Transforming the Grid to Revolutionize Electric Power in North America

December 11, 2003

Jimmy Glotfelty
Office of Electric Transmission and Distribution
U.S. Department of Energy

Electricity Modernization

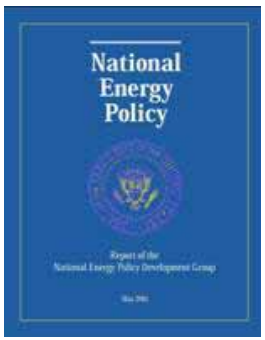
"…it's clear that the power grid needs an overhaul. It needs to be modernized. As we go into an exciting new period of American history, we want the most modern electricity grid for our people… we need more investment; we need research and development…"

George W. Bush
September 15, 2003

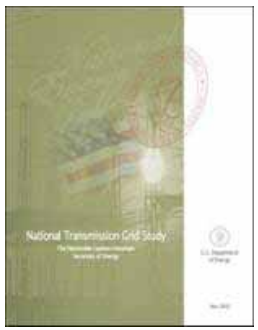
Leadership from all Levels

"…It is a plan to modernize our electricity delivery system. It is a plan which is needed now. It is needed for economic security. It is needed for national security…"

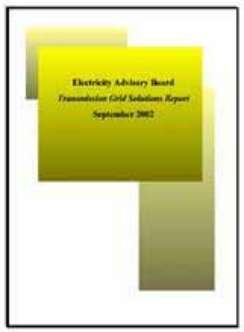
George W. Bush February 6, 2003



May 2001



May 2002

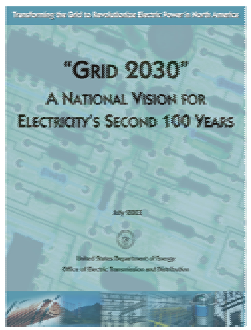


Sept 2002

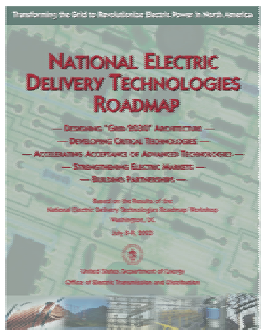
Presidents Council of Advisors On Science and Technology

Report on Energy Efficiency Findings and Recommendations

April 2003



July 2003



Draft Sept2003

"When the lights go out, modern life as we know it grinds to a sudden halt. Transportation is interrupted, communications fail, water systems shut down, factory work is disrupted, food spoils, businesses lose money, and people are inconvenienced and even endangered. "

Spencer Abraham, September 3, 2003

Electricity and Economic Growth

"If the energy structure of this country is inadequate or in some way excessively costly, it will undermine economic growth, and is therefore a major issue that must be addressed."

Alan Greenspan
Chairman, Federal Reserve Board
January 25, 2001

August 14th Blackout

By-The-Numbers

2 Canadian Provinces

3 deaths

8 U.S. states

12 airports closed

23 cases of looting in Ottawa

250+ power plants

9,266 square miles

61,800 MW of power lost

1.5 million Cleveland residents without water

50 million people

$6,012 billion in economic activity lost

National Reliability Challenges

- ***Prevention*** **– keep problems from occurring**
- ***Detection*** **– ready for immediate action**
- ***Response*** **– proper ”tool kits” for any contingency**
- ***Modernization*** **– “next generation” of grid technologies**

Prevention

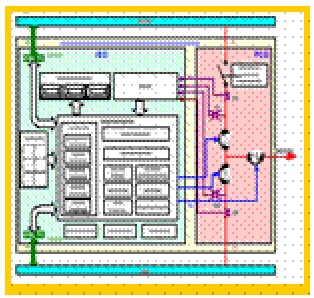
Stop reliability problems from occurring in the first place

Technologies for Today

- **Advanced conductors and tower designs**
- **Modeling and system planning tools**
- **Communications**
- **Training**

