EPRI's Distributed Resources Program

DOE's 1st Annual DER Program Conference and Peer Review

November 28-30, 2001

Dan Rastler

Area Manager Distributed Resources

drastler@epri.com

EPRI

Agenda

- **Strategic Directions of EPRI's DR Program**
  - Vision, mission, goals
  - Industry support
  - Key outcomes we hope to achieve
- **Program Content**
  - What we learned from past work
  - Key Activities, and Key Results
- **Coordination Efforts**
  - Existing and New Collaborative Initiatives

EPRI: The Electric Power Research Institute

One of America's Largest and Most Successful R&D Consortia

- Over 700 North American members and 130 international participants
- $350 million annual R&D budget,
- Distributed Resources (DR) part of EPRI's program for 25 years,
- Current Industry Support is ~$10 million/year and growing.

EPRI's DR Business Vision

VISION: *Be the Global Source for Knowledge, Technology and Solutions for the evolving DR Industry by providing….*

- ✓ Premier One-Stop for Knowledge
- ✓ Strategic Positioning through Technology Development
- ✓ Smarter Decisions through Applications & Services

Enable our customers to understand, execute, and profit from business strategies involving distributed resources

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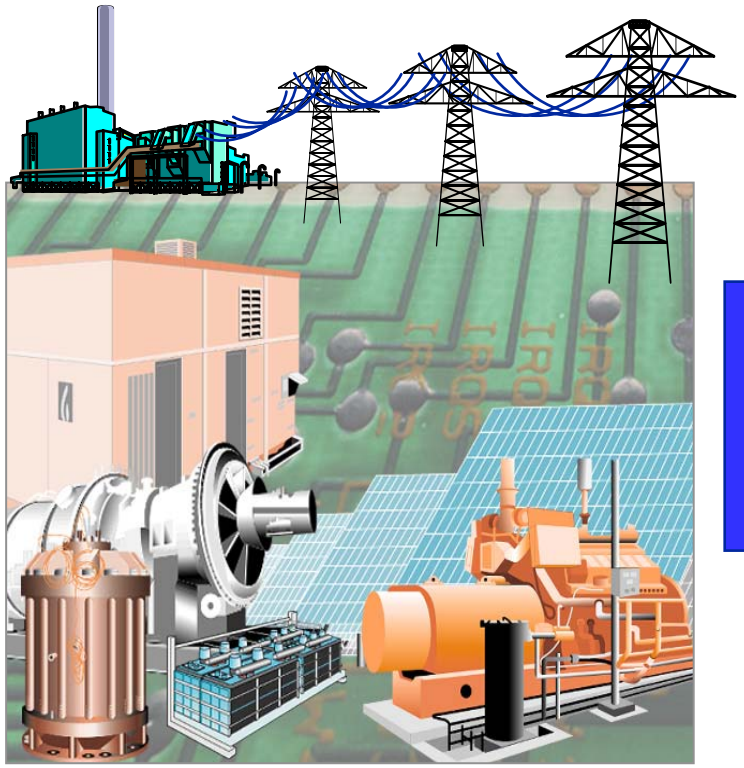
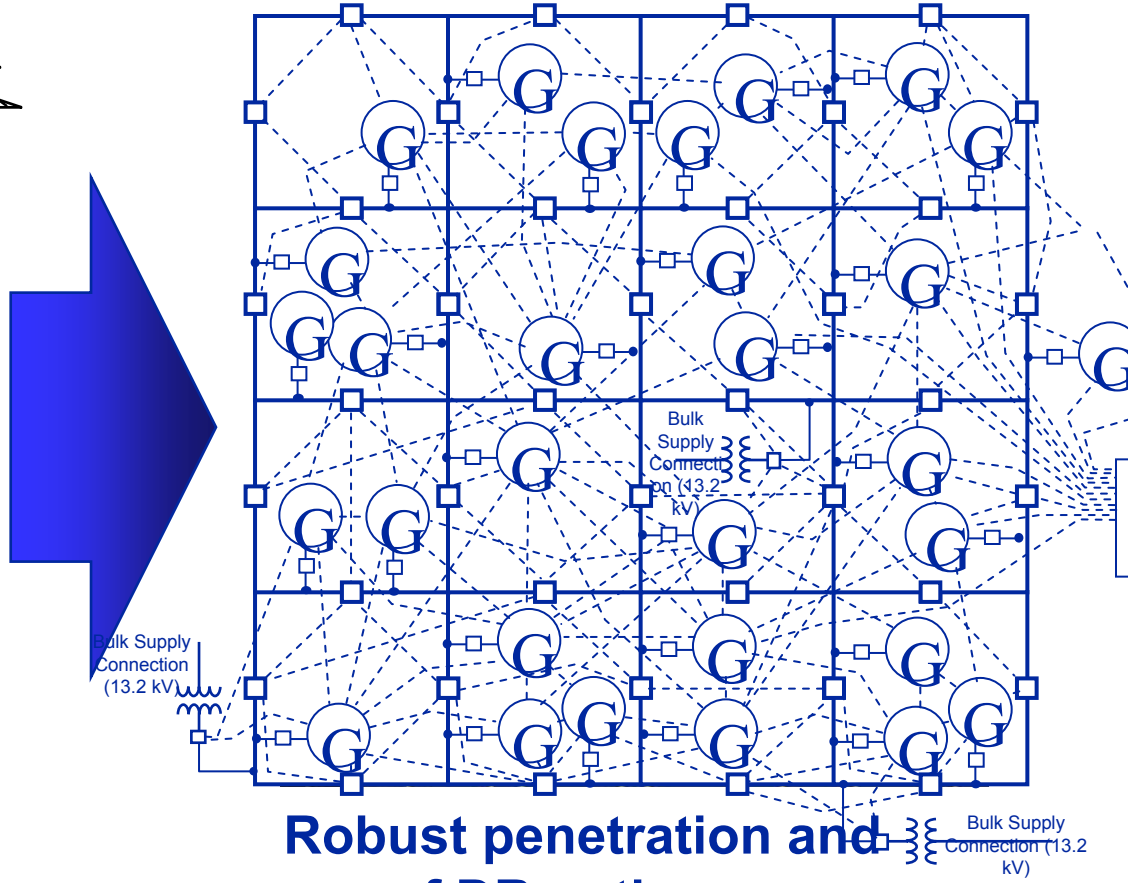
What we hope to Achieve …

Move DR from niche to Market Scale





Isolated niche DR applications to support end-user needs and support the power grid

Robust penetration and use of DR options integrated and active part of grid operations

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What we hope to achieve ...

Conduct R&D and develop information to support Utility Business Drivers and Models

- Improve Service Reliability -- get the most out of existing T&D assets - use DR to leverage the T&D business
- Create Value for Energy Services - add flexible generation to targeted areas - use DR to enhance the generation and trading business
- Leverage the Customer Interface and improve customer satisfaction -use DR to offer new services: premium power; reliability; CHP

Program Content ...
Overview of EPRI DR Product Line

The EPRI Family		
EPRI501	*EPRIsolutions*	*EPRI DR - Peac*
Target 34 "Information for Business Strategy"	**Target 33 Emerging DR Technology**	**Customized Services**
• On-line Knowledge Resources • Market Intelligence • Educational Material for Policy • DR for Retail Strategies • Interconnection Std. IEEE Std • DR for Wires Companies • Interconnect/Application Guide • Electrical characteristics model • DR as premium power • Market Research in Commercial Sectors • DR as a CHP device • Micro-Grid Definition	• Emerging Tech Assessment • Strategic Intelligence • Business Venture Forum • Advanced IC engines • Small Gas Turbines • Micro-turbines • Fuel Cells • Interconnection Technology • Grid-Gate-Way • Energy Storage • Early Stage R&D of break through technology	• Custom Market Analysis • Technology Strategy • T&D Asset Optimization • Due Diligence • Selective R&D Collaboratives • DR Field Testing • In-house DR Training

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What we have learned …
15 years of R&D

- Role of DR in De-regulated Electricity Markets
- Utility (Energy Company) DR Business Cases
- Scale of the DR Market (US and World Wide)
- Plausible Business Cases and their Viability
- Objective review of technology options - current and emerging
- DR in Utility T&D Planning
- 30+ utility site-specific case studies
- Test and validation of emerging technology
- Tools for site-specific evaluation and area T&D asset management

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What we have learned …
The current Reality

- Need Affordable, Clean, and Reliable DR Options
- Need to fully integrate DR into wires system to realize value and benefits
- Need to define value proposition and deliver real value to customers
- Dis-aggregated DR benefits need to be monetized into a business model
- Need - open architecture communication & control leveraging off Internet Assets

