



NREL DER Program Activities and P1547 - SCC21 Interconnection Standards Development Status

**Presented at the Power Electronics for Fuel Cells
Workshop
August 8, 2002 National Fuel Cell Research Center
University of California, Irvine
Irvine, California**

**Dick DeBlasio
NREL DER Technology Manager
IEEE SCC21/P1547 Chair and Standards Board Member**



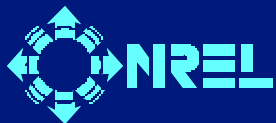
NREL DER Program Activities

The Distributed Power Program conducts RD&D on interconnection and system integration technologies and on regulatory policies to remove Technical, Institutional and Regulatory barriers impeding realization of the full potential of distributed energy resources.

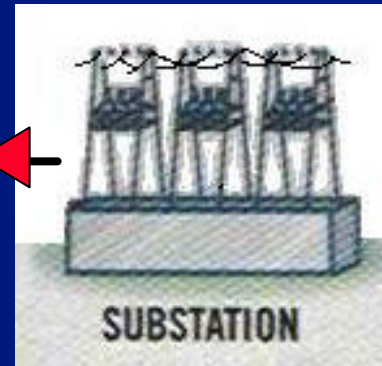
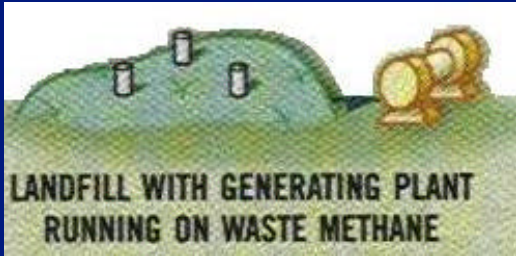
The Thermal Storage Systems activities address R&D and demonstration of advanced thermal storage system technology integrated with renewable thermal energy technology.

Thermally Activated Technologies—Desiccants: activities are directed at testing of advanced desiccant components and systems both solid and liquid and R&D of novel material and processing techniques for advanced systems for humidity control and mitigation of indoor air quality (IAQ) and other airborne contaminants.

Develop and Support the DOE DER WEB site (www.eren.doe.gov/der/)

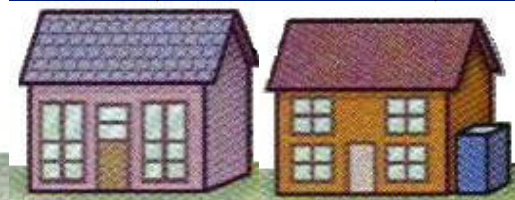
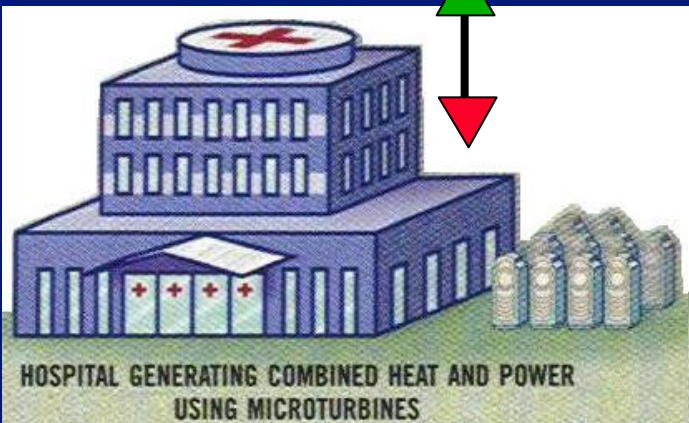


