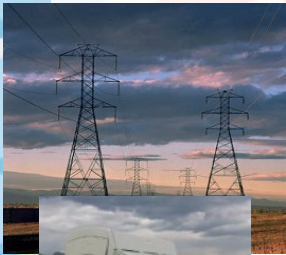




IEEE Smart Grid Series of Standards IEEE 2030™ (Interoperability) and IEEE 1547™ (Interconnection) Status

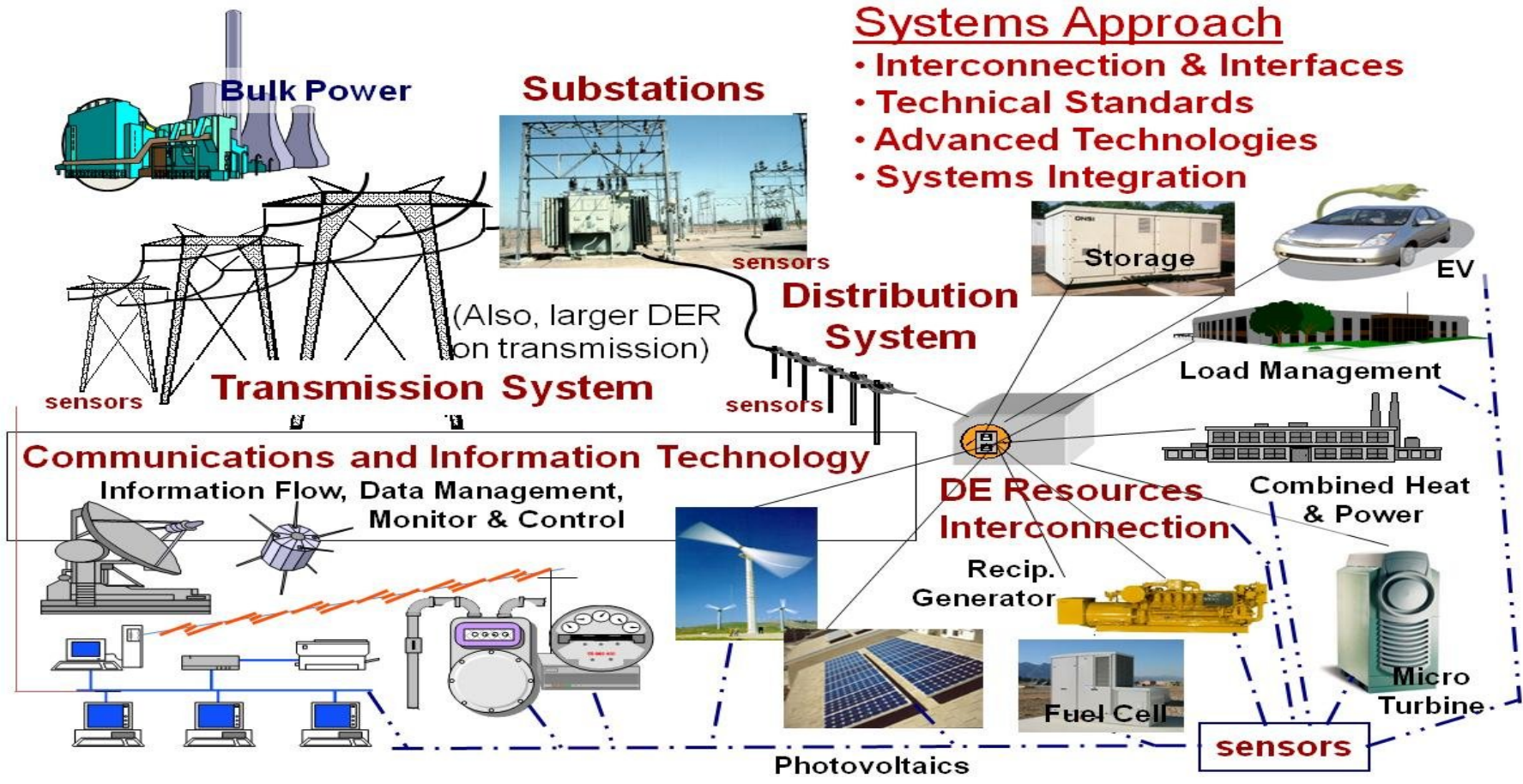
Thomas Basso

Electricity, Resources and Building Systems Integration Center,
DeBlasio, NREL Chief Engineer



Smart Grid Concepts: Interconnection and Interoperability

→ System of Systems Approach ←



- Systems Approach**
- Interconnection & Interfaces
 - Technical Standards
 - Advanced Technologies
 - Systems Integration

Smart Grid (IEEE 2030): 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.

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

Objective. To facilitate the evolution from the existing electric power system (EPS – *the grid*) into a smart grid by standards and best practices that support the advancement of smart grid technologies and implementation via standardized interconnection, integration, and interoperability requirements, conformance test procedures, operating practices, and consumer education.

Technical scope. Develop, maintain, and harmonize national and international standards and best practices for electric power system interfaces and interoperability requirements among the electric transmission and distribution systems, system markets, EPS operators, distributed energy resources (DER), customers, end-use applications and loads, including electric vehicles, energy storage and operations.

NIST Smart Grid Standards Roadmap & Interoperability Framework

NIST uses the Smart Grid Interoperability Panel (SGIP) to help develop Priority Action Plans (PAPs).

