expanded slide 3)

- Liaison between IEEE SCC21 and NERC, and SAE standards EV groups;
- Member of the NERC Smart Grid Task Force (R. DeBlasio);
- Member in NIST SGIP standards coordination group (R. DeBlasio)
- Participation in NIST: PAP7 on *Energy Storage; Smart Grid Testing and Certification Committee; Distributed Renewables Generators and Storage Domain Expert Working Group* (T. Basso)
- Coordinating DOE EERE solar (PV) codes and standards work, e.g., Solar ABCs (Solar America Board for Codes and Standards) Steering Comm. (T. Basso)
- Member of IEEE Standards Board of Governors (R. DeBlasio);
- Liaison representing IEEE Standards Board to DOE (R. DeBlasio);
- Chairman of IEEE SCC21 and 2030 Chair (R. DeBlasio);
- Participating as IEEE SCC21 Vice Chair, P1547.8 Co-chair, and Secretary for 2030, 2030.2, 1547.4, 1547.6, P1547.7 (T. Basso)
- Managing USA Technical Advisory Group and participate as its Technical Advisor for the International Electro-technical Commission Technical Committee 8 *Electric Energy Systems* (T. Basso and J. Koepfinger)
- Coordination with NERC, PJM, MADRI, IEC groups (e.g., TC8, TC57-communications, and TC82-solar) (R. DeBlasio and T. Basso)

IEEE 2030 Series (Smart Grid Interoperability) Status

- IEEE Std 2030 – 2011 *Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System and End-Use Applications and Loads* Published in 2011
- IEEE P2030.1 Draft *Guide for Electric-Sourced Transportation Infrastructure* Started in 2010
- IEEE P2030.2 – Draft *Guide for Energy Storage Systems Interoperability with Electric Power Infrastructure* Started in 2011
- IEEE P2030.3 – Draft *Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications* Started in 2011
- Potential *P2030.x Draft Standard for … Conformance Test Procedures for Smart Grid Equipment* To be determined

1547 Interconnection Standards Status

1547-2003 Standard for Interconnecting Distributed Resources (DR) with Electric Power Systems (EPS) - **Reaffirmed in 2008**

1547.1-2005 Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems – **Reaffirmed in 2011**

1547.2-2008 Application Guide for IEEE1547 Standard for Interconnecting Distributed Resources with Electric Power Systems

1547.3- 2007 Guide for Monitoring, Information Exchange and Control of DR

1547.4-2011 Guide for Design, Operation, and Integration of Distributed Resources Island Systems with Electric Power Systems *{"Micro-grids"}*

P1547.5 Draft Guidelines for Interconnection of Electric Power Sources Greater Than 10 MVA to the Power Transmission Grid *{Withdrawn December 2011}*

1547.6 -2011 Recommended Practice for Interconnecting Distributed Resources With Electric Power Systems Distribution Secondary Networks

P1547.7 Draft ***Guide to Conducting Distribution Impact Studies for DR Interconnection***

P1547.8 Draft ***Recommended Practice for Establishing Methods and Procedures that Provide Supplemental Support for Implementation Strategies for Expanded Use of IEEE Std 1547***

Workshops discussed 1547 revision needs

Reaffirmed in 2011

Published in 2011

Ballot in Oct 2012

Ballot in 2013

Smart Grid Standards Background

IEEE 1547 and 2030 series

Summary details follow

P1547.7 Guide to Conducting Distribution Impact Studies

• Describes **criteria, scope, & extent for engineering studies** of the impact of DR on distribution system.
• **Methodology for performing** engineering studies.
• Study scope and extent described as functions of **identifiable characteristics of:**

- **the distributed resource,**
- **the area electric power system, and**
- **the interconnection.**

• **Criteria described for determining the necessity** of impact mitigation.
• Guide allows a described methodology for:

- **When** impact studies are **appropriate**,
- **What data** is required,
- **How** studies are **performed**, and
- **How** the study **results are evaluated**.

P1547.8 Recommended Practice … for Expanded Use of IEEE Std 1547

- Need for P1547.8 is to address industry driven recommendations and NIST smart grid standards framework recommendations (e.g., NIST priority action plans).
- Work in progress considerations include: voltage regulation; voltage and frequency ride thru; grid support (including volt-ampere reactive support; DR high-penetration levels and multiple interconnections; two-way monitoring, information exchange and control; advanced/interactive grid-DR operations; interactive inverters; energy storage; electric vehicles; DR (and aggregates) greater than 10 MVA; advanced system protection; response to faults; etc.

P1547.8 WG participants priority draft topics of interest include:

- Allow active voltage regulation and grid support e.g.,. 4 quadrant features
- Voltage and frequency ride-through
- Better integration with utility protection and coordination
  - Frequency trip settings; under/over voltage settings; T&D interactions
  - Operation under fault conditions
- High penetration of DR
- Monitoring and control (communications, SCADA, etc.)
- Power quality
- Switching impacts of DR
- Dynamically controlled inverters and (addresses lots of topics)
- Capacity greater than 10 MVA
- Vehicle to grid
- Issues identified by IEEE Std 2030 and additional stakeholders