Composite Core Conductors

Communications Systems



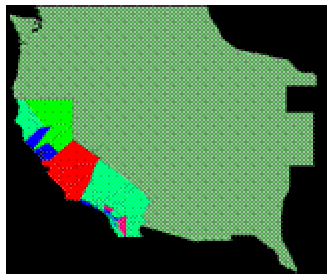
Modeling and Simulation Packages

Training Seminars

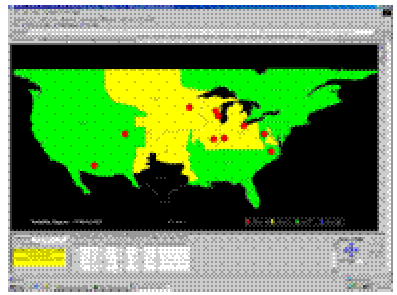
Detection

Improve grid operator readiness for taking action immediately

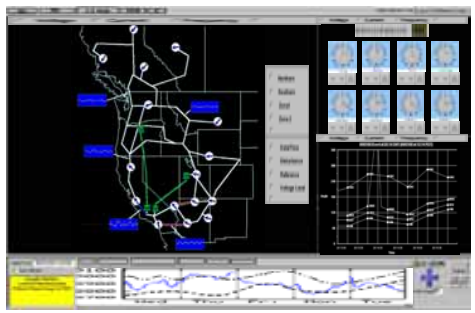
- **Monitoring Systems**
  - **Frequencies**
  - **Voltages**
  - **VARs**
  - **Phasors**
  - **Line Sag**
- **Data Acquisition**
- **Visualization Tools**
- **Communications**
- **Training**



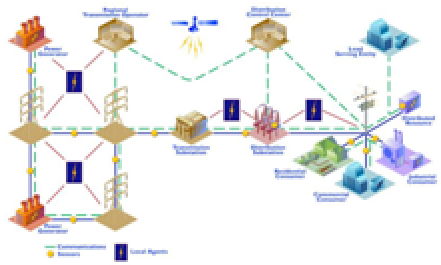
Voltage and VAR Monitoring



ACE Frequency Monitoring



Synchronized Phasor Applications



Distributed Sensing and Controls Systems

Response

Equip operators with a portfolio of resources comprising the best available tools and techniques

Technologies for Today

- **Distributed Generation**
- **Energy Storage Systems**
- **Demand Response**
- **Communications**

Industrial Gas Turbines

Aggregated Water Pumping Loads

Zinc-Bromine Battery System

Smart Thermostat

Reciprocating Engine Gen Sets

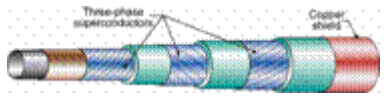
Microturbines

Modernization

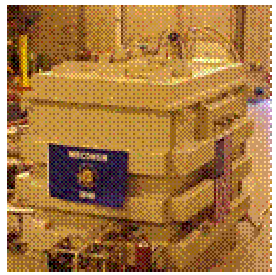
"Next generation" technologies for meeting future needs

Technologies for Tomorrow

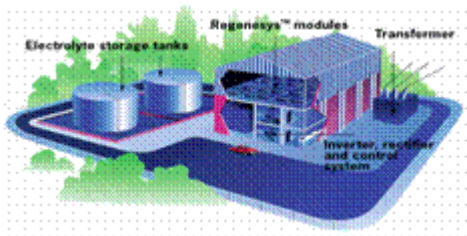
- **"GridWorks" Technologies**
  - **High temperature superconducting devices**
  - **Cables**
  - **Transformers**
  - **Motors**
  - **Fault current limiters**
- **"GridWise" Technologies**
  - **Distributed intelligence**
  - **Distributed energy**
  - **Distributed communications and controls**
- **Advanced Materials**
- **Power Electronics**