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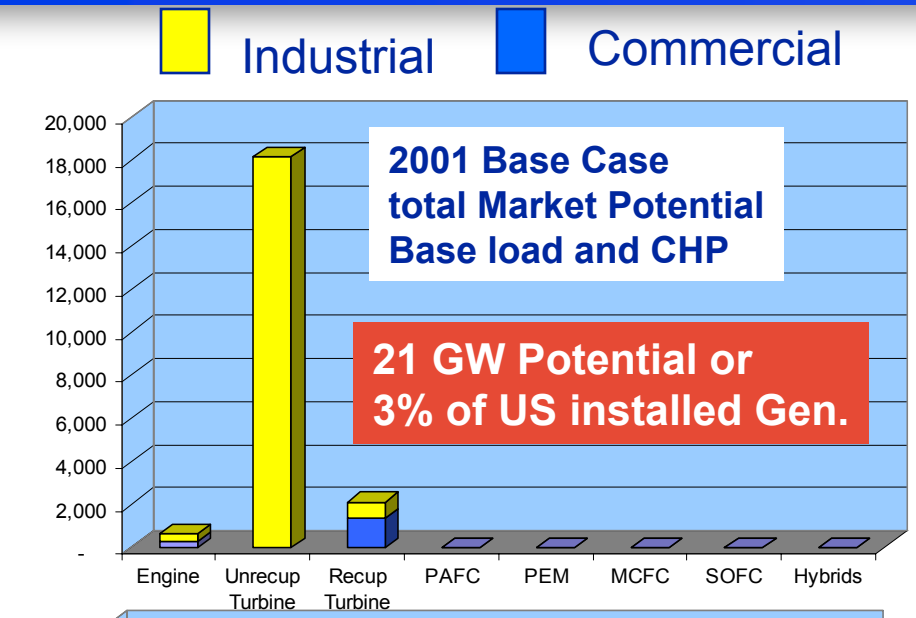
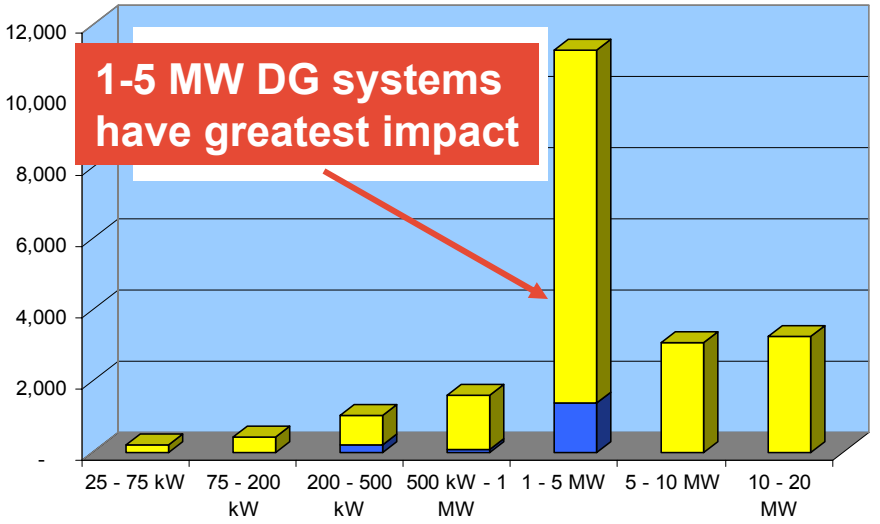
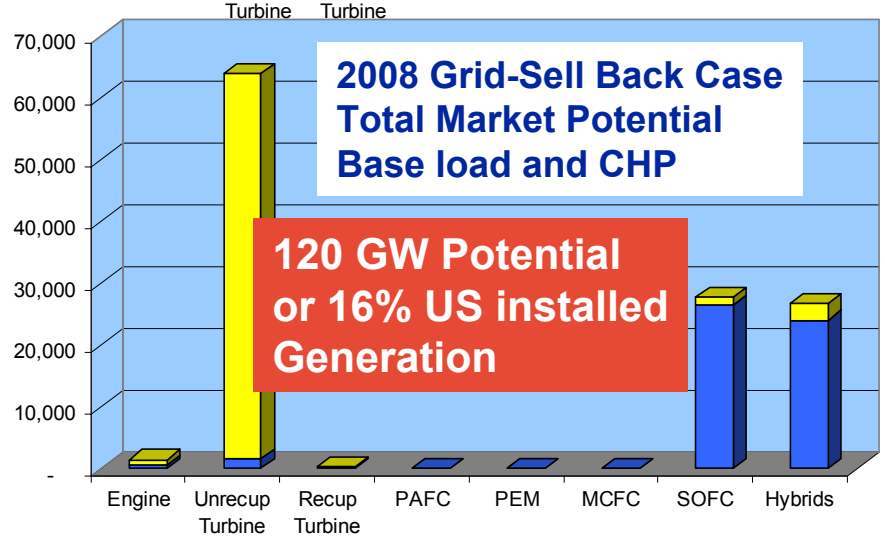
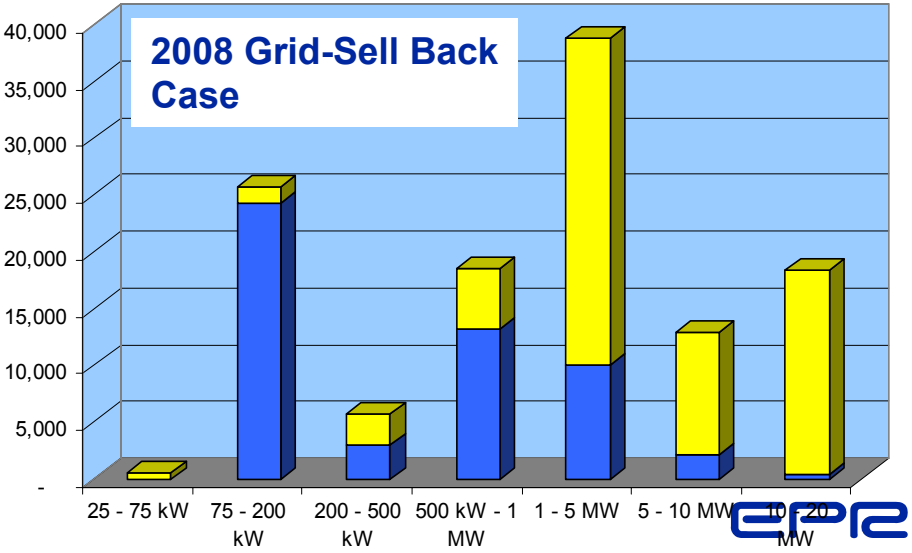
2001 Results: DR Market Size and competitiveness of Advanced DR



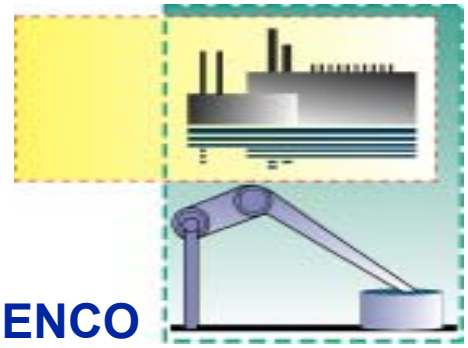






What we have Learned ….

Likely adopters and business case for Distributed Resources



GENCO
Generating Companies

UDC
Utility Distribution Companies

?

RESP
Retail Energy Service Providers

End-Users

What we have Learned ...

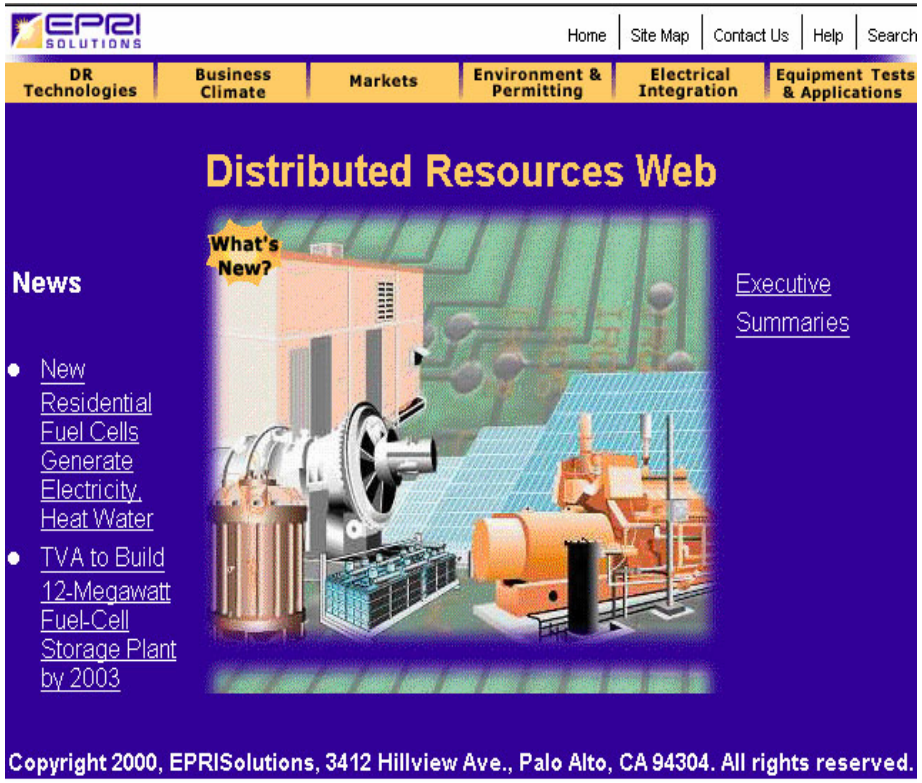
Scale and Viability of Distributed Resource Solutions and Business Cases

