



Development of Applications Guide to IEEE Std. 1547
Subcontract Number: RAT-3-32616-02

**Principal Investigator(s): N. Richard Friedman
E.J. Honton**

Sub-Tier Princ Investigator: Bob Saint, NRECA

NREL Technical Monitor: Thomas Basso

Electric Distribution Transformation Program

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Project Objectives

- Develop an *Applications Guide* (IEEE P1547.2) to better understand and apply the requirements of IEEE 1547 for interconnecting DER with the grid.
- Provide supporting facilitation, via cost-sharing, to ensure that IEEE P1547.2 is written, approved and published.
- Foster a better understanding of IEEE 1547 and ease the burden of DER interconnection by providing application guidance, tips, techniques and rules of thumb.

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IEEE P1547.2 Title

P1547.2 DRAFT APPLICATION GUIDE FOR IEEE Std. 1547, STANDARD FOR INTERCONNECTING DISTRIBUTED RESOURCES WITH ELECTRIC POWER SYSTEMS

IEEE P1547.2 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.

IEEE P1547.2 Purpose

This document facilitates the use of IEEE Std. 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.

IEEE P1547.2 Purpose - Key Words

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What 1547.2 is Intended to Do

Support understanding and facilitate the use of IEEE 1547 by

- Providing technical background.
- Providing application details.
- Characterizing the various forms of distributed resource technologies.
- Characterizing the associated interconnection issues.
- Discussing the background and rationale of the technical requirements in terms of the operation of the interconnection.
- Presenting good practice approaches.

Interpretations - “documents issued to explain and clarify the intent of passages within a standard.”

What 1547.2 Will Not Do

- Interpret IEEE 1547.
- Introduce new requirements to IEEE 1547.
- Address issues not covered in IEEE 1547, other than as needed to help enhance the user's understanding of IEEE 1547.
- Provide a "guarantee" that IEEE 1547 requirements will be met.

IEEE Standards Classification

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

Team Members

- The Resource Dynamics Corporation (RDC) and the National Rural Electric Cooperative Association (NRECA).
- History of working together for the benefit of rural electric cooperatives (RECs), their members, and other DER stakeholders.
- RECs own and operate nearly half of the distribution facilities in the U.S. while serving 35 million end-use customers.

Building on Team Resources

- RECs are a good proxy for all distribution systems due to their diverse nature (e.g. urban and rural reach).
- Ideal group to implement and evaluate the *Applications Guide* early in its development, and ensure that the final *Guide* is accurate and useful to distribution companies and end-users.

Building on Team Resources (cont.)

