



Office of Electricity Delivery and Energy Reliability

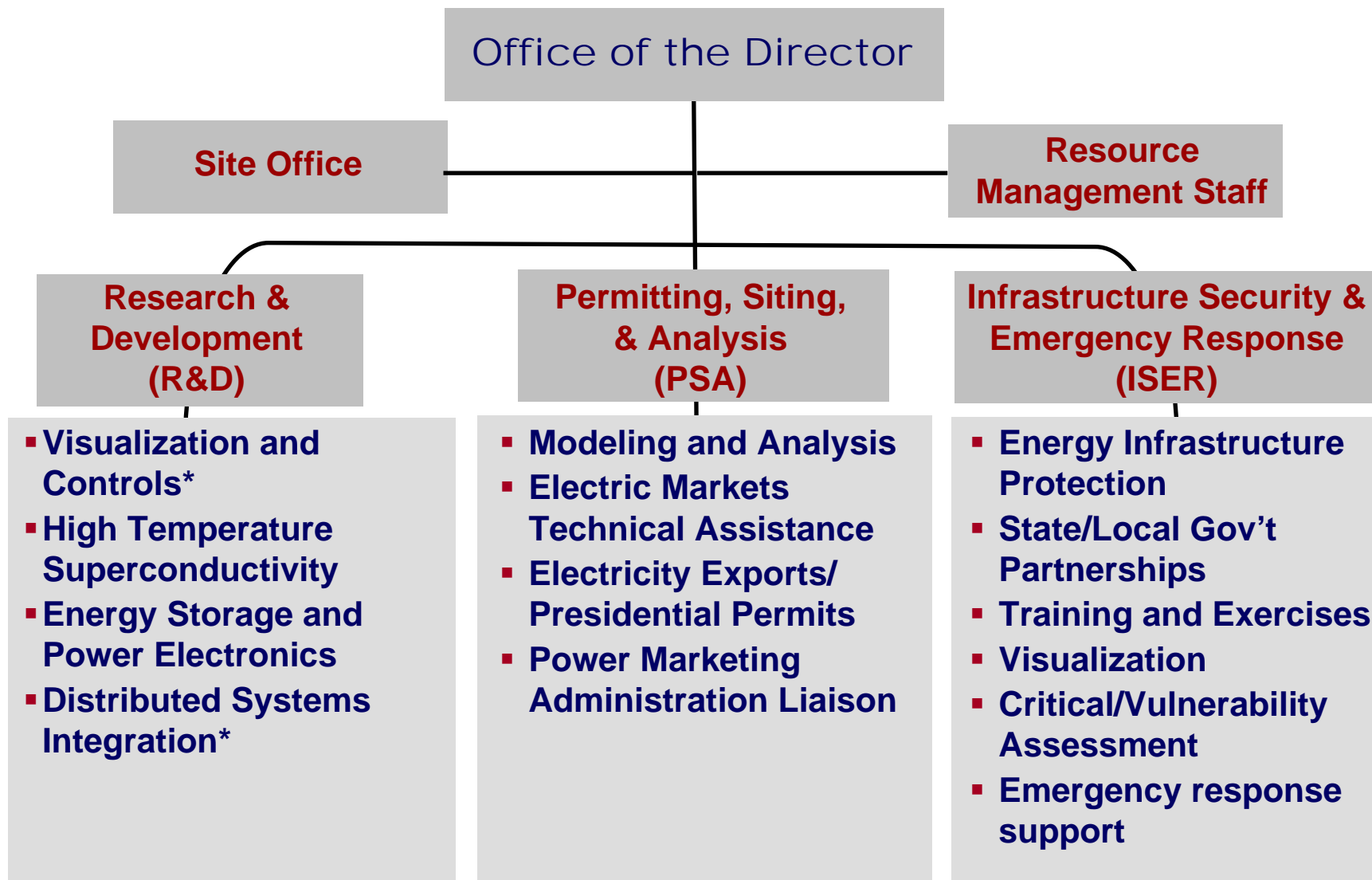
Electric Distribution R&D at DOE

Presented by:

Eric M. Lightner, Program Manager
Electric Distribution/GridWise
U.S. Department of Energy

Integrated Energy Policy Report Committee Workshop
May 10, 2007 Sacramento, CA

Office of Electricity Delivery and Energy Reliability



** Includes portion of Electric Distribution R&D Program budget*



Electric Distribution R&D

Mission

Modernize distribution grid infrastructure and operations, from distribution substations (69 kV and down) to consumers

Program Goals

Cost-effective integration of DER and load management for a 20% peak load reduction by 2015

GridWise modernization for an intelligent, secure grid



Modernizing electric distribution into the information age

Funding Summary (\$MM)

	FY03	FY04	FY05	FY06	FY07
Congressionally Directed	6.2	10.6	5.4	12.0	0
Total R&D	11.1	14.6	11.4	17.9	8.7

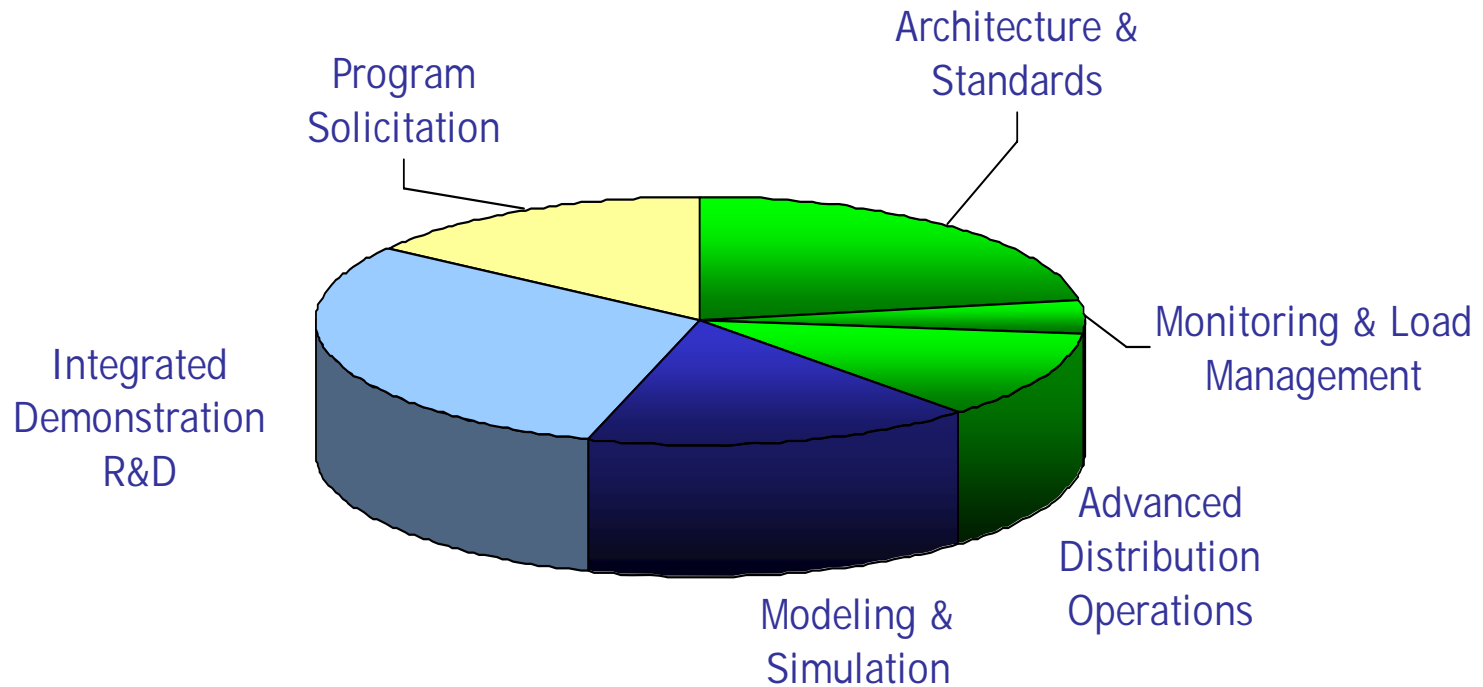
Scope

- **Electric Distribution Transformation** - Integrating DER and load management to respond to customer needs for differentiated electric delivery services in power quality and power reliability
- **GridWise** - Applying advances in information/communication/control technologies to transform the electric system into a smart automatic network



