Transforming the Grid to Revolutionize Electric Power in North America

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

“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

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

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

**Response**

Technologies for Today

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

- **Industrial Gas Turbines**
- **Aggregated Water Pumping Loads**
- **Smart Thermostat**
- **Zinc-Bromine Battery System**
- **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
- Fault current limiter
- SuperVAV System
- Superconducting Flywheel
- Advanced Energy Storage
- Grid-Friendly Appliance Controller
- Diamond Devices
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

Transmission and Distribution

Supply

Federal

Regulations

Demand

States

Markets
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 unleash innovation and strengthen our markets to allow entrepreneurs to develop a more advanced and robust transmission system 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

Prime Contractor
Wire Supplier
Installation Operation
Power Cable Assembly
Refrigeration

HTS Shield Tape
Copper Shield Wire
Liquid Nitrogen Coolant
High Voltage Dielectric
Copper Core
Thermal “Superinsulation”

Project Team

American Superconductor
LI PA
nexans
AIR LIQUIDE
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
- Local Loads
- Load Simulators

Energy Storage

Loads
**Distributed Sensing, Intelligence, & Control Technologies**

**Grid-Friendly™ Appliance (GFAs) Controller**

- Eliminate need for 100s of new power plants,
- Saving tens of billions of dollars over 20 years.
- “...given enough ants, you can move a mountain!...”
  - Impromptu reaction from a utility power engineer

**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
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”

- 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