



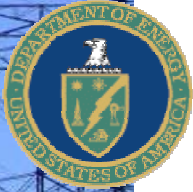
U.S. Department of Energy

Office of Electricity Delivery and Energy Reliability

SMART ULSS FORUM “Electricity”

March , 2008

Patricia Hoffman
Principal Deputy Assistant Secretary
Office of Electricity Delivery and Energy Reliability
US Department of Energy



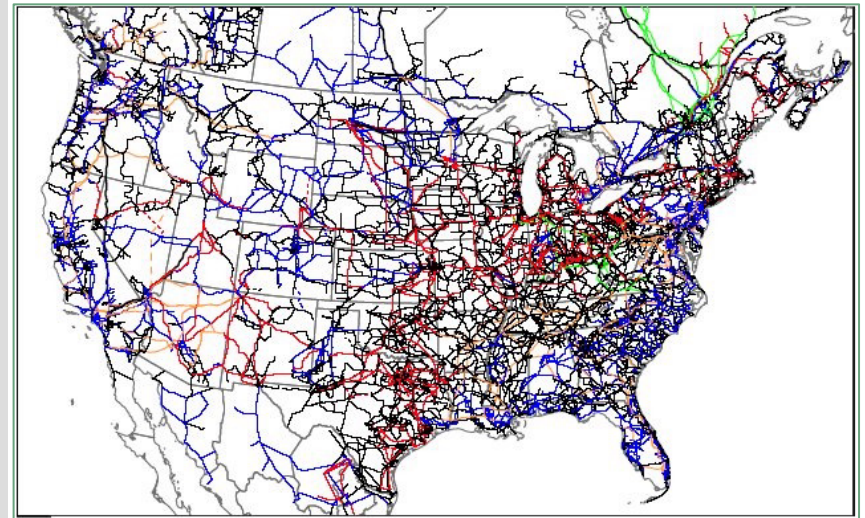
The Electric Grid is a Complex System with Unique Characteristics

Physically

- § Never holistically designed, grid developed incrementally in response to local load growth
Today, there are:
 - § 30,000 Transmission paths; over 180,000 miles of transmission line
 - § 14,000 Transmission substations
 - § Distribution grid connects these substations with over 100 million loads, i.e. residential, industrial, and commercial customers
- § Diverse industry w/o a common voice
 - § 3,170 traditional electric utilities
 - § 239 investor-owned, 2,009 publicly owned, 912 consumer-owned rural cooperatives, and 10 Federal electric utilities

Technically

- § Electricity flows within three major interconnections along paths of lowest impedance (at the speed of light); yet the grid is operated in a decentralized manner by over 140 control areas
- § Demand is uncontrolled; electricity is the ultimate “just-in-time” production process



