Electric Transmission
Are We Building What We Need?
• Nation’s largest electric power holding company, serving more than 7.5 million customers in six states
• Approximately $114 billion in assets
• Owns and operates 32,300 miles of transmission lines
• Interest in DATC is held by Duke Energy’s Commercial Businesses
• Identified $8 billion of transmission infrastructure projects, including one approved MISO Multi-Value Project
• Transmission-owning member of the MISO and PJM regional transmission organizations
• Founded in 1904 and headquartered in North Carolina with more than 29,000 employees
• Fortune 250 company listed on the New York Stock Exchange under the symbol DUK

• Formed in 2001 as the nation’s first multi-state transmission-only utility
• $3.8 billion in transmission assets
• Ownership group includes 22 municipalities and cooperatives
• Invested $3.5 billion in building more than 2,400 miles of transmission lines over the past 14 years in four Midwestern states: Wisconsin, Michigan, Minnesota and Illinois
• Projecting $3.3 billion to $3.9 billion in transmission infrastructure projects over the next decade in current service area, including three MISO Multi-Value Projects
• Owns and operates more than 9,500 miles of transmission lines and 530 substations
• Headquartered in Wisconsin with more than 650 employees
• Transmission-owning member of MISO
Are We Building What We Need?

It depends on the classification of projects and who you ask …

• Reliability projects get built because there is a clear understanding of violations and NERC requirements

• Economic / Market Efficiency projects are moving more slowly through the process because only a subset of total benefits are considered

• The next wave of Public Policy projects may not realize their full potential if we wait for the perfect time to study/build
How are needs identified and acted upon?

- Starts with the identification of constraints/violations by RTO/ISO
- RTO/ISO solicits solutions to the identified constraints/violations

<table>
<thead>
<tr>
<th>Sponsorship</th>
<th>Hybrid</th>
<th>Solicitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Developers provide solutions in form of project proposals</td>
<td>• Developers provide project proposals</td>
<td>• Stakeholders submit ideas</td>
</tr>
<tr>
<td>• RTO evaluates project submittals and selects developer based on who submitted winning proposal.</td>
<td>• Proposals are vetted to determine preferred solution</td>
<td>• Ideas are used to develop preferred solution</td>
</tr>
<tr>
<td></td>
<td>• RFP is issued to construct solution</td>
<td>• RFP is issued to construct solution</td>
</tr>
<tr>
<td></td>
<td>• RTO evaluates bids and selects developer based on scoring criteria</td>
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</tr>
</tbody>
</table>

Process can take anywhere from 1 year to 2.5 years from the time the RTO commences its annual planning process until a developer is selected or assigned to construct the project.
Observations from the early going...

- Current trends suggest competition is lowering costs to consumers
- “Two guys and a laptop” is not a legitimate concern
- Sponsorship model stresses RTO/ISO resources
- Solicitation model is an inefficient use of resources
- Arbitrary thresholds (voltage, cost, b/c) limit transmission projects available for competition
- Benefits to consumers from Economic and Public Policy projects are being delayed as sub-optimal projects chip away at broader, more beneficial solutions
- Projects to address CPP / generation retirements / fuel shifts, will challenge the existing process (scope, schedule)
Opportunities for Improvement

- Study multiple future scenarios without bias for the status quo
- Shorten the timeframe from futures development to selection
- Increase transparency in the evaluation process
- Benchmark production cost models against actual market performance
- Recognize the broader range of benefits in transmission projects
- MISO MVP portfolio was a ground-breaking example of understanding the benefits and flexibility transmission provides
- Sponsorship model brings more innovation and efficiency
- Start now…or future projects will all be reliability projects!
Electric Transmission
Are We Building What We Need?
What do we need to build?
How to evaluate transmission needs

Mark Vannoy, Chairman
Maine Public Utilities Commission
Vignette 1: PJM received a wide variety of proposals for Artificial Island...all addressing the same reliability need.
### Deterministic Needs Analysis