FY07 Funding Allocations, by Program Area

Total Budget in FY07: \$8.7M





FY07 Projects in Architecture & Standards

GridWise Architecture & Standards

- Facilitation support to GWAC and Standards development, PNNL

IEEE 1547 Series of Interconnection Standards

- Standards Development
 - 1547.2-6 series under development, NREL
- Validation Testing to Support Standards Development
 - Anti-islanding tests with multiple combinations of DR units to address interaction/stability/penetration issues, DUA
- Regional Implementation
 - Promote agreements/implementation of small generation interconnection standards in PJM/MISO regions, ACN Energy Ventures/NREL



GridWise Architecture Council

Objective

- Establish buy-in on principles and concepts to advance interoperability of information systems, thus enhancing efficiency and reliability of electricity delivery

Progress/Accomplishments

- Over 100 interviews conducted to frame fundamental principles of business, usage, technology, regulation, and governance
- GridWise Constitution Convention held with over 110 stakeholders pledging to advance the cause of interoperable electric systems
- 2006 GridWise Expo held with engagement of building communities

Future Direction

Interoperability Path Forward



A continuing process with buy-in/ownership from expanding industry sectors and with evolving technology



FY07 Projects in Monitoring & Load Management

Monitoring and management technologies for
distribution faults and I/C/R loads

- Development and demonstration of advanced monitoring systems for fault location, analysis, and prediction, EPRI Solutions
- Advanced protection methods implemented on SCE's Circuit of the Future, Southern California Edison
- **Cable Diagnostic Focused Initiative (CDFI), Georgia Tech NEETRAC**



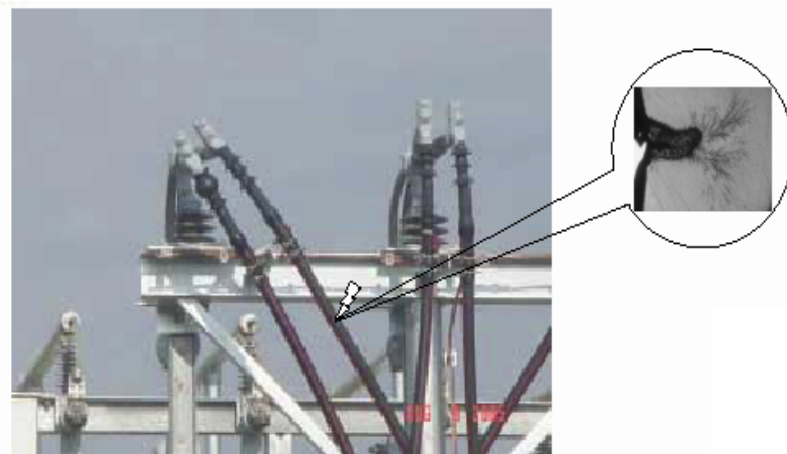
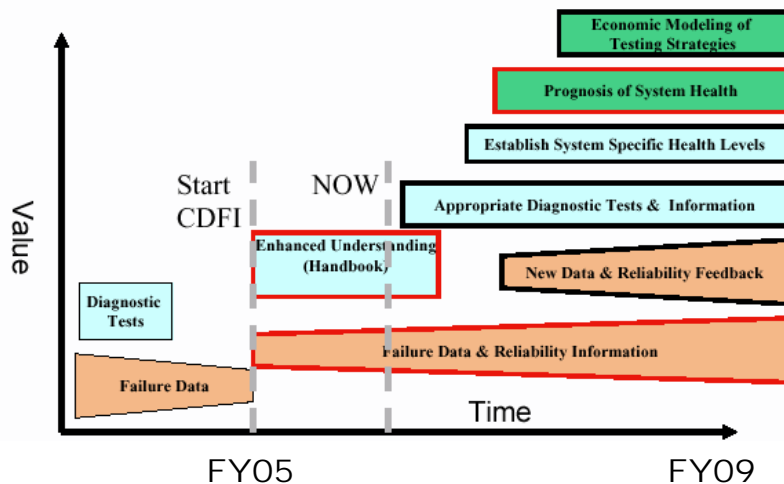
Cable Diagnostic Focused Initiative

Objective

Evaluate cable system diagnostic testing technologies that can help electric utilities prevent underground cable system failures

Progress / Accomplishments / Future Direction

The CDFI Journey



Diagnostic technologies are used to find microscopic weak spots in aged underground cable systems that could cause failures.



FY07 Projects in Advanced Distribution Operations

DER Integration

- Advanced Integration of DER into the Utility Distribution System, DTE Energy
- **3G System of the Future: Advanced Distribution Operation with DER Integration, Infotility**

Microgrid

- Microgrid Design, Development and Demonstration, GE Global Research
- Value and Technology Assessments to Enhance the Business Case for the CERTS Microgrid, University of Wisconsin, Madison