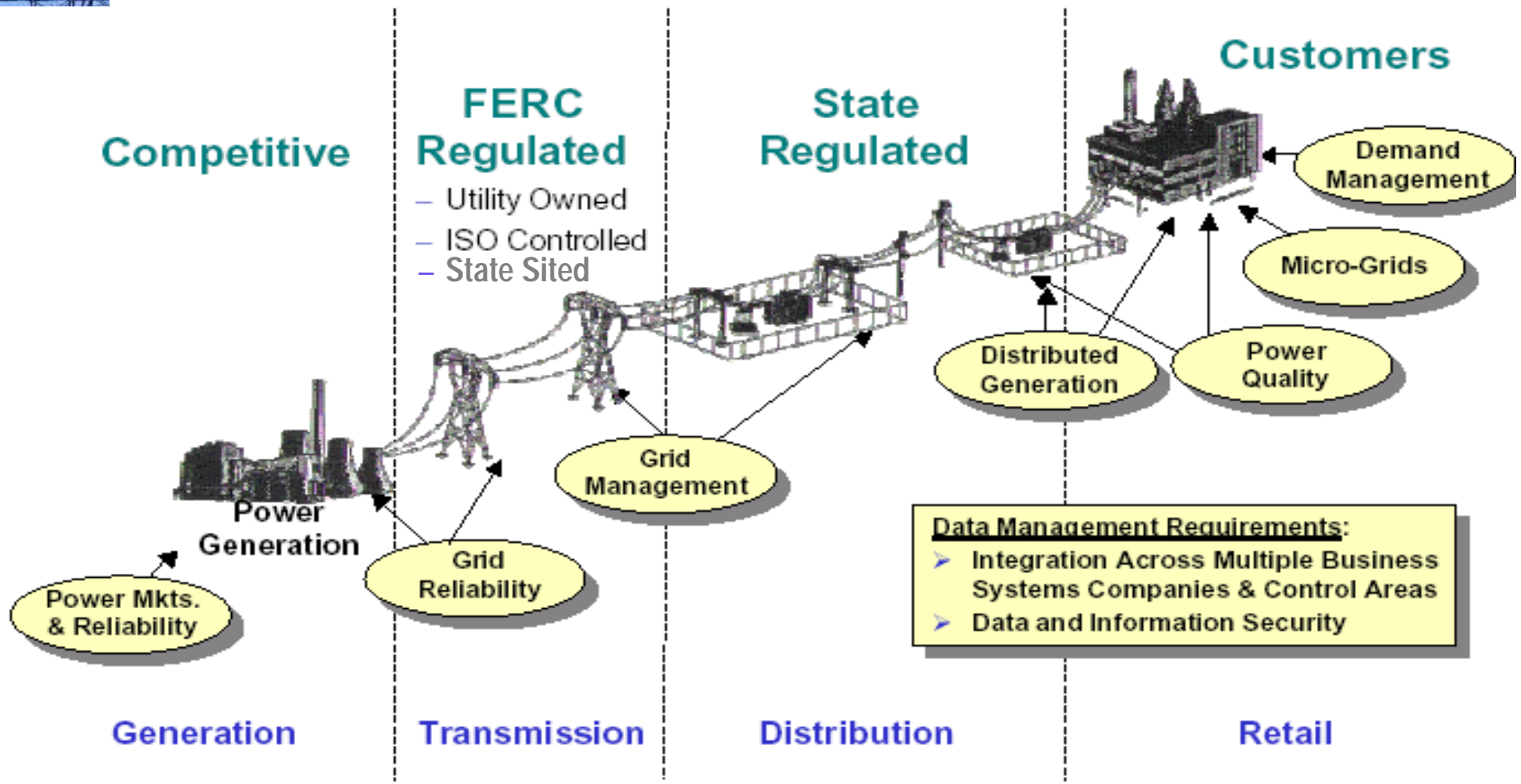
Uniqueness

- § Two things make electricity unique:
 1. Lack of flow control
 2. Lack of large-scale energy storage
- § *Change either of these and the grid delivery system will be transformed*



