Electric Energy Security in the Domestic Theater

Dr. Bill Waugaman
N-NC Energy Security WG
14 December 2009
Overview

- **Background**
  - Development of the Electric Grid
  - Physical Characteristics
  - DOD Focus
  - Power Failures

- **Engagement**
  - Partners
  - Energy Initiatives

- **Way Ahead**
  - DOD and Electric Grid Security
“Almost complete dependence of military installations on a fragile and vulnerable commercial power grid and other critical national infrastructure places critical military and Homeland defense missions at an unacceptably high risk of extended disruption.”

- Defense Science Board, February 2008
Objective – Electric Energy Security

1. Assured supply and availability of electrical energy.

2. Prevent unauthorized access affecting information, control, availability, and reliability of electric power.

Our Focus

USNORTHCOM’s unique focus is DOD mission assurance in the homeland
The National Engine

Electricity is our "national engine"

- Reliability
- Efficiency
- Security
- Resiliency

National Security
Energy Security
Electric Grid Security
Electric Grid Development

Early Urban Utilities; Like stand alone buildings

Grid interconnections to allow power to flow between utilities

Smart Grid adds in comms & intelligence

Smart Grid as a ‘Human Body’

- Digital Information and Controls Technology
- Dynamic Optimization
- Distributed Generation
- Renewables Integration
- Real Time, Automated, Interactive Control Technology
- Integrate “Smart” Appliances
- Advanced Distributed Storage
- Infrastructure Standards
- Timely feedback to consumers
- Control options
Smart Grid Cyber Vulnerabilities

Source: NIST SP 800-82
Gap in Expertise

Industrial Controls (SCADA)

Cyber Security

Physical Security

Electric Grid Security
Legislative and Policy Focus

EPAct 1992
EPAct 2005
EO 13423
EISA 2007
10 USC 2688
(Utilities Privatization)
NDAA 2008 Sec 355, 902
DODD 4140.25 (2004)
DODD 5126.46 (1987)
DOD Inst 4170.10 (1991)
DOD Inst 4170.11 (2005)

Energy Security
(Mission)

Energy Conservation
(Economics)

HSPD-7
DOD Inst 4170.10 para 4.4.6
DOD Inst 4170.11 (2005)
Northeast Blackout of 2003

- 14 August 2003 starting at 3:41 PM EDT
- 55 Million People
- New York, New Jersey, Maryland, Connecticut, Ohio, Michigan, Pennsylvania, Ontario and parts of Massachusetts
- Approx 48 Hours

Cause:
- Overgrown tree branches near Eastlake, Ohio impacted High Voltage lines during high power demand period.

Source: Natural Resources Canada - Canada-U.S. Power System Outage Task Force Interim Report
Conclusions and the Way Ahead
Dependence on a Fragile Grid
Electric Grid Security

Scope of Influence

- Law
- Policy
- Regulations
- Standards
- Implementation
### Partnering Opportunities

<table>
<thead>
<tr>
<th>Federal</th>
<th>State PUCs</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Logos of the Department of Energy, Department of Homeland Security, Department of Defense, and NIST]</td>
<td>[Logos of Dora, Department of Regulatory Agencies, and other state PUCs]</td>
<td>[Logos of NERC, Edison Electric Institute, Electric Power Research Institute, and other industry associations]</td>
</tr>
</tbody>
</table>

**National Institute of Standards and Technology**
U.S. Department of Commerce

[Logos of United States Northern Command, United States Strategic Command, Tennessee Valley Authority, and other federal logos]

[Logos of The Infrastructure Security Partnership, IEEE, and others]
Key Engagements

- **OSD (DOEP&P)** – Office of Operational Energy Plans and Programs (New)
- **OSD (HD&ASA)** – Homeland Defense & American Security Affairs
- **OSD (AT&L)** – Acquisition, Technology, and Logistics
  - **OSD (I&E)** – Installations and Environment
- **Joint Staff & Service Components**
- **COCOMs & Unified Commands**
- **Department of Energy**
  - Office of Energy/Infrastructure Security and Energy Restoration (ISER)
  - National Laboratories
- **DHS (NPPD & S&T)**
- **Department of Commerce – NIST**
- **Industry Associations and Public Utility Groups**
• Partnership in **national** and **community** initiatives
  • Smart Grid Development
    • Influence Implementation of Smart Grid in CONUS
    • JCTD – Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS)
    • Rocky Mountain Secure Smart Grid Initiative (RMSSGI)
  • Renewable Energy development on military bases
• Table Top Exercise
  • Secure Grid ’10
  • May 2010
Take Aways