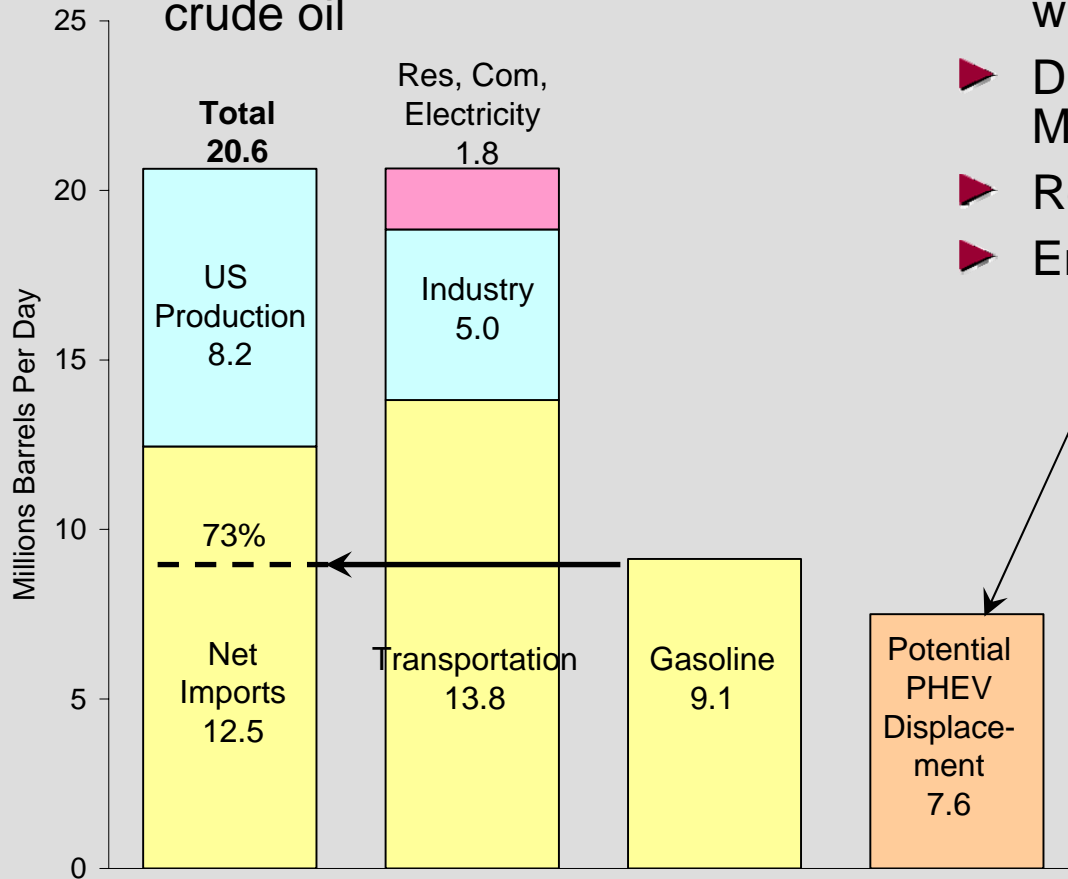


FY07 Projects in Modeling & Simulation

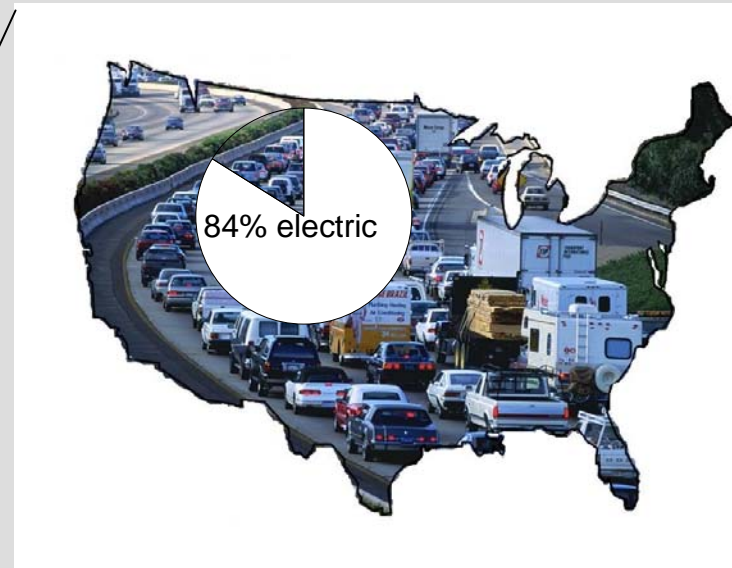
- Distribution System Modeling and Analysis using the Integrated Energy Operations Center, PNNL
- **PHEV Impact Analysis, PNNL**
- 4 SBIR Phase-I Projects awarded in April 2006
 - ❖ Standard Data Exchanges for Distribution (EnerNex Corporation, Williams-Pyro, Inc.)
 - ❖ Distribution System State Estimation (EnerNex Corporation, Techno-Sciences, Inc.)

National Significance

- ▶ Net petroleum imports 60% in 2005 and rising
- ▶ U.S. motor gasoline consumption could displace 73% of imported crude oil



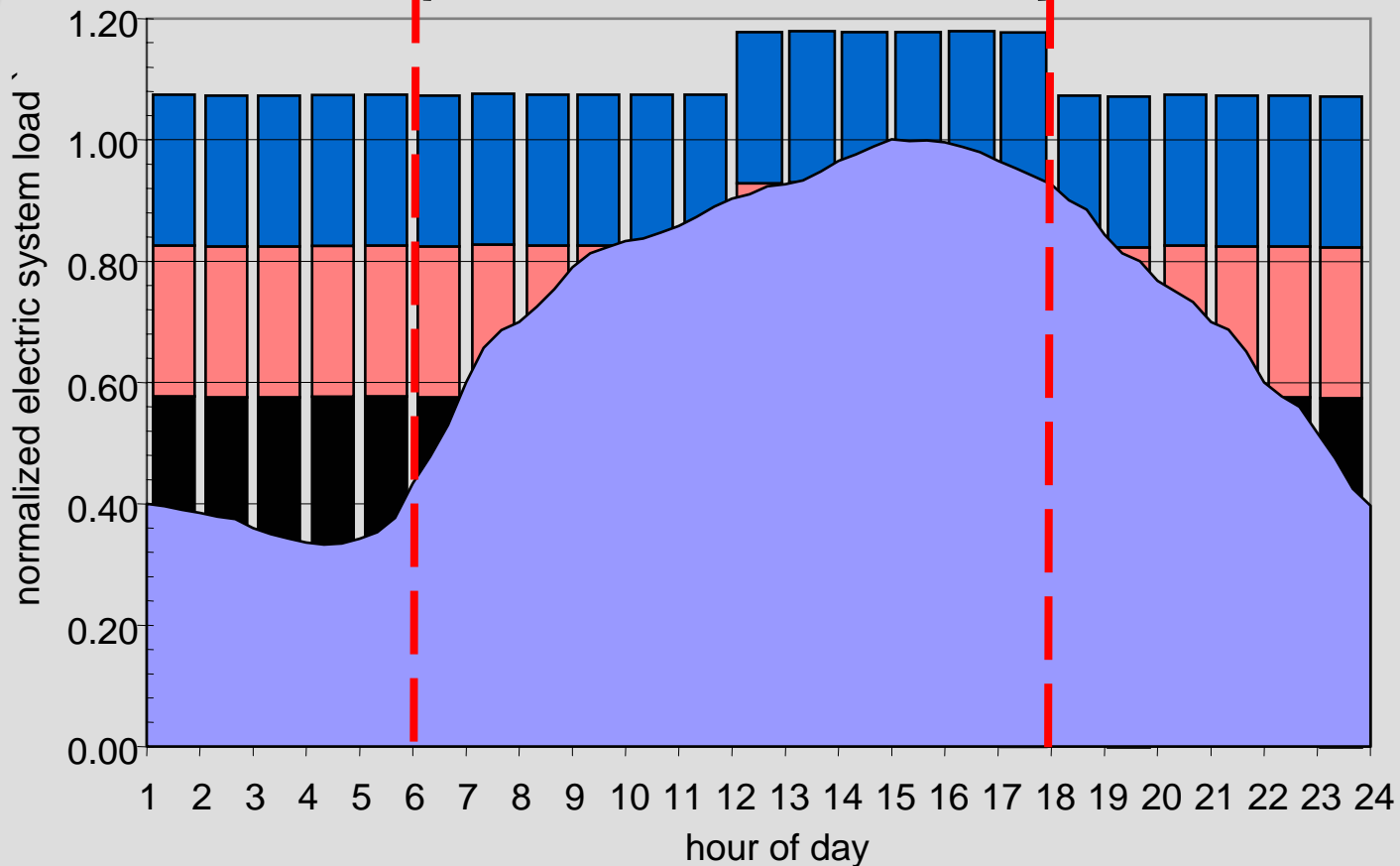
- ▶ Use significant idle electric infrastructure capacity
- ▶ Potential of up to 84% of U.S. light duty vehicle fleet to be fueled with idle electric capacity
- ▶ Displacement potential of 7.6 MMbpd, (61% of net imports)
- ▶ Revenue impact ...
- ▶ Environment impact ...



Fundamental Approach

nighttime valley-filling

daytime valley-filling



Summary

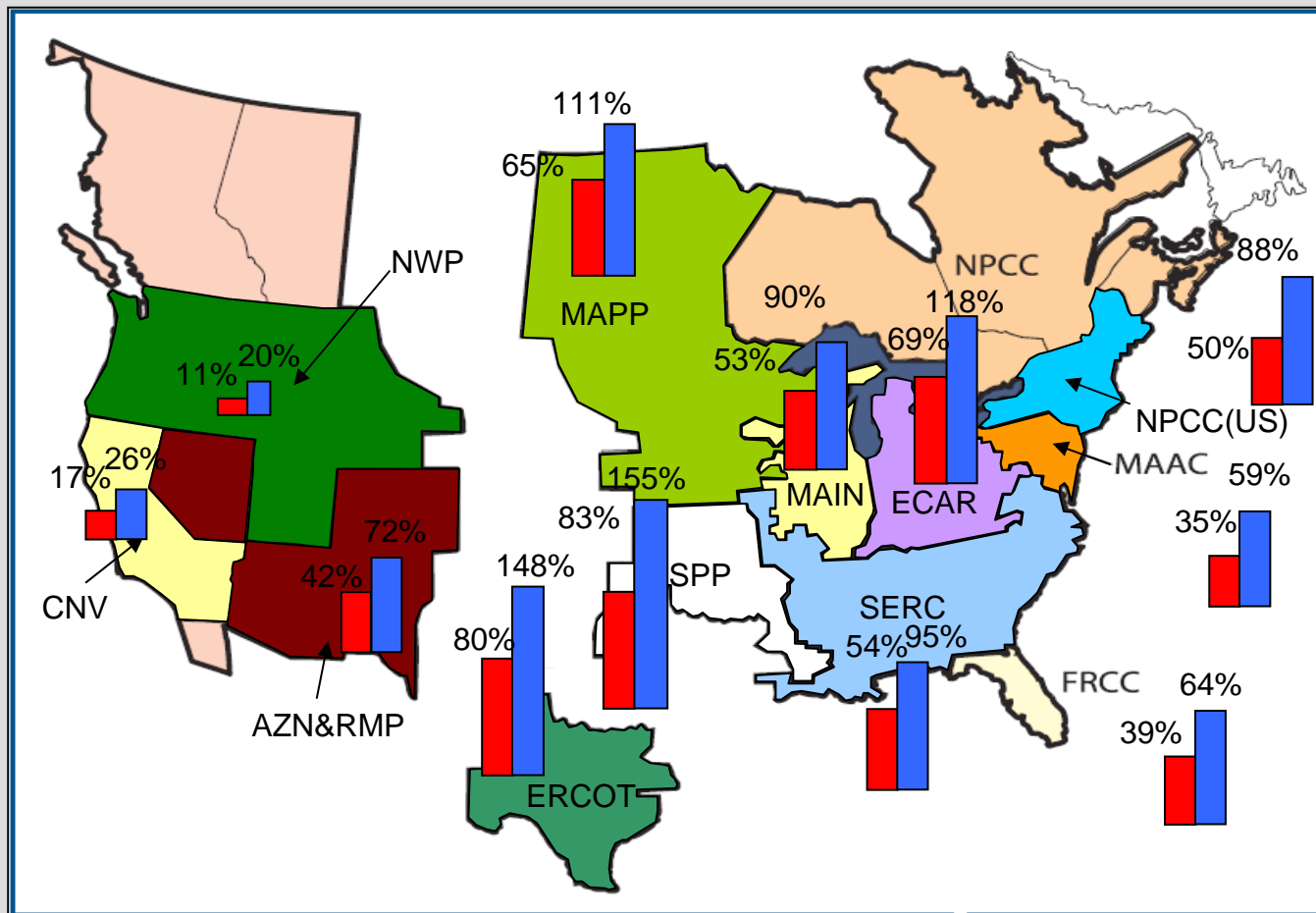
- ▶ Determine size of valley in MWh
- ▶ Use the average day in the peak season
- ▶ Constrain valley by excluding
 - Hydro
 - All other renewables
 - Nuclear
 - Peaking plants