IEEE Std 2030 -- *Smart Grid Interoperability*

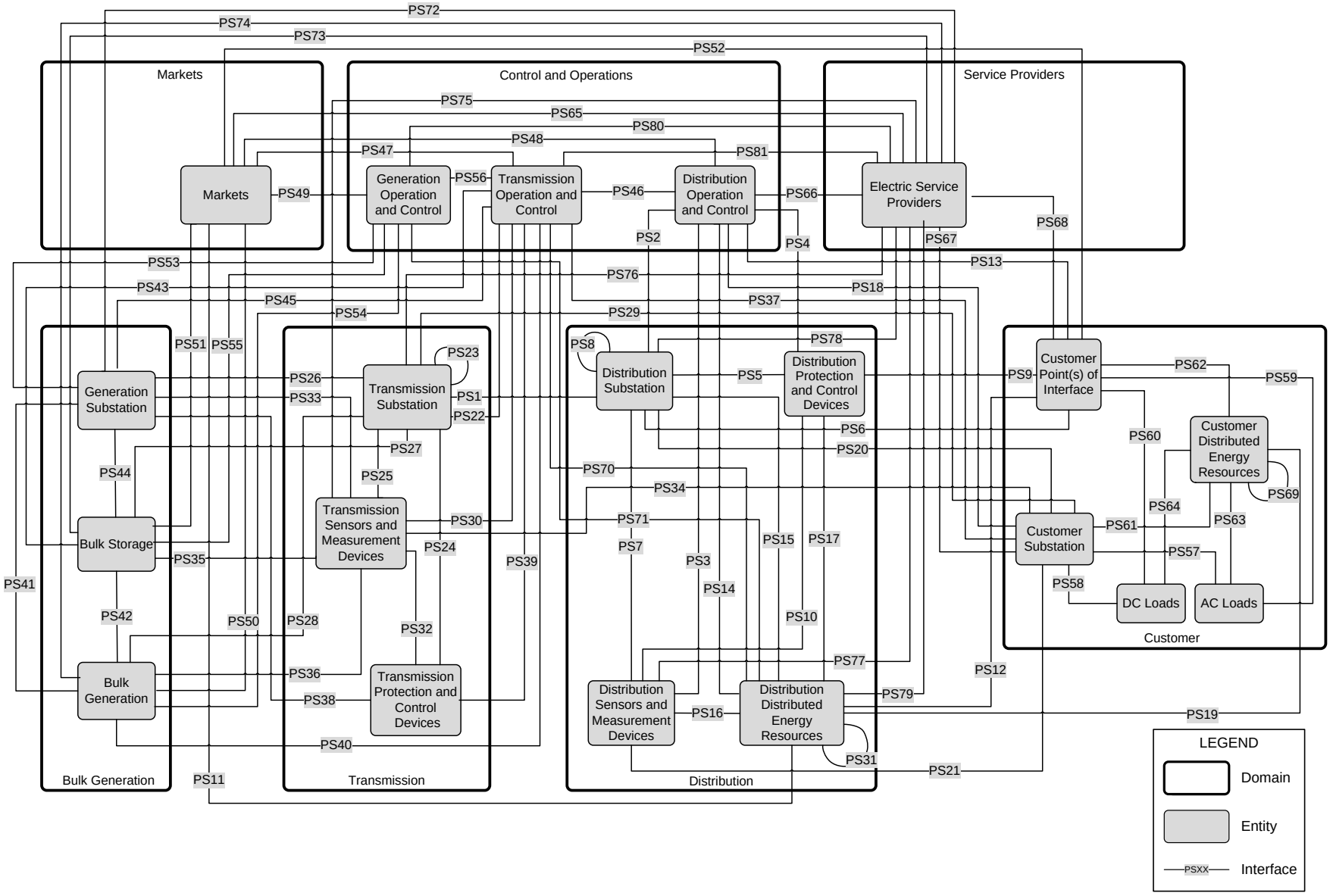
- Establishes the first systems-level consensus standard including an integrated architecture reference model
- Provides a knowledge base addressing terminology, characteristics, and smart grid functional performance.
- Establishes the Smart Grid interoperability reference model: *2030 SGIRM* -- inherently allows for extensibility, scalability, and upgradeability.
  - SGIRM defines three integrated architectural perspectives: power systems, communications technology, and information technology.
  - Emphasis is on functional interface identification, logical connections and data flows.
  - 2030 establishes design tables and classification of data flow characteristics.
  - Templates provide transparency for identification of applicable standards, protocols, communication media, security and reliability approaches, etc.