- Ensure that USNORTHCOM has a seat at the table
  - OSD Office of Operational Energy Plans and Programs
  - DOD Energy Security Task Force
- DOD test bed / JCTD
- Spread the Message
  - Mission assurance requires electric grid security, reliability, and resiliency
- The time to include security is now!
  - Industry is moving forward with Smart Grid implementation, with or without consideration of DOD security requirements
  - Better to design in security now than to patch later
BACK UP SLIDES
### History of Early Electric Grid

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1882</td>
<td>Edison Pearl Street Generating Station, New York City</td>
<td>59 Customers</td>
</tr>
<tr>
<td>1896</td>
<td>Niagara Falls Hydroelectric Plant, Westinghouse</td>
<td>First AC transmission to remote customers</td>
</tr>
<tr>
<td>1920</td>
<td>Federal Power Commission (FPC) created by Congress</td>
<td>Coordinate Hydroelectric projects under Federal control; ad-hoc staff from other Federal agencies</td>
</tr>
<tr>
<td>1930</td>
<td>Federal Power Act</td>
<td>Established five bi-partisan commissioners</td>
</tr>
<tr>
<td>1901-1932</td>
<td>Electrification of urban America</td>
<td></td>
</tr>
<tr>
<td>1930-1945</td>
<td>Electrification of rural America</td>
<td>Funded through USDA stimulus funds</td>
</tr>
<tr>
<td>1935</td>
<td>Public Utility Holding Company Act (PUHCA)</td>
<td>Beginning of regional electric monopolies</td>
</tr>
<tr>
<td>1935</td>
<td>Federal Power Act</td>
<td>Gave regulatory authority to states; FPC regulated bulk power transmission across state lines</td>
</tr>
</tbody>
</table>
## History of Electric Grid

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>Northeastern power blackout</td>
<td>Raised concerns about reliability of large interdependent power networks</td>
</tr>
<tr>
<td>1967</td>
<td>Electric Reliability Act</td>
<td>Drove establishment of electric performance standards</td>
</tr>
<tr>
<td>1968</td>
<td>North American Electric Reliability Council (NERC) created</td>
<td>Industry created non-profit self-regulating organization.</td>
</tr>
<tr>
<td>1978</td>
<td>Public Utility Regulatory Policies Act (PURPA)</td>
<td>Set the stage for deregulation and Independent Power Producers (IPP)</td>
</tr>
<tr>
<td>1979</td>
<td>Three Mile Island</td>
<td>Shut down nuclear plant construction</td>
</tr>
<tr>
<td>1992</td>
<td>Energy Policy Act (EPACT)</td>
<td>Bulk power transmission deregulation</td>
</tr>
<tr>
<td>2005</td>
<td>Energy Policy Act (EPACT)</td>
<td>Gave FERC punitive authority to enforce reliability standards</td>
</tr>
<tr>
<td>2008</td>
<td>FERC established 8 mandatory reliability standards</td>
<td></td>
</tr>
</tbody>
</table>
Today’s Electric Grid

- Centralized
- One-way power flow
- Regulated Monopoly
- Generation
- Distribution
- Inflexible demand
- Aging Infrastructure
- Manual operations
- Increasing renewables
- Lacks interoperability
Electric Grid Regions and Interconnects

Canada

Mexico

WECC

WESTERN INTERCONNECTION

MRO

SPP

RFO

SERC

FRCC

EASTERN INTERCONNECTION

TRE

ERCOT INTERCONNECTION

High Voltage DC Interconnect

QUÉBEC INTERCONNECTION
High Voltage Interconnects

EXISTING LINES
- 345-499 kV
- 500-699 kV
- 700-799 kV
- 1,000 kV (DC)

PROPOSED LINES
- New 765 kV
- AC-DC-AC Links

INTERCONNECTIONS
Major sectors of the U.S. electrical grid
- Eastern
- Western
- Texas (ERCOT)

Government
• Federal Energy Regulatory Commission
• State Public Utility Commissions

Industry
• North American Electric Reliability Corporation (NERC)
• Electric Utility Associations
  • Edison Electric Institute (EEI)
  • American Public Power Association (APPA)
  • National Rural Electric Coop Association
Northeast Blackout of 1965

- 9 November 1965 starting at 5:16 PM EST
- 25 Million People
- 80,000 Square Miles
- 12 Hours

Cause:
- Protective relay connecting Niagara Falls hydro plant with Southern Ontario
- Relay set too low of a power setting
- Surge from Robert Moses Generating Plant, Lewiston, NY, caused relay to trip
- Cascading overloads throughout grid
National Infrastructure Protection Plan (NIPP)