Percent of Vehicle Fleet Supplied

(12 and 24 hour window with base and intermediate generation)

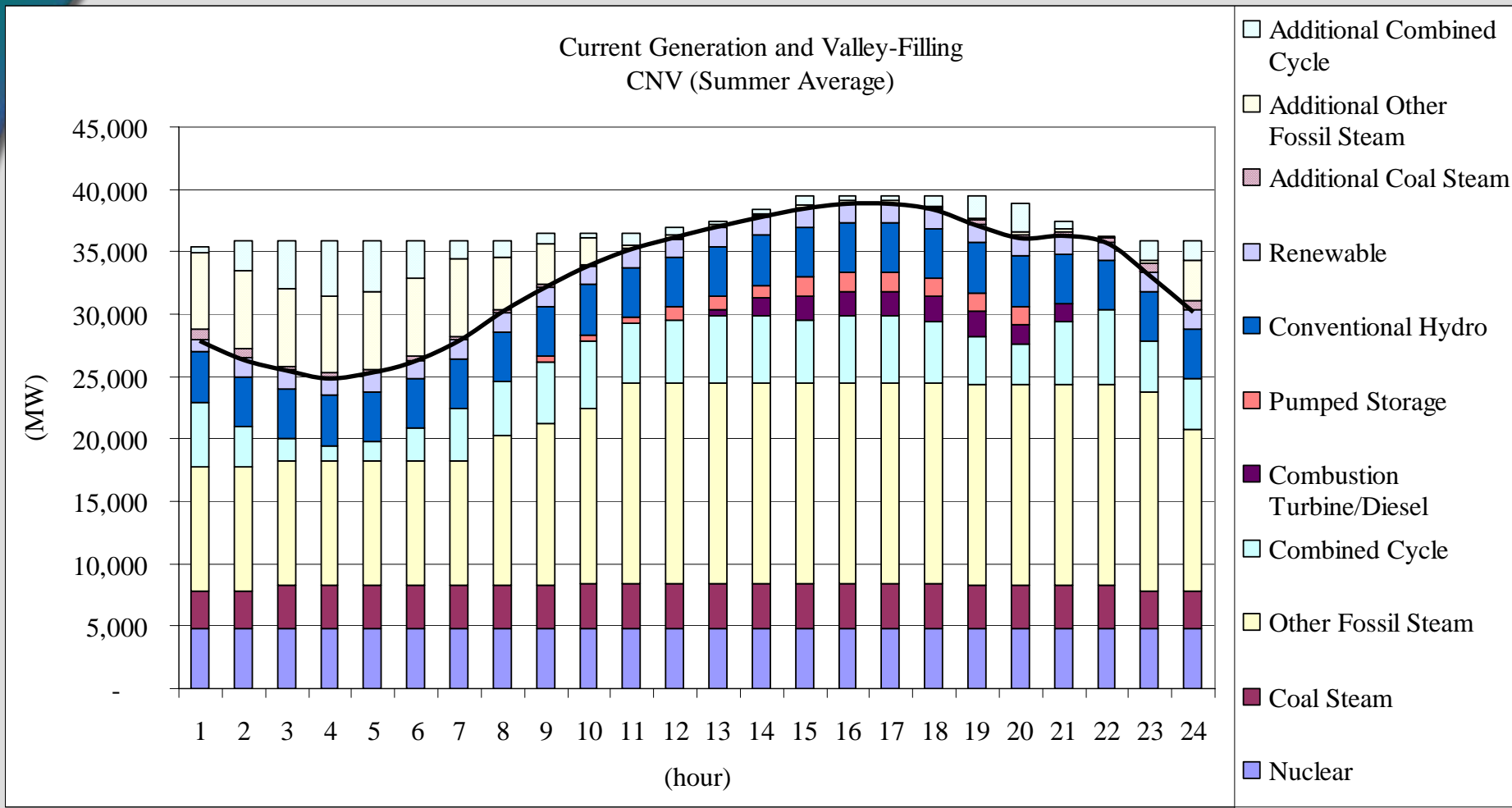
Midwest and Eastern regions: sufficient electricity capacity to provide ALL of vehicular transportation energy. It would require wider 18-6 hour window into the morning hours

Western region: limited available capacity because of large hydro share



18 – 6 hour Valley filling (red bar)
0 – 24 hour Valley filling (blue bar)

Current Generation and “Valley-Filling” CNV, Summer



Comparison of Results for Selected Regions

	ECAR	ERCOT	MACC	MAIN	MAPP	NPCC	FRCC	SERC	SPP	PNW	AZN&RMP	CNV
	Power Generation Composition											
Other Fossil Steam	12%	59%	48%	29%	0%	55%	38%	20%	59%	0%	21%	59%
Combined Cycle	19%	36%	26%	13%	1%	37%	30%	37%	19%	42%	42%	34%
Coal	68%	6%	26%	58%	99%	9%	31%	43%	22%	57%	37%	7%
<i>Emissions</i>	Emissions Ratio (Electric Vehicle/Gasoline Vehicle)											
GHGs	0.90	0.75	0.82	0.91	1.01	0.76	0.81	0.81	0.82	0.83	0.79	0.76
VOC: Total	0.11	0.08	0.09	0.12	0.14	0.08	0.09	0.09	0.10	0.10	0.09	0.08
CO: Total	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
NOx: Total	1.12	0.86	0.99	1.17	1.35	0.87	0.96	0.93	1.03	0.93	0.88	0.88
PM10: Total	1.59	1.04	1.24	1.56	1.94	1.07	1.28	1.34	1.22	1.46	1.27	1.07
SOx: Total	4.13	1.40	2.48	4.07	5.96	1.59	2.70	3.01	2.29	3.77	2.69	1.56
VOC: Urban	0.01	0.02	0.02	0.01	0.00	0.02	0.02	0.01	0.02	0.01	0.01	0.02
CO: Urban	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01
NOx: Urban	0.16	0.44	0.37	0.26	0.09	0.41	0.32	0.22	0.44	0.10	0.22	0.44
PM10: Urban	0.63	0.79	0.75	0.69	0.58	0.78	0.72	0.67	0.79	0.61	0.67	0.79
SOx: Urban	0.50	0.77	0.74	0.67	0.51	0.73	0.64	0.48	0.85	0.31	0.46	0.78

Improved GHG emissions in ALL regions, except MAPP (100% coal as marginal generation)

Increase Total SOx and PM10 emissions

Improved urban criteria emissions. Emissions moved from tailpipes to power plants



FY07 Projects in Integrated Demonstration R&D

Field integration testing and applications to transition advanced technologies into use

- Pacific Northwest GridWise testbed demonstration, PNNL
- **Advanced Grid Applications Consortium (GridApp), Concurrent Technologies Corp**
- **Modern Grid Initiative Developmental Field Test (DFT), NETL**
- GridWise demo in NM, Energy Controls

Autonomous Storm Detector/ Adaptive Relay

Performers/Partners

- **FirstEnergy and the GridApp™ Consortium**



Adaptive relaying to allow substation to autonomously switch relays to 'storm or fuse-saving mode' when a storm is in the area and to switch back to 'normal or fuse-blowing mode' when the storm has passed.