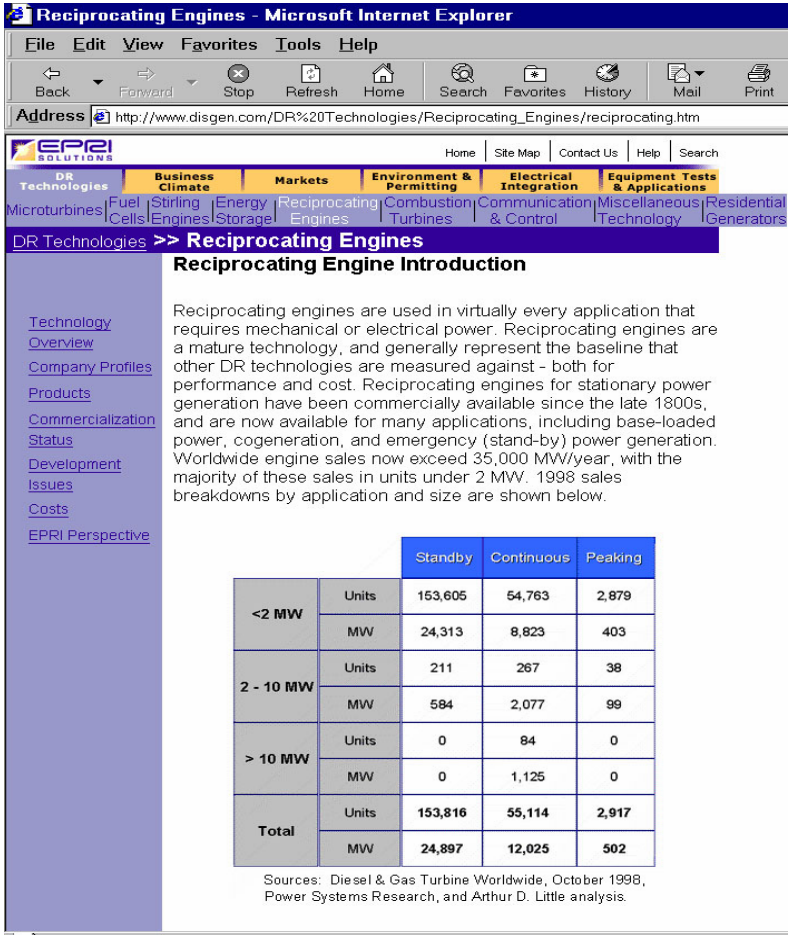
- Premium Power: Standby, Primary
- Combined Heat and Power (CHP)
- Peak Shaving - demand reduction
- Transmission Support, Ancillary Services
- Distribution System Support
- Price Risk Management

EPRI research examined and quantified the business case for DR in each of these areas.

Key Results…
On-Line Technical Assessment Guide

One-stop information resource on DR Technology, Markets, and Vendors



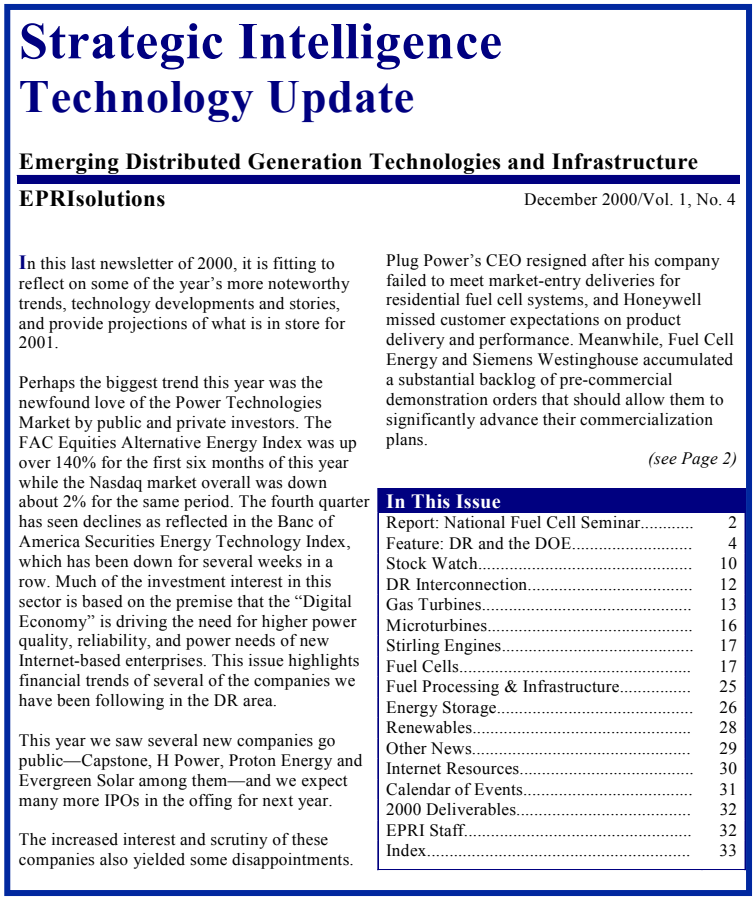


EPRI Product: *www.disgen.com*

Key Results: Strategic Intelligence Reports on DR Business and Emerging Technology

Insights and perspectives on developments of distributed power markets and technologies

- Quarterly updates on companies developing distributed generation products
- Inside intelligence on company strategies, alliances, and innovations
- Early stage business opportunities
- EPRI perspectives on new developments



Strategic Intelligence
Technology Update

Emerging Distributed Generation Technologies and Infrastructure

EPRIsolutions December 2000/Vol. 1, No. 4

In this last newsletter of 2000, it is fitting to reflect on some of the year's more noteworthy trends, technology developments and stories, and provide projections of what is in store for 2001.

Perhaps the biggest trend this year was the newfound love of the Power Technologies Market by public and private investors. The FAC Equities Alternative Energy Index was up over 140% for the first six months of this year while the Nasdaq market overall was down about 2% for the same period. The fourth quarter has seen declines as reflected in the Banc of America Securities Energy Technology Index, which has been down for several weeks in a row. Much of the investment interest in this sector is based on the premise that the "Digital Economy" is driving the need for higher power quality, reliability, and power needs of new Internet-based enterprises. This issue highlights financial trends of several of the companies we have been following in the DR area.

This year we saw several new companies go public—Capstone, H Power, Proton Energy and Evergreen Solar among them—and we expect many more IPOs in the offing for next year.

The increased interest and scrutiny of these companies also yielded some disappointments. Plug Power's CEO resigned after his company failed to meet market-entry deliveries for residential fuel cell systems, and Honeywell missed customer expectations on product delivery and performance. Meanwhile, Fuel Cell Energy and Siemens Westinghouse accumulated a substantial backlog of pre-commercial demonstration orders that should allow them to significantly advance their commercialization plans.

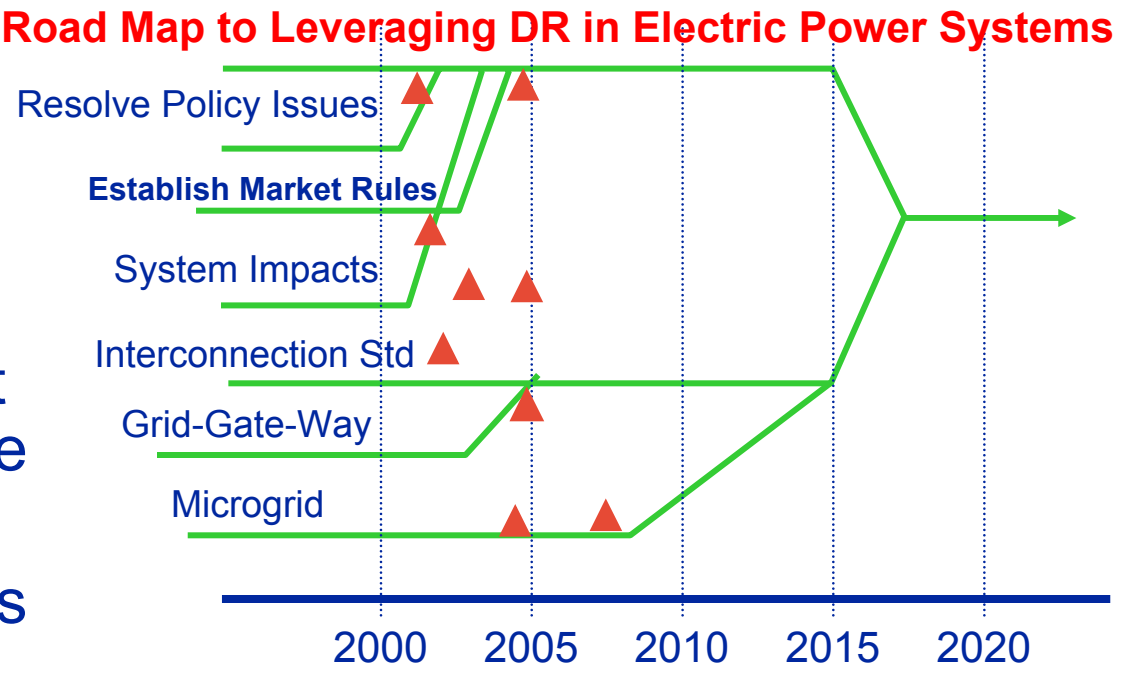
(see Page 2)