IEEE Std 2030: Power System Integrated Architectural Perspective

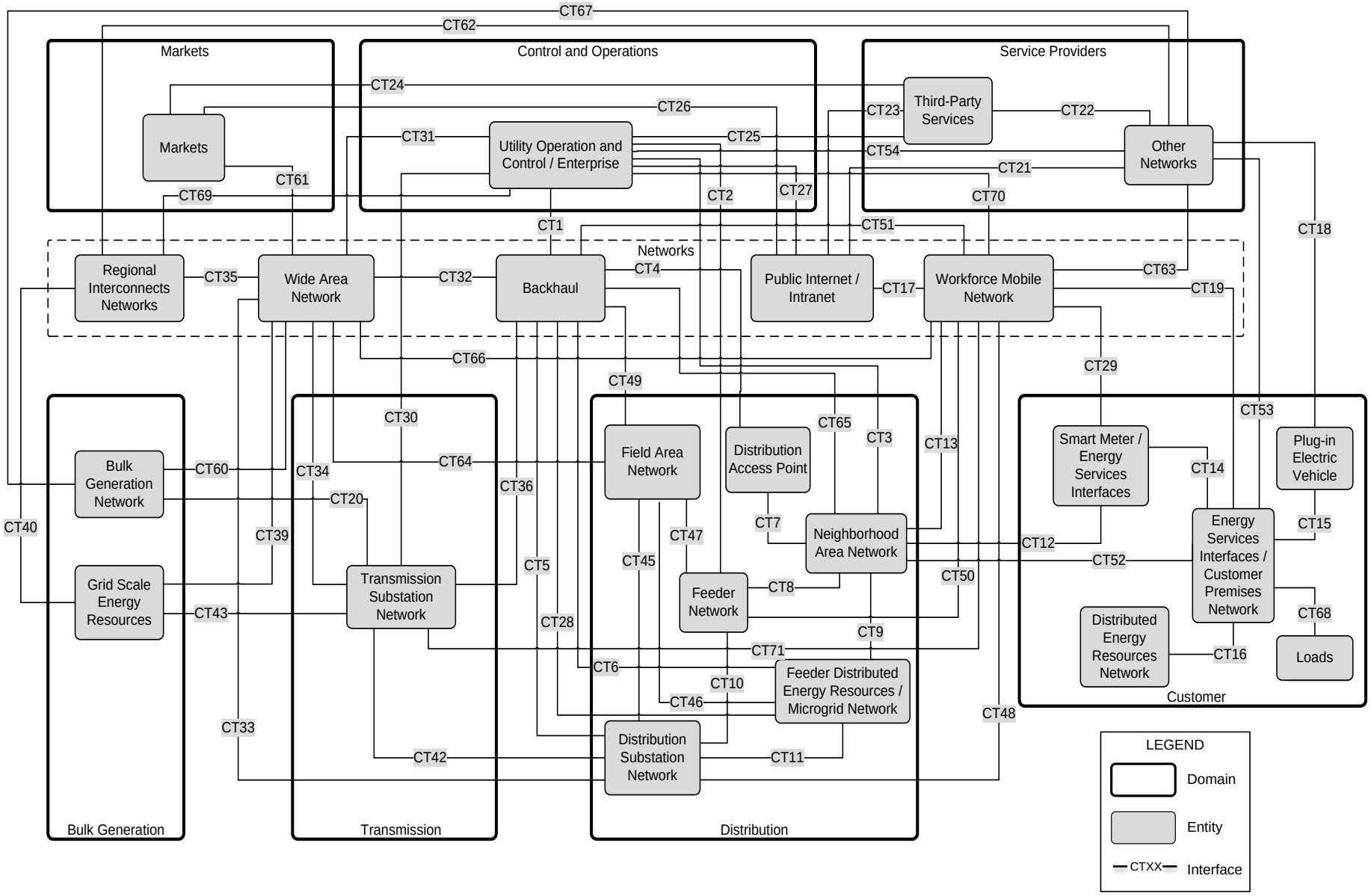
Smart Grid: the integration of power, communications, and information technologies for an improved electric power infrastructure serving loads while providing for an ongoing evolution of end-use applications. (IEEE Std 2030)

Interoperability: the capability of two or more networks, systems, devices, applications, or components to externally exchange and readily use information securely and effectively. (IEEE Std 2030)

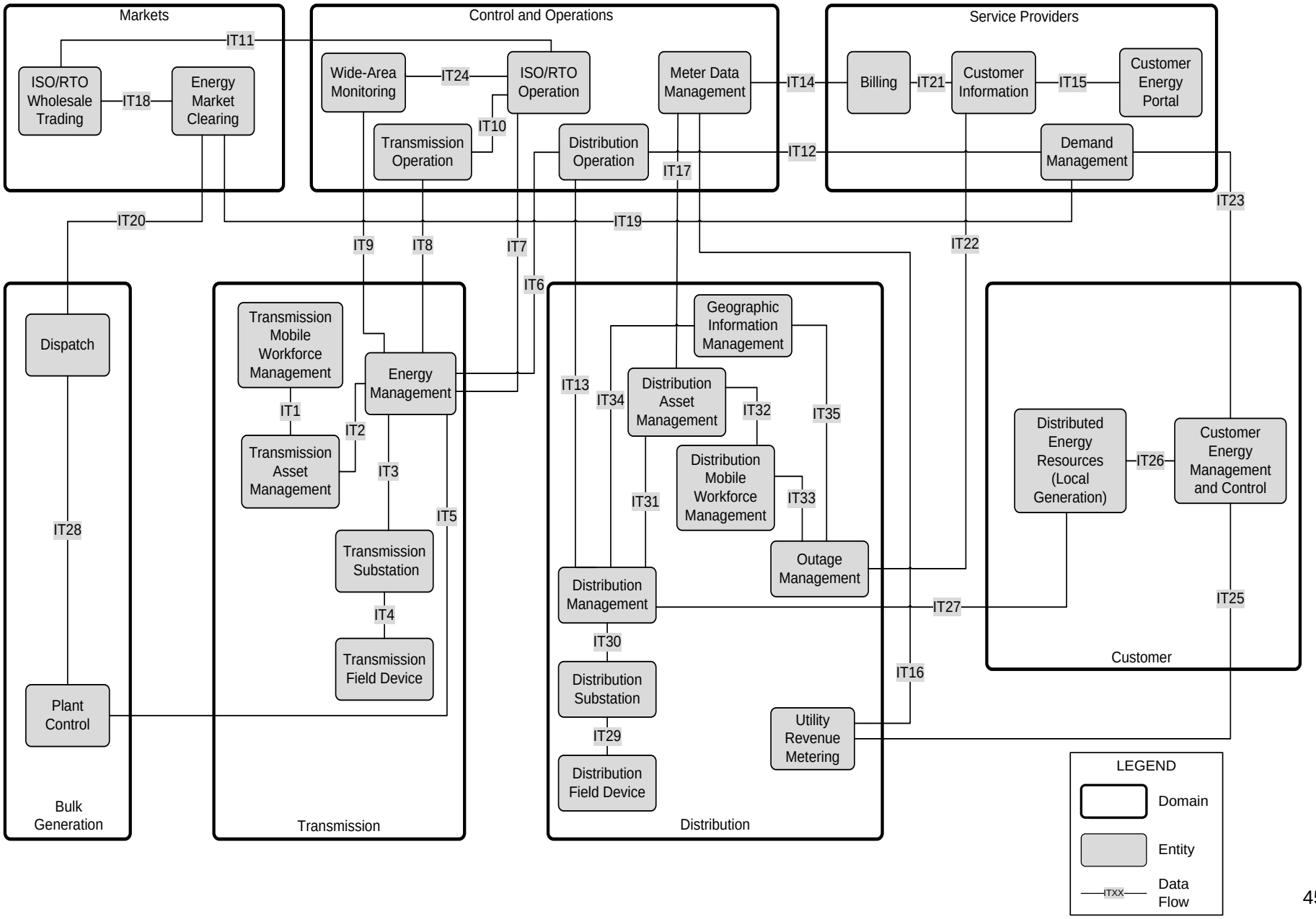
IEEE Std 2030: Power System Integrated Architectural Perspective



