Chicago Superconductor Cable Project and Vision for the Technology

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56th Annual Minnesota Power Systems Conference
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ComEd
An Exelon Company
Exelon Utilities serves ~10M customers, covering over 24,000 sq. miles, and with peak load over 53 GW

**Operating Statistics**

<table>
<thead>
<tr>
<th>Commonwealth Edison</th>
<th>Potomac Electric Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers:</td>
<td>Customers:</td>
</tr>
<tr>
<td>4,000,000</td>
<td>856,000</td>
</tr>
<tr>
<td>Service Territory:</td>
<td>Service Territory:</td>
</tr>
<tr>
<td>11,400 sq. miles</td>
<td>640 sq. miles</td>
</tr>
<tr>
<td>Peak Load:</td>
<td>Peak Load:</td>
</tr>
<tr>
<td>23,753 MW</td>
<td>6,674 MW</td>
</tr>
</tbody>
</table>

**PECO Energy**

| Customers:                          | Service Territory:             |
| 2,100,000                            | 640 sq. miles                  |
| Service Territory:                   | Peak Load:                     |
| 2,100 sq. miles                      | 2,797 MW                       |
| Peak Load:                           |                                |
| 8,983 MW                             |                                |

**Atlantic City Electric Co.**

| Customers:                          | Service Territory:             |
| 550,000                              | 2,800 sq. miles                |
| Service Territory:                   | Peak Load:                     |
|                                  | 2,797 MW                       |
| Peak Load:                           |                                |
|                                  |                                |

**Baltimore Gas & Electric**

| Customers:                          | Service Territory:             |
| 1,970,000                            | 5,000 sq. miles                |
| Service Territory:                   | Peak Load:                     |
| 2,300 sq. miles                      | 4,121 MW                       |
| Peak Load:                           |                                |
| 7,236 MW                             |                                |

**Delmarva Power & Light**

| Customers:                          | Service Territory:             |
| 631,000                              | 5,000 sq. miles                |
| Service Territory:                   | Peak Load:                     |
|                                  | 4,121 MW                       |
| Peak Load:                           |                                |
|                                  |                                |
ComEd, An Exelon Company

- 4 million electric customers in northern Illinois, including the City of Chicago
- ~6,400 Employees
- Service Territory: 11,429 square miles
- Peak Load: 23,753 MW (7/20/2011)
- 541,200 distribution transformers
- 113,100 circuit miles
  - 40,900 of low voltage
    - 15,400 (38%) overhead, 25,500 (62%) underground
  - 66,400 of primary distribution
    - 34,800 (52%) overhead, 31,600 (48%) underground
  - 5,800 circuit miles of transmission
    - 5,400 (93%) overhead, 400 (7%) underground
- 801 substations
  - 277 transmission-connected, 524 distribution-connected
### AMSC’s Resilient Power Solutions

From power generation to transmission and distribution using proprietary products based on core technologies: smart software/controls and smart materials

<table>
<thead>
<tr>
<th>What it is</th>
<th>What it does</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electrical Control System for wind turbines (wtECS™)</strong></td>
<td>Components and controls that act as the “brain” and “nerves” of turbines</td>
</tr>
<tr>
<td><strong>Transmission Voltage Management (D-VAR®)</strong></td>
<td>Voltage regulation solution, driven by power electronics components</td>
</tr>
<tr>
<td><strong>Distribution Voltage Optimization (D-VAR VVO®)</strong></td>
<td>Direct connect 15Kv class power quality system for distribution network</td>
</tr>
<tr>
<td><strong>Resilient Electric Grid (REG) systems</strong></td>
<td>System that increases electric grid resiliency, reliability, and load serving capacity</td>
</tr>
<tr>
<td><strong>Ship Protection Systems (SPS)</strong></td>
<td>Advanced HTS-based systems that enhance operational safety</td>
</tr>
</tbody>
</table>
REG NETWORKS: ACHIEVING ENHANCED RESILIENCY IN TODAY’S GRID
Resilient Electric Grid (REG) Networks

