

# **IEEE P1547 – Electric Power Resources Interconnected with the Electric Power System**

**U.S. Department of Energy Office of Power Technologies  
Distributed Power Program/Industrial DG Program  
Annual Review**

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Member-IEEE Standards Board



# 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



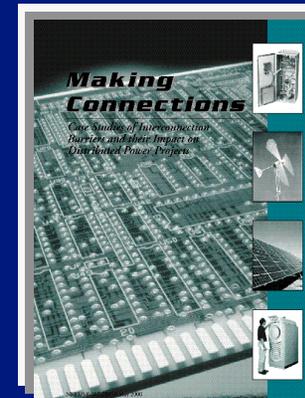
## Standards and Codes

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

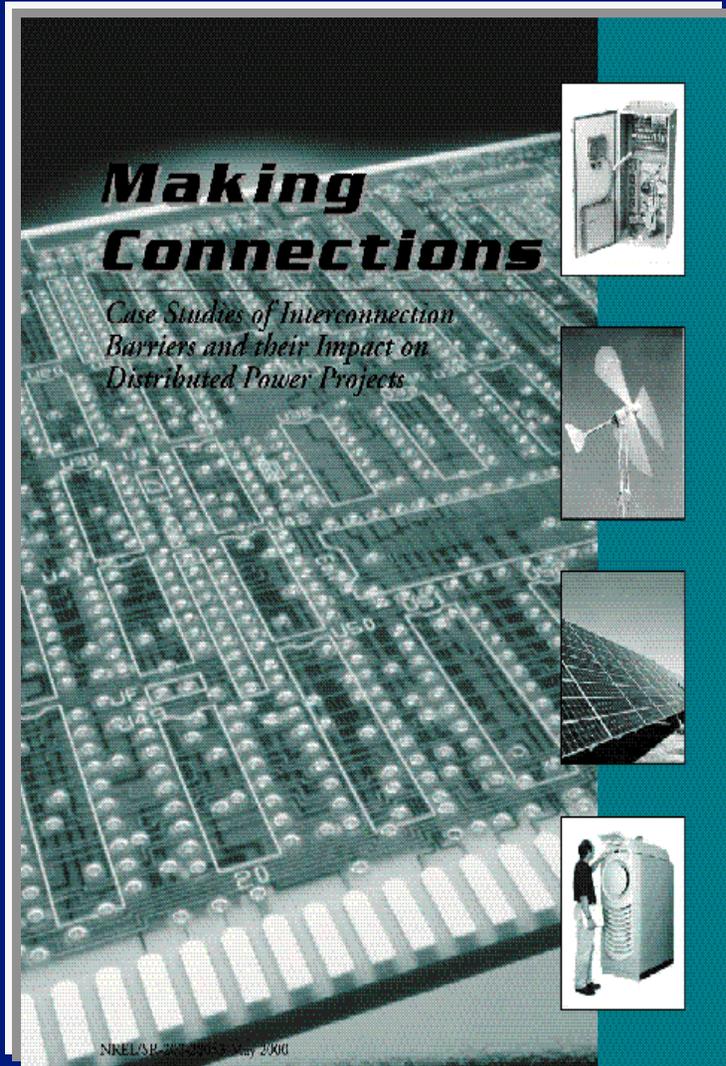
IEEE P1547  
Draft Standard for Interconnecting Distributed  
Resources with Electric Power Systems

## 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
- 90 DG projects identified, 65 surveyed, 26 summarized in report
- Projects ranged from 0.3 kW (PV) to 26 MW (gas turbine)
- Available on the Web at:  
<http://www.eren.doe.gov/distributedpower/barriersreport/>



# Making Connections – Ten-Point Action Plan

- Reduce Technical Barriers
  - Adopt uniform technical standard for interconnecting
  - Develop testing and pre-certification procedures for DG equipment
  - Develop distributed power control technology
- Reduce Business Practice Barriers
  - Establish standard commercial practices for utility review
  - Establish standard business terms for interconnection agreements
  - Develop tools for utilities to assess the value and impact of distributed power at any point on the grid
- Reduce Regulatory Barriers
  - Develop new regulatory principles for distributed power choices in both competitive and utility markets
  - Adopt regulatory tariffs and utility incentives for DP
  - Establish expedited dispute resolution processes
  - Define the conditions necessary for a right to interconnect



# IEEE Interconnection Standard P1547

- **Title:** *Standard for Interconnecting Distributed Resources with Electric Power Systems*
- **Scope:** This standard establishes criteria and requirements for interconnection of distributed resources (DR) with electric power systems (EPS).
- **Purpose:** Provide a uniform standard for interconnection of distributed resources with electric power systems, and requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection.
- **Sponsor:** IEEE SCC21 -- *Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage*; Chair, R. DeBlasio.



