Interconnection Standards
Development and Regional Implementation of IEEE 1547 Standards

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Contributing to OE RDSI Key Performance Improvements

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DOE, OE and RDSI Goals and Focus

• DOE Goal - Energy Infrastructure: Create a more flexible, more reliable, and higher capacity U.S. energy infrastructure.

• OE: Lead national efforts to modernize the electric grid, enhance security and reliability of the energy infrastructure, and facilitate recovery from disruptions to the energy supply.

• RDSI: focuses on integrating renewable energy, distributed generation, energy storage, thermally activated technologies, and demand response into electric system planning and operations.
RDSI Goals and Metrics (OE R&D Division Strategic Plan 9/07)

By 2012, complete development of IEEE 1547 series of standards, with DG islanding applications verified and validated by 2015:

- Develop interconnection equipment reliability database and tools for renewable and distributed systems integration and interoperability by FY2010.


- Complete IEEE P1547.4 - Guide to islanding DG with the grid by FY2011, with recommended design topologies, equipment for grid operational configurations

- Revise American National Standard IEEE 1547 Interconnection of DR with the Electric Power System (or extension to next generation document) by FY2012.

- Develop recommendations for interconnection systems improvements and cost reduction by FY2012

- Verify and validate the application of distributed energy systems for safe, secure, and cost-effective “islanding” operations while in compliance to 1547.4 by FY2015.
Project Objectives and Approach

Objectives are to develop and harmonize states, regional, national and international standards and their implementation for interconnection and integration of distributed resources (DR) and electric power systems and to help develop modern technologies, smart grid, and operations for integration, interface and interconnection with electric power systems and local loads.

Approach — systems, interfaces, interconnection, & integration:
- IEEE American National Standards (consensus, industry driven partnerships, balanced stakeholder participation);
- IEC (International Electrotechnical Committee) standards;
- States, regional, national and international implementation;
- Coordination/collaboration across DOE programs and tasks;
- Support IEA Task related activities.
Project Approach: Standards and Implementation for Advanced Technologies and Infrastructure Modernization

E.g., 2005 EPACT and 2007 EISA

NREL can’t do it alone ... Making connections with partners is crucial for success – Consensus Counts
Standards Development Approach

• **IEEE American National Standards** -- national consensus standards established via industry driven partnerships; balanced stakeholder participation.

• **IEEE SCC21 Fuel Cells, Photovoltaics, Dispersed Generation and Energy Storage** – sponsors and develops standards: Chair - R. DeBlasio (also IEEE Standards Board Liaison to DOE).

• **IEEE Smart Grid** Interoperability Framework (2007 EISA section 1305) IEEE point of contact R. DeBlasio.

• **Harmonization** of IEEE SCC21 national and international standards - International Electro-technical Commission IEC/TC8 *System Aspects of Electrical Energy Supply* (TC8 facilitates functioning of electricity supply systems; encompasses T&D including interfaces with users).

• **US/Technical Advisory Group/TC8** managed by NREL; Co-Technical Advisors are J. Koepfinger & T. Basso.
2008 Results: 1547 Related

- Led and managed reaffirmation of IEEE Std 1547 (181 ballot pool);
- Managed completion of new (2009 publication) IEEE Std 1547.2 (guide to 1547; Chair R. Saint, National Rural Electric Coop Association, Vice Chair D. Bassett, PPL utility; Sect’y. T. Basso, NREL; 218 ballot pool);
- Managed completion of new (2007) IEEE Std 1547.3 (guide for DR communications; Chair F. Goodman, EPRI; Vice Chair J. Koepfinger, retired Duquesne Power; Sect’y T. Basso, NREL; 103 ballot pool);
- Led development of IEEE P1547.4 (Draft 5 - microgrids/planned islands; Chair: B. Kroposki and Secretary T. Basso, NREL; 65 members).
- Managed development of IEEE P1547.6 (Draft 3 - DR on networks; Chair J. Koepfinger, IEEE Standards Board Emeritus Member; Vice Chair J. Bzura, National Grid; Secretary T. Basso, NREL; 55 members).
- Established new P1547.x std project (DR system impacts on distribution).
- Achieved NEC 2008 new Article 705 requiring interconnection equipment be suitable for its intended use per IEEE Std 1547, 1547.1, and UL1741.
- PJM LLC references IEEE 1547 and 1547.1 as technical requirements for PJM interconnection standards (0–10 MVA and for 10-to-20 MVA).
2008 Results: Harmonize States, Regional, National, and International Standards and Their Implementation