IEEE Std 2030 CT Integrated Architectural Perspective



IEEE Std 2030: IT Integrated Architectural Perspective



IEEE Std 2030: SGIRM Data Classification Table

IEEE 2030 Table 5-1—SGIRM data classification reference table [a]

Data characteristic	Classification/Value range			
Data use category	To be determined by the user of the table based on the intended use of the data (i.e., control data, protection data, and/or monitoring data)			
Reach	meters (feet)		kilometers (miles)	
Information transfer time	<3 ms	Between 3 ms and 10 s	Between 10 s and minutes	hours
Data occurrence interval	milliseconds	seconds	minutes	hours
Method of broadcast	Unicast	Multicast	Broadcast	All
Priority	Low	Medium	High	
Latency	Low-low (<3 ms)	Low (<16 ms)	Medium (<160 ms)	High (≥160 ms)
Synchronicity	Yes		No	
Information reliability	Informative	Important	Critical	
Availability (information reliability)	Low (limited impact)	Medium (serious impact)	High (severe or catastrophic impact)	
Level of assurance	Low	Medium	High	
HEMP, IEMI	Hardened, yes		Hardened, no	
Data volume	bytes	kilobytes	megabytes	gigabytes
Security	Low (limited impact)	Medium (serious impact)	High (severe or catastrophic impact)	
Confidentiality	Low (limited impact)	Medium (serious impact)	High (severe or catastrophic impact)	
Integrity	Low (limited impact)	Medium (serious impact)	High (severe or catastrophic impact)	
Availability (security)	Low (limited impact)	Medium (serious impact)	High (severe or catastrophic impact)	

[a] Table 5-1 is to be read from left to right, and each data characteristic listed in the left column is to be assigned one classification/value range.

P2030.2 – *Draft Guide for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure*

Scope: This document provides guidelines for **discrete and hybrid energy storage systems** that are integrated with the electric power infrastructure, including end-use applications and loads. This guide **builds upon IEEE Std 2030** Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation With The Electric Power System (EPS), and End-Use Applications and Loads.

Purpose: The purpose is to provide guidance in understanding and defining technical characteristics of energy storage systems, and how discrete or hybrid systems may be **integrated with and used compatibly as part of the electric power infrastructure**. Further, the standard fills the need for guidance relevant to a knowledge base addressing **terminology, functional performance, evaluation criteria, operations, testing, and the application of engineering principles** for energy storage systems integrated with the electric power infrastructure.

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P2030.2 – storage systems interoperability

- Extended outline established
- Implementation of IEEE Std 2030 Smart Grid interoperability reference model (SGIRM) and tools
- Initial focus includes applications for:

  -frequency regulation,

  - hybrid photovoltaic/community energy storage systems,

  - and voltage regulation.