# IEEE P1547/D8 Contents

- **INTRODUCTION**
- **1.0 OVERVIEW**
- **2.0 REFERENCES**
- **3.0 DEFINITIONS and ACRONYMS**
- **4.0 INTERCONNECTION TECHNICAL SPECIFICATIONS AND REQUIREMENTS**
- **5.0 TEST SPECIFICATIONS AND REQUIREMENTS**
- **ANNEXES – INFORMATIVE**
  - ANNEX A -- FLICKER INFORMATION
  - ANNEX B -- INTERCONNECTION TESTS
  - ANNEX C -- COMMISSIONING TESTS
  - ANNEX D -- BIBLIOGRAPHY



# Technical Requirements Fall Into Several Categories

- General Requirements
- Response to Area EPS Abnormal Conditions
- Power Quality
- Islanding
- Test Specifications and Requirements



# P1547 Development Approach

- **Voluntary consensus standard**
  - Hallmark of the standards process
  - Open to all dedicated parties
  - IEEE ballot member categories:
    - General Interest, Producer, User
- **Fast-track schedule**
  - April 1999 -- IEEE approved P1547 project
  - March 2001 – Completed initial ballot action
  - October 2001 – Completed ballot recirculation



# IEEE P1547 Development Status

- **Ballot of Draft 7: Feb. 27 - Mar. 28, 2001**
- **Recirculation ballot Draft 8 Completed 10/2/01**
  - Draft 8: 34 pages of criteria, requirements, and information
  - 167 Ballot members
- **P1547 Working Group (WG) at 350 members**
- **P1547 WG organization**
  - R. DeBlasio (NREL) -- Chair
  - J. Koepfinger (Duquesne) -- Vice Chair
  - F. Goodman (EPRI) -- Vice Chair
  - T. Basso (NREL) -- Secretary
- **Meetings every 2 months (started Dec. 1998)**
- **Last P1547 WG Meeting October 16-19, 2001**
  - Draft 7 ballot and Draft 8 recirculation ballot results
  - Prospective new IEEE DR project activities
- **P1547 Web site <http://grouper.ieee.org/groups/scc21/1547>**



# IEEE P1547 Interconnection Standard Status

(Requirements for adoption: 75% return, 75% affirmative)

## Round 1

- 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

- Recirculation completed 10/2/01
- 96% ballot returns
- 66% affirmative
- Draft 8 recirculation TBD

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



## **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**



## Some Concerns

May be addressed in a Guide (P1608) and not 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)