In This Issue

Key Results: Electrical System Integration

EPRI's Focus: Understand and resolve DR electrical integration issues and gaps

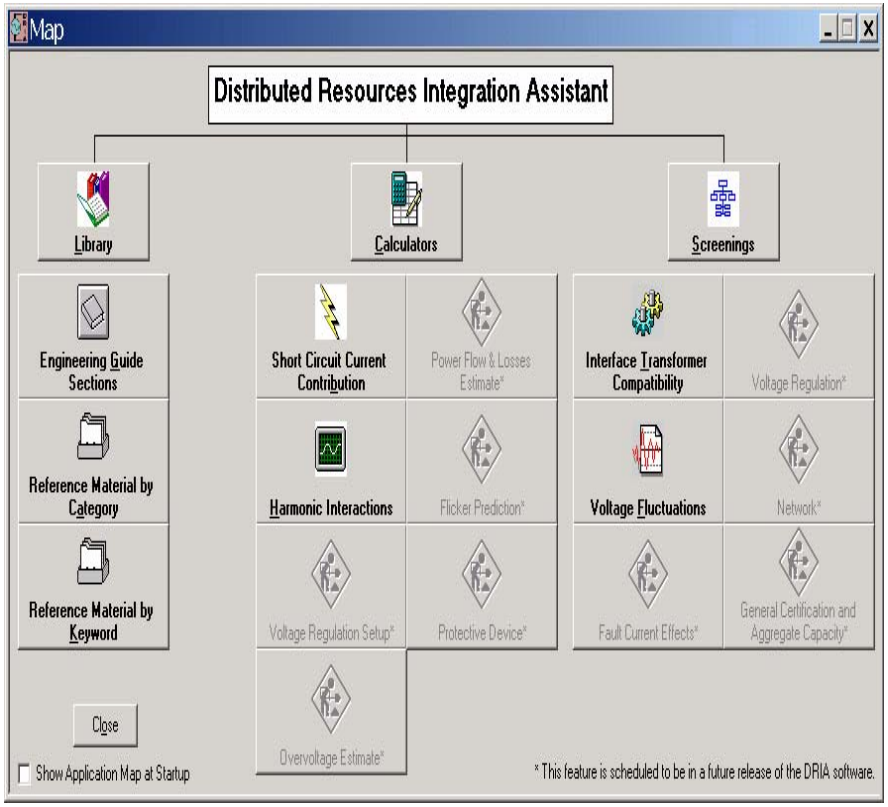
- Electrical Engineering Guide. EPRI # 1000419
- DR Integration Assistant soft ware tool
- DR Integration White Paper to educate Policy
- Technology Assessment of Interconnect Hardware
- DR Training on Interconnection Practices



Key Result: DR Integration Assistant

Software tool facilitates Screening and Solution to DR integration Problems Methodology

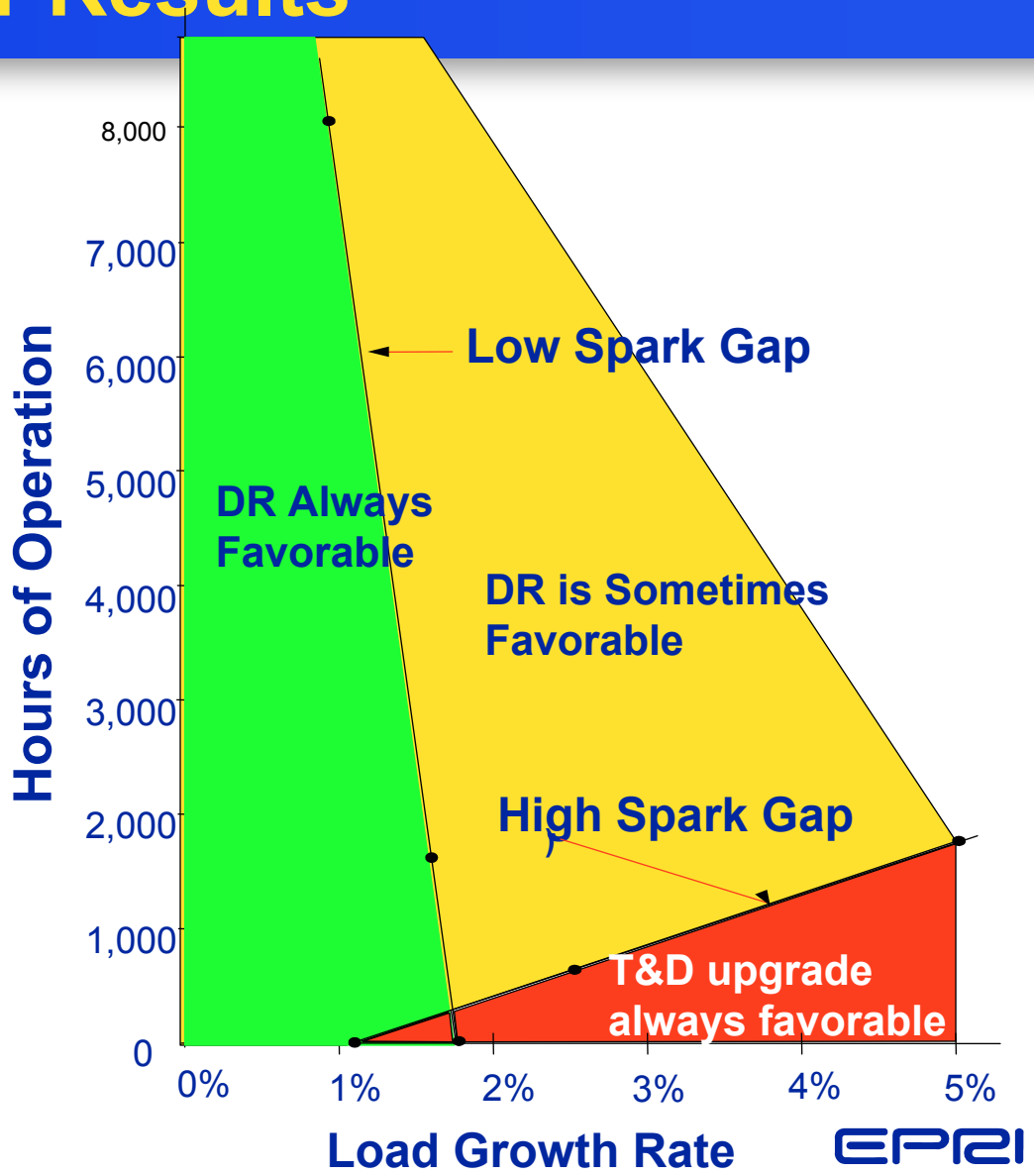
- **Software implementation of the Engineering Guide and IEEE-1547.**
  - tools that can be used to perform a first order analysis of potential DR applications.
  - Modularity (Can add modules as DR Integration evolves)
  - Ease of Use
  - Calculators, Screenings
- **Organized information on various facets of DR application.**
  - Library (Engineering Guide, Documents by Category and Keyword)
- ***Not* a replacement for detailed engineering analysis tools**