- P2030.2 Draft 1 reviewed at May 1-2, 2012 meeting (co-located with Electricity Storage Association meeting, Washington DC)

http://grouper.ieee.org/groups/scc21/2030_2/2030_2_index.htm

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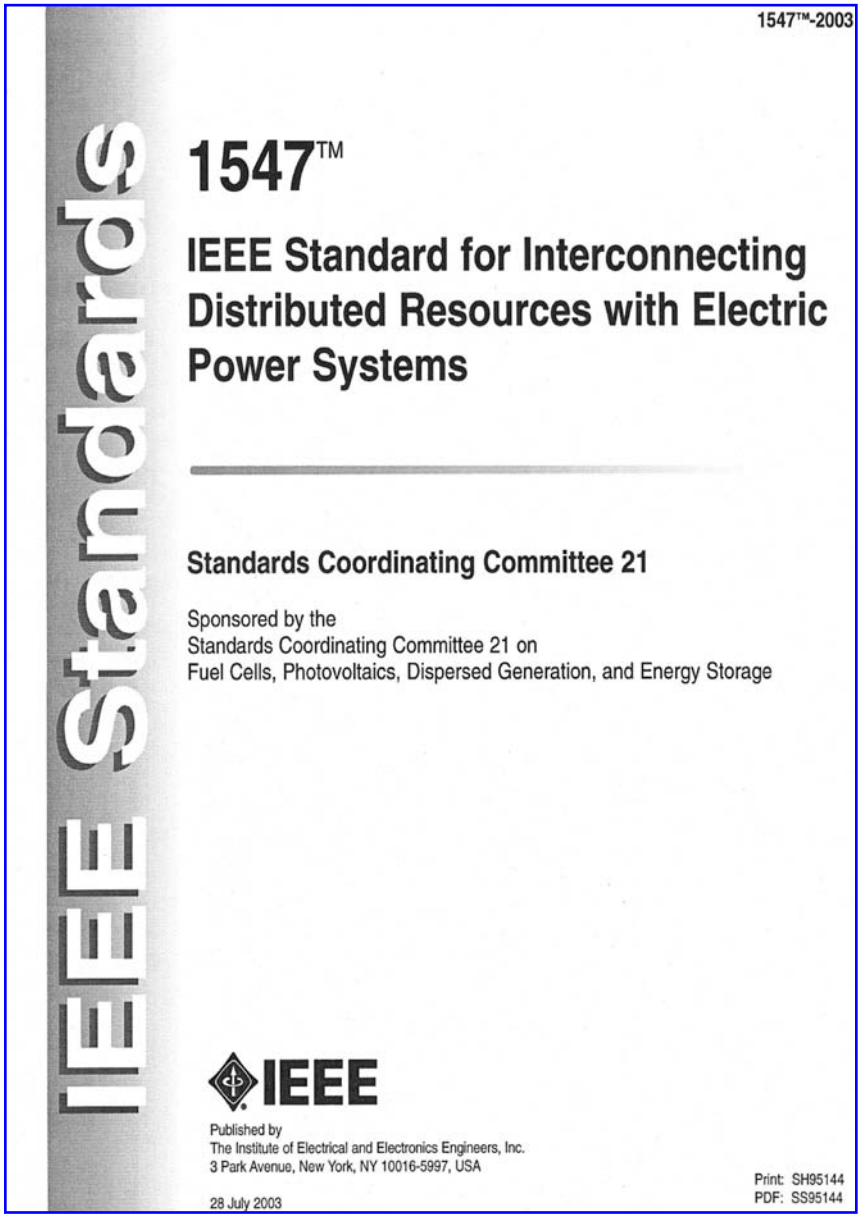
ANSI/IEEE Standard 1547 (2003, reaffirmed 2008)



1-2-3 Overview, Definitions, References

4.0 Interconnection Technical Specifications and Requirements:

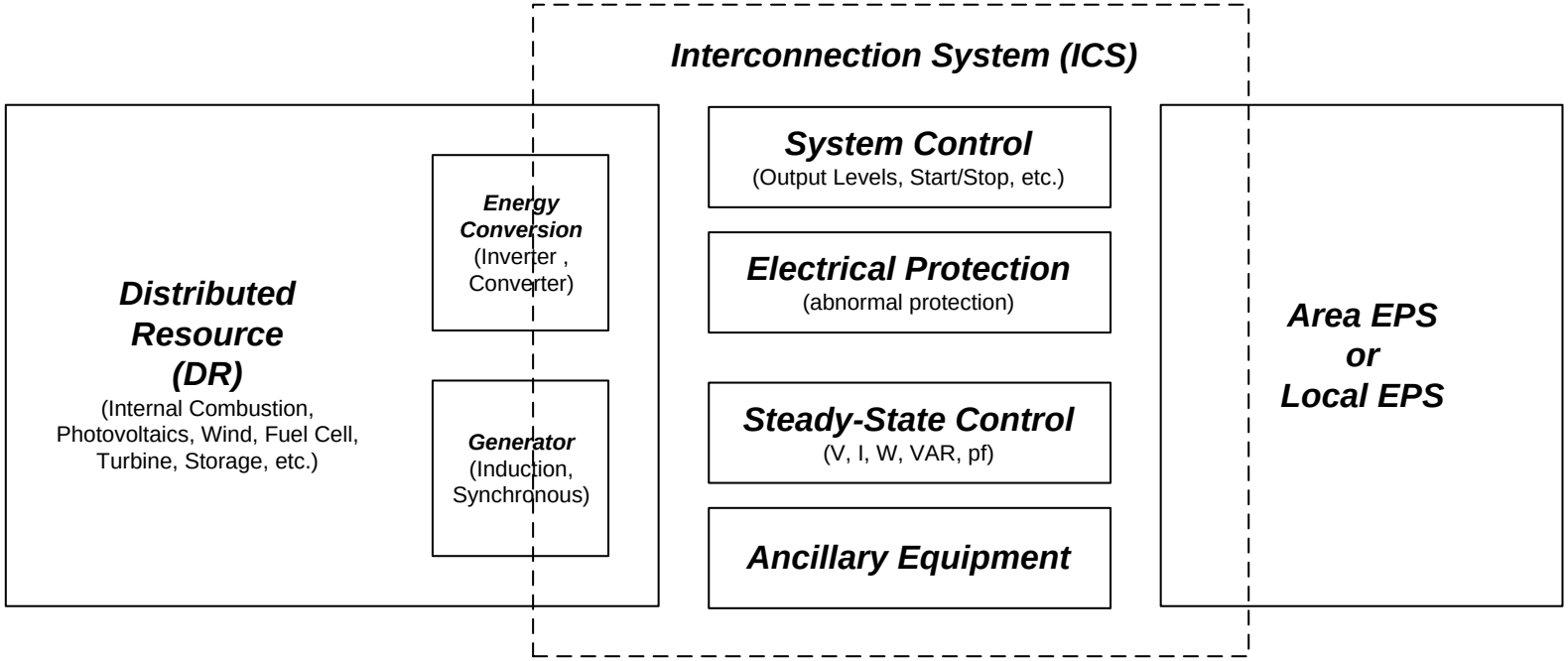
. General Requirements
. Response to Area EPS Abnormal Conditions
. Power Quality
. Islanding