## 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 and interconnection system cost



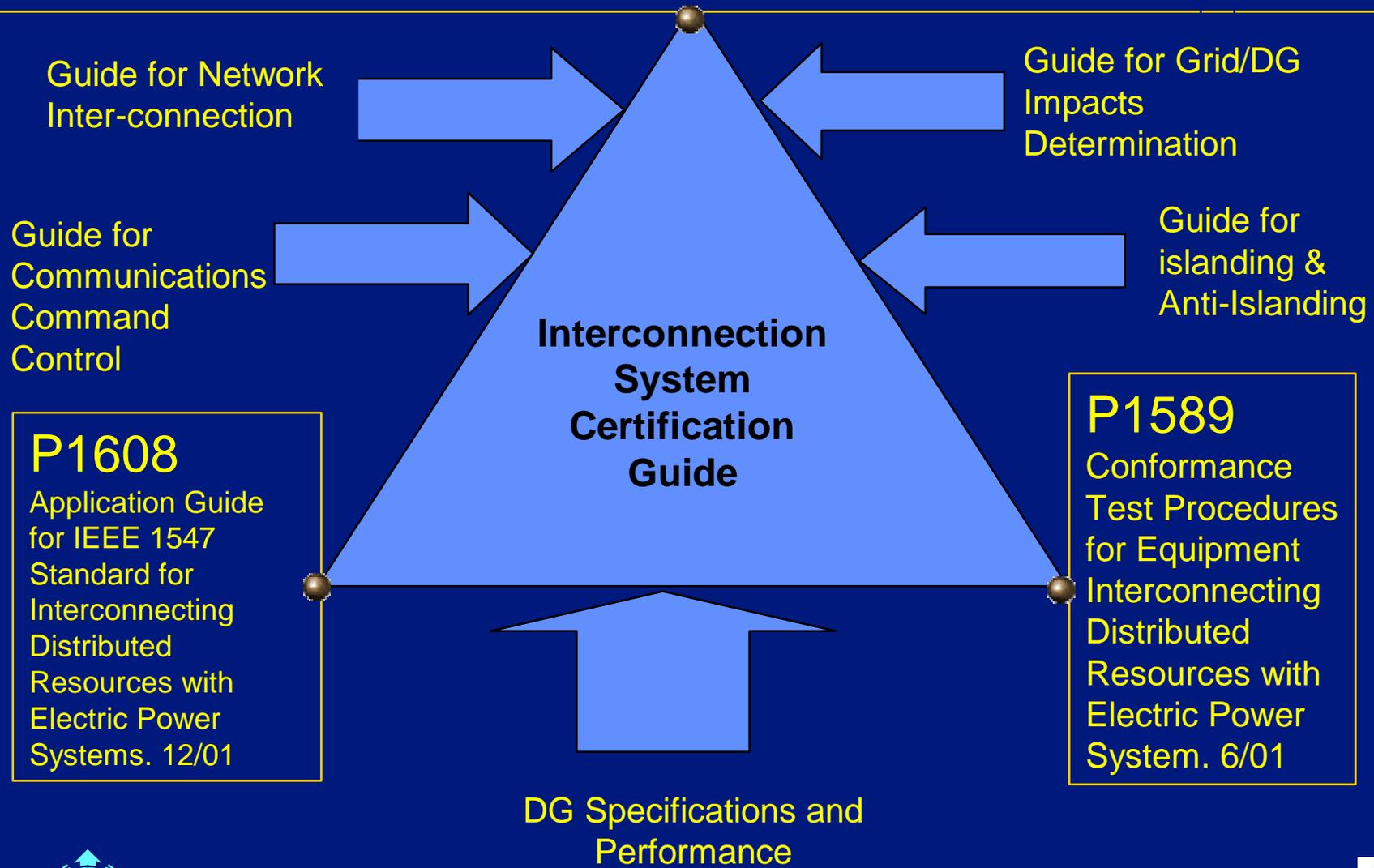
## IEEE Standards Classification

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)



# BODY OF STANDARDS

## 1547 Draft 8 Interconnecting Distributed Resources with Electric Power Systems. 3/99



## Scope of Current SCC21 DER Interconnection Projects

Title: IEEE P1547 - Standard for Interconnecting Distributed Resources with Electric Power System.

Scope: This Standard establishes criteria and requirements for interconnection of distributed resources (DR) with electric power systems (EPS)

Title: IEEE P1589 – Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems.

Scope: This Standard specifies the type, production, and commissioning tests that shall be performed to demonstrate that the interconnection functions and equipment of a distributed resource (DR) conform to IEEE Standard 1547

Title: IEEE P1608 – Application Guide for IEEE Standard 1547 for Interconnecting Distributed Resources with Electric Power System.

Scope: This Guide provides technical background and application details to support the understanding of IEEE 1547, Standard for Interconnecting Distributed Resources with Electric Power Systems.



# Prospective New IEEE DR Activities

**DR unit**

## **Interconnection System**

**Area EPS**

- P1547 Draft Std. for Interconnection of DR with EPS
- P1589: Draft Std.for Interconnection System Conformance Testing
- P1608 Application Interconnection Guide for P1547
- NEW: Guidelines for Communication-Control of DR
- NEW: Guidelines for DR Equipment Certification

- NEW: Guidelines for Network Specifications & Applications with DR
- NEW: Recommended Practice for Distributed Generators and Equipment-Specifications and Performance



