Electric Grid Situational Awareness

VERDE
Visualizing Energy Resources Dynamically on Earth

NASPI Meeting

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OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY
Where is Oak Ridge, TN?
ORNL is DOE’s largest multipurpose science laboratory

- $1.04 billion budget
- 4,000 employees
- 3,000 research guests annually
- Nation’s largest unclassified scientific computing facility

- Nation’s largest science facility: the $1.4 billion Spallation Neutron Source
- Nation’s largest concentration of open source materials research
- Nation’s largest energy laboratory
- $300 million modernization in progress
ORNL performing R&D to assist DOE in improving electric grid reliability

Ensure the Reliability & Security of the Nation’s Grid

Reduce Transmission Congestion
Improve Power Quality
Reduce Major Outages
Improve Restoration Times
ORNL Simulation and Modeling

- ORNL-led team selected to build the National Leadership-class Computing Facility

- Cray X1 evaluation completed
  - Expanded from 256 to 512 processors
  - Global ocean simulation: 50% higher simulation throughput than on Japanese Earth Simulator for equal number of processors

- Plan is to increase capability to 1 petaflop (1,000 trillion calculations per sec)

- Research Areas include:
  - astrophysics - supernova research
  - climate and carbon research - climate simulation
  - computational biology
  - fusion simulation - plasma energy research
  - industrial innovation - combustion simulation
  - materials research - precise calculations of molecular structures
  - nanomaterials theory

Is there an opportunity to utilize this resource?
Developing tools to improve situational awareness of the electric grid

- DOE Office of Electricity Delivery and Energy Reliability sponsored effort
- Response to the devastating hurricanes in 2005
- Coordinate federal response to natural disasters or major events
- ORNL, in partnership with TVA, developing real-time grid visualization tool
- Initially assess status of transmission lines in the Southeast

Two platforms have been developed
- Google Earth
- ORNL developed EDGAR
VERDE Capabilities

- Platform to provide wide area visualization capability
  - Flexible system
- Real-time status of transmission lines
- Real-time weather overlays
- Predictive impact models & Animated replay
- Data analysis
- Energy infrastructure interdependencies:
  - Coal delivery and rail lines
  - Refinery and oil wells
  - Natural gas pipelines
  - Transportation and evacuation routes
  - Population impacts - LandScan

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Key Elements of Process Flow

- ICCP data from NERCnet provides real-time data every minute
- TVA extracts data and translates line status – in or out of service
- ORNL overlays weather, population, transportation, electrical network data – electric dynamic grid analysis
- Visual displays are sent to DOE every minute

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Because the data is owned by each utility company, agreements have been executed to allow DOE access.
Agreement Structure to Reflect National Effort

DOE

Contractor

ORNL

TVA

Sub-Contractor

Data Agreements With Participating Utilities
Transmission Line Status

- Line flow in megawatts is retrieved every minute
  - If flow is greater than 5 MW then line status is “On”
  - If flow is less than 5 MW then line status is “Abnormal”
    - Low power flow
    - Actually out-of-service
- Data quality flag from SCADA is also retrieved
  - No update due to communications failure

<table>
<thead>
<tr>
<th>Line Status</th>
<th>Data Quality</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
<td>Bad</td>
</tr>
<tr>
<td>(number of lines)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On, greater than 5 MW flow</td>
<td>675</td>
<td>2</td>
</tr>
<tr>
<td>Abnormal, less than 5 MW flow</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>695</td>
<td>8</td>
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VERDE Tool

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Displaying Outages
Next Steps

- Complete Atlantic Coast mapping of real-time transmission line status
- Next phase is to look at national visualization effort
  - Storms, earthquakes, fires, physical and cyber attack
- Define additional value to utilities
  - Incorporate PMU data into visualization tool
  - Develop different permissions depending on stakeholder