5.0 Test Specifications and Requirements:

. DesignTests
. Production Tests
. Interconnection Installation Evaluation
. Commissioning Tests
. Periodic Interconnection Tests

IEEE Std 1547.1 (2005; reaffirmed 2011)

… *Standard for Conformance Test Procedures* …specifies the type, production, and commissioning tests that shall be performed to demonstrate that interconnection functions and equipment of a distributed resource (DR) conform to IEEE Std 1547.



1547.1 Figure 1 - Boundaries between the interconnection system, EPS and DR.

IEEE Std 1547.2 (application guide to IEEE 1547)

… background and rationale of {IEEE 1547} technical requirements are discussed… Presented ... are technical descriptions, schematics, applications guidance, and interconnection examples to enhance the use of IEEE 1547...

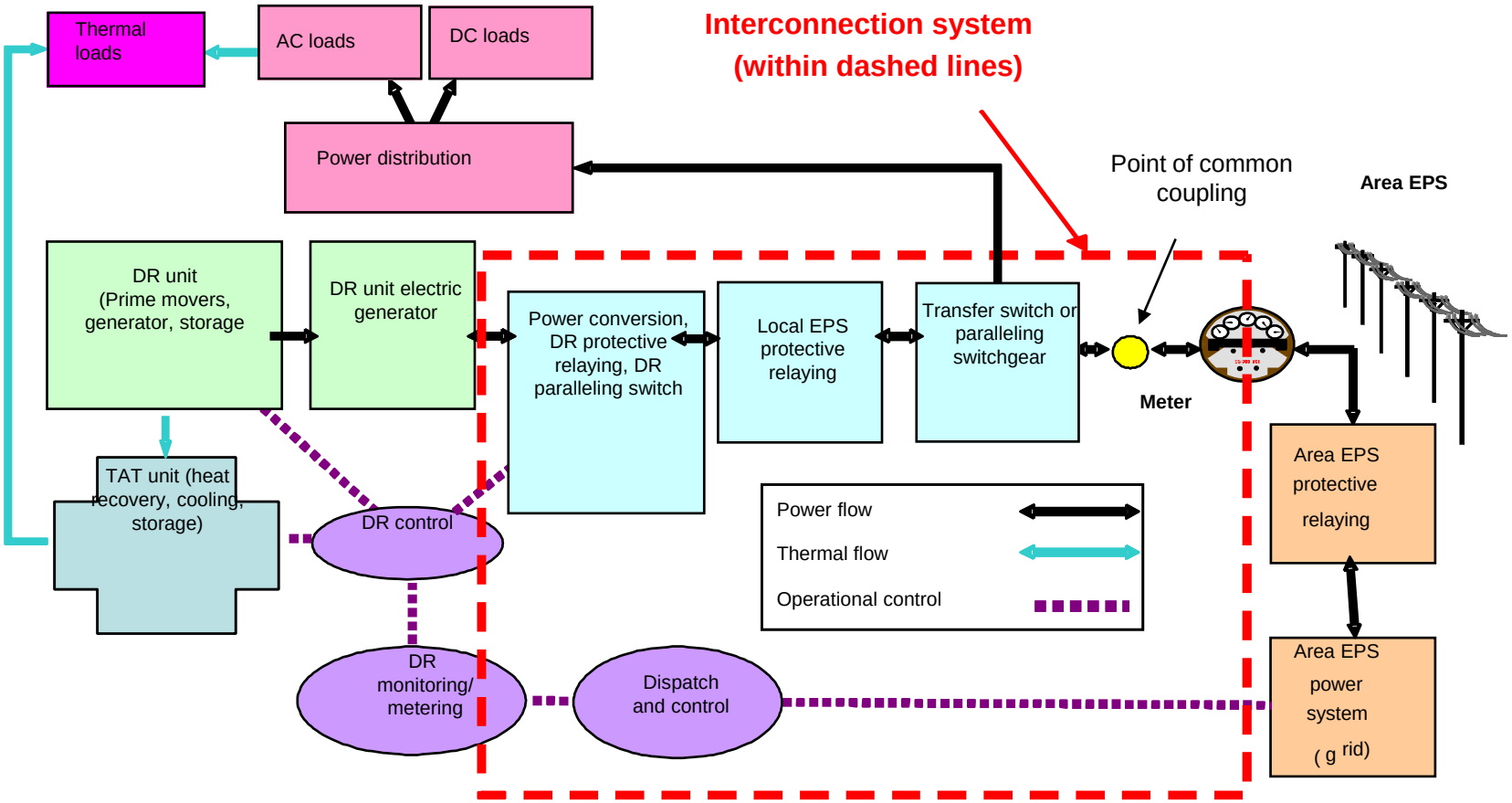


Figure A.1 – Functional diagram of an interconnection system