Key Result:
Research to Enable Utility T&D Companies to Leverage DR2001 Results

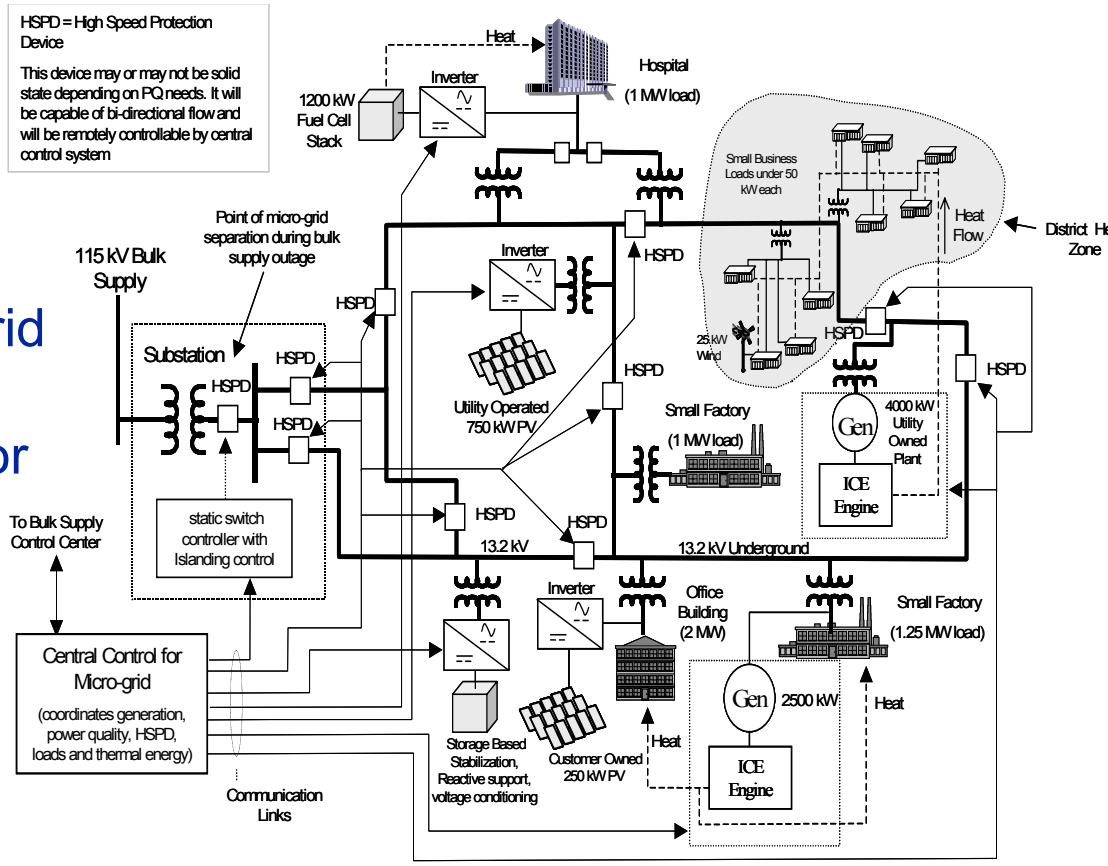
- DR Cost Impacts on T&D Systems
  - EPRI 1003975
- *Feasibility Regions of DR vs. T&D*
- *DR Applications for T&D Support*

- Siting of DR Units: Process and Issues
  - EPRI 1003974
- *Siting Process and Permitting Issues*
- *DR Siting Guidelines*



Key Result: Investigation of Technical & Economic Feasibility of Micro-Grids

- What are micro-grids?
- Example configurations
- Why use micro-grids in the future?
- Evaluation of various micro-grid architectures
- Power options best suitable for micro-girds
- Interface considerations and requirements
- Costs & benefits



Networked Primary-Based Micro-Grid Adapted for Power Quality Business Park Application

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Electrical Integration White Paper for Public Policy Makers

- Executive Summary describing DR electrical integration issues in layman's terms
- "Easy to understand" document discusses key technical interconnection issues associated with DR – aimed at regulators and planners
- Educational Briefs to continue in 2002 on topical subjects related to DR.

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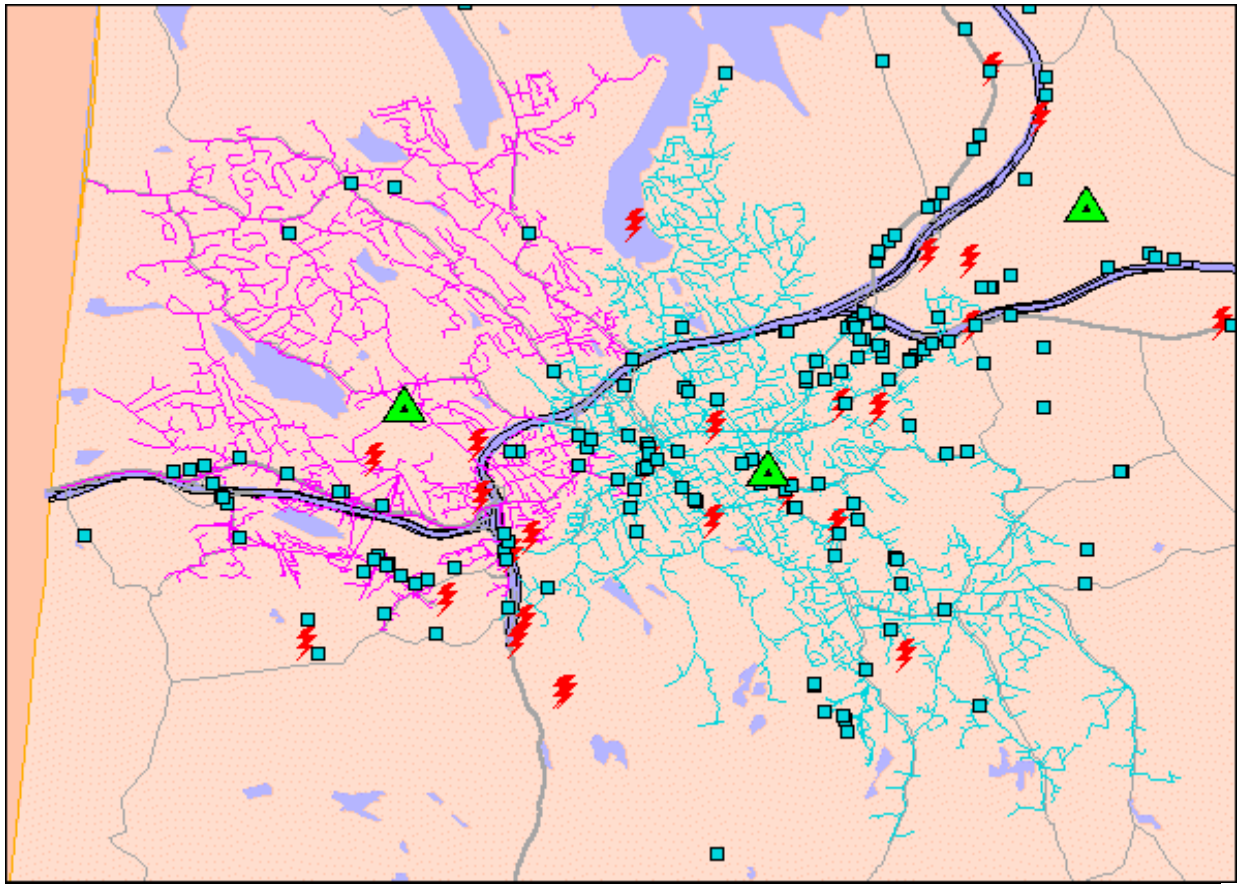
Key Results: EPRI Tool can help site DR for best T&D Asset Management and End-User Benefits

Graphical display helps plan, target, and manage DR

- Regional Map Data
- Service territories
- Electrical Distribution Network
- End User locations
- Best DR Locations



Organized Data and Information for Planning and Markets

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Small CT's for T&D Support

7 MW CT at NYSEG

CT Modified for Quick Installation

Value: EPRI 2001 report details installation, permitting and application and operational experiences

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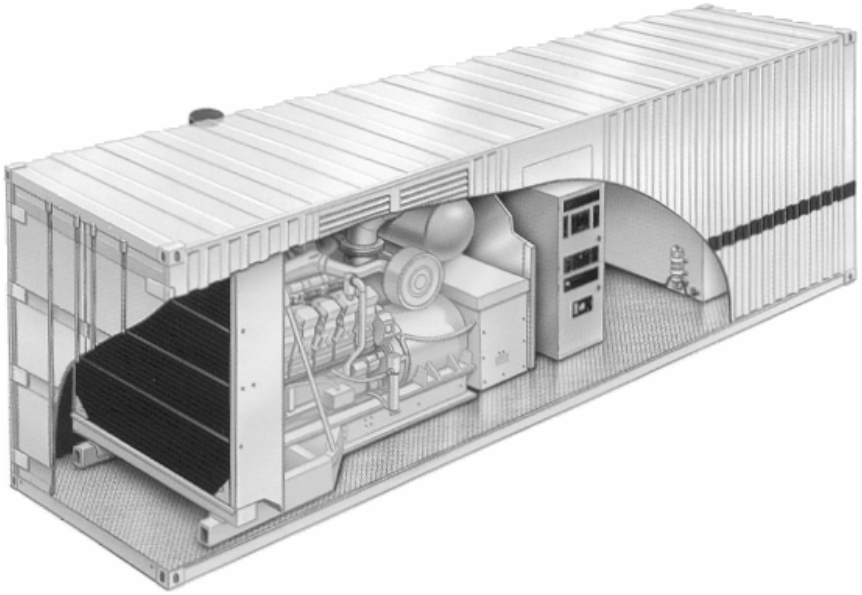
Emerging Technology - Advanced IC Engines 2001 Results

- Update on advanced engine developments
  - EPRI 1003959
- Vendor offerings and updates
  - EPRI 1003960
- Case Studies for using engines for T&D support
  - EPRI 1003962
- 2 MW pre-commercial CAT natural gas engine Demo planned in 2002