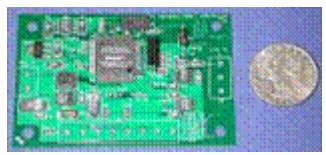
Superconducting Cable



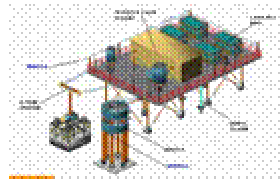
Superconducting Transformer



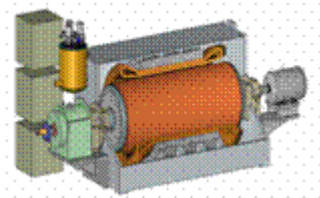
Advanced Energy Storage



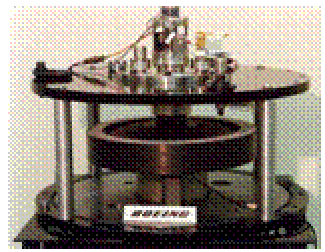
Grid-Friendly Appliance Controller



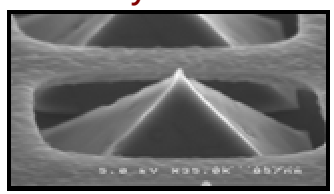
Fault current limiter



SuperVAR System



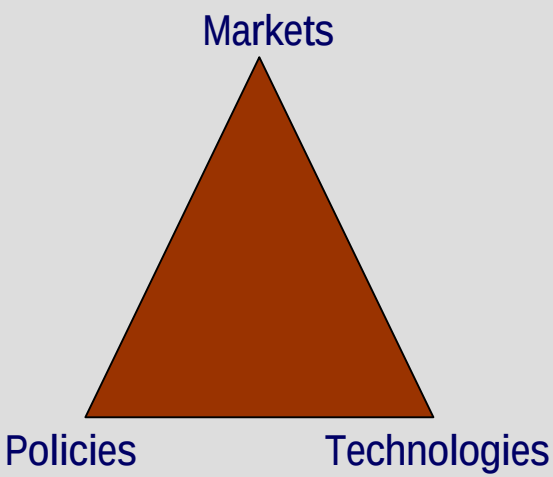
Superconducting Flywheel