NIPP
- Unifies effort for protection of critical infrastructure and key resources

Energy Sector Specific Plan
- Collaborative process between the private sector, state, local, and tribal governments,
- Identify threats, mitigate vulnerabilities, minimize consequences
DOD Energy Consumption

Source: DOE EIA Annual Energy Review 2009
Electricity Production by Energy Source

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Capacity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>449,389</td>
<td>41.31%</td>
</tr>
<tr>
<td>Coal</td>
<td>336,040</td>
<td>30.89%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>105,764</td>
<td>9.72%</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>77,644</td>
<td>7.14%</td>
</tr>
<tr>
<td>Petroleum</td>
<td>62,394</td>
<td>5.74%</td>
</tr>
<tr>
<td>Pumped Storage</td>
<td>20,355</td>
<td>1.87%</td>
</tr>
<tr>
<td>Wind</td>
<td>16,596</td>
<td>1.53%</td>
</tr>
<tr>
<td>Wood Fuels</td>
<td>7,510</td>
<td>0.69%</td>
</tr>
<tr>
<td>Other Biomass</td>
<td>4,834</td>
<td>0.44%</td>
</tr>
<tr>
<td>Geothermal</td>
<td>3,233</td>
<td>0.30%</td>
</tr>
<tr>
<td>Other Gases</td>
<td>2,663</td>
<td>0.24%</td>
</tr>
<tr>
<td>Other</td>
<td>866</td>
<td>0.08%</td>
</tr>
<tr>
<td>Solar</td>
<td>503</td>
<td>0.05%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,087,791</strong></td>
<td><strong>100.00%</strong></td>
</tr>
</tbody>
</table>

Production Capacity In Megawatts (MW)

Source: DOE Energy Information Administration, Electric Power Annual Report 2007 (Released 21 Jan 09)
Source: DOE Energy Information Administration, State Energy Profiles
http://tonto.eia.doe.gov/state/
Electric Energy Initiatives

• Advanced Metering Initiative
• Renewable Energy
• Smart Grid

Wind Turbines at F.E. Warren AFB, WY
Solar Array at Fort Carson, CO
Electric Utility Control Systems

The Smart Grid

- Digital Information and Controls Technology
- Dynamic Optimization
- Distributed Generation
- Renewables Integration
- Real Time, Automated, Interactive Control Technology
- Integrate “Smart” Appliances
- Advanced Distributed Storage
- Infrastructure Standards
- Timely feedback to consumers
- Control options

Source: DHS Smart Grid System Report, July 2009
Electric Grid Security Objectives

- Ensuring proper access control to the smart grid network and role-based access control to its operations
- Protecting physical access to the smart grid network and devices
- Protecting individual smart grid components from exploitation
- Maintaining functionality during adverse conditions
- Restoring systems and services after an incident
<table>
<thead>
<tr>
<th>Standard</th>
<th>Application</th>
<th>Smart Grid Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMI-SEC System Security Requirements</td>
<td>Advanced metering infrastructure (AMI) and Smart Grid end-to-end security</td>
<td>IT</td>
</tr>
<tr>
<td>ANSI C12.19/MC1219</td>
<td>Revenue metering information model</td>
<td>IT</td>
</tr>
<tr>
<td>BACnet ANSI ASHRAE 135-2008/ISO 16484-5</td>
<td>Building automation</td>
<td>COM</td>
</tr>
<tr>
<td>DNP3</td>
<td>Substation and feeder device automation</td>
<td>COM</td>
</tr>
<tr>
<td>IEC 60870-6 / TASE.2</td>
<td>Inter-control center communications</td>
<td>COM</td>
</tr>
<tr>
<td>IEC 61850</td>
<td>Substation automation and protection</td>
<td>COM</td>
</tr>
<tr>
<td>IEC 61968/61970</td>
<td>Application level energy management system interfaces</td>
<td>COM</td>
</tr>
<tr>
<td>IEC 62351 Parts 1-8</td>
<td>Information security for power system control operations</td>
<td>COM</td>
</tr>
<tr>
<td>IEEE C37.118</td>
<td>Phasor measurement unit (PMU)communication</td>
<td>COM</td>
</tr>
<tr>
<td>IEEE 1547</td>
<td>Physical and electrical interconnections between utility and distributed generation (DG)</td>
<td>POWER</td>
</tr>
<tr>
<td>IEEE 1686-2007</td>
<td>Security for intelligent electronic devices (IEDs)</td>
<td>COM</td>
</tr>
<tr>
<td>NERC CIP 002-009</td>
<td>Cyber security standards for the bulk power system</td>
<td>COM</td>
</tr>
<tr>
<td>NIST Special Publication (SP) 800-53, NIST SP 800-82</td>
<td>Cyber security standards and guidelines for federal information systems, including those for the bulk power system</td>
<td>COM</td>
</tr>
<tr>
<td>Open Automated Demand Response (Open ADR)</td>
<td>Price responsive and direct load control</td>
<td></td>
</tr>
<tr>
<td>OpenHAN</td>
<td>Home Area Network device communication, measurement, and control</td>
<td></td>
</tr>
<tr>
<td>ZigBee/HomePlug Smart Energy Profile</td>
<td>Home Area Network (HAN) Device Communications and Information Model</td>
<td></td>
</tr>
</tbody>
</table>
Comparison of World Electric Production and Consumption