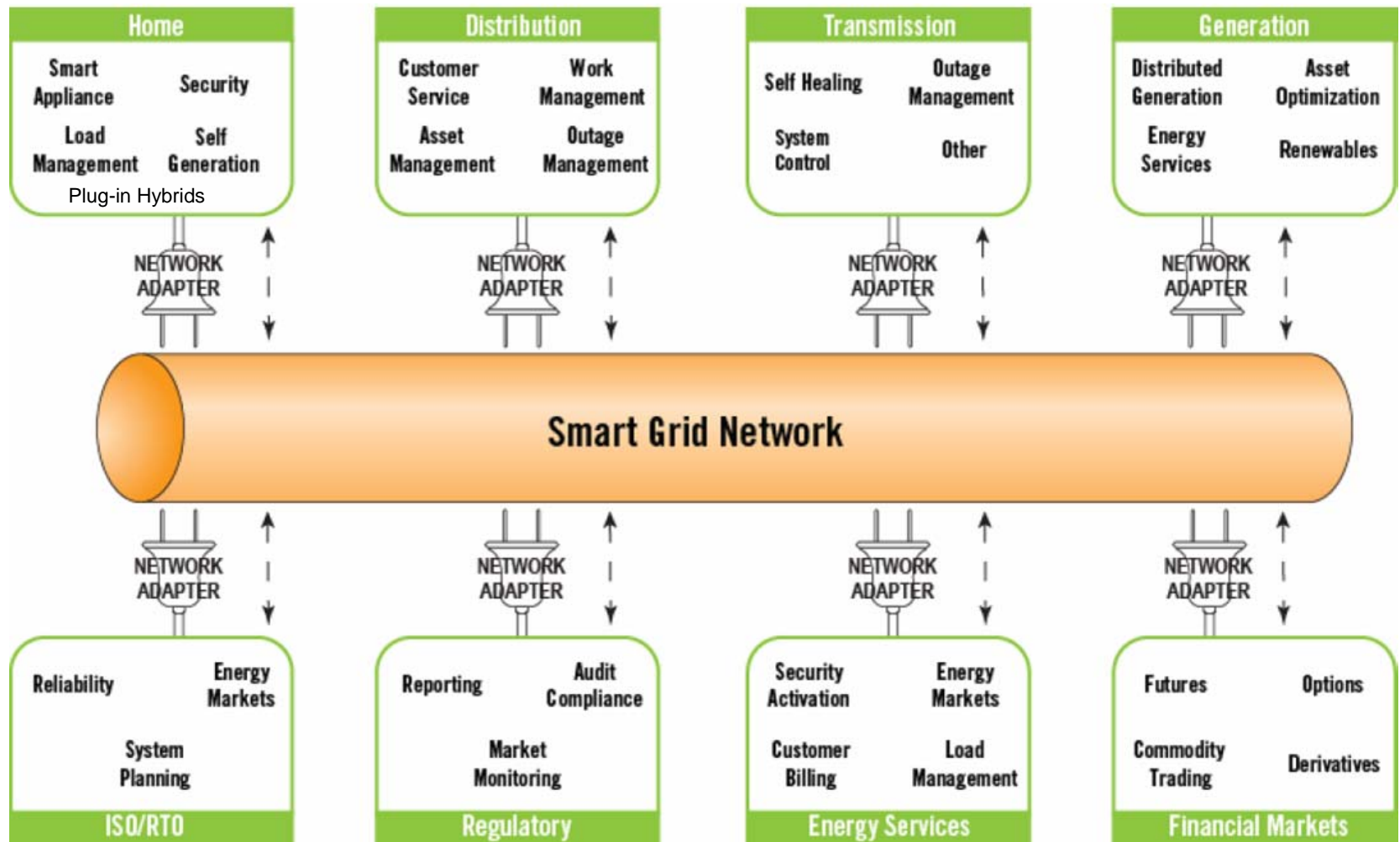


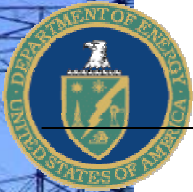
Electric Power Infrastructure





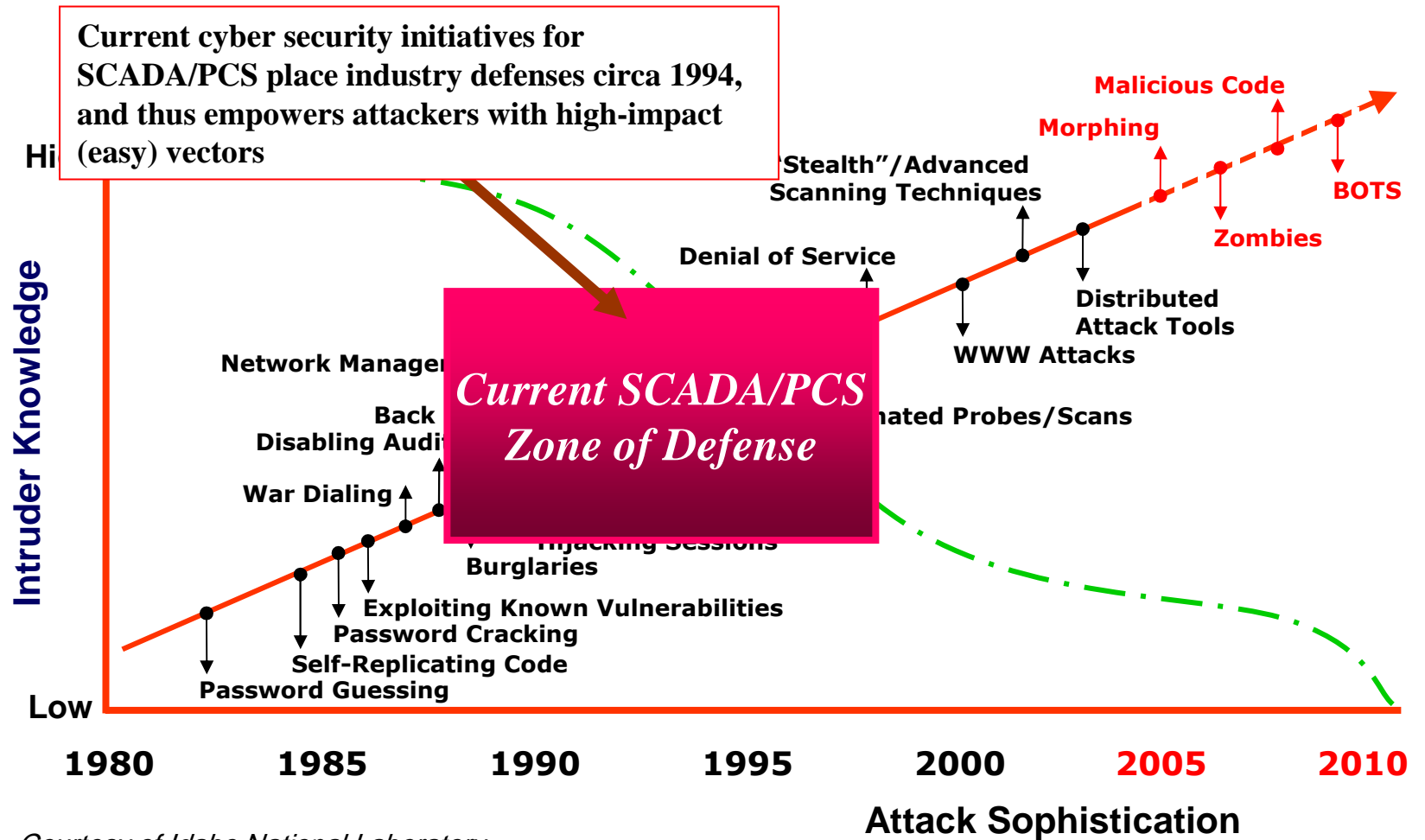
Communications Integration



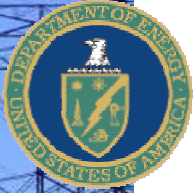


Cyber Threat Trends

Attacker sophistication has decreased due to proliferation of Easy-to-Use (automated) attack tools



Courtesy of Idaho National Laboratory



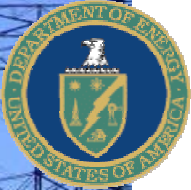
Resiliency/N-X Contingency

Isolation of critical services-MUST RUN

Backup, Diversity and Redundancy

Recovery





Visualization and Controls Transmission Reliability

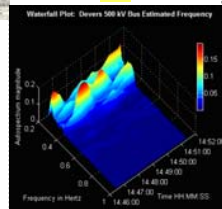
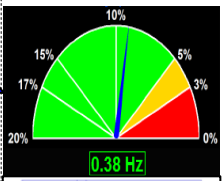
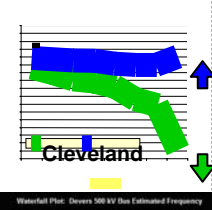
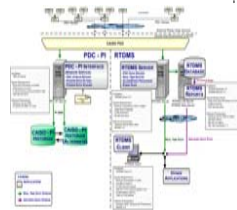
Phasor Measurements, Real Time Wide-Area Situational Awareness, Visualization, Infrastructure Monitoring, Alarming, and Control

<ul style="list-style-type: none"> • 1996 Western Interconnection Blackouts • 2003 Northeast Blackout 	<ul style="list-style-type: none"> § TVA Super PDC § IEEE 37.118 § NIST SynchroLab 	<ul style="list-style-type: none"> • Real Time Dynamics Monitoring System 	<ul style="list-style-type: none"> • CAISO Operating Engineers Workstation • Baselining Static Angles in East 	<ul style="list-style-type: none"> • Small Signal Stability Monitoring § Intelligent Alarming § State Estimation § Adaptive Islanding 	<ul style="list-style-type: none"> § EIPP -> NASPI § WECC WAMTF § Research Roadmap
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GOAL