National Consensus Standards Development – IEEE standards development is 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).

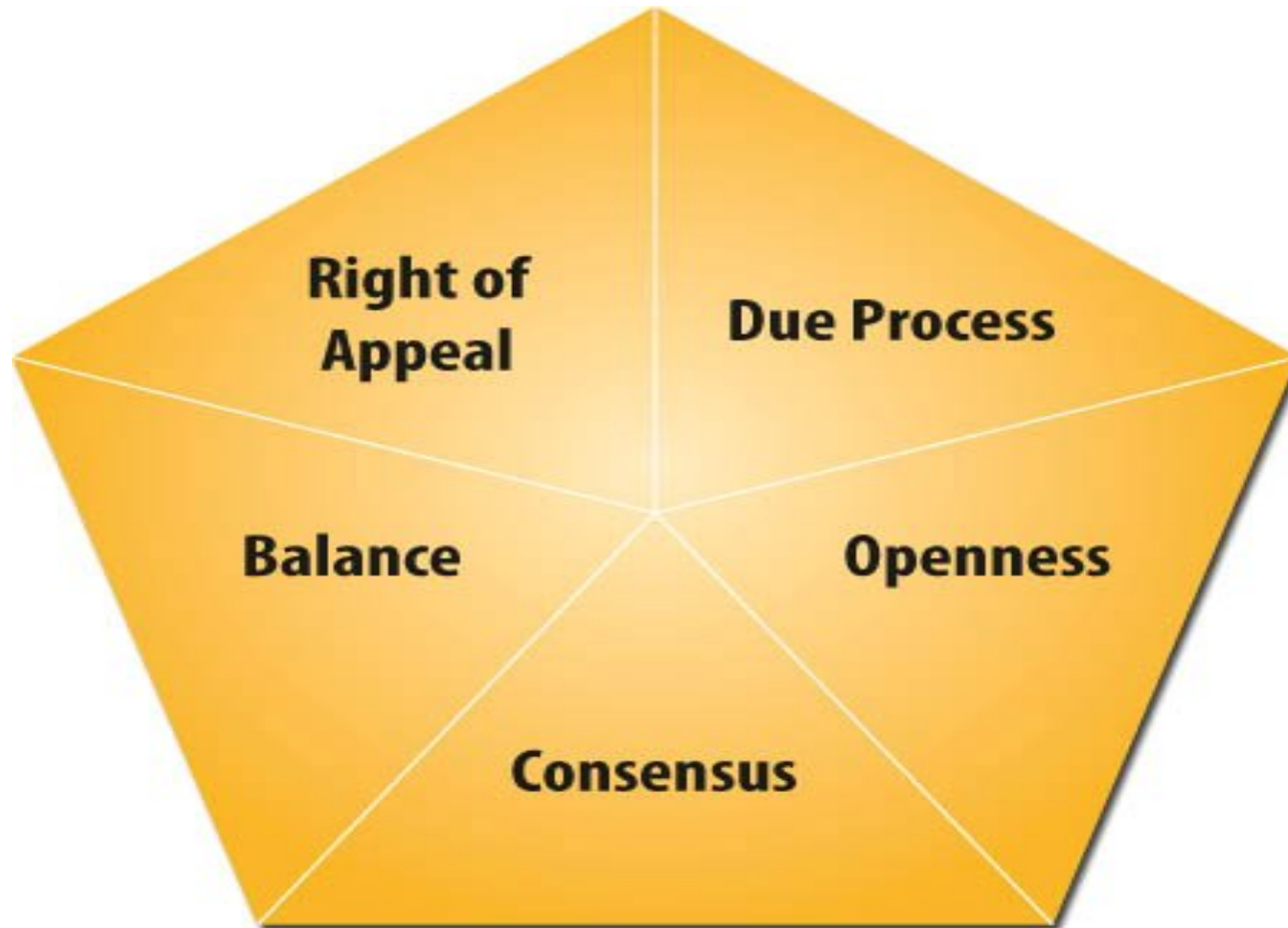
IEEE Standards Coordinating Committee 21 (IEEE SCC21):

Fuel Cells, Photovoltaics (PV), Dispersed Generation and Energy Storage – sponsors and develops 1547 interconnection and P2030 interoperability series of 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 Co-Technical Advisors: T. Basso and J. Koepfinger (IEEE Standards Board Emeritus member); in 2011, IEEE 1547 Std as IEC/IEEE dual logo Publically Available Specification (PAS).

IEEE Standards Development

Five principles guide standards development
Ensuring integrity and wide acceptance for IEEE standards



IEEE standards follow the standardization principles as stated by the WTO

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 *“Microgrids”* Distributed Resources Island Systems with Electric Power Systems

P1547.5 Draft Guidelines for Interconnection of Electric Power Sources Greater Than 10 MVA to the Power Transmission Grid