- USA expert in IEA Task 17 (DSM and RE Integration).
- Initiated IEC/IEEE 1547 dual-logo consideration; initial IEC comments received.
- Supported state 1547/best practices activities (2005 EPACT Sec. 1254 *Interconnection*) - participated in DC, DE, FL, IL, MD, MI, NM, NY, OR, SD, and UT.
  - Six interconnection rules supported rank in top seven as being most progressive in encouraging small, clean DG: IL (first), NJ, PA, NM, MD, MA, and OR (per Network for New Energy Choices).
- Participated in FERC, MADRI, MISO and PJM regional interconnection and 1547 implementation activities.
- Supported DOE OE-EERE (e.g., solar) coordination, such as joint statement “Distributed Energy Interconnection Procedures Best Practices for Consideration”
State Implementation of Interconnection
American National Standard *IEEE 1547*

States supported 2007 - 2008:
DC, DE, FL, MD, IL, NM, NY, OR, SD and UT
2008 Results: Interoperability & Smart Grid

- IEEE Standards Board appointed R. DeBlasio (NREL) as IEEE Smart Grid Lead and Point of Contact for smart grid interoperability standards development and all IEEE Smart Grid related activities. (Also, see 2007 Energy Independence & Security Act SEC.1305 Smart Grid Interoperability Framework; and see NIST Domain Expert Working Groups charged to identify use cases, key standards, standards gaps, for inclusion in the future Smart Grid Standards Interoperability Roadmap: Building-to-Grid (B2G), Industrial-to-Grid (I2G), Home-to-Grid (H2G), Transmission and Distribution (T&D), and Vehicle to Grid (V2G) [NIST EISA Smart Grid Coordination Plan6/2/08 www.nist.gov/smartgrid/ ]

- IEEE Smart Grid Ad-hoc Committee established for standards and related activities -- includes industry and IEEE entity representation (see next slide).
2008 Results: IEEE supporting 2007 EISA Smart Grid Interoperability Framework - NIST

• IEEE Power and Energy Society POC - S. Pullins, Secretary, Intelligent Grid Coordinating Committee;
• IEEE Computer Society POC – J. Waltz, IEEE CS/VP;
• Members at large to date: S. Sciacca (CEO/Microsol); J.Pace, G. Flammer, J.Ramasastray (Silver Spring Networks); C.Knudsen (PG&E); P.Slack/G.Casio (FPL); B.Heile (chair IEEE 802.15); G.Mulligan (chair – 6LoWPAN); A.Gelman (CTO/ NETovations); C.Adams (IBM Program Director Stds); L.Kotewa (SCC31/Community Energy); J.Koepfinger (Standards Board Emeritus); B.Grow (IEEE Standards Board Chair/Intel, Corp.); S.Mills (Hewlett-Packard Company); J.P. Faure (P1901 chair); T.Basso (SCC21 Representative – NREL staff); and C.Tom (IEEE Stds Office).
2009 Plans and Expectations

Focus includes interconnection, interoperability, smart grid and plug-in hybrid electric vehicles (PHEV) to advance technology development, deployment & grid modernization.

- Provide USA leadership for IEC/IEEE dual logo for 1547;
- IEC/USTAG/TC8: manage US technical advisory group and participate in next TC8 meeting in Sao Paulo Brazil.
- Ongoing participation as USA expert to IEA Task 17;
- Provide targeted collaboration with DOE EERE regarding interconnection, integration, smart grid, and EERE technologies, deployments, and related efforts.
- Support USA priority standards, implementation and harmonization activities, e.g., utility scale renewable DR to be more significant; PJM & others may use IEEE 1547.2; states may revisit best practices; national, and international synergism; increasing smart grid activities.
2009 Plans and Expectations (cont’d)

• Manage new P1547.x guide for DR distribution system impacts consensus development - inaugural meeting this winter (e.g., grid support, distribution automation, loads, etc.);
• Lead development toward ballot ready draft for IEEE P1547.4 (guide for DR island systems) in FY 2009 and ballot completion in 2010;
• Lead development toward ballot ready draft for IEEE P1547.6 (DR on distribution secondary grid networks) in FY2009 and ballot completion in 2010;
• Lead development of new IEEE standards project for a PHEV IEEE interconnection guide (OE, EERE Transportation Program, other national labs, etc.);
• Increased development and harmonization activities (web and in-person), e.g., DR grid-support, islanding, networks, communications, etc.
2009 Plans: e.g., IEEE PHEV (V2G) stds projects

Potential IEEE and IEEE SCC21 standards projects for EV Interconnection with the electric grid based on IEEE 1547:

• Guide for EV Interconnectivity to the Electric Grid- IEEE P1547.xx

• Standard for EV Interconnectivity to the Electric Grid - Functional Requirements - IEEE P1547.xx