#### N-1 Voltage Violations

<table>
<thead>
<tr>
<th>Bus Name</th>
<th>Worst- Case Contingency</th>
<th>Worst- Case Voltage Violations (One Unit OOS)</th>
<th>Worst Case Voltage Violation (Two Units OOS)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biddeford – 115 kV</td>
<td>Loss of XYZ Transformer</td>
<td>.92</td>
<td>.92</td>
<td>Violation not seen if local Jet in service</td>
</tr>
<tr>
<td>Chestnut Hill – 115 kV</td>
<td>Breaker Failure</td>
<td>.93</td>
<td>.93</td>
<td>Not seen with Jet on</td>
</tr>
<tr>
<td>Rumney 115 kV</td>
<td>Double Circuit failure</td>
<td>.92</td>
<td>.92</td>
<td>Not seen with Jet on</td>
</tr>
</tbody>
</table>

#### N-1-1 Thermal Violations

<table>
<thead>
<tr>
<th>Element ID</th>
<th>Overloading Element</th>
<th>Initial Element OOS</th>
<th>Worst Case Contingency</th>
<th>Highest Loading (One Unit OOS)</th>
<th>Highest Loading (Two Units OOS)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1333-2</td>
<td>Orrington - Surroweic</td>
<td>XYZ Autotransformer</td>
<td>Breaker failure</td>
<td>126%</td>
<td>133%</td>
<td>Highest loadings when local gen out of service</td>
</tr>
<tr>
<td>1333-3</td>
<td>Harpswell - Poland</td>
<td>Line 1756</td>
<td>Breaker Failure</td>
<td>133%</td>
<td>159%</td>
<td>Highest loadings when local gen out of service</td>
</tr>
<tr>
<td>1859</td>
<td>Chester – Bolt Hill</td>
<td>Line 1792</td>
<td>Double Circuit Tower</td>
<td>120%</td>
<td>135%</td>
<td>Highest loadings when local gen out of service</td>
</tr>
<tr>
<td>1150</td>
<td>Maxcies-Buxton</td>
<td>Local fast start</td>
<td>Three phase ground fault</td>
<td>119%</td>
<td>130%</td>
<td></td>
</tr>
</tbody>
</table>
## Probabilistic Reliability Analysis

**Expected Energy Not Served (MWh/year)**

<table>
<thead>
<tr>
<th>Year</th>
<th>EENS Do Nothing Option</th>
<th>Looping Option (a.1)</th>
<th>Tapping Option (a.2)</th>
<th>Station Option (a.3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010/11</td>
<td>4215</td>
<td>1567</td>
<td>1633</td>
<td>1623</td>
</tr>
<tr>
<td>2011/12</td>
<td>4635</td>
<td>1598</td>
<td>1660</td>
<td>1650</td>
</tr>
<tr>
<td>2012/13</td>
<td>4958</td>
<td>1625</td>
<td>1679</td>
<td>1668</td>
</tr>
<tr>
<td>2013/14</td>
<td>5463</td>
<td>1663</td>
<td>1708</td>
<td>1697</td>
</tr>
<tr>
<td>2014/15</td>
<td>5993</td>
<td>1702</td>
<td>1743</td>
<td>1730</td>
</tr>
<tr>
<td>2015/16</td>
<td>6532</td>
<td>1752</td>
<td>1777</td>
<td>1764</td>
</tr>
<tr>
<td>2016/17</td>
<td>7121</td>
<td>1787</td>
<td>1802</td>
<td>1788</td>
</tr>
<tr>
<td>2017/18</td>
<td>7972</td>
<td>1841</td>
<td>1842</td>
<td>1828</td>
</tr>
<tr>
<td>2018/19</td>
<td>8984</td>
<td>1906</td>
<td>1879</td>
<td>1863</td>
</tr>
<tr>
<td>2019/20</td>
<td>10062</td>
<td>1974</td>
<td>1919</td>
<td>1902</td>
</tr>
<tr>
<td>2020/21</td>
<td>11383</td>
<td>2044</td>
<td>1968</td>
<td>1950</td>
</tr>
</tbody>
</table>

BC Hydro Central Vancouver Island Transmission Project

Electric Transmission
Are We Building What We Need?
Electricity network optimization technologies

Tim Heidel
Program Director
Advanced Research Projects Agency – Energy (ARPA-E)
U.S. Department of Energy

NARUC Summer Committee Meetings
Nashville, TN
July 27, 2016
ARPA-E catalyzes and supports development of transformational, disruptive energy technologies

**Goals:** Ensure America’s

- Economic security
- Energy security
- Technological lead in advanced energy

**Means:**

- Identify and promote revolutionary advances in fundamental and applied sciences
- Translate scientific discoveries and cutting-edge inventions into technological innovations
- Accelerate transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty

If it works… **will it matter?**
Network optimization technologies are an attractive complement to traditional transmission investments

- ARPA-E has funded development of a wide variety of network optimization technologies (both software and hardware) based on recent advances in power electronics, applied mathematics, optimization, and high performance computing.