Future Electrical Generation



Red Arrows:
Power sold by central generators to homes and commercial buildings

Green Arrows:
Power flowing from distributed generators back to substations



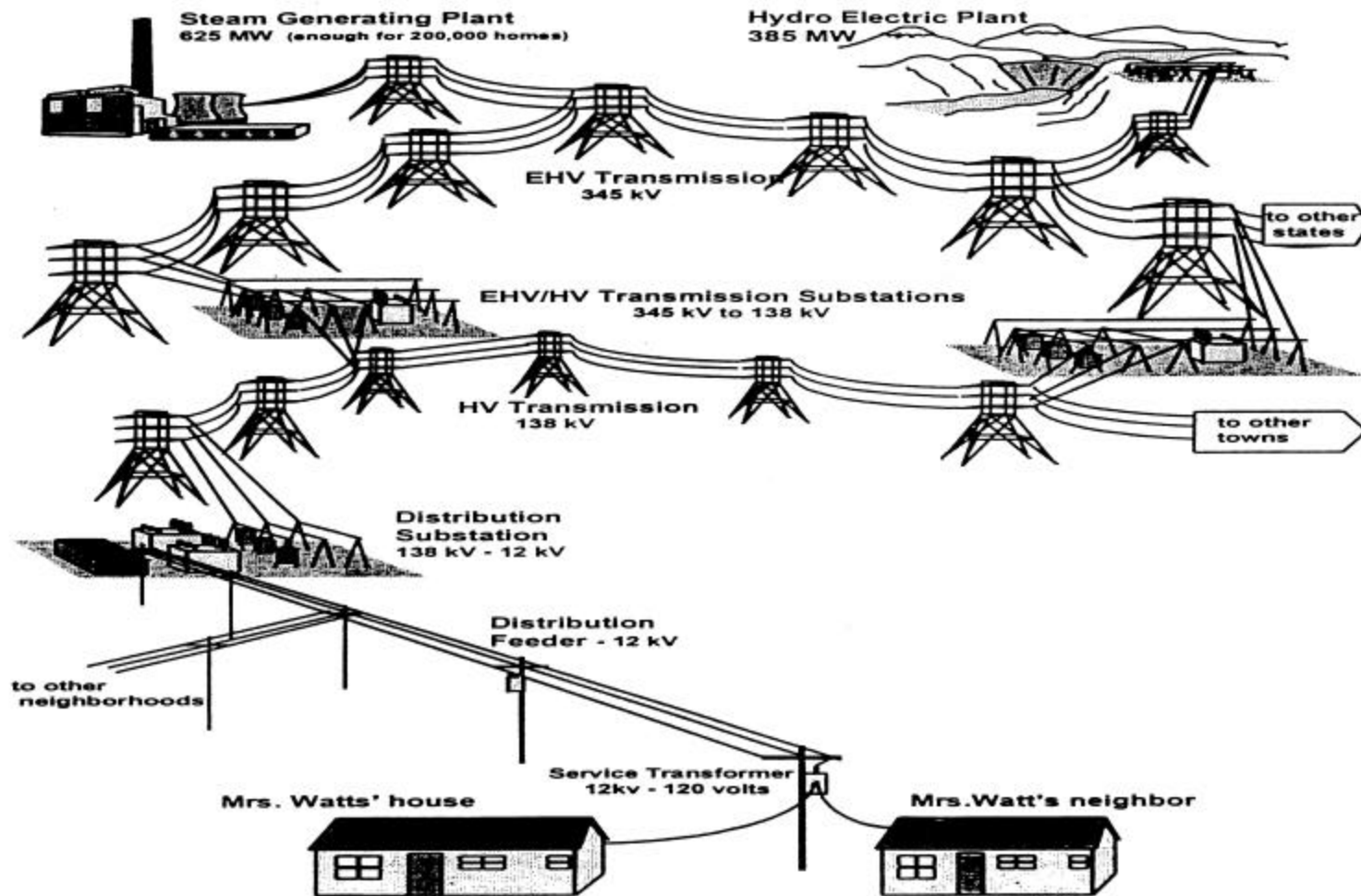
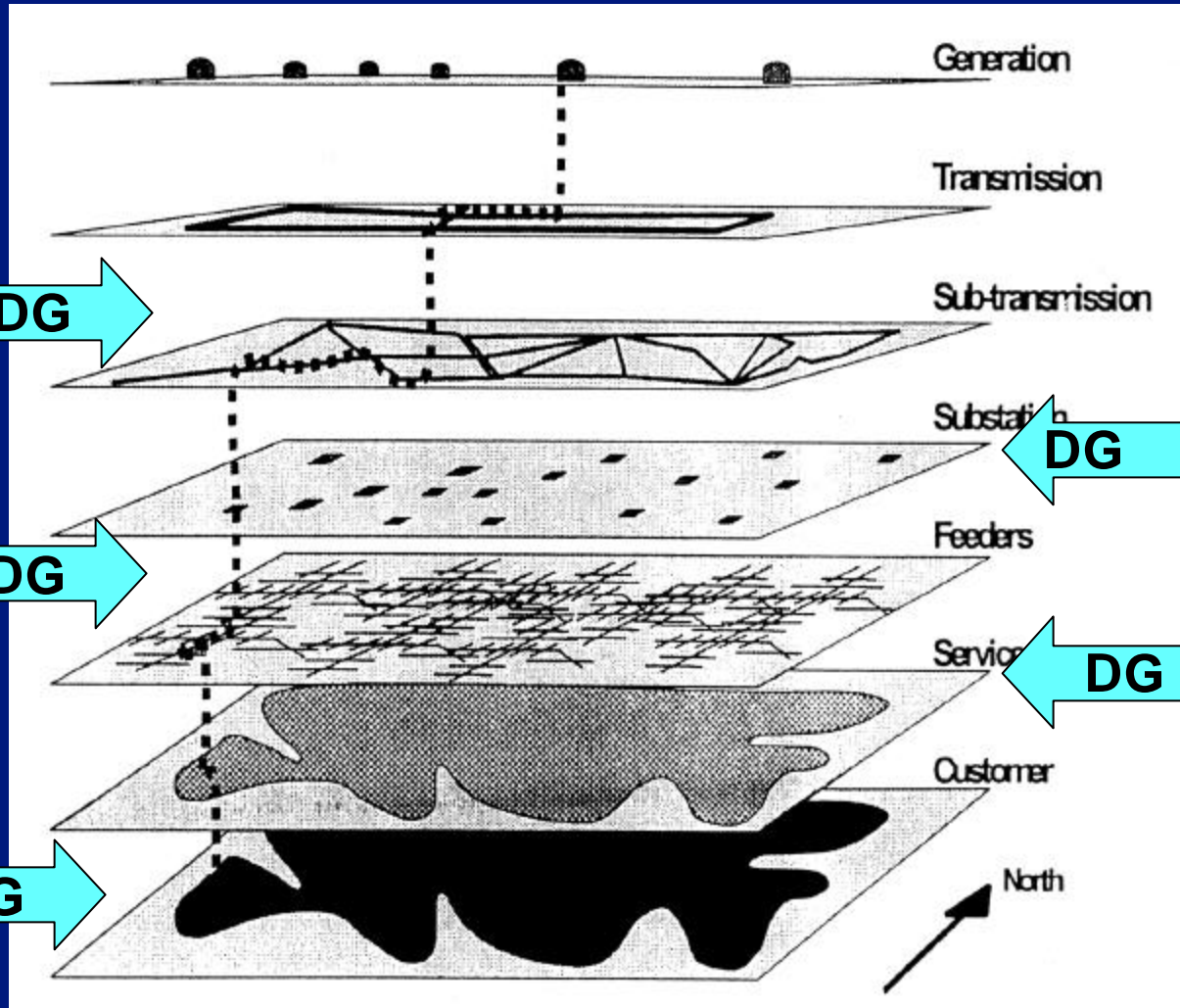