IEEE Std 1547.3 MIC for DR

… guidelines for MIC (monitoring, information exchange, and control) for DR (distributed resources) interconnected with electric power systems (EPS).

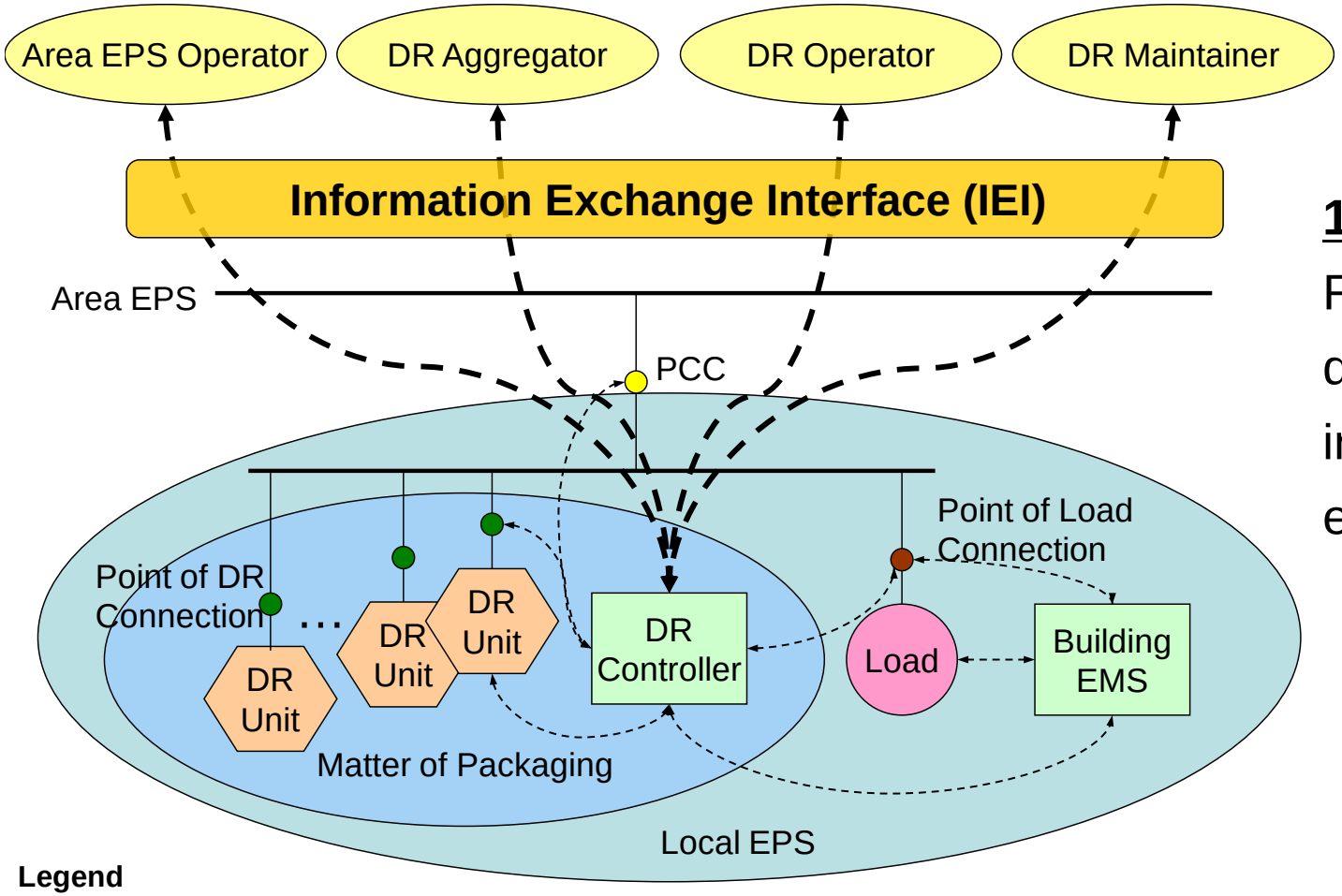
...

4. General information about monitoring, information exchange and control (MIC)
   - 4.1 Interoperability
   - 4.2 Performance
   - 4.3 Open Systems Approach
   - 4.4 Extensibility
   - 4.5 Automatic Configuration Management
   - 4.6 Information Modeling
   - 4.7 Protocols
5. Data exchange guidelines based on 4.1.6 of IEEE Std 1547
6. Business and operation processes
7. Information exchange model
8. Protocol Issues
9. Security guidelines for DR implementation

Annexes (informative)

IEEE Std 1547.3 Guide for MIC for DR

… guidelines for monitoring, information exchange, and control (MIC) for distributed resources (DR) interconnected with electric power systems (EPS).