Diamond Devices

U.S. DOE's Strategic Response

An Integrated Approach



Electricity RD&D

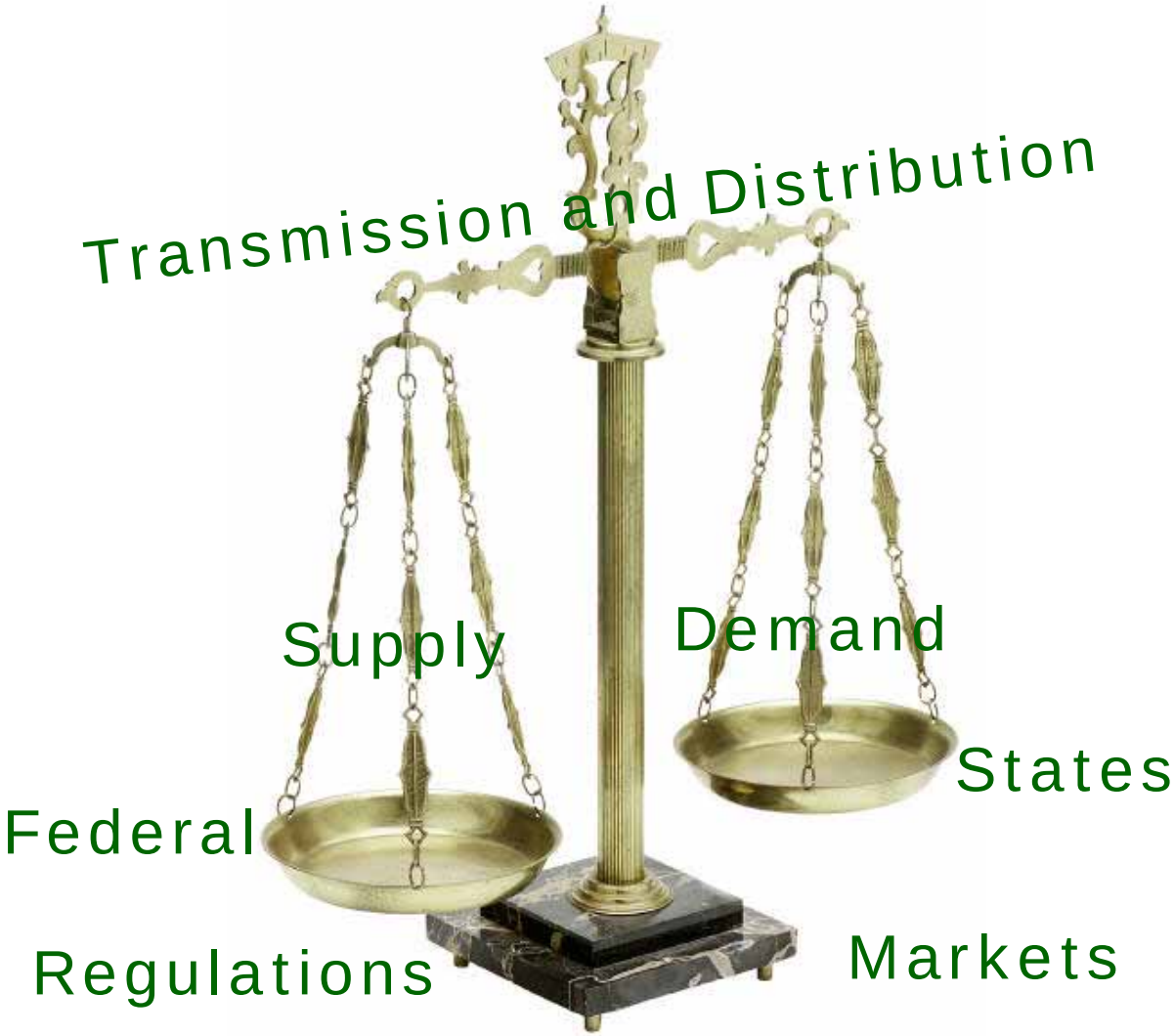
Analysis, modeling, and data

Federal, Regional, and State Coordination

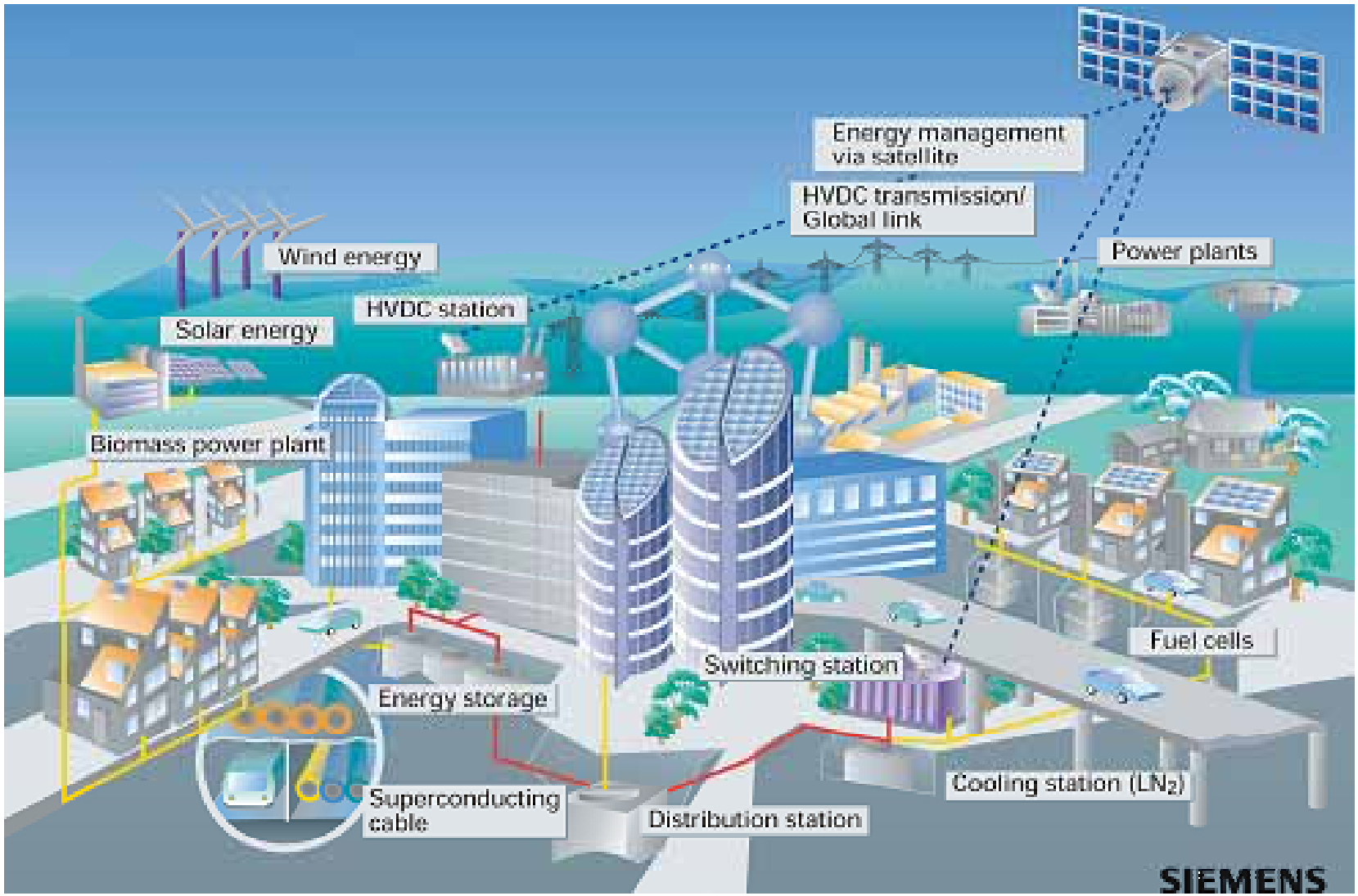
OETD Mission

To lead a national effort to modernize and expand America's electric delivery system to ensure a more reliable and robust electricity supply, as well as economic and national security.