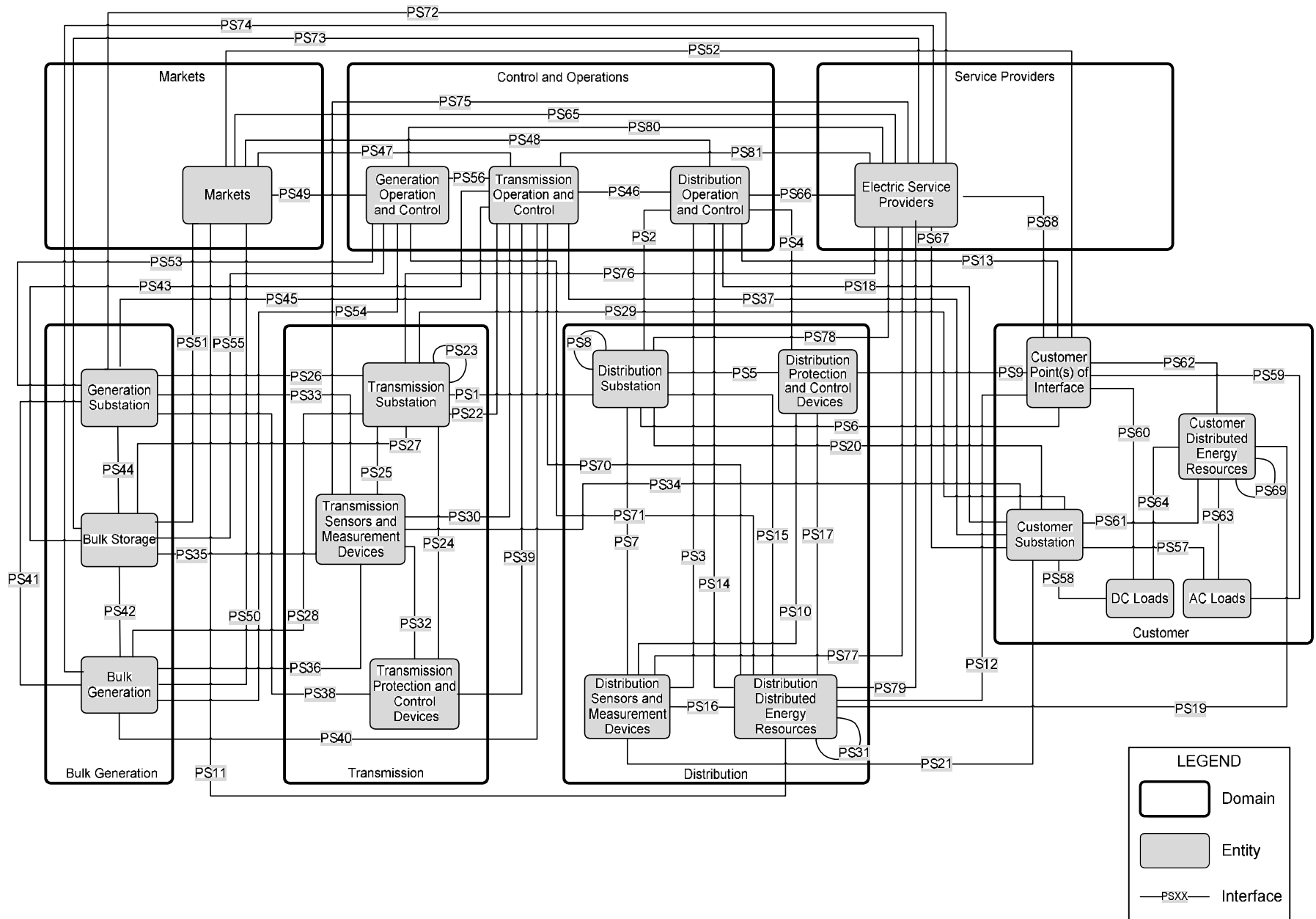
1547.6 -2011 Recommended Practice for Interconnecting Distributed Resources With Electric Power Systems Distribution Secondary Networks