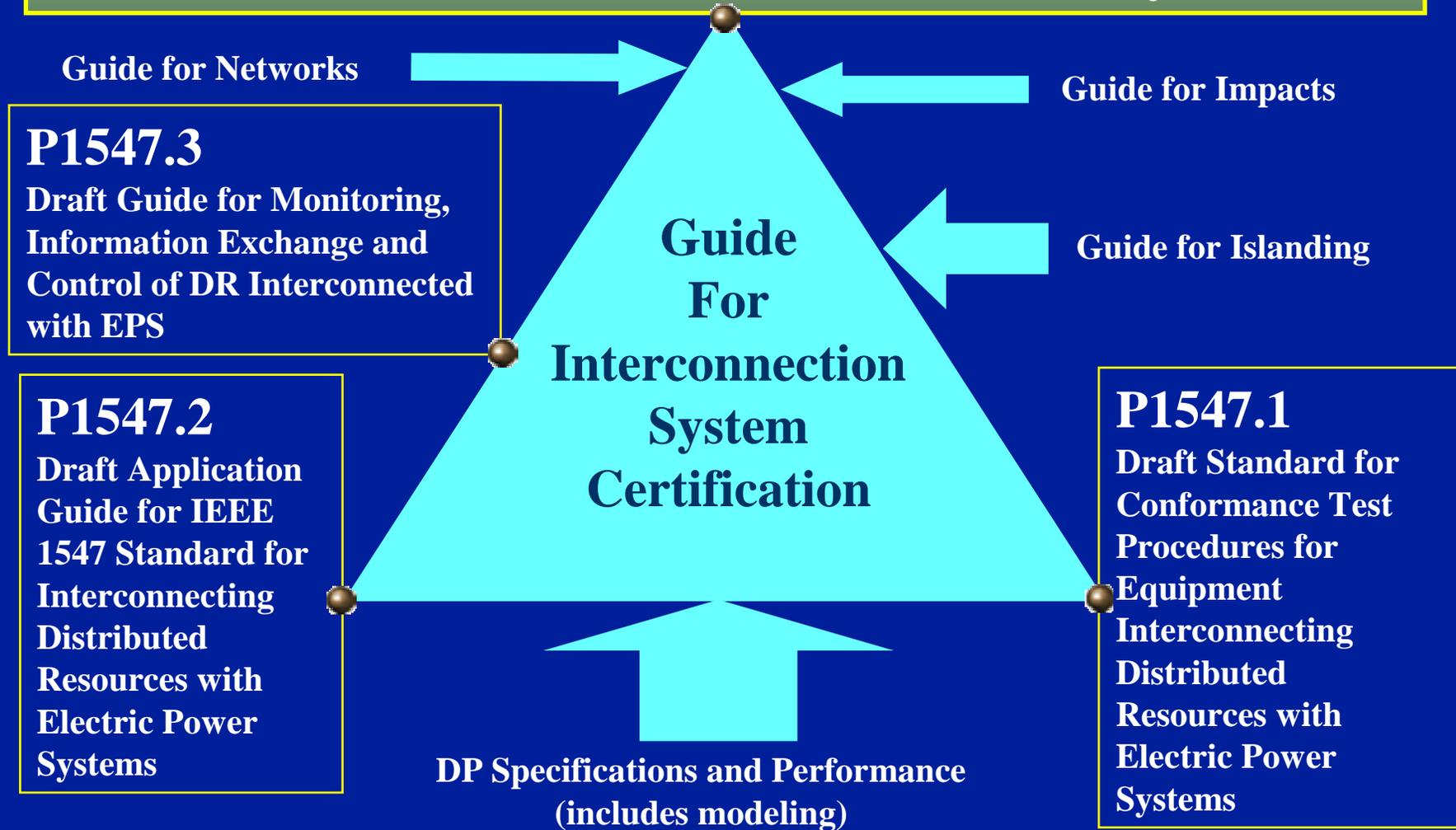
- RDC has considerable interconnection and DER research experience developed in over 20 years of directly relevant project research.
- NRECA brings major assets to the project:
 - long history conducting research for RECs
 - use of the existing *NRECA Application Guide to 1547* as a starting platform for this effort
 - Project Review Team of distribution system engineers with special customer relationships

History of IEEE Std. 1547

- Developed by collegial work of nearly 400 volunteers
- Broad representation of utilities, manufacturers and regulators
- Takes functional rather than prescriptive approach to technical requirements
- Approved by IEEE Standards Board on June 12, 2003

IEEE SCC21 1547 Series of Interconnection Standards

IEEE Std 1547TM (2003) Standard for Interconnecting Distributed Resources with Electric Power Systems



The above identifies existing IEEE SCC21 standards development projects (1547 series) and activities under discussion by SCC21 Work Group members.

Technical Approach

- Task 1 - Identify and collect reference material
- Task 2 - Form research and writing teams
- Task 3 - Develop preliminary drafts of *Guide*
- Task 4 - Conduct coordinated review process
- Task 5 - Track/incorporate updates to 1547
- Task 6 - Produce consensus draft for ballot