■ Morgantown, WV

- Allegheny Power
- Design and install a feeder automation plan that can support advanced control and sensing for MGI type feeder automation component planned for Phase II.
- Phase I and Phase II Objectives:
 - Install a “Weak Tie” between adjacent feeders to automatically restore service to circuit segments not affected by an outage (utilizes feeder’s existing capacity).
 - Demonstrate the use of a capacity limited alternate source during outages, similar to limited DG and/or Battery sources.
 - Test the ability to dynamically, in real time, monitor and match the available capacity to the new circuit load.
 - Implements customer side Demand Management as needed.
 - Proves the autonomous operation of an advanced distribution automation system.
- Delivers a major improvement in electric service reliability.
- Identifies an application that can be transferred to utilities nationwide.



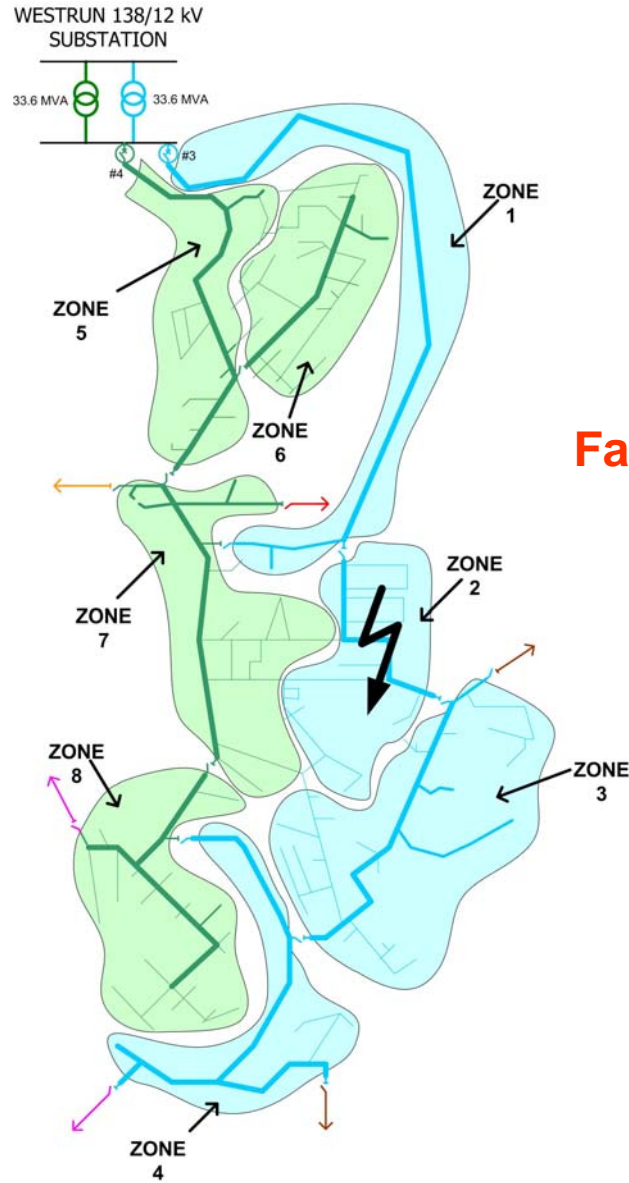
- **Autonomous Dynamic Feeder Reconfiguration System:** The intended system will dynamically collect data from distribution feeders and, in case of a fault, will automatically isolate the fault and restore electric service using available capacity from adjacent feeders. The unique concept of this design is the real time determination and transfer of available capacity from adjacent feeders. This is capacity that is normally not utilized with conventional (manual) load transfer schemes.
- **Advanced Communications for autonomous operation**
- **Medium Voltage Switchgear**
- **Intelligent Electronic Devices at substation and circuit levels**
- **State-of-the-Art Sensing and Measurement**



- **Significantly improve reliability indices (SAIDI, CAIDI, SAIFI, MAIFI, etc)**
- **Defer or avoid some planned capital investments by improving the utilization of the existing system**
- **Extend the lifetime of the power equipment by being exposed to fewer short-circuit currents**
- **Improve power quality**
- **Minimize the labor cost associated with fault location**