Emerging Technology - Validated Testing of Micro Turbines

EPRIsolutions Product #1000769

Performance

- Efficiency
- Emissions
- Part-Load
- Audible Noise

Electrical Characteristics

- Power Quality
- Responses to Grid Events
- EMF
- Transients
- Load Carrying

ENT 4000 ~ 400 kW mini turbine test planed for 2002

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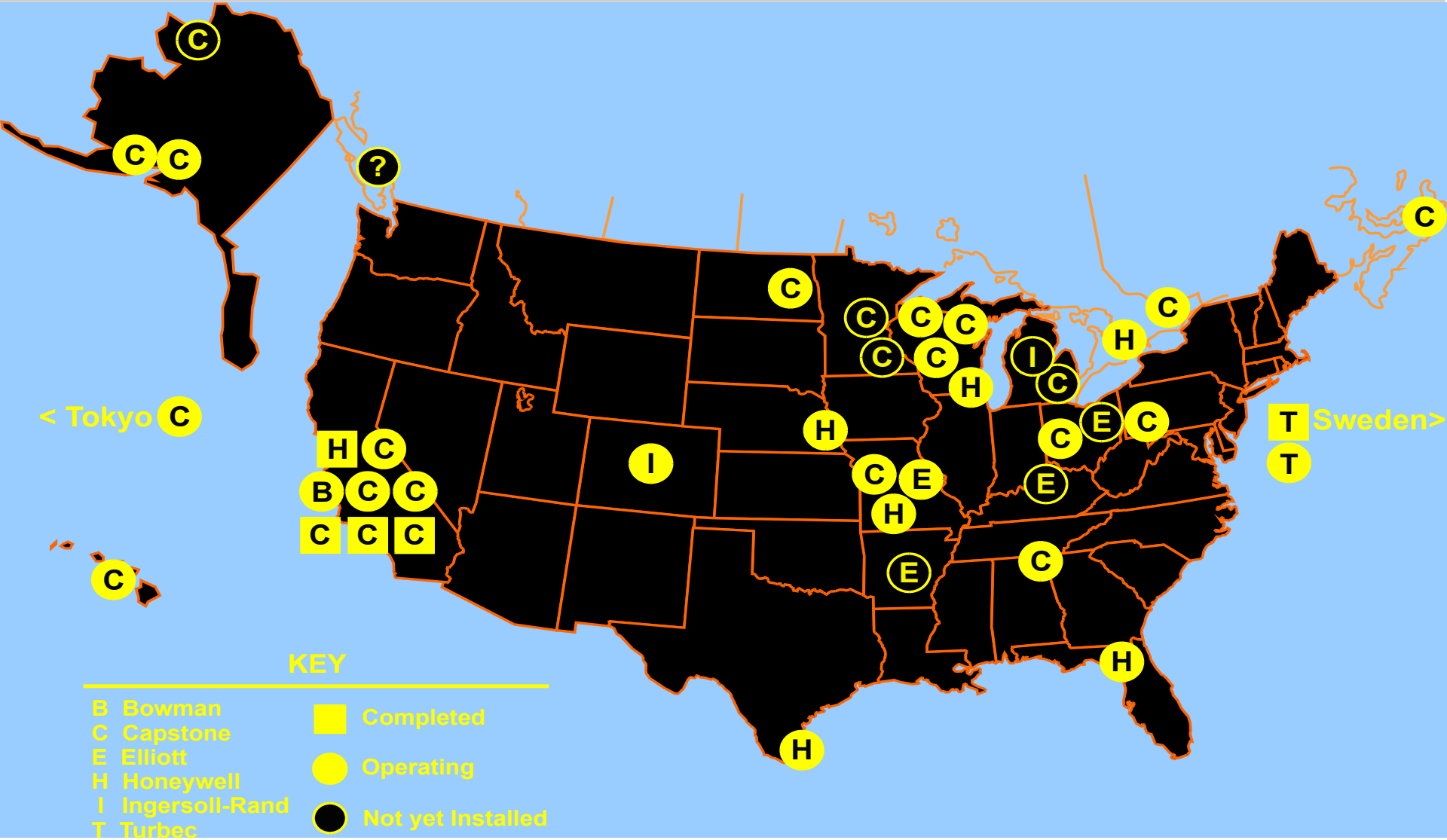
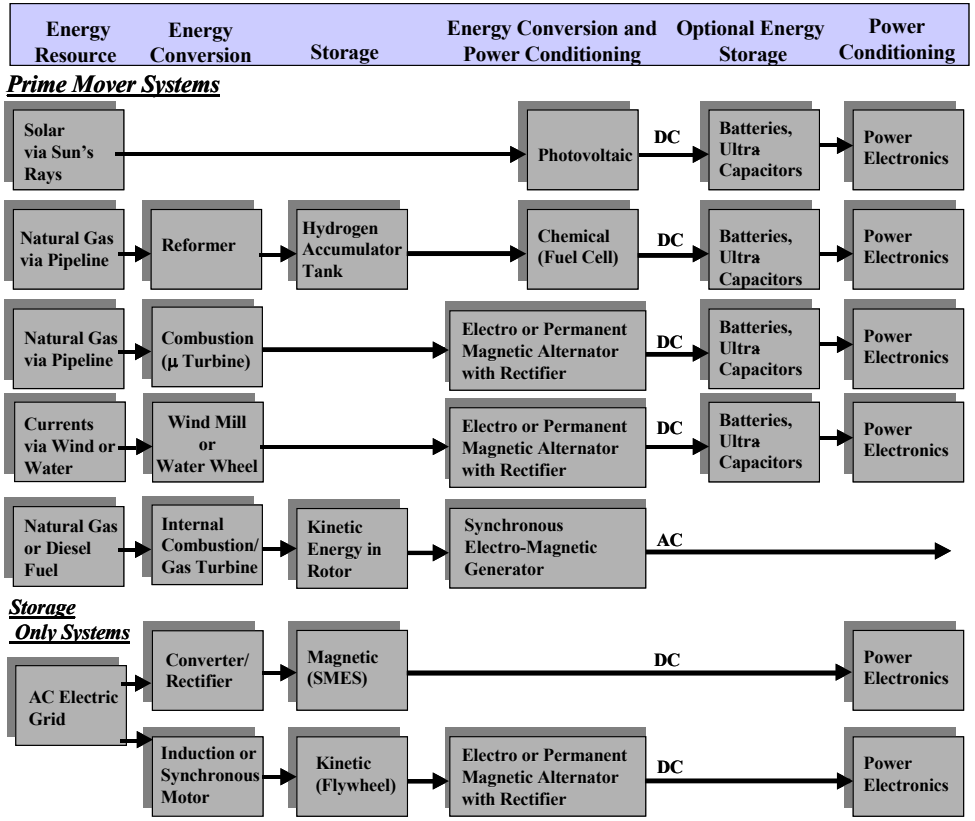
EPRI Micro-turbine Users Group Demo Program Installations . . .



Key Result: Guide for Performance Characterization of Emerging DR Technologies

- Guideline provides uniform methodology for consistent evaluation and testing of emerging DR technologies
- Appropriate test standards referenced, example test menus and sequences set up.
- DR test protocols in current use and a sample test agreement provided
- Technical report 1003963



Typical DR Equipment Applications, Components and Interfaces

Emerging Technology - Validated Testing of Stirling Engines

- Technology Update and assessment of Stirling Engines

- Test of 3 kW unit at EPRI-Peac

- Test of high efficiency 25 kW unit

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EPRI Fuel Cell Program

2001 Results: Technology and Vendor Update

Polymer Electrolyte Membrane (PEM)

- T~ 120°C
- Billions $ investment for transportation applications
- need fuel reformers
- Platinum Catalyst
- low efficiency

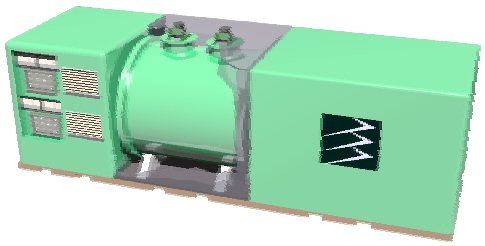
DaimlerChrysler PEM fuel cell vehicle

Phosphoric Acid Fuel Cells

- T = 180°C
- Commercially available
- Low efficiency
- High Cost

ONSI 200kW PAFC unit

Molten Carbonate Fuel Cells



- T = 650°C
- Electrolyte Mgt..
- Low Power Density
- Cost ?
- Bulky
- Durability ?

FCE 250 kW unit

Solid Oxide Fuel Cells (SOFC)

- T ~1000°C
- High efficiency
- High Quality heat
- Rapidly Advancing
- Durability ?
- Cost?

Siemens Westinghouse 100kW unit

Fuel Cell Program: Test and Field
Deployment of Residential Fuel Cells

5 kW PEM Fuel Cell Courtesy of International Fuel Cells

5 kW SOFC Fuel Cell Courtesy of Fuel Cell Technology

Value:

Analysis of key vendor programs and technology readiness

Baseline validation testing

RPG User's Group - collaborative data and experiences

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Emerging Technology - Validated Testing

Ultra-High Efficient Solid Oxide Fuel Cell Hybrid Systems

EPRIsolutions Product #1000751

Assess and develop break-through technology to improve efficiency and lower capital cost.