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

- 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***

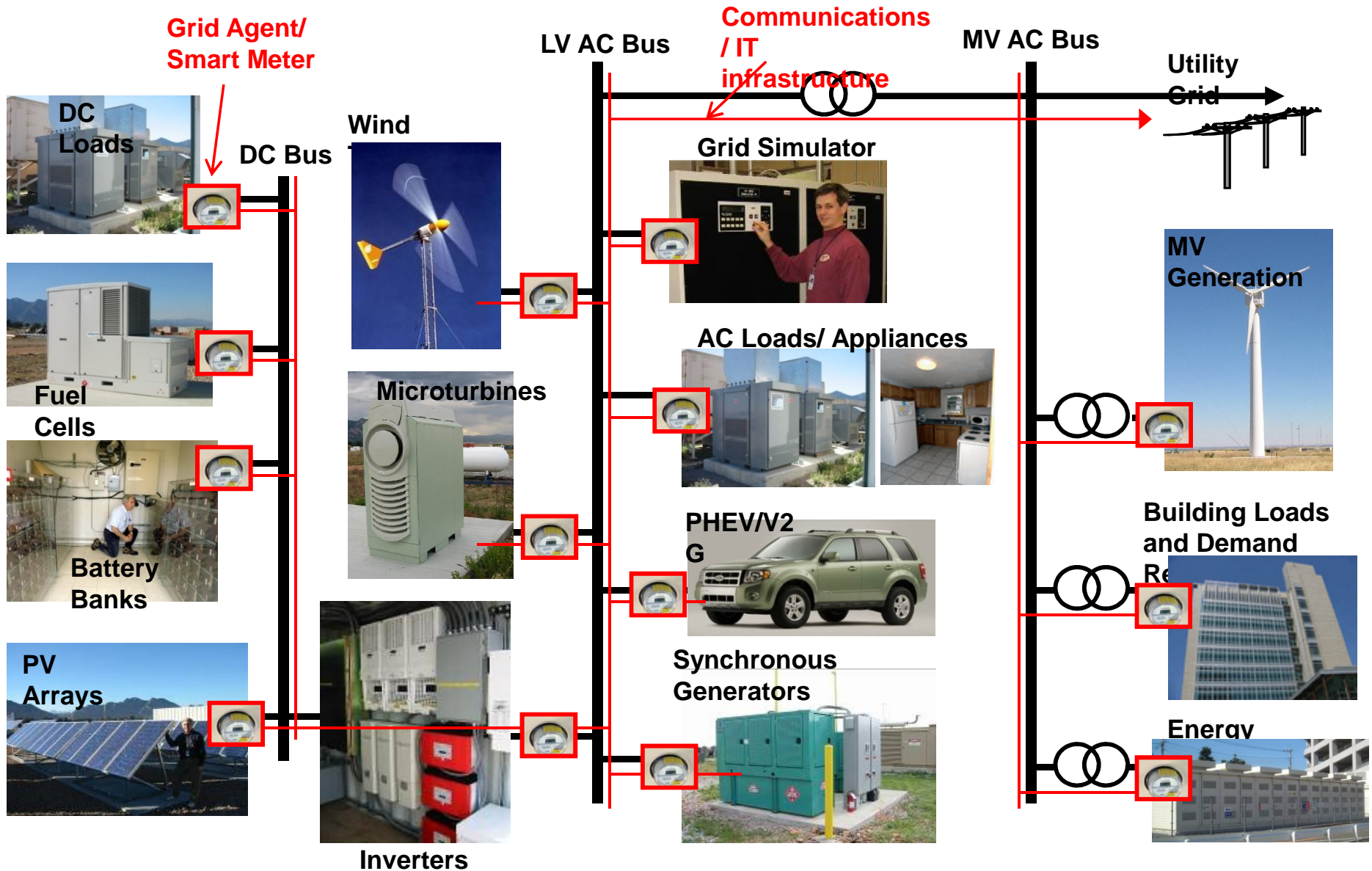
- Provides a knowledge base addressing terminology, characteristics, and smart grid functional performance.
- Establishes the Smart Grid interoperability reference model: *2030 SGIRM* -- inherently allows for extensibility, scalability, and upgradeability.
- SGIRM defines three integrated architectural 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.



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 (=160ms)
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 HEMP, IEMI	Low	Medium	High	
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.





IEEE 1547 series Background Slides Follow



1547™-2003


IEEE Standards

1547™

IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems

Standards Coordinating Committee 21

Sponsored by the
Standards Coordinating Committee 21 on
Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage



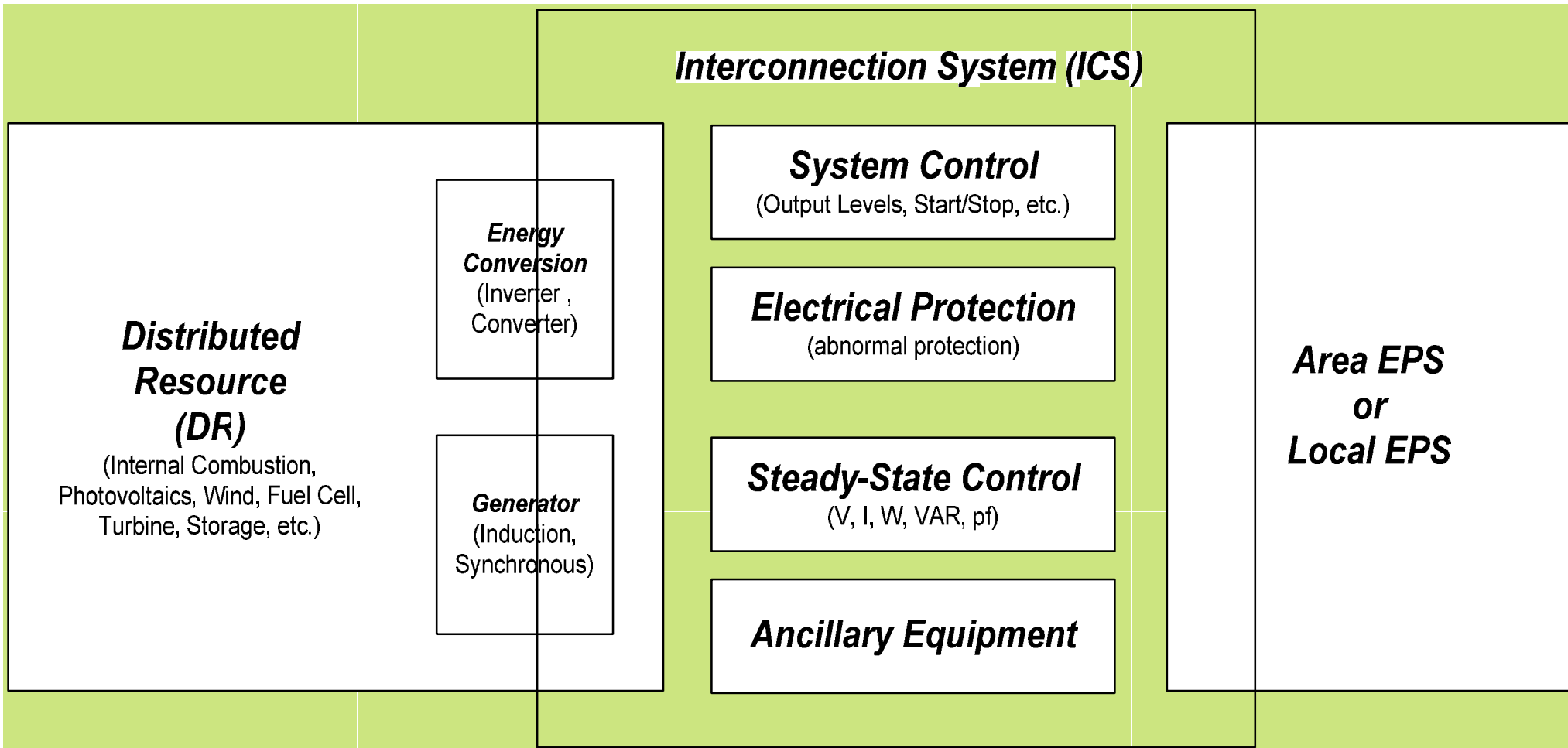
Published by
The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