Balancing Act



The Vision … "Grid 2030"



Electric Delivery Technologies Roadmap

An *Action Agenda* for Turning the Vision into Reality

Design "Grid 2030" Architecture

Conceptual framework that guides development of the electric system from transmission to end-use

Develop Critical Technologies

Advanced conductors, electric storage, high-temperature superconductors, distributed intelligence/smart controls, and power electronics that become building blocks for "Grid 2030"

Accelerate Technology Acceptance

Field testing and demonstrations that move the advanced technologies from the laboratory and into the "tool kit" of transmission and distribution system planners and operators

Strengthen Market Operations

Assessing markets, planning, and operations; improving siting and permitting; and addressing regulatory barriers bring greater certainty and lower financial risks to electric transactions and investment

Build Partnerships

Leveraging stakeholder involvement through multi-year, public-private partnerships; working with States to address shared concerns

Public-Private Partnerships

- Electricity Consumers
- Electric and Gas Utilities
- Independent System Operators
- Independent Power Producers
- Equipment Manufacturers
- IT Companies
- State Agencies
- Other Federal Agencies
- Canada, Mexico, and other countries
- Trade Associations
- Environmental and Labor Groups
- Universities
- National Laboratories

Energy Legislation

- **Mandatory Reliability**
- **RTO's**
- **Incentive Rates**
- **Standard Market Design**
- **Transmission Siting**
- **Transmission Tax Incentives**

Blackout Investigation

- **Working Groups**
  - **Security Update**
  - **Nuclear Update**
  - **Electric System Update**
- **Timing of Report**
- **Root-cause Analysis**

Conclusion

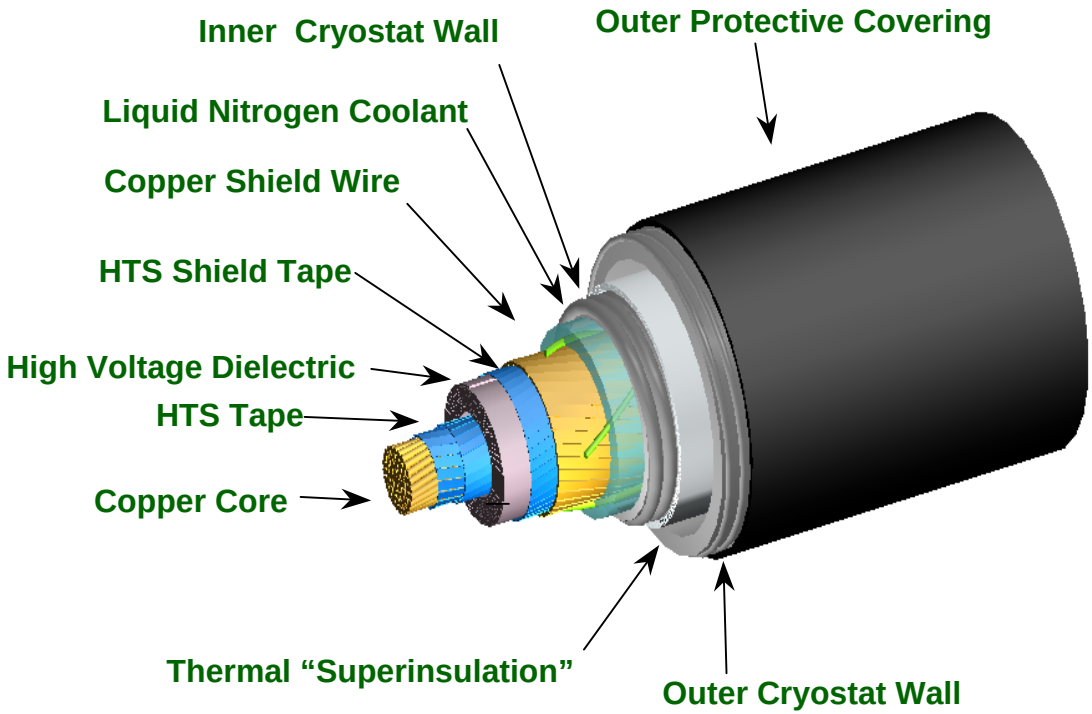
"We will work to <u>unleash innovation</u> and strengthen our markets to allow <u>entrepreneurs</u> to develop a more advanced and <u>robust transmission system</u> that meets growing energy demand in the years ahead."