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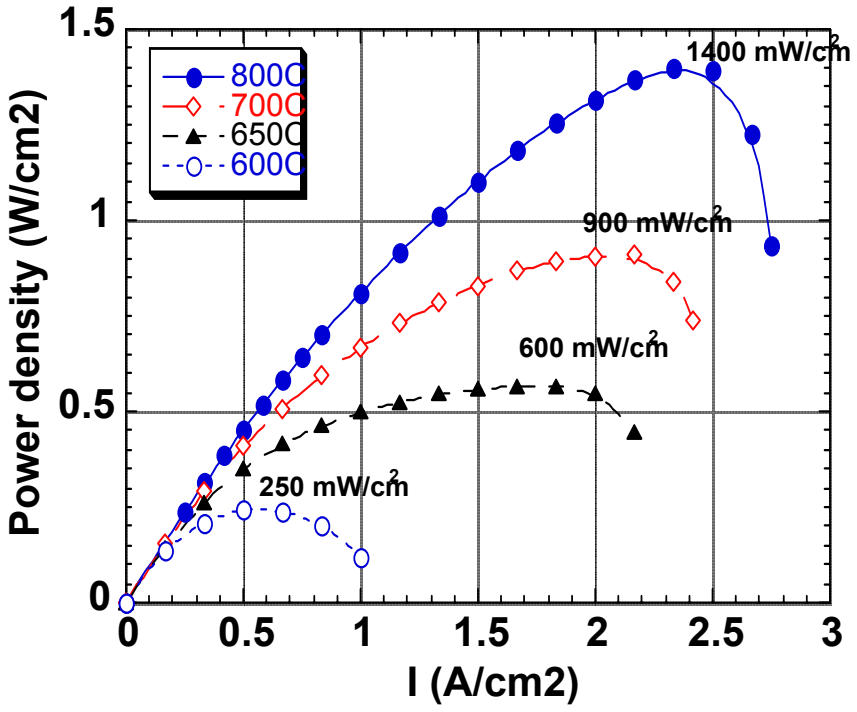
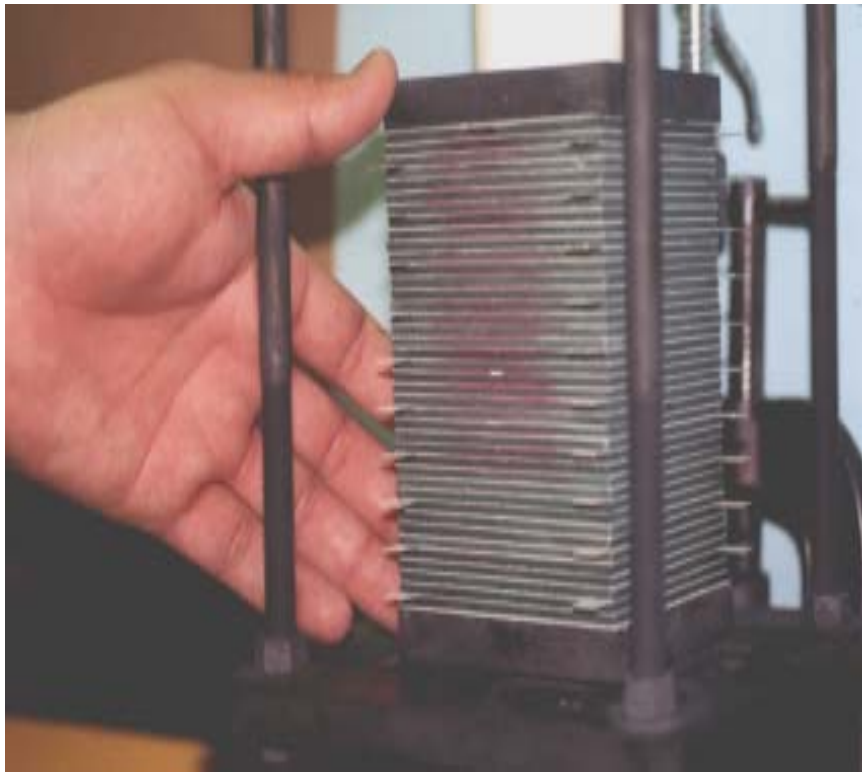
Fuel Cell Program- 2001 Results

In-depth Technology Assessment of Emerging Solid Oxide Fuel Cells: Configurations, Material & Manufacturing





Value:

- Assessment of Development and Investment Opportunities in SOFC
- Technology validation
- R&D Partnering Opportunities

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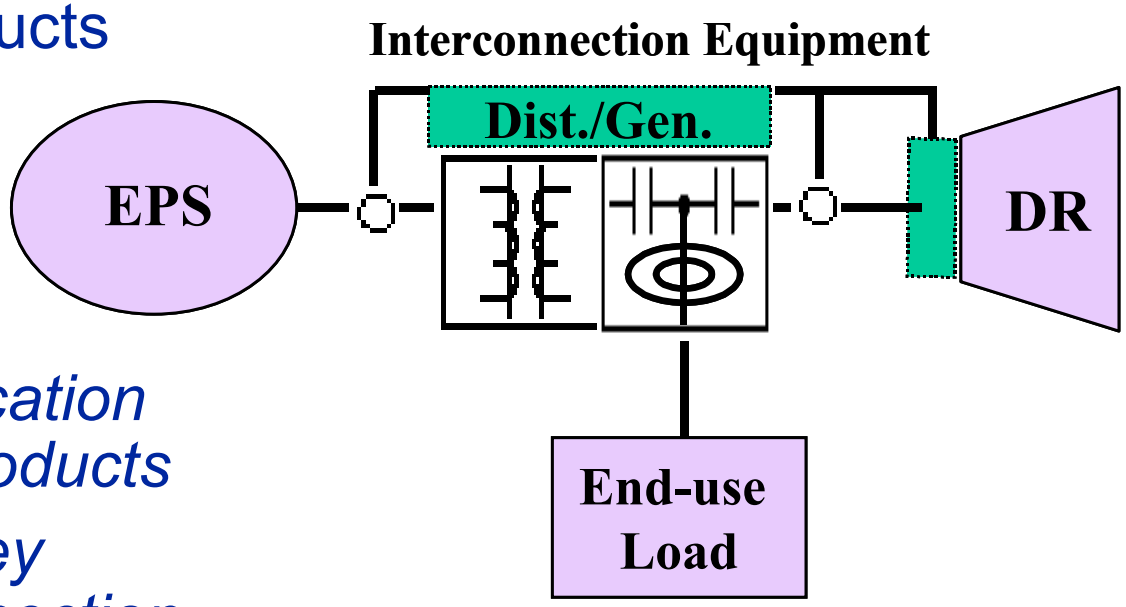
Assessment of DR Interconnection Hardware
2001 Results

- Technology Assessment of Interconnection Products for DR: Update 2001
  - EPRI 1003969
- *Assist planners in understanding the availability and application of interconnection products*
- *Identify and define key functions of interconnection hardware*
- *Assess the development needs (technology gaps) for interconnection equipment*



Development of Capacitor-Stabilized Soft-Transfer Interface System for Inverter-Connected DR

2001 Results EPRI Report 1003970

Key Result: Demonstration at San Diego Gas & Electric

DG Experiences at Customer Sites

- Five DR Systems Tested:
  - ICE “substation” trailer
  - Capstone 30 kW
  - Honeywell MTG
  - 2 Beacon flywheels for
  - Elektryon 100kW ICE
- Evaluate:
  - Operational experiences
  - Customer perspective
  - Emissions, efficiency, operations
- EPRI Report on Lessons Learned

Existing Areas Collaboration
DR Certification & Accreditation

- This project defines a certification and lab accreditation process, demonstrates their application through pilot testing based on emerging connection standards.
- 3-year Deliverables include:
  - certification and labeling criteria
  - test protocols and test results
  - handbook on interconnection agreements
  - web-based information hotline and technical training materials