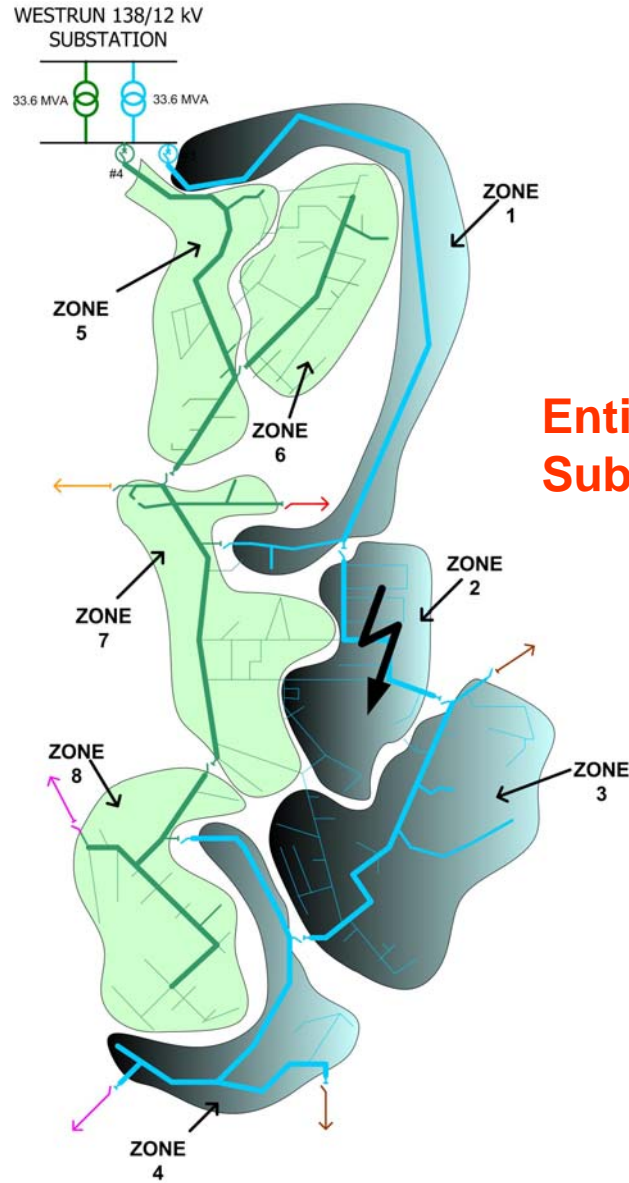


Autonomous Dynamic Feeder Reconfiguration



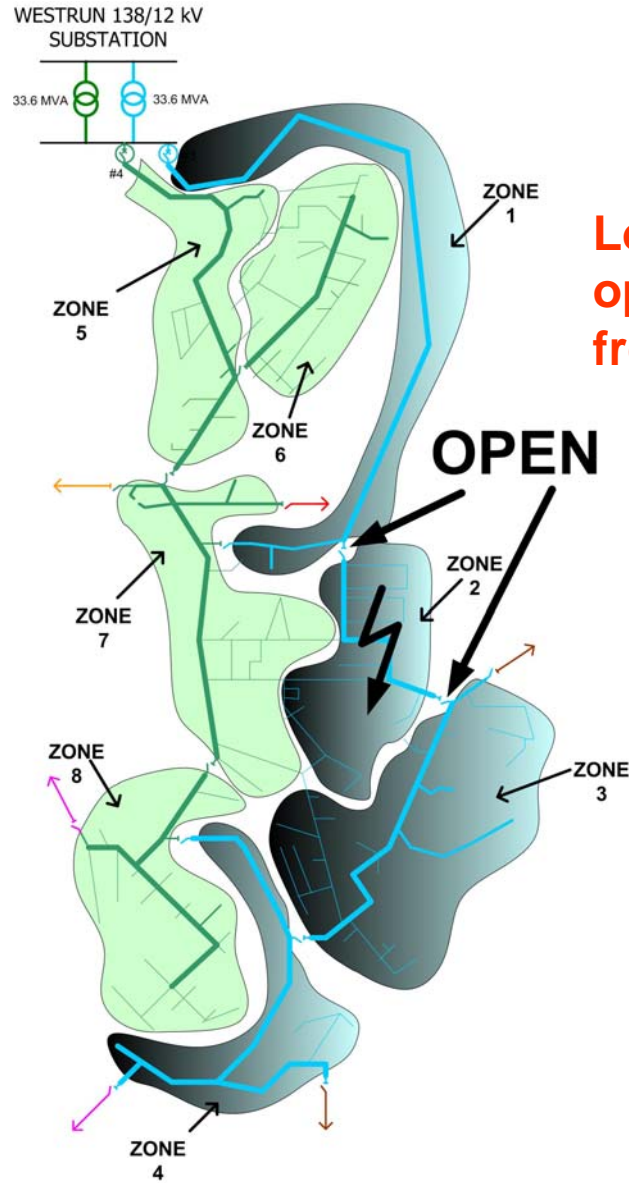
Fault in Zone 2

Autonomous Dynamic Feeder Reconfiguration



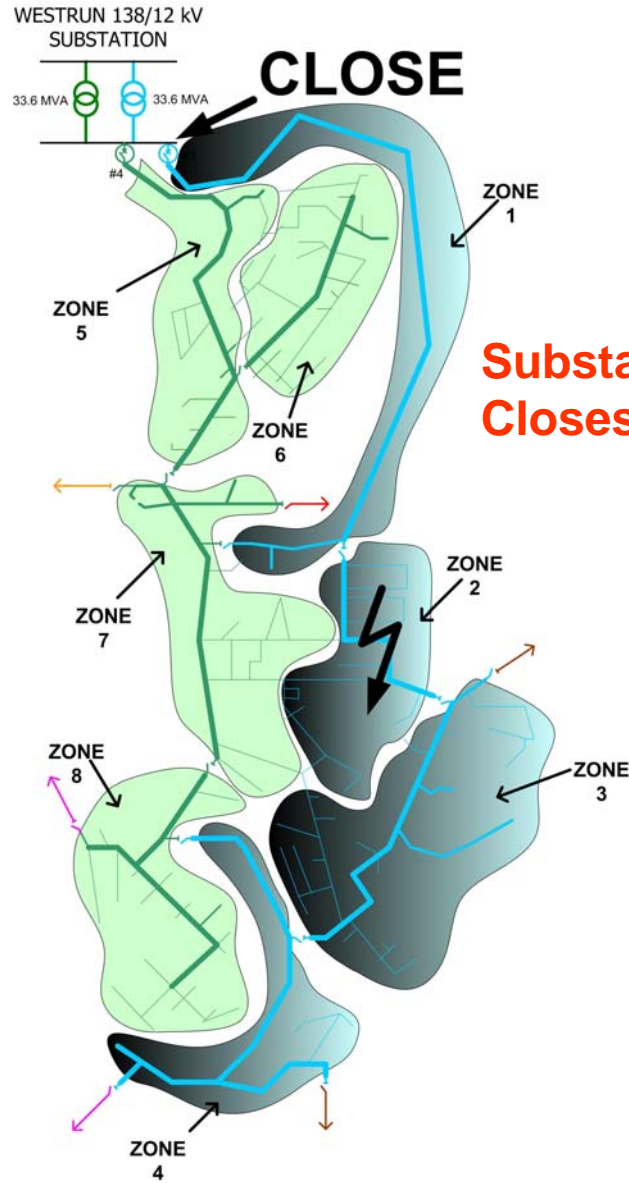
**Entire Circuit Trips at
Substation Breaker**

Autonomous Dynamic Feeder Reconfiguration



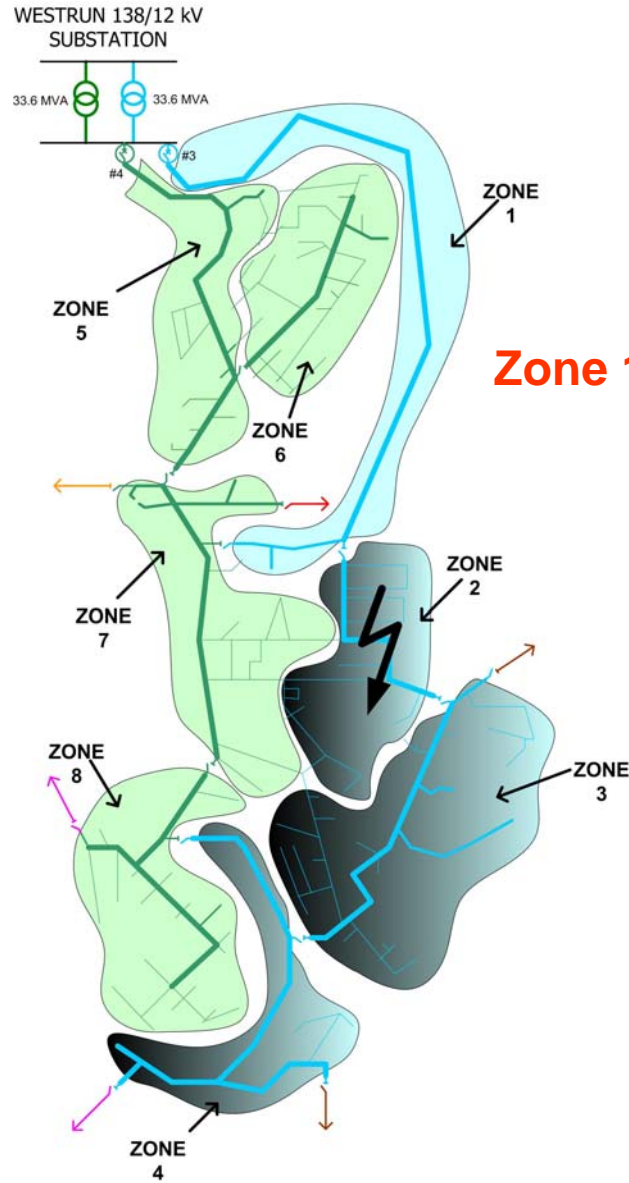
**Load Break Switches
open isolating Zone 2
from the Circuit**