Source: CIA World Factbook
Relative Growth in Electric Generation and Consumption

Sources: DOE EIA International Energy Outlook 2009
DOE EIA International Generating Capacity, 1980-2006
DOE EIA International Electric Projections, 1990-2030
World Electric Generation Projections By Source

Source: DOE Energy Information Administration, Report #:DOE/EIA-0484 (Released May 2009)
• 104 Reactors Licensed to operate in U.S.
  • 32% of worldwide electric production by nuclear power
• 437 Operational Reactors Worldwide

Source: Nuclear Regulatory Commission 2008-2009 Information Digest
U.S. Geothermal Energy Potential

Average Annual Wind Power Potential

Solar Energy Potential

Photovoltaic Solar Resource of the United States

Annual average solar resource data are shown for a tilt-latitude collector. The data for Hawaii and the 48 contiguous states are a 10 km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005.

The data for Alaska area 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).

Author: Billy Roberts - October 20, 2008

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.
Concentrating Solar Resource
of the United States

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.
Source: DOE Energy Information Administration, State Energy Profiles http://tonto.eia.doe.gov/state/
Deregulation

Electricity Restructuring by State

Source: Energy Information Administration
• USNORTHCOM is a key partner within DOD advocating for a reliable, efficient, secure, and resilient electrical power grid.

• USNORTHCOM strongly encourages increased energy efficiency based on sound technical solutions that fully consider security implications.

• USNORTHCOM will continue to partner with DOE, DHS, and NIST to integrate electrical infrastructure security as an intrinsic element of the Smart Grid.
Quad Chart:  
SPIDERS JCTD FY11-13

- Operational Problem: The ability of today's warfighter to command, control, deploy, and sustain forces is adversely impacted by a fragile, aging, and fossil fuel dependent electricity grid, posing a significant threat to national security.

- OV-1:

Operational Capabilities:
- Combined resilient, fault and attack tolerant smart grid architecture consisting of:
  - Cyber security and smart grid equipment, renewable and conventional distributed generation, microgrids, emergency generators, energy storage, intrusion detection, rapid forensic capability

Technology:

<table>
<thead>
<tr>
<th>TRL</th>
<th>Today</th>
<th>FY13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyber Defense</td>
<td>4-8</td>
<td>6-9</td>
</tr>
<tr>
<td>Energy Mgt Control &amp; Ops</td>
<td>4-9</td>
<td>7-9</td>
</tr>
<tr>
<td>Integration of Renewables</td>
<td>5-6</td>
<td>7-8</td>
</tr>
</tbody>
</table>

Participants:
- User Sponsor: U.S. Pacific & Northern Commands
- Lead Agency: U.S. Navy
- OM: PACOM & NORTHCOM
- TM: OSD Power Surety Task Force
- Asst TM: DOE
- XM: DESC

Schedule:
- Acquisition FY11Q2 - 11Q4
- Tech Demo FY11Q4 - 12Q2
- Installation FY11Q2 - 12Q4
- Integration FY12Q4 - 13Q2
- Eval & Transition FY13Q3 - 13Q4

Transition:
- Results will support the creation of a regional smart grid test bed, leveraging DOD and Federal installations and renewable energy infrastructure
- Operationally exercise & validate smart grid standards
- DOD installations as the early technology adopter

Funding:
- U.S. Navy - ARRA-funded PV project + $2M PV array at Camp Smith funded by PPA. Ft Carson - 3 MW PV array
- DOE FEMP - $347K (HI) & $700K (CO) (pre JCTD)
- DHS - $1-2 M
- DOE - $2M
- Uncommitted: OSD (I&E), USA/IMCOM - TBD
- Remaining PACOM - $53M, NC - $25 - 30M