Problems and Needs Driving DER Interconnection

Utility Concerns

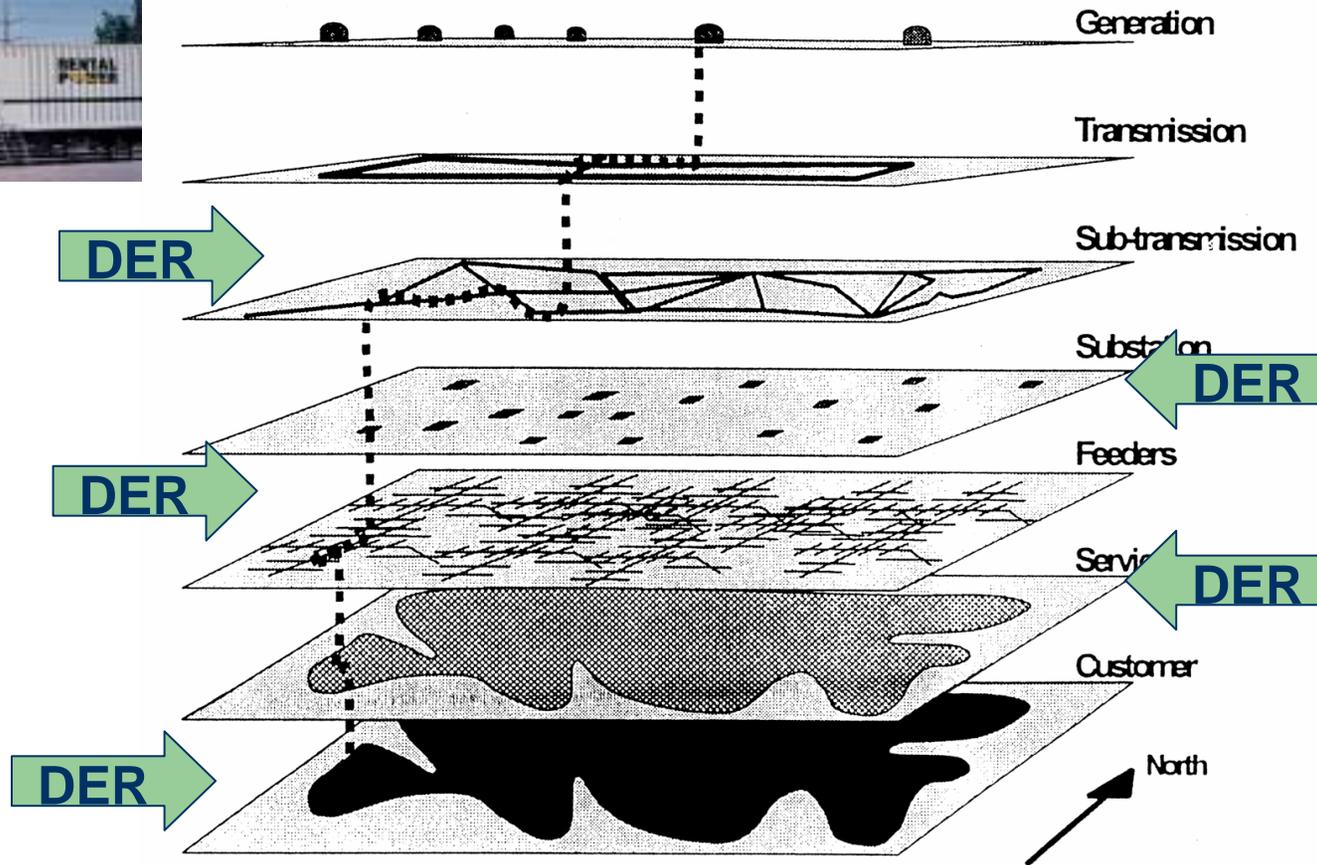
- Electric power distribution systems designed for one-way operation.
- Personnel safety and grid stability are dominant issues.
- Utilities reluctant to rely on unfamiliar, customer-supplied protective relaying schemes.
- Integrated interconnection “packages” are still fairly new.