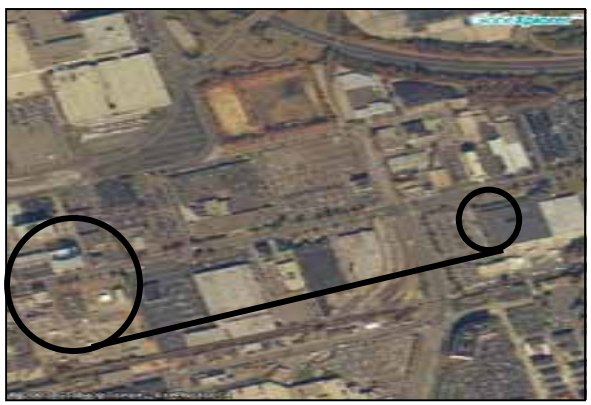
Secretary of Energy
Spencer Abraham

Back-ups

HTS Transmission Cable Project

- Electrical Operating Characteristics
  - Voltage/Power – 138kV/600MVA
  - Design Fault Current – 69,000A
- Physical Characteristics
  - Length – 610m
  - Three 610m long Phase Conductors
  - Six 161kV Outdoor Terminations
  - One 161kV Splice
  - One Refrigeration System

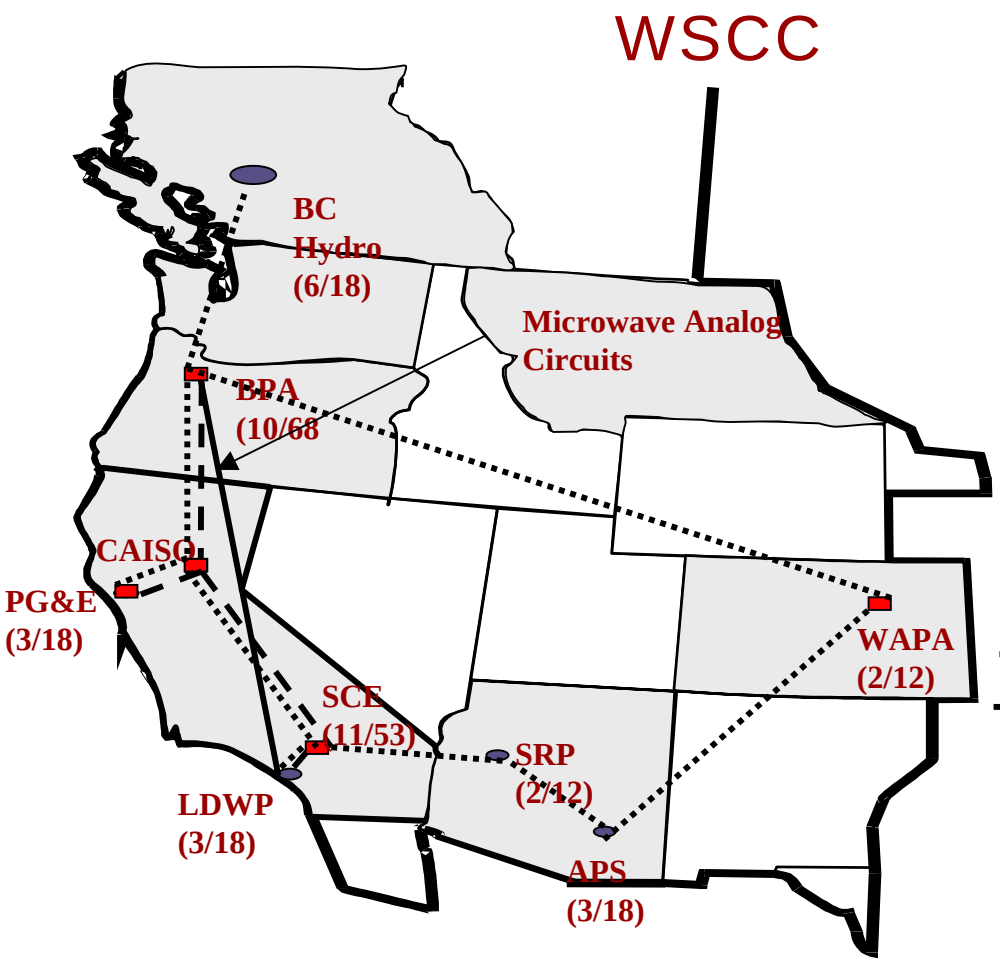




Project Team

American Superconductor	LIPA	Nexans	AIR LIQUIDE
Prime Contractor Wire Supplier	Installation Operation	Power Cable Assembly	Refrigeration

Synchronized Phasor Network



WECC TOTALS

40 PMUs
217 Phasors
2 Inter Data Links

CONVENTIONS

- States with PMU Installations
- Custom Data Concentrator
- BPA PDC
- Current Data link
- WECC Phasor Network Under Development
- Future Phasor Network