Figure 7.8 A power system consists of several levels: generation, extra high voltage (EHV) transmission, high voltage (HV) transmission, distribution, and utilization.

Distributed Power Interconnection



NREL Distributed Power Systems Integration Activities

Engineering and Test Development

Research on advanced interconnection systems including hardware and software for DR interconnected with electric power systems



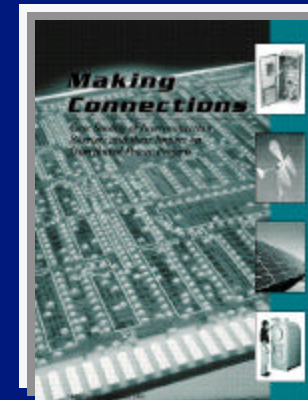
Standards and Codes

Development of standards and codes that address safety, reliability, power quality, and interconnection issues related to the integration of distributed resources with power systems

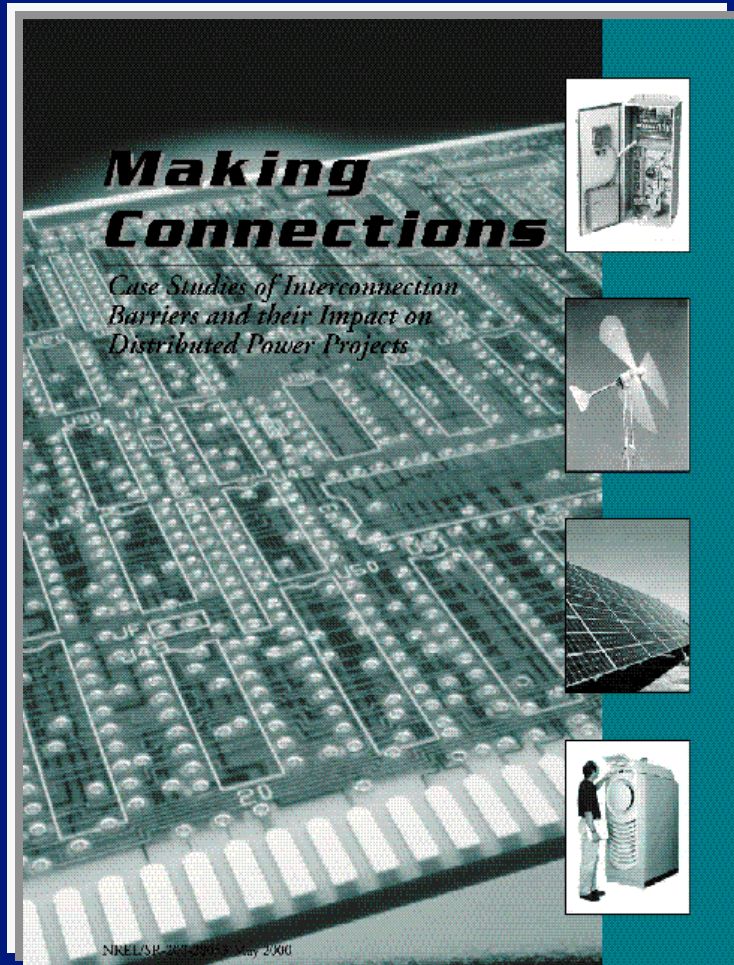
IEEE P1547
Draft Standard for Interconnecting Distributed
Resources with Electric Power Systems