NREL/ORNL/DOE EPRI-PEAC Collaboration

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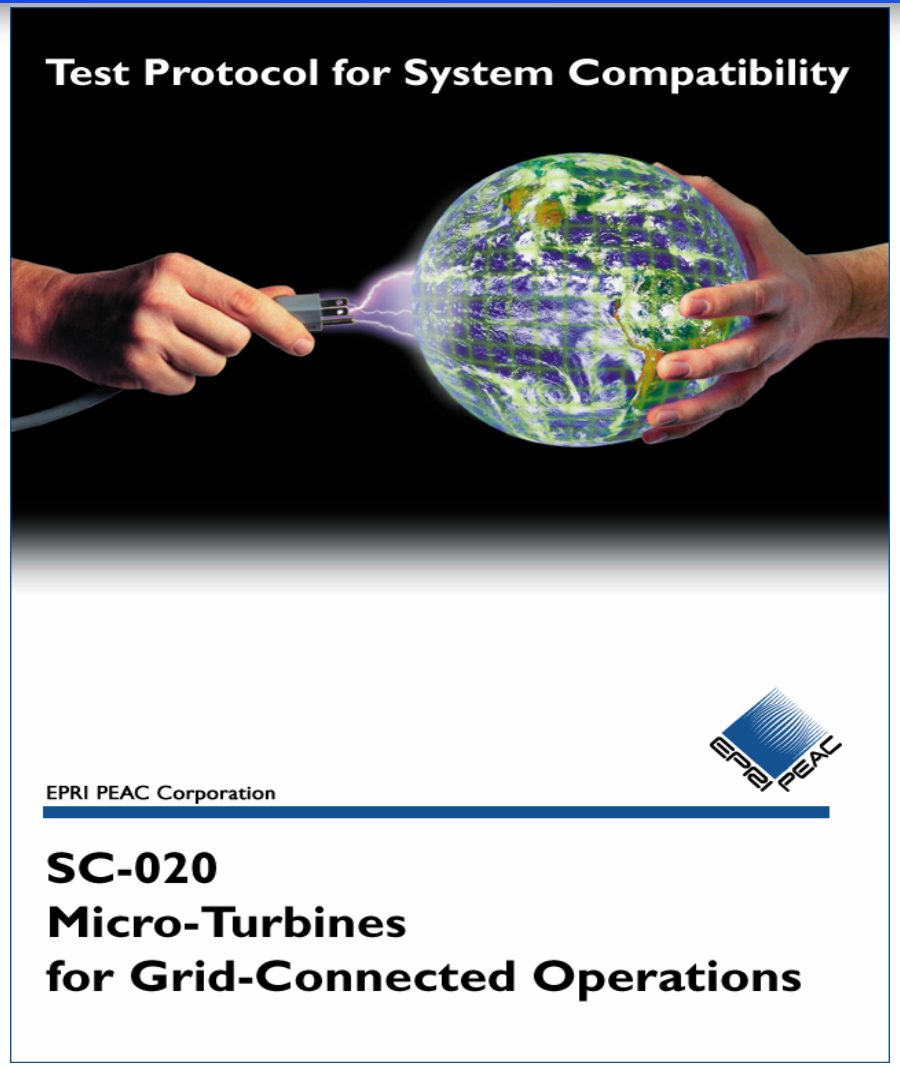
Completing The Circuit 2001 Results

A Utility Industry Response for Removing Potential Barriers to Interconnection of Distributed Resources

- Test drive 1547, gain experience, validate applications, identify issues and solve problems
- Conduct System Compatibility Research
  - **Performance criteria and test methods**
  - **Characterize DER equipment (with utilities' and manufacturers' participation)**
  - **Develop application-specific test protocols for various categories of DER**



Collaboration: New Initiatives

Conduct Electrical System Integration and Impact Tests in Real World Setting with Industry Partners

- AEP Walnut Substation configured for DR testing
- 12 kV / 138 kV Circuits
- 4 -- DR test bays
- 190 psi gas line
- DR Monitoring Trailer
- Plans to test 1 MW CT
- 2 MW advanced ICE
- Others tbd

AEP and EPRI seek Industry Collaboration to Resolve Electrical System Impact and Integration Issues

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Collaboration: New Initiatives
EPRI / Silicon Valley DER Assessment

Vision: *Attain Energy Security for Silicon Valley Stakeholders through targeted use of DER Options in concert with existing T&D infrastructure*

Goals:

- ✓ Assessment to Quantify Reliability, Energy Savings and Other DER Benefits
- ✓ Collaboration with key state and regional stake-holders
- ✓ Establish basis for go-forward SVMG, stakeholder win-win business model

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Collaboration: New Initiatives

Conduct Research to assess the Environmental Impacts Distributed Resources

- This initiative supports
  - **development of well-informed environmental regulations for DR**
  - **building of public-private partnerships to fill research gaps and complement ongoing programs**
- Projects include:
  - **DR deployment scenarios**
  - **emissions characterization**
  - **air quality impacts modeling**
  - **solid/liquid waste impacts**
  - **assessment of environmental tradeoffs**

Information to streamline DR siting, environmental permitting, and promote well-informed regulation

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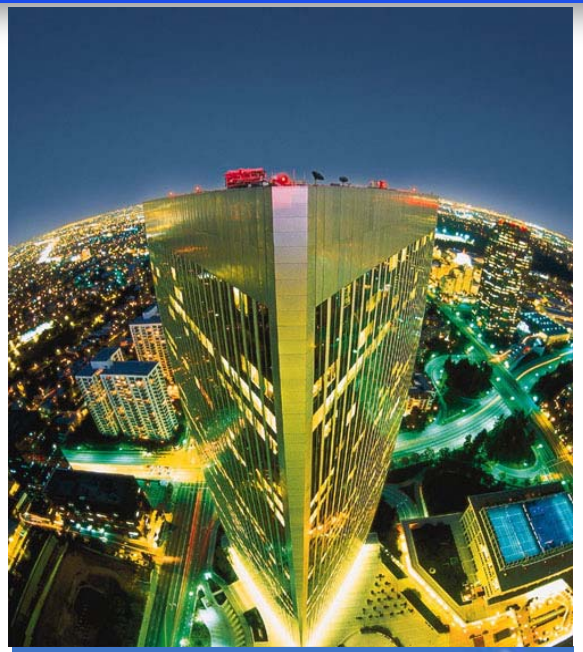
Collaboration: New Initiatives

Research and Development to create an open communication architecture for integrating DR into utility system automation.

- Gain state-holder alignment on the open architecture vision:
  - Development of a portfolio of DR object models to enable communication & control of DR
- Fast-track development of models for ICE's and CT's; field trials with utilities; refinement and submission to IEEE and IEC.



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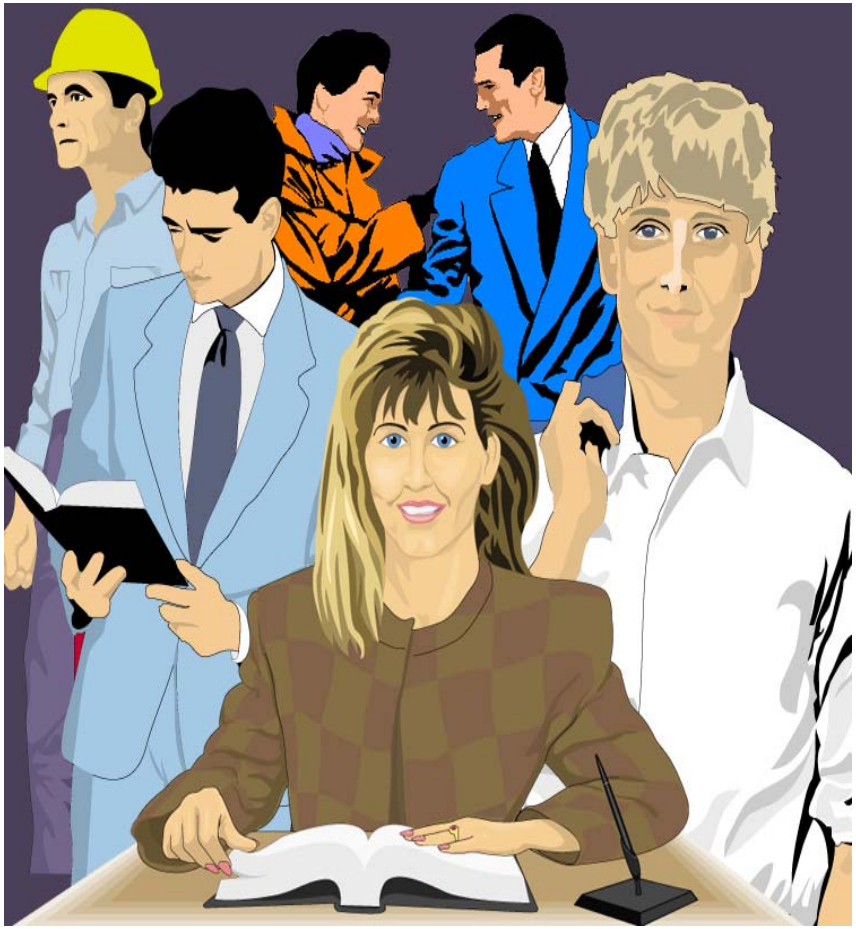
Collaboration: New Initiatives

EPRI is leading a new public/private initiative to move Distributed Resources to the next phase of commercialization.

- DR faces significant near-term challenges that could threaten its long-term viability.
- A public/private initiative could be an important response to these challenges, to keep DR moving towards commercialization and allowing us to realize its benefits
- An EPRI workshop planned for Jan 22nd, '02 will bring key stake-holders together to explore mutual needs, interests and future possibilities.



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EPRI's PEAC

Distributed Resources Park – Knoxville, TN

EPRI's Center for

DR Testing

Training

Prototype Development

EPRI

Shaping the Future with EPRIsolutions

EPRIsolutions Supplemental DR Services

- In-house DR Training and Workshops
- Interconnection and System Impacts Studies
- Client Confidential Market Assessments
- End-user DR / PQ Solutions
- DR Field Testing and Monitoring
- Early stage R&D to develop “break-through” Technology