(aa/bb) # PMUs / # Phasors

Interconnection Standards & Technologies

Interconnection Technology and System Integration

Distributed Energy Resources

Fuel Cell

PV

Microturbine

Wind

Energy Storage

Generator

Interconnection Technologies

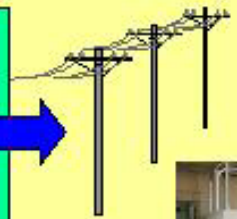
Inverter

Switchgear, Relays, & Controls

Functions

- Power Conversion
- Power Conditioning (PQ)
- Protection
- DER and Load Control
- Ancillary Services
- Communications
- Metering

Electric Power Systems


Utility Grid

Utility Grid Simulator
Micro Grids

Loads

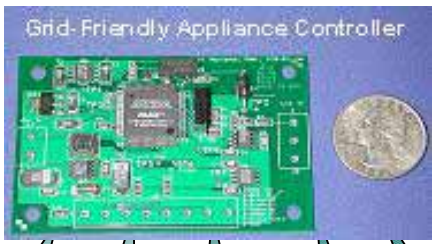
Local Loads

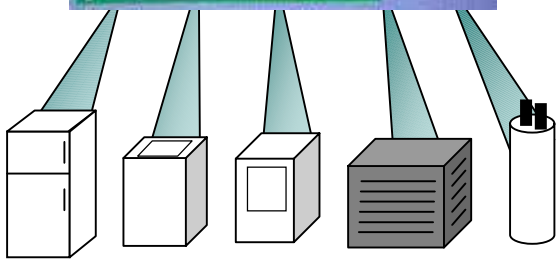
Load Simulators

Distributed Sensing, Intelligence, & Control Technologies

Grid-Friendly™ Appliance (GFAs) Controller

Millions of GFAs





eliminate need for 100s of new power plants,

saving tens of billions of dollars over 20 years.

Grid-friendly appliances …

… instantaneous, automatic response to grid crises
… displace need for spinning reserves
… allow grid to run "closer to the edge" safely
… 10 min. interruptions unnoticeable by consumer
… mass marketing/mass customization opportunity
… platform for active communication & control
  — pre-heat/pre-cool to coast through peaks
  — utilize & value thermal storage
… increase reliability & security

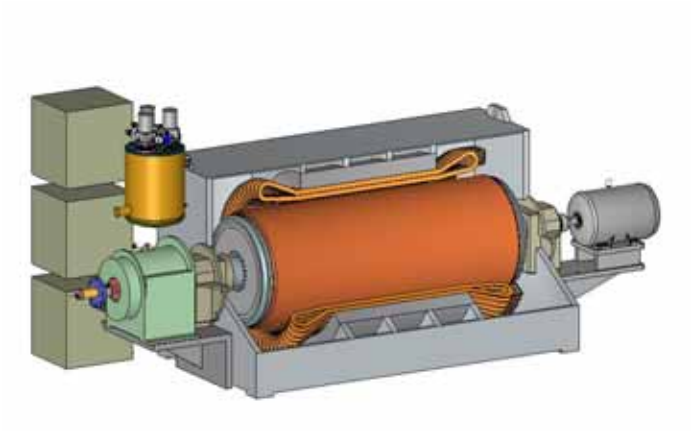
"…given enough ants, you can move a mountain!…"

impromptu reaction from a utility power engineer

Other Reliability Technologies

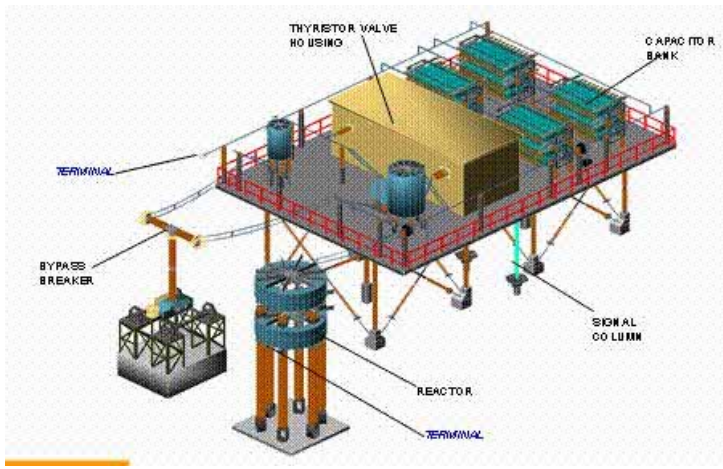
SuperVAR

- **New lower cost option to provide dynamic reactive power**
- **Prototype to be field-tested in TVA service area**