28 July 2003

Print: SH95144
PDF: SS95144

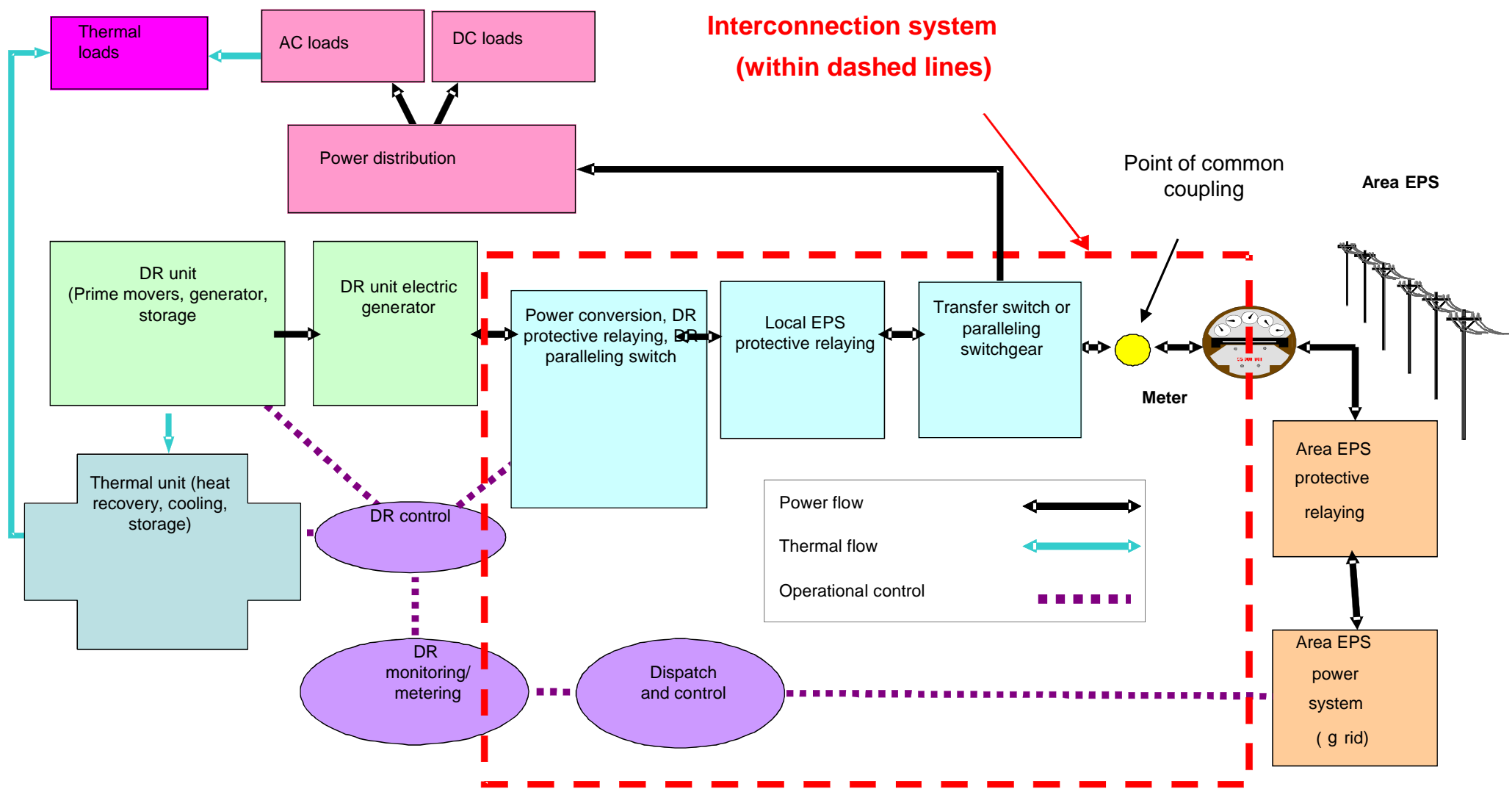
- ...
- ### 4.0 Interconnection Technical Specifications and Requirements:
- . General Requirements
 - . Response to Area EPS Abnormal Conditions
 - . Power Quality
 - . Islanding
- ### 5.0 Test Specifications and Requirements:
- . Interconnection Test
 - . Production Tests
 - . Interconnection Installation Evaluation
 - . Commissioning Tests
 - . Periodic Interconnection Tests

... **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.