Regulatory and Institutional Issues

Working with industry, state and local government organizations to eliminate unnecessary barriers to the use of distributed power



“Making Connections” Report



- Released May 1, 2000
- Financed and published by DOE/NREL
- 90 DG projects were identified, 65 surveyed, 26 summarized and included in report
- Projects ranged from 0.3 kW (PV) to 26 MW (gas turbine)
- Available on the Web as PDF file at the following address:
<http://www.eren.doe.gov/distributedpower/PDFs/28053.pdf>

IEEE P1547 Timeline

- **March 1999: IEEE Standards Board approves P1547 project**
- **March 2001: Completed initial ballot action (Draft 7)**
 - 167 Ballot members; Too few affirmatives to move forward
 - Draft 7 reworded to Draft 8 for recirculation ballot
- **October 2001: Completed ballot recirculation (Draft 8)**
 - Too few affirmatives to move Draft 8 forward
- **June 2002: P1547 Work Group & Writing Group Meetings**
 - Expanded Writing Group presented Draft09; revised to Draft 10
- **COMPLETING P1547-- July 2002 to ...**
 - **July 2002: Establish new ballot group**
 - **September 2002: complete ballot on Draft 10**
 - **October 2002: P1547 Work Group & Writing Group Meetings**
 - Draft 10 Ballot results consideration
 - **December 2002: IEEE Standards Board Meeting**

IEEE Standards Classification

1. Standards: documents with mandatory requirements (**shall**)
2. Recommended Practices: documents in which procedures and positions preferred by the IEEE are presented (**should**)
3. Guides: documents in which alternative approaches to good practice are suggested but no clear-cut recommendations are made (**may**)