# Overview of 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



# NREL DER Test Facility

## Interconnection and Systems Integration

### Testing includes:

Validation of IEEE P1547 Requirements

Development of IEEE P1589 Test Procedures

Currently testing microturbines and inverters

Capstone 30 kW  
Microturbine



Two 100kW Load Simulators



200 kW Grid Simulator



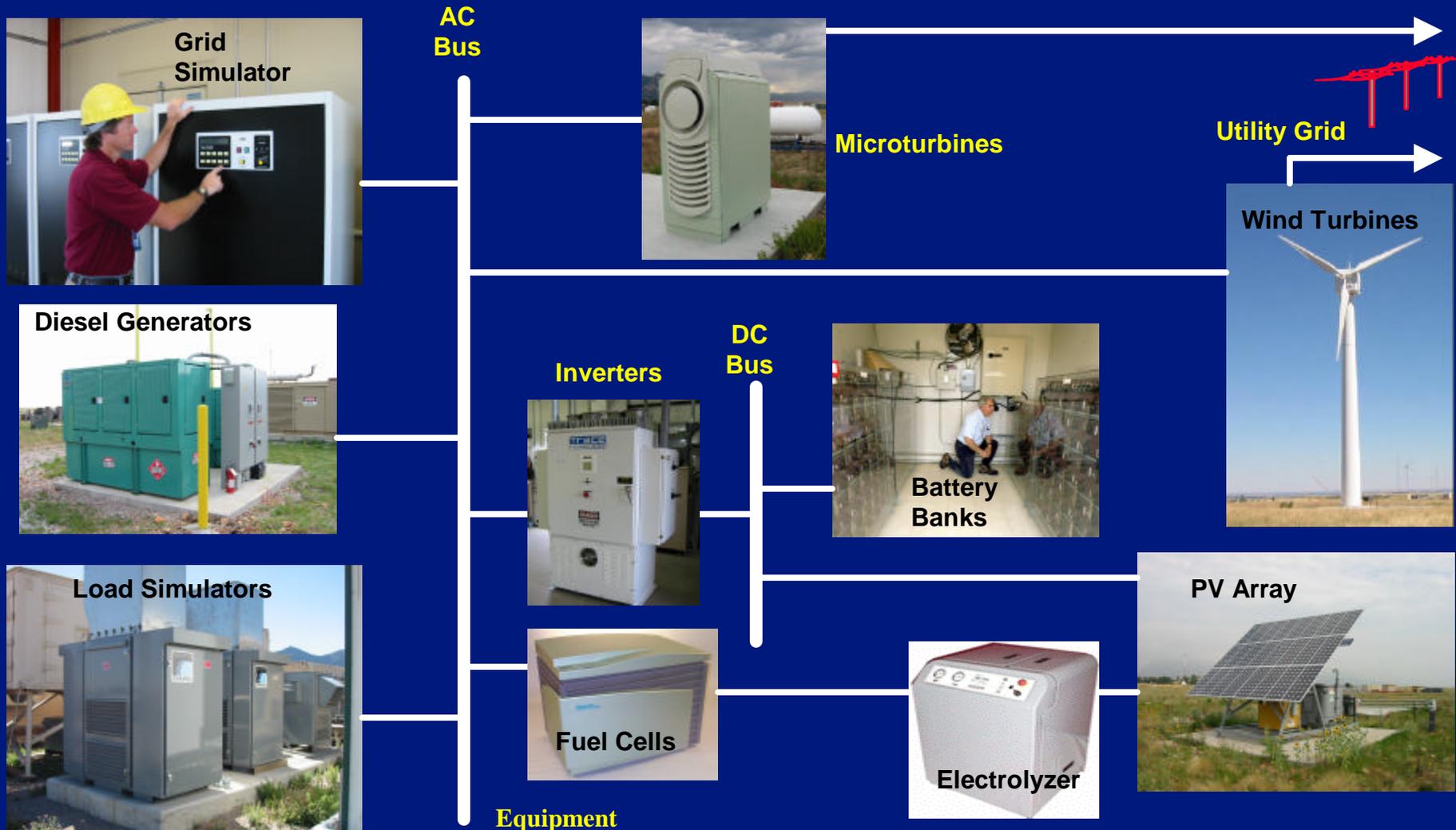
PV Array



Inverters



# Distributed Power Systems Testing



## Equipment

- Distributed Generation
- Distributed Storage
- Protective Equipment
- Switches
- Electronics
- Controls and Communications

## Measurements

- Power Quality
- Stability
- Response to disturbances
- Performance/ Functionality





# DOE Distributed Power Program Field Validation Test at the Nevada Test Site

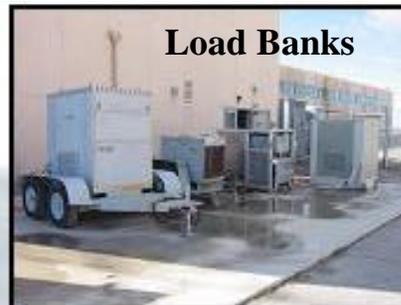


Exploratory field tests to validate interconnection and commissioning tests in IEEE P1547 Interconnection Standard

NREL is also developing a long-term testing plan for NTS.

Testing has been conducted on 2 different types of DG:

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



# Contact Information

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    **voice: (303) 275 - 4333**                                      **Golden, CO 80401-3393**
- **NREL -- <http://www.nrel.gov>**
- **IEEE SCC21 -- IEEE Standards Coordinating Committee 21 on Fuel Cells, Photovoltaics, Dispersed Generation, & Energy Storage**  
    **<http://grouper.ieee.org/groups/scc21/>**
- **P1547 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/>**
- **DOE Distributed Power Program**  
    **<http://www.eren.doe.gov/distributedpower>**