Fault Current Limiter

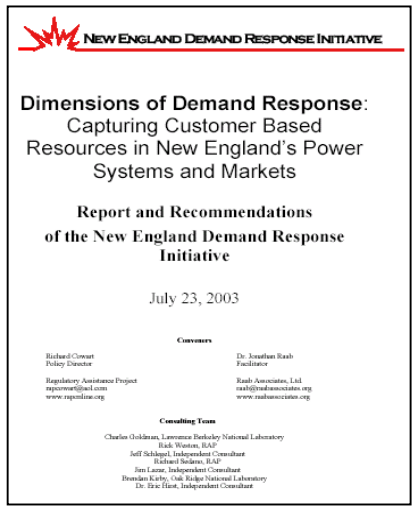
- **Tradeoff between fault control, bus capacity, and system stiffness has persisted for decades**
- **HTS design offer solution with no impedance**



New England Demand Response Initiative (NEDRI)

"Getting the Rules Right"

- NEDRI Final Report: "Dimensions of Demand Response: Capturing Customer Based Resources in New England's Power Systems and Markets"
- 38 consensus recommendations for incorporating demand response in retail and wholesale – first ever in U.S.!
- IMPACTS:
  - ISO-NE creates new Demand Response department
  - NEPOOL files revised summer 2003 DR programs based on NEDRI recommendations -- FERC approves
  - NH investigates advanced pricing/metering options
  - ME legislative hearings; VT Senate bill drafting
  - NY ISO working groups considering several NEDRI recommendations
  - CT, MA, RI proposing to adopt NEDRI-recommended emissions rule for DG participating in DR programs



NEW ENGLAND DEMAND RESPONSE INITIATIVE

Dimensions of Demand Response: Capturing Customer Based Resources in New England's Power Systems and Markets

Report and Recommendations of the New England Demand Response Initiative

July 23, 2003

Conveners

Richard Cowart
Policy Director

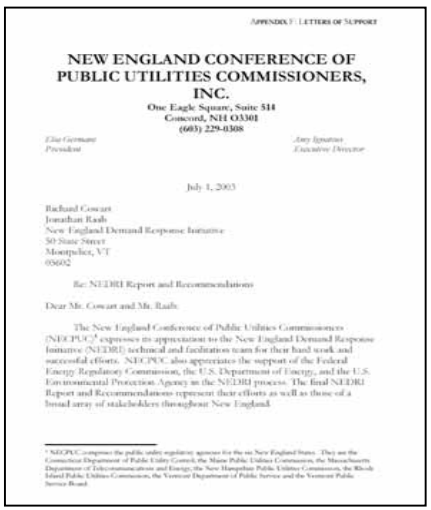
Regulatory Assistance Project
rapcowart@aol.com
www.raponline.org

Dr. Jonathan Raab
Facilitator

Raab Associates, Ltd.
raab@raabassociates.org
www.raabassociates.org

Consulting Team

Charles Goldman, Lawrence Berkeley National Laboratory
Rick Weston, RAP
Jeff Schlegel, Independent Consultant
Richard Sedano, RAP
Jim Lazar, Independent Consultant
Brendan Kirby, Oak Ridge National Laboratory
Dr. Eric Hirst, Independent Consultant



APPENDIX F: LETTERS OF SUPPORT

NEW ENGLAND CONFERENCE OF PUBLIC UTILITIES COMMISSIONERS, INC.
One Eagle Square, Suite 514
Concord, NH 03301
(603) 229-0308

Elia Germani
President

Amy Ignatius
Executive Director

July 1, 2003

Richard Cowart
Jonathan Raab
New England Demand Response Initiative
50 State Street
Montpelier, VT
05602

Re: NEDRI Report and Recommendations

Dear Mr. Cowart and Mr. Raab:

The New England Conference of Public Utilities Commissioners (NECPUC)[a] expresses its appreciation to the New England Demand Response Initiative (NEDRI) technical and facilitation team for their hard work and successful efforts. NECPUC also appreciates the support of the Federal Energy Regulatory Commission, the U.S. Department of Energy, and the U.S. Environmental Protection Agency in the NEDRI process. The final NEDRI Report and Recommendations represent their efforts as well as those of a broad array of stakeholders throughout New England.

[a] NECPUC comprises the public utility regulatory agencies for the six New England States. They are the Connecticut Department of Public Utility Control, the Maine Public Utilities Commission, the Massachusetts Department of Telecommunications and Energy, the New Hampshire Public Utilities Commission, the Rhode Island Public Utilities Commission, the Vermont Department of Public Service and the Vermont Public Service Board.