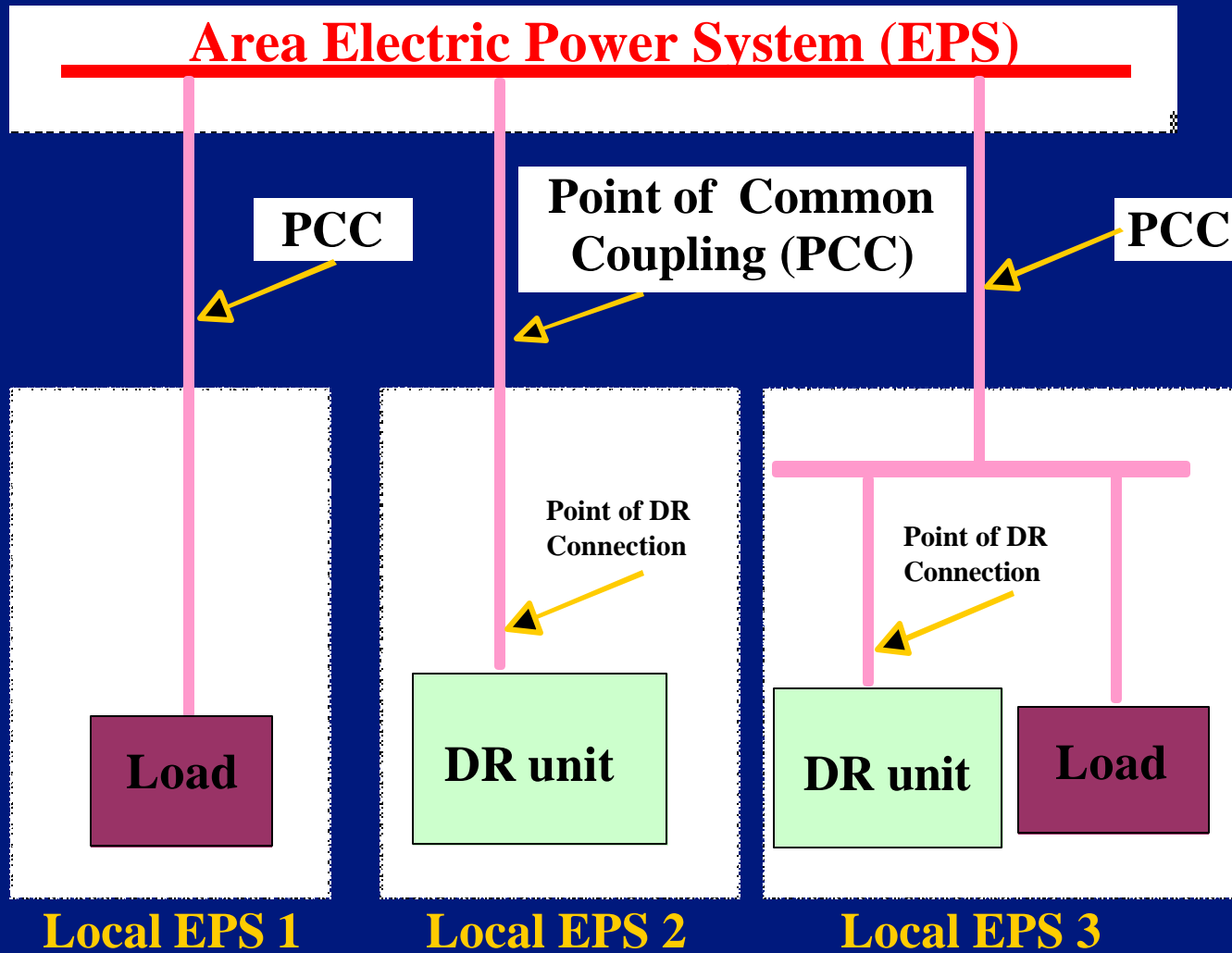
P1547: Interconnection Is The Focus

**Distributed
Resource
(DR)
unit**

**Interconnection
System**

**Area
Electric
Power
System
(EPS)**

P1547 Interconnection Terms



Note: There can be any number of Local EPSs.



Body of Standards

P1547 Standard for Interconnecting Distributed Resources with Electric Power Systems. 4/99

Guide for Network Interconnection

Guide for Grid/DG Impacts Determination

P1614 Guide for Monitoring, Information Exchange and Control of DR Interconnected with EPS (6/02)

Guide for islanding & Anti-Islanding

Interconnection System Certification Guide

P1608 Application Guide for IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems. 12/01

P1589 Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power System. 6/01

DG Specifications and Performance

Current SCC21 Interconnection Projects

Title	Scope & Purpose
P1547 <u>Standard</u> for Interconnecting Distributed Resources with Electric Power Systems.	<ul style="list-style-type: none">• This <u>Standard</u> establishes criteria and requirements for interconnection of distributed resources (DR) with electric power systems (EPS).• This document provides a uniform standard for interconnection of distributed resources with electric power systems. It provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection.
P1589 <u>Standard</u> for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems.	<ul style="list-style-type: none">• This <u>Standard</u> 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.• Interconnection equipment that connects distributed resources (DR) to an electric power system (EPS) must meet the requirements specified in IEEE Standard P1547. Standardized test procedures are necessary to establish and verify compliance with those requirements. These test procedures must provide both repeatable results, independent of test location, and flexibility to accommodate a variety of DR technologies.

Current SCC21 Interconnection Projects

Title	Scope and Purpose
P1608 Application <u>Guide</u> for IEEE Standard 1547 for Interconnecting Distributed Resources with Electric Power Systems	<ul style="list-style-type: none">• This <u>Guide</u> provides technical background and application details to support the understanding of IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems.• This document facilitates the use of IEEE 1547 by characterizing the various forms of distributed resource technologies and the associated interconnection issues. Additionally, the background and rationale of the technical requirements are discussed in terms of the operation of the distributed resource interconnection with the electric power system. Presented in the document are technical descriptions and schematics, applications guidance and interconnection examples to enhance the use of IEEE 1547.
P1614: <u>Guide</u> for Monitoring, Information Exchange and Control of Distributed Resources Interconnected with Electric Power Systems	<ul style="list-style-type: none">• This document provides guidelines for monitoring, information exchange, and control for distributed resources (DR) interconnected with electric power systems (EPS).• This document facilitates the interoperability of one or more distributed resources interconnected with electric power systems. It describes functionality, parameters and methodologies for monitoring, information exchange and control for the interconnected distributed resources with, or associated with, electric power systems. Distributed resources include systems in the areas of fuel cells, photovoltaics, wind turbines, microturbines, other distributed generators, and, distributed energy storage systems.

IEEE P1547 Interconnection Standard

Drafts 7 and 8 Ballot Status

Requirements for adoption: 75% ballot return, 75% affirmative

Round 1– Draft 7

- Balloting completed 4/1/01
- 91% ballot returns
- 66% affirmative
- Addressed negative comments

<u>Voter Category</u>	<u>Affirm</u>	<u>Negative</u>
- User	30	23
- Producer	35	12
- General Interest	28	15

Round 2 -- Draft 8

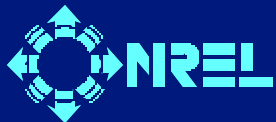
- Recirculation completed 10/2/01
- 96% ballot returns
- 66% affirmative
- New Draft TBD

<u>Voter Category</u>	<u>Affirm</u>	<u>Negative</u>
- User	25	33
- Producer	43	6
- General Interest	35	14