Problems and Needs Driving DER Interconnection

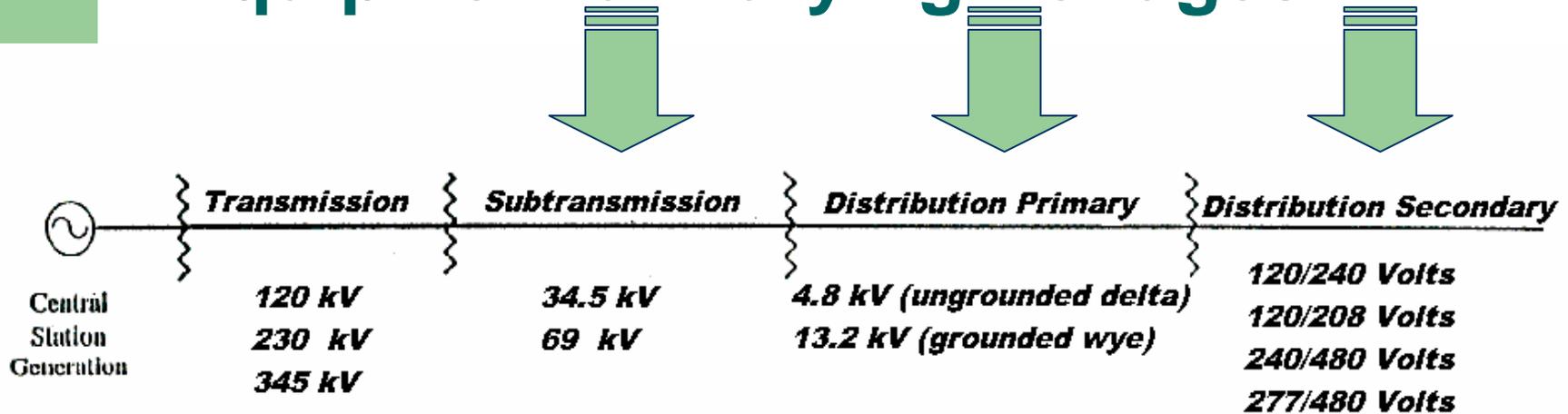
DER/Customer Concerns

- Utility interconnection costs can be a “deal breaker” for smaller-sized projects.
- Some requirements not understood by customer, and may appear unreasonable.
- Manufacturer, customer and utility DER activities are frequently not coordinated.
- Interconnection requirements are far from standard.

DER Can Interconnect in Several Places



Requiring Dispatch and Control Equipment at Varying Voltages



Complexity also varies by whether a single or multiple gensets are being interconnected



The Interconnection System

- Why is it Important?



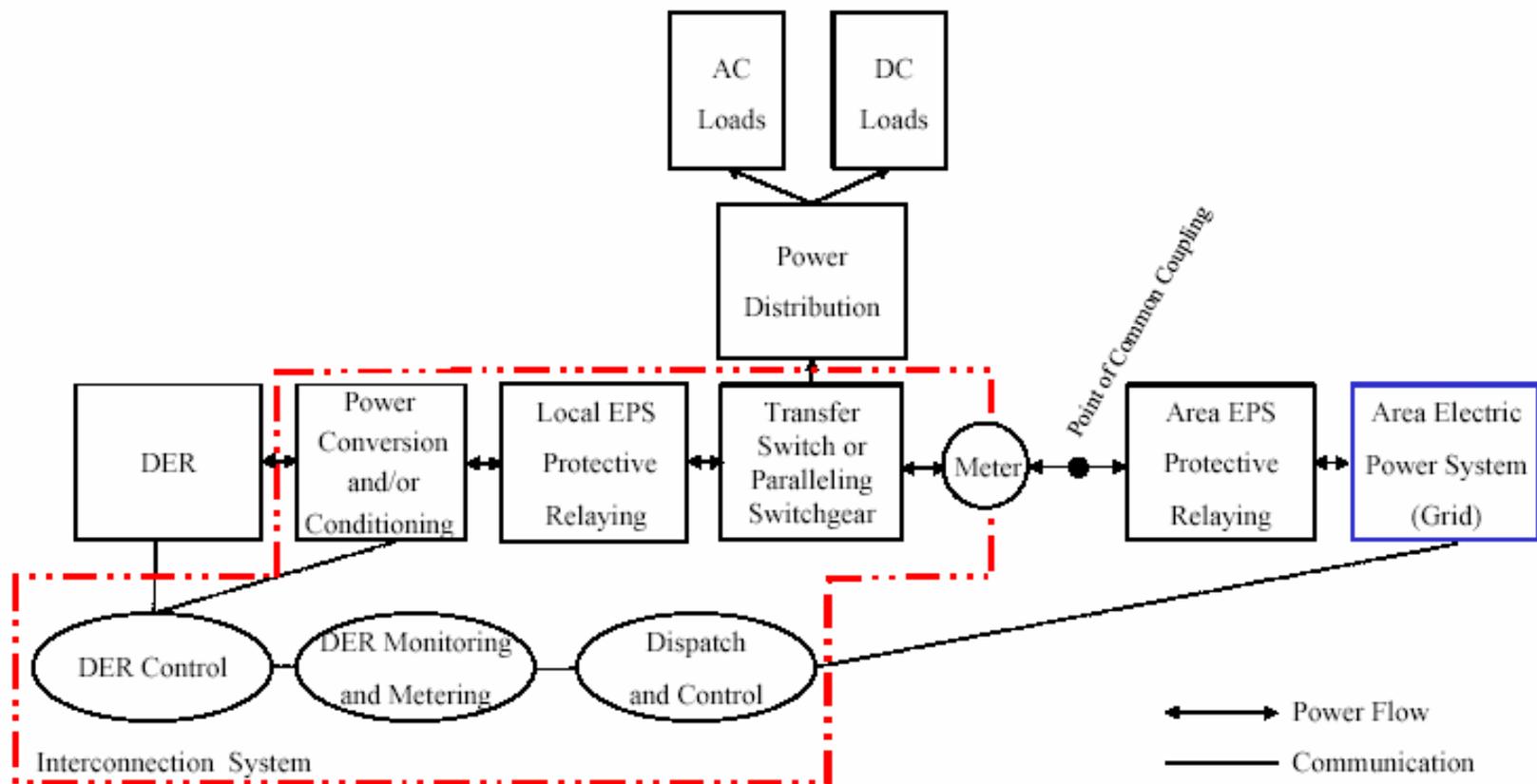
- Understanding the interconnection market is important to understanding the future role of and barriers to DER.
- The interconnection package is advancing quickly, with functional performance available today that was not possible even 1 year ago.
- The convergence of software and hardware is providing protection relaying and coordination functions at lower cost and at higher reliability.