1547.3 Figure 1
Reference diagram for information exchange.

IEEE Std 1547.4 (micro-grids/planned DER Islands)

E.g., DER (generation and energy storage) technologies are integrated with all others including the grid technologies to form **Micro-grids (planned islands**; includes – load management, voltage & VAR control, active participation, etc.)

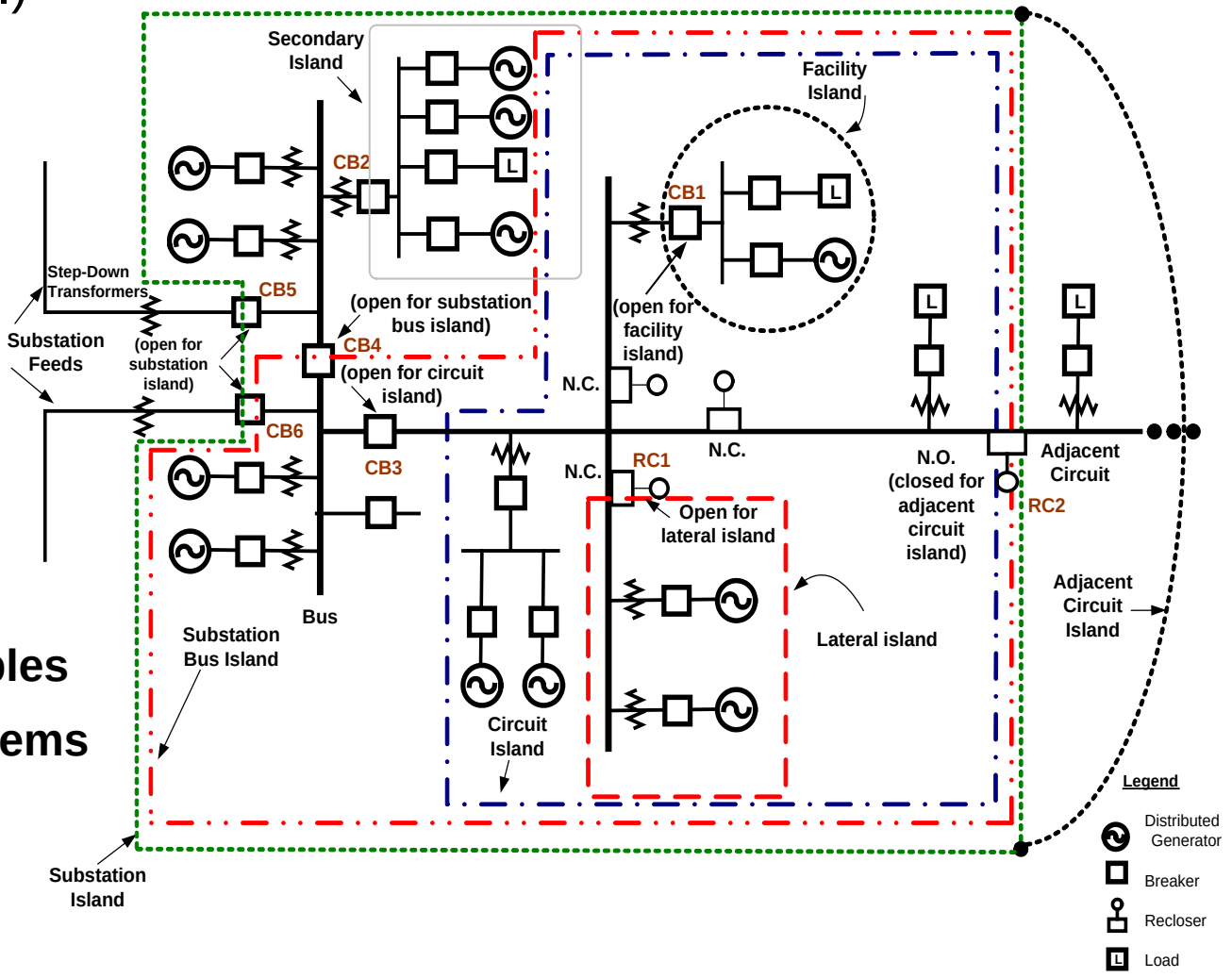


Figure 1 – Examples of DR island systems

IEEE 1547.6 (2011) Recommended Practice for Interconnecting Distributed Resources With Electric Power Systems Distribution Secondary Networks

Scope. This standard builds upon IEEE Standard 1547 for the interconnection of distributed resources (DR) to distribution secondary network systems. This standard establishes recommended criteria, requirements and tests, and provides guidance for interconnection of distribution secondary network system types of area electric power systems (Area EPS) with distributed resources (DR) providing electric power generation in local electric power systems (Local EPS).

Purpose. This standard focuses on the technical issues associated with the interconnection of Area EPS distribution secondary networks with a Local EPS having DR generation. The standard provides recommendations relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection. In this standard consideration is given to the needs of the Local EPS to be able to provide enhanced service to the DR owner loads as well as to other loads served by the network. Equally, the standard addresses the technical concerns and issues of the Area EPS. Further, this standard identifies communication and control recommendations and provides guidance on considerations that will have to be addressed for DR interconnections