Autonomous Dynamic Feeder Reconfiguration



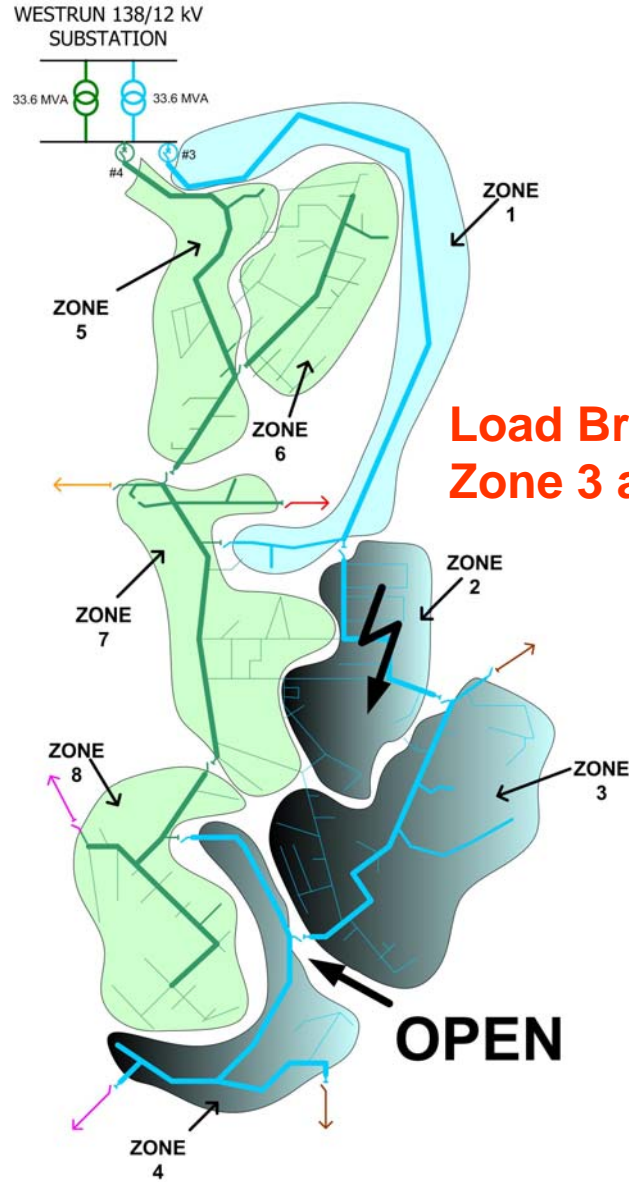
**Substation Circuit Breaker
Closes**

Autonomous Dynamic Feeder Reconfiguration



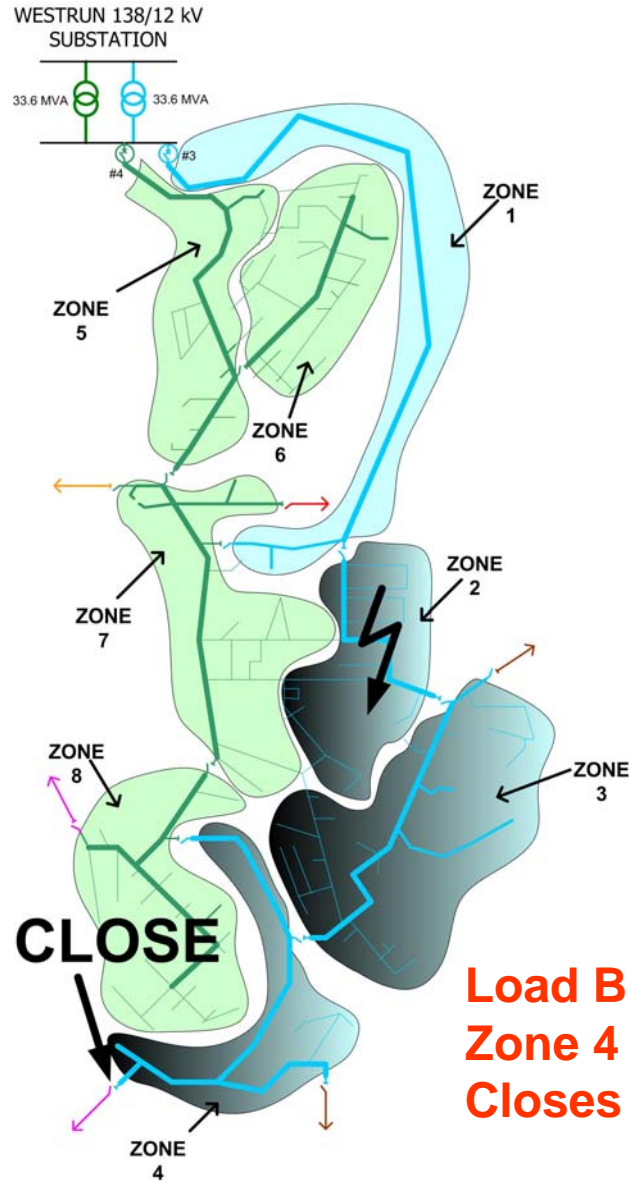
Zone 1 is now reenergized

Autonomous Dynamic Feeder Reconfiguration



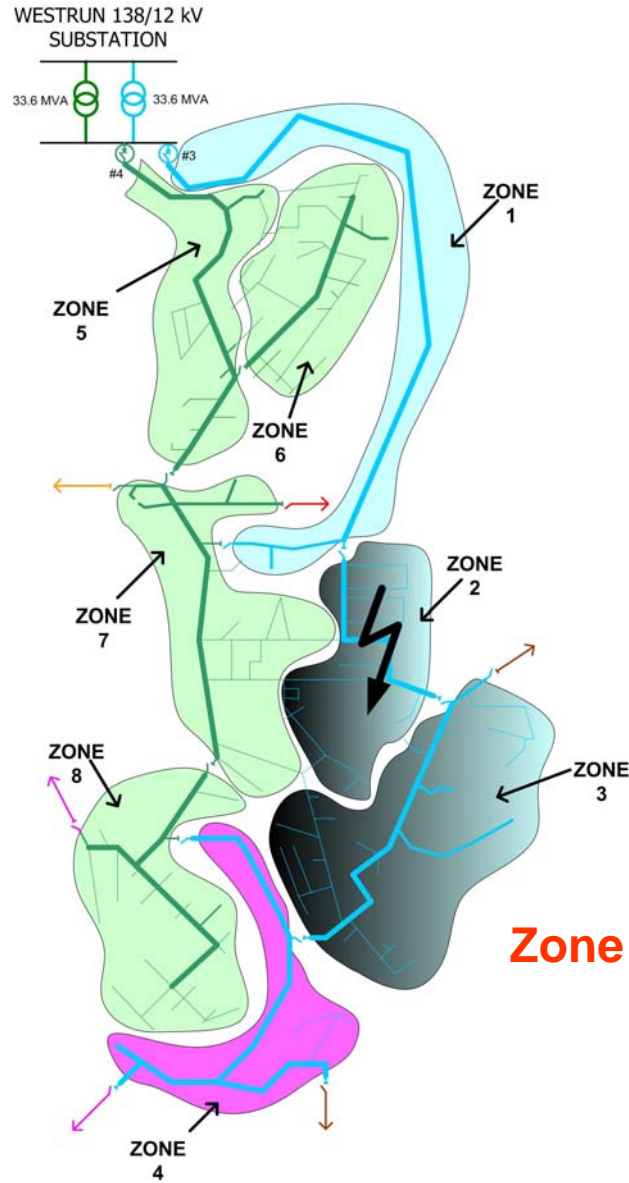
**Load Break Switch between
Zone 3 and Zone 4 opens**