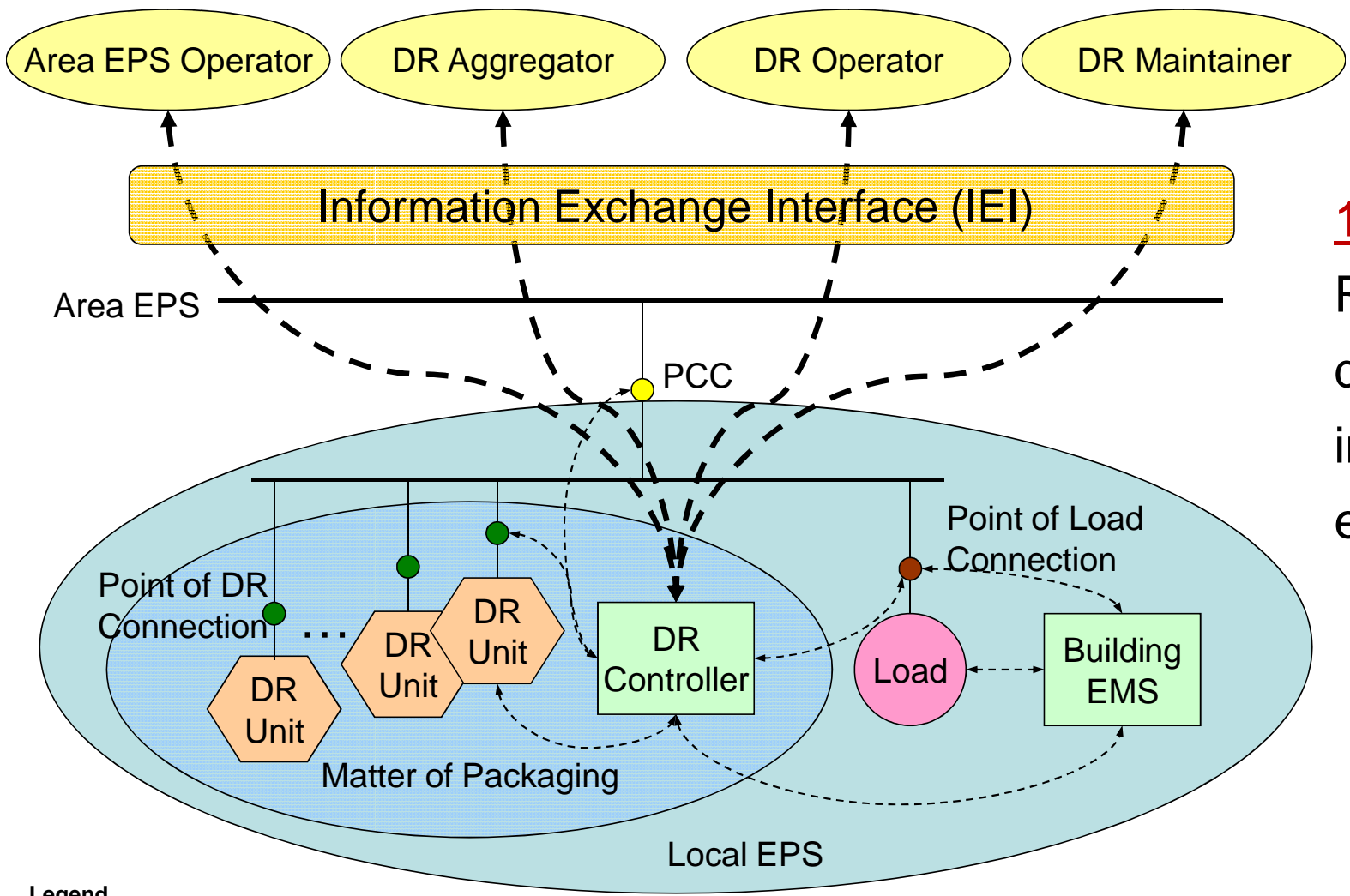
1547.1 Figure 1. Boundaries between the interconnection system, EPS and the DR.