P1547 Drafts 7 & 8 Ballot:

Some Key Issues

- **Minimum vs Maximum Requirements**
- **Field Testing vs Type Testing**
- **Secondary Grid and Spot Networks**
- **Grid/DG Monitoring and Control**
- **Voltage Regulation/Stability**
- **Grounding/Faults**
- **DG Penetration/Aggregation**



P1547 Drafts 7 & 8 Ballot:

Some Concerns

**May be addressed in a Guide (P1608)
and Not addressed in a Standard (P1547)**

- 1. EPS Impacts and Analysis (is it necessary and when)**
- 2. Penetration (ideal allowable aggregation)**
- 3. Safety (functional vs operational modes)**
- 4. Re-Fit EPS (What to do)**
- 5. Cost of EPS Re-Fit (How and Who Pays)**
- 6. Operation (which standard and who is in control)**
- 7. Reliability (operational issues – durability vs availability)**
- 8. Federal/State Implementation and Impacts (Rules)**
- 9. Misunderstanding/application (limited experience/knowledge)**
- 10. User disagreement (not all utilities and DGs are alike)**

P1547 Drafts 7 & 8 Ballot: Working Group Broader-DER Interconnection Concerns and Issues

1. Fully Commercialized/Certified Products
2. After Sale Service Support/Warranties
3. Liability (DG vs Grid Operators)
4. Full-Scale remote/unattended Operation (Autonomous vs Semi-Autonomous)
5. Integrated Controls & Protective Relaying (design/location)
6. Functionality of Interconnection package (always more to add)
7. Where to include the Interconnection capabilities (“black box”, generator control, etc.)
8. Interface Standards between DER and Interconnection package (equipment manufacturing design standards)
9. Issues of Scaling to different power levels
10. Lower interconnection system cost

P1547 Draft 10 Development

- **Jan. 2002: Draft 8 pointed & focused review**
 - **Follow P1547 WG fundamental principles**
 - mandatory requirements
 - universally needed for interconnection
 - technology neutral
 - aggregate size up to 10 MVA
 - **Recognition that some comments and content go beyond the P1547 principles**
 - **Expanded Writing Group**
- **Feb. – May 2002: Expanded writing group held 3 meetings and established Draft 9 as mandatory requirements presented that at June 2002 P1547 meeting**
- **June 2002: Draft 9 presented and reviewed at P1547 meeting; Draft 10 completed by writing group**
- **June - July – August 2002: Draft 10 ballot documentation to IEEE**



IEEE P1547/D10 Contents

INTRODUCTION

1.0 OVERVIEW

1.1 Scope

1.2 Purpose

1.3 Limitations

2.0 REFERENCES

3.0 DEFINITIONS



IEEE P1547/D10 Contents

4.0 INTERCONNECTION TECHNICAL SPECIFICATIONS AND REQUIREMENTS

4.1 General Requirements

4.2 Response to Area EPS Abnormal Conditions

4.3 Power Quality

4.4 Islanding

5.0 INTERCONNECTION TEST SPECIFICATIONS AND REQUIREMENTS

5.1 Design Test

5.2 Production Tests

5.3 Interconnection Installation Evaluation

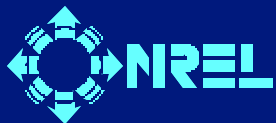
5.4 Commissioning Tests

5.5 Periodic Interconnection Tests

ANNEX A (INFORMATIVE) BIBLIOGRAPHY

Contact Information

- **Tom Basso, P1547 Secretary**
email: thomas_basso@nrel.gov
voice: (303) 275 - 3753
<http://www.nrel.gov>
NREL
1617 Cole Blvd. MS-1614
Golden, CO 80401-3393
- **IEEE SCC21 -- IEEE Standards Coordinating Committee 21 on Fuel Cells, Photovoltaics, Dispersed Generation, & Energy Storage**
<http://grouper.ieee.org/groups/scc21/>
- **P1547 Standard for Interconnecting Distributed Resources with Electric Power Systems -- web site and archives**
<http://grouper.ieee.org/groups/scc21/1547>
<http://grouper.ieee.org/groups/scc21/1547/archives/>
(scc21 web site being revised to include P1589, P1608, P1614, etc.)