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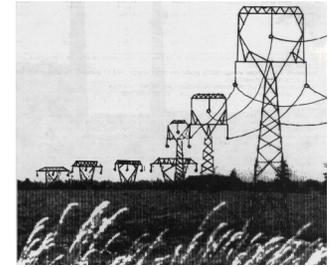
Interconnection System Functional Schematic



Source: "Distributed Energy Resources Interconnection Systems: Technology Review and Research Needs", NREL/SR-560-32459.

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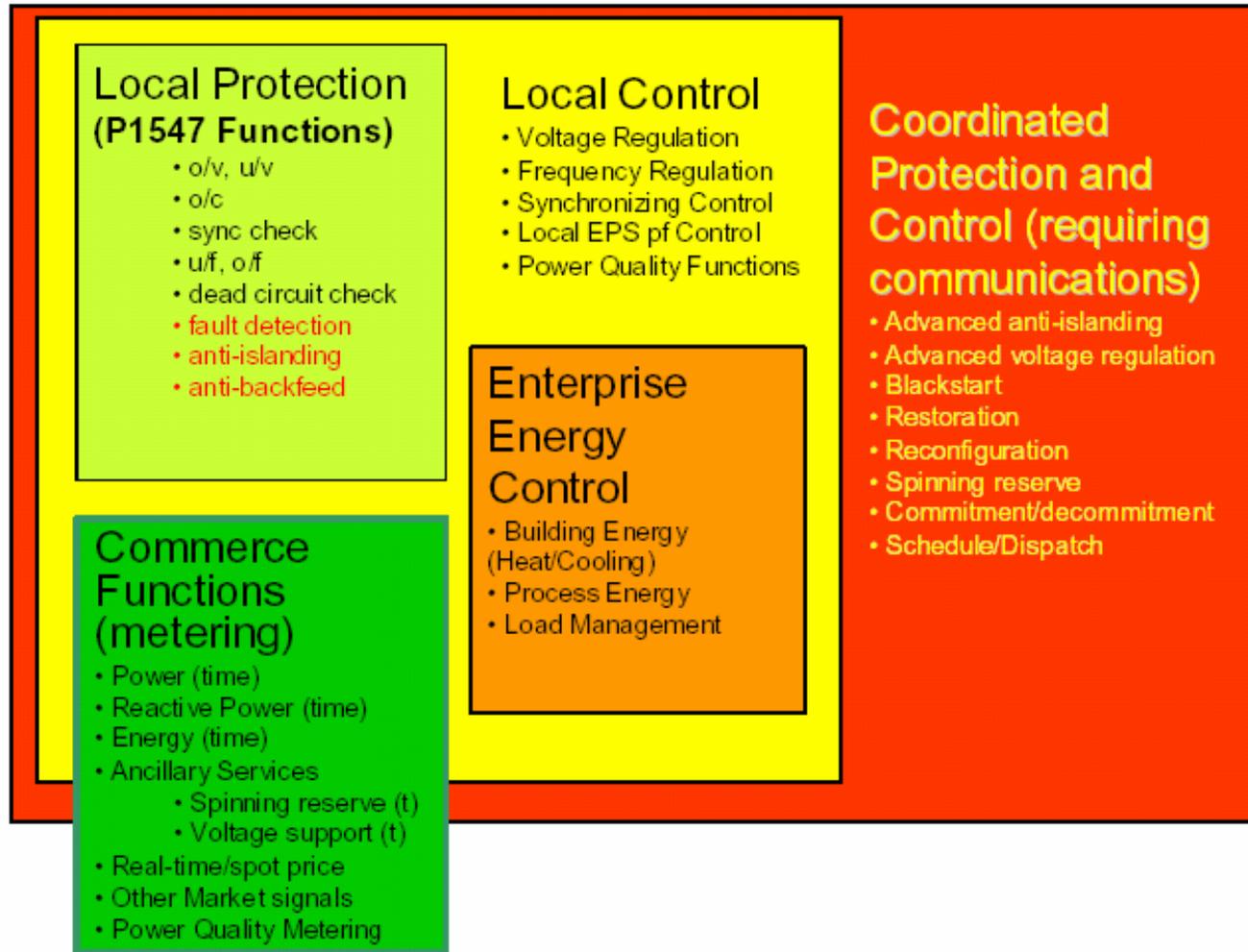
DER Interconnection Technology Development at a Crossroads