Industry Approach to Phasor Technology Research and Applications:

- § Visualization
- § State Estimation
- § Mode Monitoring
- § Alarming
- § Real Time Controls



PROBLEM IDENTIFICATION

INFRASTRUCTURE DEVELOPMENT

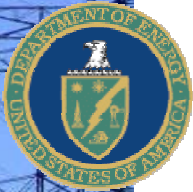
VISUALIZATION FOR WIDE-AREA SITUATIONAL AWARENESS

FORENSIC ANALYSIS/ BASELINING

APPLICATIONS

INDUSTRY ADOPTION





Reliability Metrics and Compliance Monitoring Tools

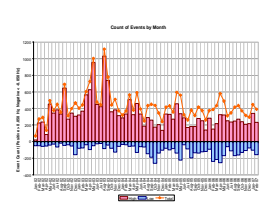
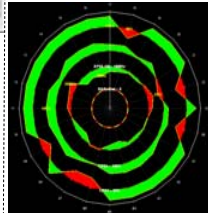
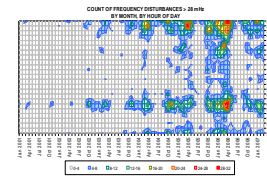
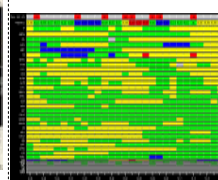
Visualization, Compliance, Monitoring, Infrastructure, Real Time Wide-Area Standards Compliance and Situational Awareness

- 1999 Low Frequency Events on Eastern Interconnection
 - Declining System Performance
 - Frequency Excursions
- Wide-area visualization infrastructure
 - Relational time-series database
- Wide-area real time ACE-Frequency monitoring tool
 - Suppliers performance for AGC and frequency response
- Interchange Error (AIE) Monitoring
 - Wide-area Inadvertent Monitoring
- Performance standards research, validation, field trials
 - Resources adequacy load-generation analysis and assessment
- CPS-BAAL monitoring and analysis
 - Research for situational awareness for resource adequacy

GOAL

Common Wide-Area, Real Time Monitoring Platform – Standards Compliance, Key Metrics for Reliability Intelligent Alarms, Reports, and Event Analysis Situation Awareness Visualization Dashboards for NERC, DOE, and FERC

Layer 4 - Wide-Area Visualization Solutions			
Geo-Spatial	Real-Time	Web-Cap	Dashboard
RESEARCH FOR HIGH-LEVEL, VISUAL SOLUTIONS			
Layer 3 - Wide-Area Real Time Monitoring Applications - Risk, Probabilistic Based			
Real Time ACE Frequency	Real Time Dynamics	Real Time Suppliers Performance	Real Time Voltage Security
CPS-BAAL, AIE	Monitoring	For AGC and FR	Monitoring and Assessment
Web-based	Web-based	Web-based	Web-based
RESEARCH FOR FUTURE SITUATIONAL AWARENESS APPLICATIONS			
Layer 2 - Common Archiving, Event, Alarm and Logging Monitoring Services			
Long Term Archiving Database	Real Time Ingestion	Real Time Data Quality	Real Time Data Quality and Performance Metrics
With PR-Tagging	Capabilities for Historical Data Analysis and Archiving	Event and Disturbance Processor and Services	Reporting and Notification
Layer 1 - Relational Memory Based Database with Time Series Capability			
Layer 1 - Data Communications, NET, COM, OPC, Web Based and Data Converter (AP)			



PROBLEM IDENTIFICATION

INFRASTRUCTURE DESIGN

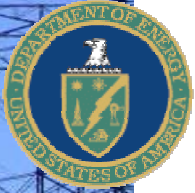
VISUALIZATION

WIDE-AREA MONITORING

FORENSIC ANALYSIS

COMPLIANCE MONITORING





Characteristics (Now and Future)

- § Interoperability
- § Flexible (generation diversity, disruptive technologies)
- § Reliable: N-X contingency (X=1, 2, etc)
- § Eco-centric (Impact)
- § Provider of Last Resort?
- § Human behavior (hybrids, demand response)