NREL DER Testing Activities

DER Distributed Power Program - (In-House and Industry Partnerships)

Simulation and Modeling

University of Wisconsin
Orion - University of Massachusetts (Lowell)
Industry Partners - DTE, GE, NiSource

Characterization R&D

NREL - DER Test Facility
EPRI - PEAC
University of Wisconsin

Certification

EPRI-PEAC
Underwriters Laboratories

Field Testing and Validation

Nevada Test Site
Distributed Utility Integration Test - DUA
Industry Partners - GE, NYSERDA, GRI, NRECA,
NiSource, Real Energy, DTE



DER Electric Systems Integration Testing Strategy

Characterization R&D Testing

NREL DER Test Facility

- Work with Manufacturers to characterize and improve electrical interfaces of DR before field testing
- Test for compliance to Interconnection Standards
- Test small scale integration issues with multiple DGs



NREL DER Test Facility

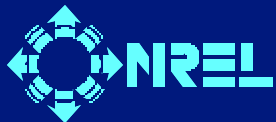


NTS DER Field Test Area

Field Testing

Nevada Test Site

- Test Integration of DRs with Electric Power Systems in controlled setting including effects of DR on distribution system protection equipment
- Test for compliance to Interconnection Standards in field setting
- Test large scale integration issues with multiple DRs
- Advanced Distribution System Technologies



DOE/NREL Distributed Energy Resources (DER) Test Facility

Interconnection and Systems Integration



Testing includes:

- Validate IEEE P1547 Requirements
- Develop IEEE P1589 Test Procedures
- Currently testing microturbines and inverters

NREL DER Test Facility

Grid Simulator

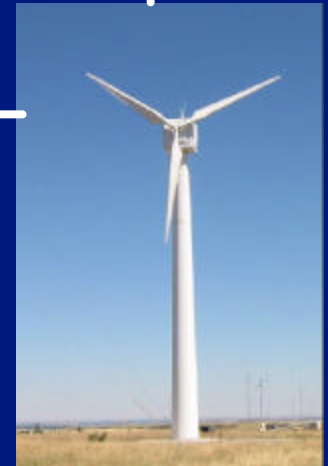


AC Bus



Microturbines

Utility Grid



Wind Turbines

Inverters



DC Bus



Battery Banks



PV Array

Fuel Cells



Electrolyzer



Diesel Generators

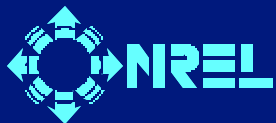


Load Simulators



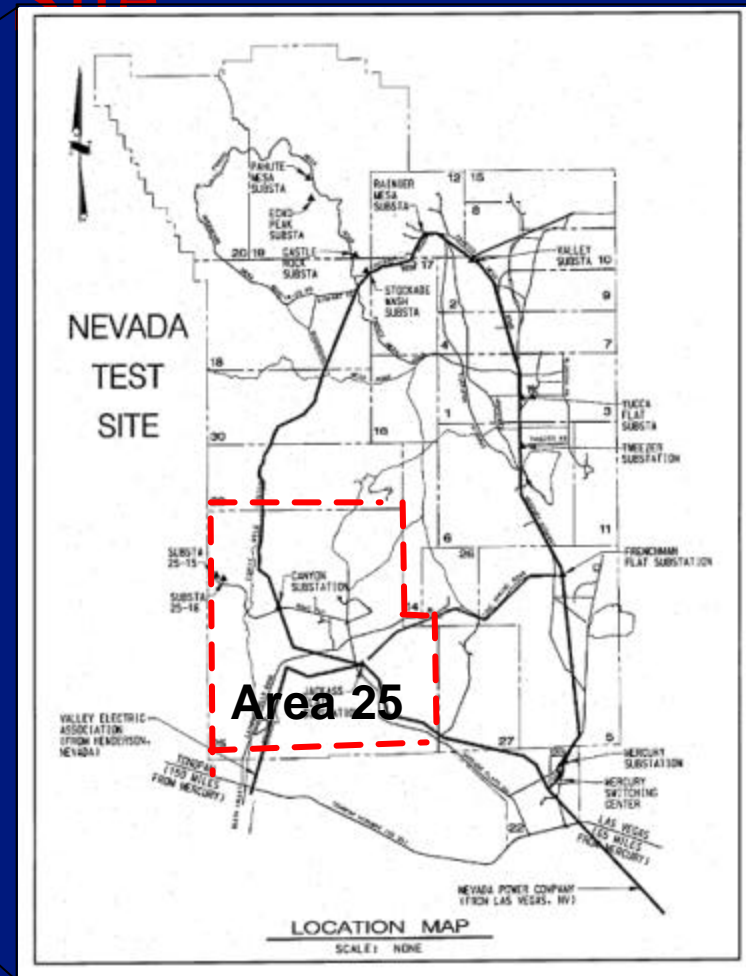
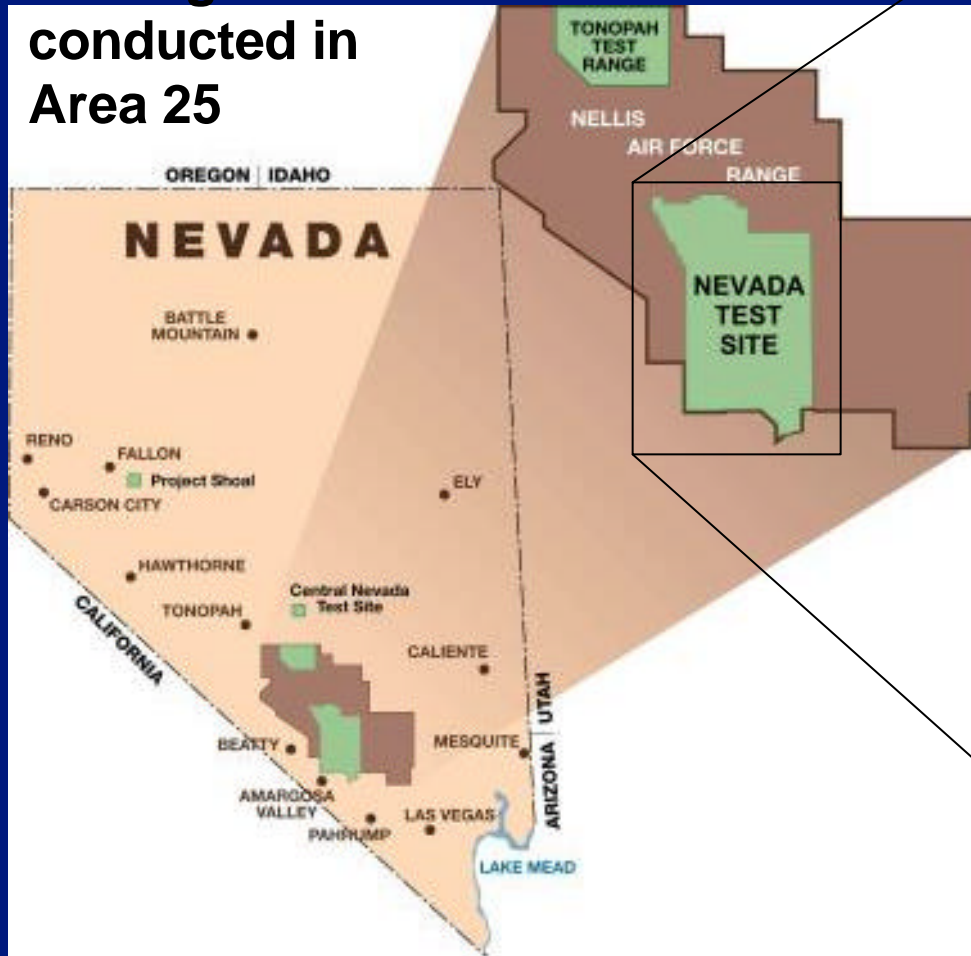
Distributed Power NTS Testing