- Digital, multi-function relays emerging.
- Rise of inverter technology opened door to inverter-based protective relaying.
- Utility protection and coordination practices have been based on “discrete” relays on the utility side of meter.
- Utility protection engineers are now learning and becoming familiar with digital circuitry.
- Technology development is now coupled with electronic information age.

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Global Functionality of Universal Interconnection



Source: "Universal Interconnection Technology (UIT) Workshop Proceedings", July 25-26, 2002, Chicago, Illinois, NREL/BK-560-32865.

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Challenges of Current Practice

- Expanded 2-way electron flow on distribution feeders.
- Ensuring personnel safety and grid stability.
- Assessing impacts on the electric power system.
- Lowering interconnection cost and lead time.
- Better coordination of stakeholder DER activities.

Meeting the Needs of Interconnection

(Relevance to Problems and Needs)

- Standards development establishes common stakeholder understanding of issues associated with DER interconnection.
- Foster a better understanding and ease of use of IEEE 1547.
- Ease the burden of DER interconnection by providing application guidance, tips, techniques and rules of thumb.
- Disseminate the basics of standardized interconnection to a wide range of stakeholders.

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Impacts and Benefits on Affordability and Reliability

- Expedite and lower the cost of interconnection.
- Establish foundation for widespread understanding of technical issues of interconnection.
- Present “hands-on” solutions to interconnection challenges and barriers.
- Encourage DER interconnection with increase in robustness, reliability and restorability of the T&D system.
- Help transform and modernize the grid through standardized and intelligent addition of DER.

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Impacts and Benefits on Affordability and Reliability (cont.)

- Standardization will push the availability of affordable and reliable modular interfaces.
- Standards help create a regulatory and institutional environment that recognizes the benefits of DER and supports its use.

Encourage Greater Security and Resiliency of Distribution System

- Improve overall system reliability by interconnecting alternative power supply option.
- Export power to the grid or to the power pool in case of system emergency.
- DER interconnection can improve customer reliability with utility backup power in the event of a DER system outage (eliminates need for complete system redundancy).

Technical Accomplishments/ Progress to Date (FY03)

Contract not yet finalized

- Significant pre-contract activity:
 - June 2003 meeting of *Applications Guide* Working Group.
 - Formation of research and writing teams.
 - Establish Writing Group for *Applications Guide*.
 - Identification and collection of reference material.
 - Discussion of audience for *Guide*.
 - Development of detailed outline and possible format of *Applications Guide*.