... Annex A (informative) Interconnection system equipment



1547.2 Figure A.1 – Functional diagram of an interconnection system

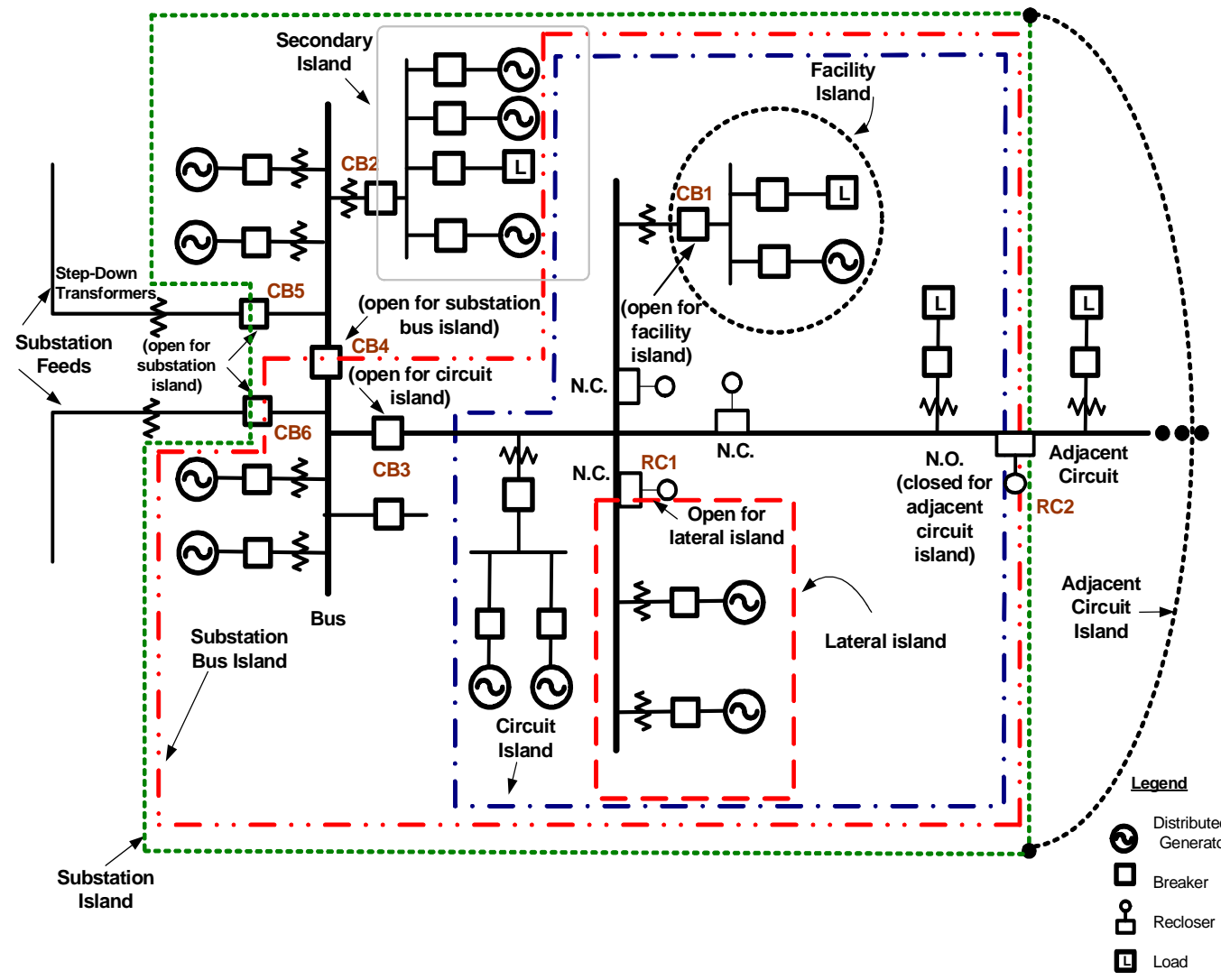
... guidelines for monitoring, information exchange, and control (MIC) for distributed resources (DR) interconnected with electric power systems (EPS).



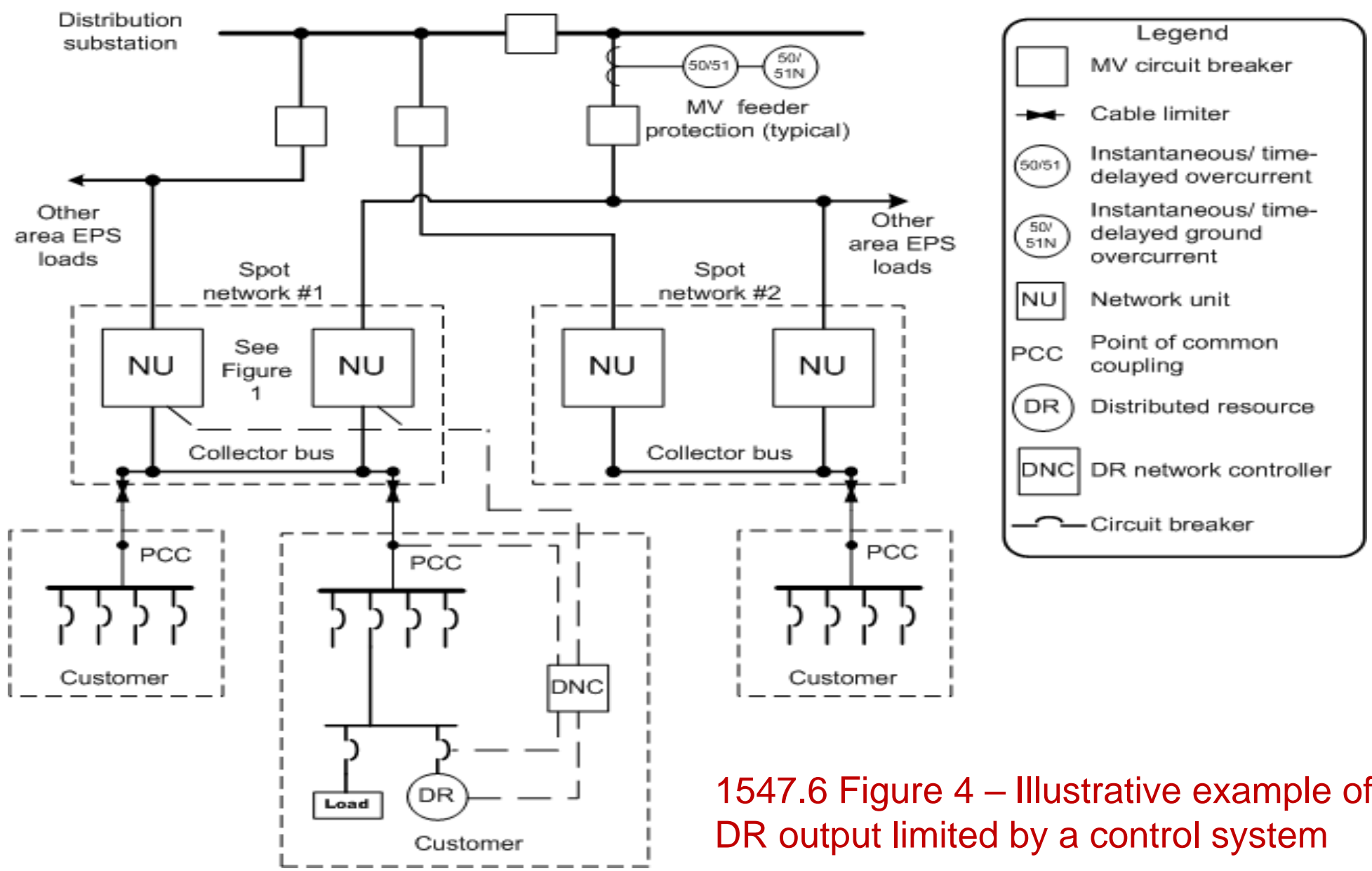
1547.3 Figure 1.
Reference diagram for information exchange.