- Congressional direction to conduct distributed power demonstration activities (\$500K in FY00 and \$500K in FY01)
- Held Meetings with Nevada Operations Office and Bechtel Nevada
- Held Workshop with Industry and Universities in November 2000 (ASCO, DTE, DRI, UNLV, EPRI, Capstone)
- Pilot Test at NTS to examine IEEE P1547 testing issues and develop working relationship with DOE/NV and Bechtel/NV



Nevada Test Site

DER Field Testing was conducted in Area 25



DER Pilot Test at NTS

DOE/NREL Distribute Power Program conducted exploratory field tests to validate interconnection and commissioning tests included in the IEEE P1547 interconnection standard at the Nevada Test Site.

Tested the interconnection systems of 2 different types of DG:

1. Static Inverter (5kW Inverter with PV array)
2. Synchronous generator (100kW diesel gensets w/ paralleling package).

DG Test Location



Substation 25-10



Feeder 25-1202 at Area 25 of Nevada Test Site

DOE/NREL Distributed Power Program Web Site for Current Information

<http://www.eren.doe.gov/distributedpower/>





IN THE NEWS...

DOE/NREL Announce Letter of Interest Solicitation for DG R&D

July 2002 - ANNOUNCING: Letter of Interest Solicitation - "DOE/NREL Distributed Power Program - Distributed Energy Resources Electric Power System Integration Research and Development"

The National Renewable Energy Laboratory is issuing a Letter of Interest (LOI) Solicitation for research and development efforts through relationships and partnerships with industry, the university community and other qualified organizations and consultants to address a range of activities related to interconnecting and integrating distributed energy resources. These activities are organized into four categories as follows:

- A. Advanced Universal Interconnection Technology,
- B. Field Testing of Distributed Power Technology for Interconnection Standards and Electrical Power Systems Configurations,
- C. Standards for Distributed Energy Resources System Integration, Interconnection and Operation with Electric Power Systems,
- D. Analysis and Research on Alternative Rates and Tariffs for Distributed Energy

The full text of the Solicitation is available on the [NREL Current Solicitations](#) website. Organizations desiring a printed copy of the solicitation should make a written request to the address below, referencing Synopsis No. RAT-2-32616. Telephone requests will not be accepted. William Algiere, NREL, 1617 Cole Blvd., MS#2713, Golden CO, 80401