Autonomous Dynamic Feeder Reconfiguration

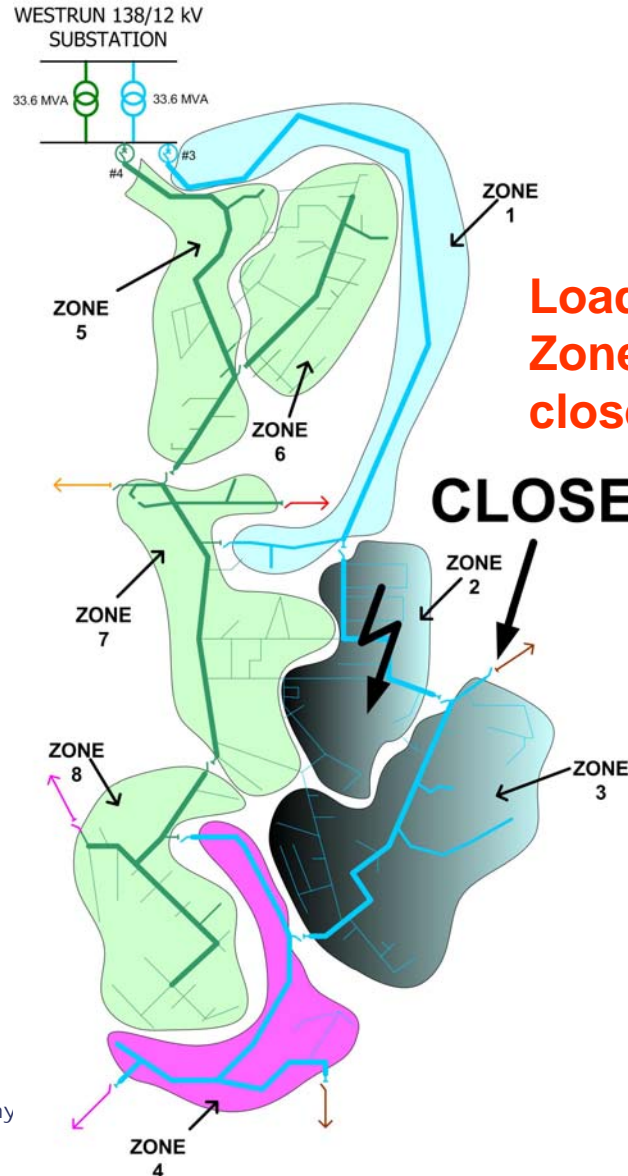


**Load Break Switch between
Zone 4 and Adjacent Feeder
Closes**

Autonomous Dynamic Feeder Reconfiguration



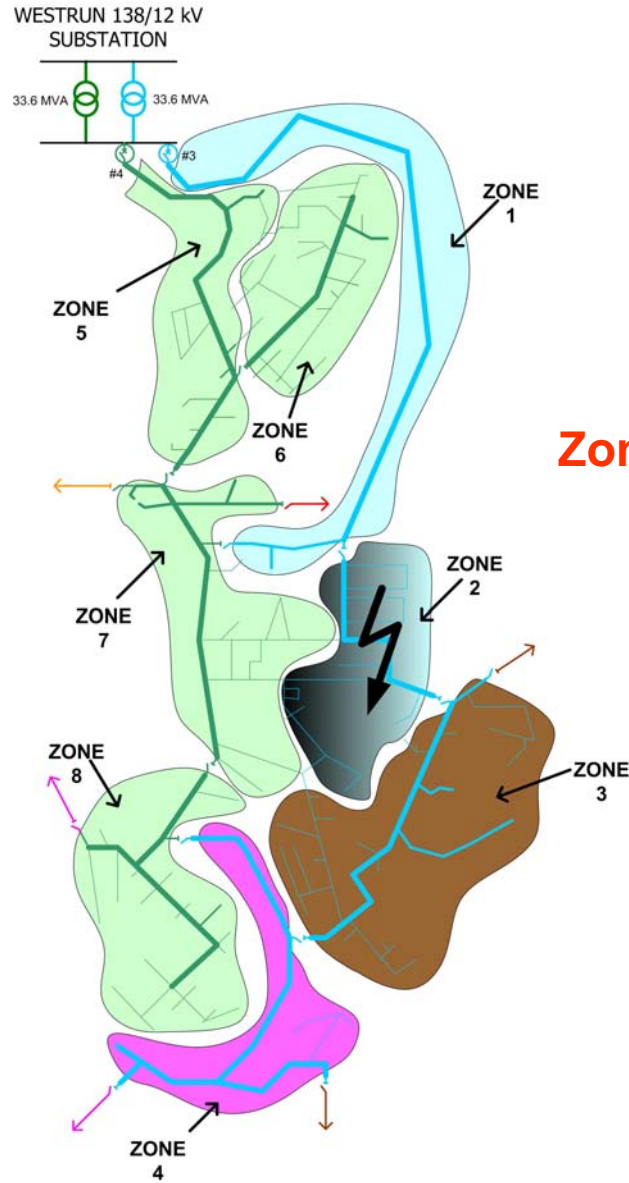
Autonomous Dynamic Feeder Reconfiguration



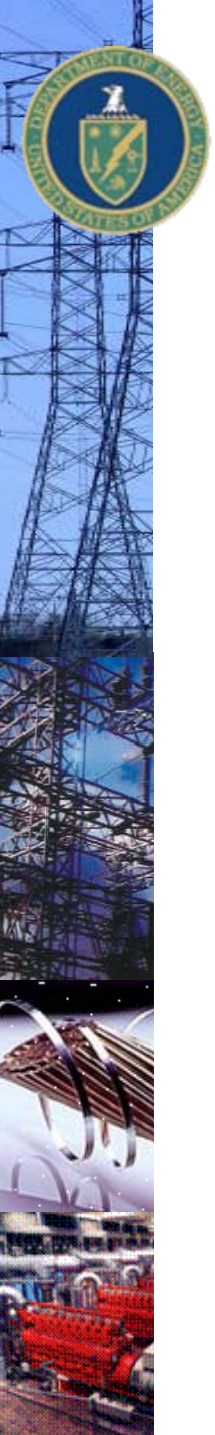
Load Break Switch between Zone 3 and adjacent feeder closes

CLOSE

Autonomous Dynamic Feeder Reconfiguration



Zone 3 is reenergized



FY07 Program Solicitation (DE-PS26-07NT43119)

Competitive solicitation for key Distributed System Integration Program activities identified in the Electric Transmission and Distribution Five-Year Program Plan (FY 2008-2012)

- Open from April 26, 2007 – June 19, 2007
- Approximately 6 awards, ranging in sizes
- \$30+ M of total DOE funding over 5 years (pending out-year budget appropriations; non-federal cost share required)
- Anticipated award dates: September 2007
- Solicitation administered by DOE/NETL and available at (<http://www.netl.doe.gov/business/solicitations/index.html#43119>)

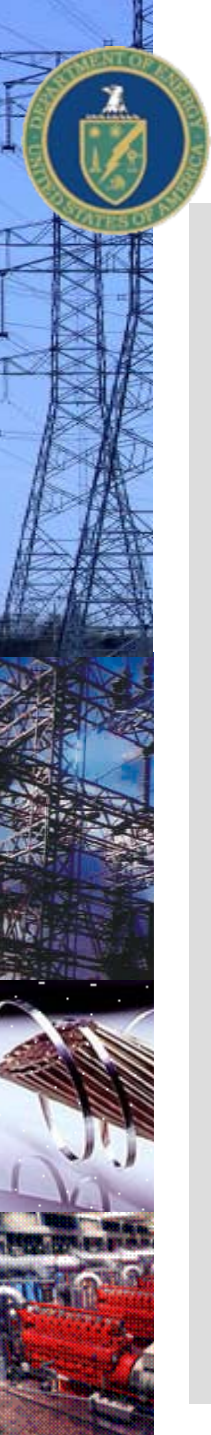


FY07 Program Solicitation (cont'd)

Development and demonstration projects that will integrate significant amounts of distributed resources for peaking power and other ancillary services, including three optional sub-areas in support of electric distribution operations:

- **Low-Cost Sensors for Distribution Level Cables**
 - Measurements of steady-state current, voltage, and temperature for state estimation
 - Completion with field installations of >100 sensors
- **Advanced Monitoring for Distribution Automation**
 - Volt/VAR management, fault location and isolation, feeder reconfiguration, service restoration, and emergency response
 - Pilot demo at a “typical” distribution utility site
- **Consumer Information Gateway Development**
 - 2-way communication between load serving entities and electric loads within consumer premises
 - Pilot demo of enabling functionalities in a real operating environment

The above is for general info only; please refer to DE-PS26-07NT43119 for specific requirements.



Program Review/Workshop/Conference

- **V&C Program Review, Oct 2006 in DC**
 - Some electric distribution R&D projects reviewed
 - Latest review of the entire portfolio in May 2006; the next biennial review planned in May 2008

- **Technical Workshop on PHEV Grid Impact Analysis, March 2007 in DC**
 - Scenarios and assumptions for impact analyses; future analysis needs
 - Co-sponsorship with DOE EERE

- **National GridWeek 2007, April 2007 in DC**
 - **Aligning and coordinating a national agenda on grid modernization**
 - **634 participants, including federal/state/industry/Lab leaders; planning for being an annual event**



A broad and diverse Smart Grid space in technology, system integration, policy & regulations





Program Building Industry Partnerships

Continued to sponsor, support, or coordinate with public/private partnerships



GridWise™ Alliance

- Industry alliance, in collaboration with DOE, to work cooperatively for smart grid solutions, including:
 - Technology
 - Regulatory/Policy
 - Business

<http://www.gridwise.org/>



Advanced Grid Applications Consortium

- A utility consortium dedicated to transition best technologies & practices into broad use
- Fast track development of high-impact technologies through β -testing phase

<http://www.gridapp.org/>



NEETRAC Cable Diagnostic Focused Initiative

- 28 members (utilities, manufacturers, and diagnostic service providers) join DOE for diagnostic solutions for underground cables

<http://www.neetrac.gatech.edu/>



Collaborative R&D Planning and Coordination

Leverage all available R&D resources to achieve common objectives



Collaborating with Electric Distribution Program in:

- Joint portfolio assessments
- Microgrid roadmapping and development
- Interconnection system integration testing
- Mutual participation in respective program reviews

<http://www.energy.ca.gov/pier>



Collaborating and coordinating in areas of:

- Architecture
- Communication standards
- Project Advisory Group
- Review panel participation

<http://www.epri.com/IntelliGrid>

GMC
(Grid Modernization Collaborative)

A virtual consortium of consortia collaborating in:

- Testing/demo/deployment
- Standards implementation
- Benefits/tech transition
- System simulation/modeling

Collaborative in early stage of coordination planning



Contact Information

Eric M. Lightner

Program Manager, Electric Distribution/GridWise
Office of Electricity Delivery and Energy Reliability

Department of Energy

(202) 586-8130

eric.lightner@hq.doe.gov

For more Office/Program information please see,

OE

<http://www.electricity.doe.gov/>

Electric Distribution/GridWise

<http://www.electricdistribution.ctc.com/>

GridWise Architecture Council

<http://www.gridwiseac.org/>

GridWise™ Alliance

<http://www.gridwise.org/>