Legend
 Interconnection Info Path (focus of this guide) - - - - -
 Local Info Path (not addressed in this guide)
 Electric Path (not addressed in this guide) _____

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.)



1547.4 Figure 1
Examples of DR island Systems

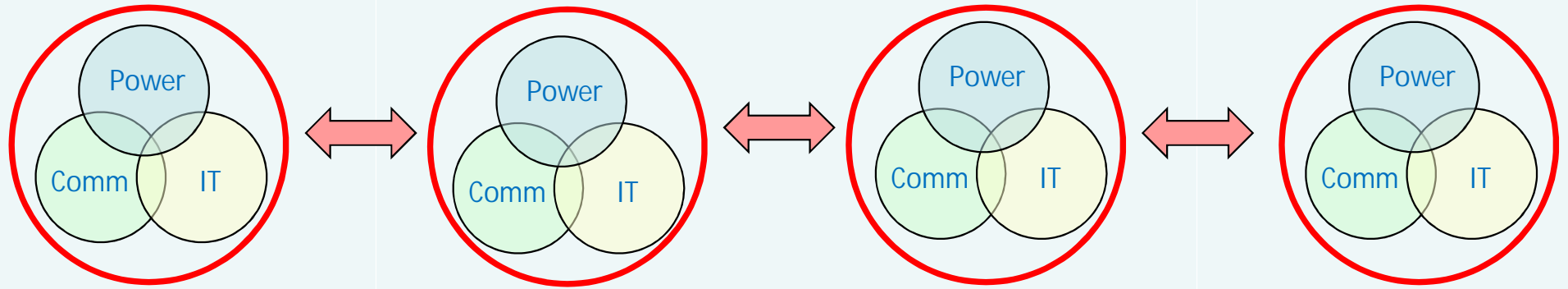


1547.6 Figure 4 – Illustrative example of DR output limited by a control system

- Describes criteria, scope, and 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.

- Capacity greater than 10 MVA
- High penetration of PV
- Vehicle to grid
- Allow active voltage regulation
- Voltage and frequency ride-through
- Better integration with utility protection coordination
 - Frequency trip settings – under/over voltage
 - Operation under fault conditions
- Switching impacts of DR
- Power quality
- Monitoring and control (SCADA, etc.)
- Dynamically controlled inverters (addresses lots of topics)
- Issues identified by IEEE Std 2030

Smart Grid (system of systems) Interoperability



Smart Grid Device Interoperability



➤ **Thomas Basso**

Senior Engineer, Electricity, Resources, & Buildings Systems Integration Center, NREL*; IEEE SCC21 Vice Chair; Co-Chair P1547.8; Secretary 2030; 1547; 1547.2; 1547.3; P1547.4; P1547.6; P1547.7; IEC/USTAG/TC8 Chair and Technical Advisor

Email: Thomas.Basso@nrel.gov; Phone: (303) 275-3753

➤ **Dick DeBlasio**

NREL* Chief Engineer; IEEE Board of Governors; Chair IEEE SCC21, 2030, 1547; IEEE Standards Board Liaison to DOE; Standards Board IEEE Smart Grid Standards Contact and Liaison to NIST

Email: Dick.DeBlasio@nrel.gov; Phone: (303) 275-4333

➤ **Benjamin Kroposki**

NREL* Executive Director, Energy Systems Integration; IEEE Chair 1547.4, and Secretary 1547.1

Email: Benjamin.Kroposki@nrel.gov; Phone (303) 275-2979

➤ **The National Renewable Energy Laboratory** (www.nrel.gov)

1617 Cole Blvd., MS 3503

Denver, Colorado 80401-3393

➤ **IEEE SCC21 -- IEEE Standards Coordinating Committee 21 on Fuel Cells, Photovoltaics, Dispersed Generation, & Energy Storage** (<http://grouper.ieee.org/groups/scc21/>)

- IEEE Std 1547 Interconnection Series of Standards
- IEEE Std 2030 Smart Grid Interoperability Series of Standards
- IEEE American National Standards for Photovoltaics