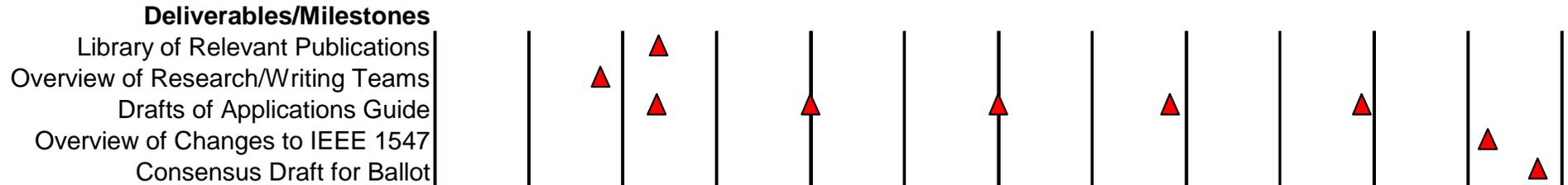
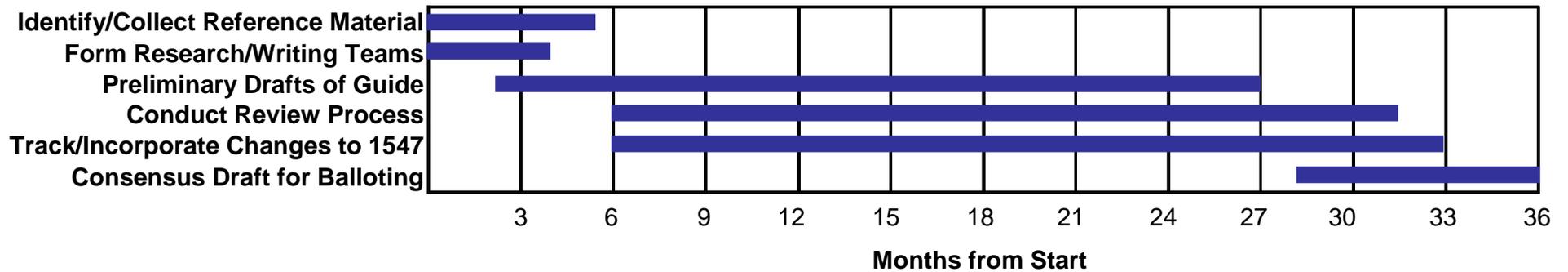
Accomplishments to Date (FY03, continued)

- Recent activity:
 - Virtual meetings to organize activities of Writing Group.
 - Develop Draft 01 of *Applications Guide* focusing on technical requirements.
 - Organize initial reviews of Draft 01.
 - Prepare for November 12-14, 2003 IEEE Standards Committee meeting.

Planned '04 Activities

- 3 meetings of full Standards Working Group.
- Extensive interaction with NRECA Project.
- Review Committee and System Planning Subcommittee in review of draft material.
- 2 new drafts of *Applications Guide*.
- 5-10 meetings of Writing Group.
- Documentation of library of relevant publications.

Project Timeline and Milestones



Project Budget

	Total (\$K)	DOE/NREL	RDC/NRECA
Base Year	425	200	225
Option Year 1	400	200	200
Option Year 2	400	200	200
Total	1,225	600	625

Stakeholder Engagement

(Leverage of Funds and Collaborations)

1. Industry participation and commitment:
 - over 100 organizations participating in *Guide* development
 - commitments of over \$500,000 annually in time and travel of volunteer Working Group members
 - technical input helping dramatically push state-of-the-art of interconnection
 - voluntary industry consensus hallmark of the IEEE Standards development process

Stakeholder Engagement (cont.)

(Leverage of Funds and Collaborations)

2. Regulatory interaction:

- direct participation by state regulators
- NARUC and states closely following IEEE 1547 series of standards developments
- states deferring to IEEE when standards are approved and promulgated
- FERC also recognizing importance and impact of IEEE work

Stakeholder Engagement (cont.)

(Leverage of Funds and Collaborations)

3. Additional resource leveraging:

- numerous technical reports and interconnection guidelines being offered as foundation for *Applications Guide* development
- NRECA members and other end-users and utilities offering additional cost-share support of over \$200K annually
- Working Group members bring nearly 2,000 years of experience and expert judgement to the standards development table

Publications/References

- Resource Dynamics Corporation, "*Distributed Energy Resources Interconnection Systems: Technology Review and Research Needs*", NREL/SR-560-32459, National Renewable Energy Laboratory, September 2002.
- Resource Dynamics Corporation, "*Universal Interconnection Technology (UIT) Workshop Proceedings*", July 25-26, 2002, Chicago, Illinois, NREL/BK-560-32865.

Publications/References (cont.)

- IEEE Applications Guide Website:
http://grouper.ieee.org/groups/scc21/1547.2/1547.2_index.html
- Resource Dynamics Corporation, *Application Guide for Distributed Generation Interconnection: The NRECA Guide to IEEE 1547, Second Edition*, NRECA, Arlington, VA, April 2003.

Contact Information



- E.J. Honton, Director, Resource Dynamics Corporation, 2046 NW Flanders, Suite 24, Portland, OR 97209, 541-462-3118, ejh@or.rdcnet.com
- N. Richard Friedman, Chairman & CEO, Resource Dynamics Corporation, 8605 Westwood Center Drive, Suite 410, Vienna, VA 22182, 703-356-1300 ext. 203, nrf@rdcnet.com
- www.rdcnet.com and www.distributed-generation.com