Achieve Major Increases in **Reliability**

**AND**

- Avoid land acquisition for new or expanded substations
- Avoid construction of new transmission circuits
- Minimize public disruption during construction
- Enable new options for installation in congested ROW
- Avoid the delay and risk of transmission siting and permitting
- Avoid public debate of new sources of EMF
- Avoid oil and SF6
REG Networks’ Unique Value

✓ Allows for much simpler permitting, siting, and installation in smaller Rights-of-Way, due to near zero thermal and EMF signature

✓ Provides an option to improve resiliency that is effective even in areas served by multiple Transmission Voltage levels

✓ Expected lower total project costs due to lower voltage equipment and smaller footprints and Rights-of-Way requirements and eliminating the need for costly land acquisition
REG Networks Utilize High Temperature Superconductor (HTS) Cables

Creating a higher level network above the existing Urban Secondary System

- REG Networks provide **resiliency** by creating grid **redundancy**

- REG Networks **connect** urban substations on the **distribution side**, effectively **reinforcing** the transmission system

- REG Networks provide **high capacity, distribution voltage connections** with minimal footprint, civil work and permitting

- Approach is independent of **transmission voltage levels**, but compliments the existing transmission system
COMED PROPOSED PROJECTS
Focus on Resiliency

✓ There are many variations of what resiliency means, but fundamentally they all encompass the following three areas:

**Withstand**
- Eliminating or Preventing the event or resulting damage

**Recover**
- System and plans to provide rapid damage assessment and restoration

**Survive**
- The ability to maintain some basic level of electrical functionality

- Superconductor Cable
REG Benefits from Possible Second Project in Chicago’s Central Business District
Intended to Provide Greater Resilience with Lower Cost and Less Disruption

✓ Expected to increase reliability in the heart of the Chicago central business district:

✓ **Two stations** are radial substations, served from **69kV** sources. **One station** is looped at **138kV**.

✓ Project intended to loop together all three substations into a network, increasing reliability and resiliency for all to N-3.

✓ **Expected to be far less disruptive** to the downtown core area than conventional transmission upgrades and not to:
  • Require **additional high voltage transformation**
  • Require **significant infrastructure construction**
  • Require **land acquisition for substation expansion**
Possible Second REG Project in Chicago’s Central Business District

Chicago’s Central Business District (CBD)

- Green line indicates superconducting cables:
  - Location: Chicago’s Central Business District (CBD)
  - Three 12kV, 62MVA superconductor cables

Illustration for Discussion Only
Initial Project - Northwest
Smaller scale initial phase with similar benefits

✓ As a prelude to the possible CBD project, ComEd will implement a REG Network at different Chicago substation to increase the reliability level from N-1 to N-2

✓ Project will serve to increase the reliability within the substation by providing a high-capacity link between two terminals in the substation

✓ Effort will provide experience and lessons learned to be incorporated into the possible CBD project
Superconductor Cable – Initial Project
Construction Progress

✔ Photos of the trough installation and HTS Termination foundations
Superconductivity Cable Applications

Potentially economically viable solutions today

• New Suburban Station that brings capacity into a City station, avoiding the expensive property expansion

Potentially economically viable solutions in the future?

• Replacing an existing LPFF or HPFF cable, leveraging the existing pipe for conduit and pumping plant location for new cryogenic plants

• Directly competing against an installation of XLPE cable

• Directly competing against a new overhead installation
Risks and Challenges to Utilizing Superconductivity Cable

Total cost of ownership

- Initial capitalization costs
  - Cable
  - Cryogenics
  - Civil work
- Ongoing maintenance costs over a 40 year life
- Competition is XLPE and pipe type cable, both of which have pros and cons

Operations risks and challenges

- Level of Cryogenic system redundancy to be installed
- New technology hurdle needs to be overcome
  - Worker safety associated with liquid nitrogen
  - Community acceptance of a system with liquid nitrogen
  - Uncertainty of operational life