• Standard for EV Interconnectivity to the Electric Grid - Validation Tests of Functional Requirements - IEEE P1547.xx
Technology Transfer, Collaboration, Partnerships, Publications and Presentations (also see prior slides)

- IEEE 1547 series & SCC21 *Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage*
  - Industry driven, open, consensus partnerships
  - Each SCC21/1547 project per year: 2-to-3 meetings & 2-to-3 major draft revisions;
  - SCC21 new liaison with NERC standards group
- Smart Grid IEEE point of contact for all IEEE standards development and related activities, e.g., established IEEE Smart Grid Ad-Hoc Group;
- IEEE Standards Board Liaison to DOE;
- State PUCs, CEC, workshops, regional ISOs, etc.
- US/TAG for IEC Technical Committee 8 *System Aspects of Electricity Supply Systems*;
- IEA Task 17 (DSM and RE Integration);
- OE-EERE technology related.
Technology Transfer, … Partnerships, Publication (cont’d1)

• “Status of IEEE SCC21 1547…” EPRI Power Quality Applications and Advanced Distribution Automation Conference; T. Basso, R. DeBlasio (various similar presentations at other conferences and workshops);
• Utilities: Southern Cal Edison; SMUD; PG&E, National Grid; DECO; FPL; Xcel; EPRI; National Rural Electric Coops; etc.
• Manufacturers: Siemens; Westinghouse; GE; Eaton; Basler; ASCO; SEL; NEMA; EGSA; etc.
• FERC; NERC; PJM; MISO; WECC; Mid Atlantic Distributed Resources Initiative; Hawaii Clean Energy Initiative; etc.
• Underwriters Laboratories; Canadian Standards Association; IEC (and beyond TC8); India Ministry of Power; Tokyo Electric Power Company; other foreign national entities.
Technology Transfer, … Partnerships, Publications … (cont’d2)

• “Automated Energy Distribution and Reliability System: Final Report” NIPSCO (e.g., 1547 series development support);
• “DG System-Utility Grid Interconnection and Operation: Status Report” NiSource Energy Technologies, Inc. (e.g., 1547 series development support, and report of their experiences with interconnection).
• IEA Task 17 reports:
  – The Country Questionnaire for the U.S.A.
  – United States Country Report on DG, RES, DR/DSM
  – Six (6) case studies of projects in the U.S.A.
Second International Conference on the Integration of Renewable Energy Sources and Distributed Energy Resources:
- “Standards Testing Protocols, Opportunity for Round-Robin Testing and Inter-Laboratory Conformity Assessment” T. Basso, workshop;
- “DER Interconnection Standards, Requirements, & Certification” (workshop);
- “Small Generator Interconnection in Regional Transmission Organization Operations -- Success Stories from North America” presentation J. Burdis (PJM) and T. Basso (NREL).

OE-EERE Solar Energy Technologies Related:
- “High-Penetration, Grid-Connected PV Technology Codes and Standards” (T. Basso, NREL publications at www.nrel.gov )
- “Utility-Interconnected PV Systems: Evaluating the Rationale for the Utility-Accessible External Disconnect Switch” M. Coddington, NREL; and presented at states interconnection workshops and at 33rd IEEE Photovoltaic Specialist Conference;
Moving Forward -- we need to address: smart grid interoperability; load/DER/grid integration; impacts solutions; modeling; advanced interconnections and grid support; qualified grids; etc.

**DER Electrical Integration**

- **AC Loads**
- **DC Loads**
- **Power Distribution**
- **DE Unit (prime movers, generator, storage)**
- **Thermal Unit (heat recovery, cooling, storage)**
- **DER control**
- **DER monitoring/metering**
- **Power Conversion, DE Protective Relaying, DE Paralleling Switch**
- **Local EPS Protective Relaying**
- **Transfer Switch or Paralleling Switchgear**
- **Dispatch and control**
- **Power Flow**
- **Thermal Flow**
- **Operational Control**

**Interconnection System**

**Distribution System**

- **Point of Common Coupling**
- **Meter**
- **Area EPS Protective Relaying**
- **Area EPS Power System (grid)**
In Closing

- Smart grid standards will extend across the entire grid, i.e., need interoperability standards (top down) and building block standards (bottoms up).
- Smart grid equipment standards will be needed to handle information data management, communications, monitoring and control.
- Flexible smart grid system interoperability design and operational standards will allow near term and long term smart grid evolution.

Development of a body of interoperability
Smart Grid Standards needs to be initiated now.
Contact Information

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

• **IEEE SCC21** PV and Battery/Energy Storage Standards
  http://grouper.ieee.org/groups/scc21/pv/index.html

• **IEEE Std 1547** Series of Interconnection Standards --
  http://grouper.ieee.org/groups/scc21/dr_shared/