- The emerging network optimization technologies funded by ARPA-E have been successfully validated by ARPA-E and industry partners via field pilots and/or large-scale software simulations.

- Network optimization technologies can increase the value of both existing and new facilities, thereby making transmission more cost effective on a $/MW-mile basis. This may allow for additional transmission investments that reduce overall system-wide costs.
Cost effective, reliable power flow controllers

Power flow controllers enable power to flows to be adjusted in real-time throughout transmission networks:

- Impedance control
- Series voltage injection
- Reactive voltage support

New generation of hardware promises lower cost and higher reliability:

- Fractionally rated converters (limited power device ratings)
- Modular designs (increases manufacturability)
- Series connected equipment with fail normal designs (gradual degradation)

Distributed Series Reactors
(PI: Dr. Frank Kreikebaum, Smart Wires)

Compact Dynamic Phase Angle Regulator
(PI: Dr. Deepak Divan, Georgia Tech & Varentec)
Network optimization software tools

**Transmission topology control algorithms** *(PI: Dr. Pablo Ruiz, Boston University & NewGrid)*

- Fast optimization algorithms allow grid operators to optimize transmission network topology in day ahead and real time
- > $100M / year estimated production cost savings in PJM RT markets (50% cost of congestion) based on 2010 conditions\(^a\)
- 40% reduction in renewable curtailments\(^b\)

**Real-time dynamic transmission path ratings** *(PI: Dr. Henry Huang, PNNL)*

- Software to calculate transmission path limits in real time (e.g. every 10 min)
- Considers voltage violations, thermal violations, voltage stability and transient stability limits
- Previous BPA/CAISO study using real-time EMS snapshots indicated 340 – 670 MW increase in the California-Oregon Intertie (COI) path rating under certain conditions

\(^a\) Based on simulation results for three historical weeks
\(^b\) PJM Integration Study Scenario: 30% low off-shore best sites on-shore

http://energyenvironment.pnnl.gov/highlights/highlight.asp?id=2315
Network optimization technologies (hardware or software) could be an effective and low cost investment option in many circumstances.

Many industry, government, and regulatory decision makers have limited awareness of network optimization alternatives to transmission expansion.

Existing state and federal policies typically recognize only traditional ("wires") solutions and non-transmission alternatives.

These and other yet to be understood factors appear to be slowing the adoption of cost-effective network optimization technologies.

Barriers to adoption:

1. Technical validation
2. Operator confidence
3. Business process changes

- Remedial action plans for contingencies
- Emergency procedures
- Transmission flexibility
- Devices in grid dispatch
- Effect on congestion (LMPs/FTRs)

Classes of transmission congestion relief investments:

- Offline applications
  - Outage scheduling & coordination
  - Operational planning
- Reliability options
  - Remedial action plans for contingencies
  - Emergency procedures
- Market operations
  - Transmission flexibility
  - Devices in grid dispatch
  - Effect on congestion (LMPs/FTRs)

1. Validation of net benefits
2. Stakeholder acceptance
3. Market design changes
Electric Transmission
Are We Building What We Need?
U.S. Department of Energy

Proposed Integrated Interagency Pre-Application Process for Transmission
Samuel Walsh, Deputy General Counsel for Energy Policy
Overview

- Section 216(h) of the Federal Power Act directs DOE to coordinate federal authorizations and related environmental reviews for electric transmission projects requiring multiple federal authorizations.
- In February 2016, DOE published a proposal rule creating an integrated, interagency pre-application (IIP) process for transmission projects.
- Purpose is to facilitate better coordination and information sharing among agencies, leading to better-informed applications and shorter permitting times.
Key Features of the IIP Proposal

‣ Two pre-application meetings attended by all affected agencies

‣ Agencies provide feedback to applicant on environmental concerns, data gaps, and other issues that might slow processing of an application

‣ IIP process culminates in DOE preparing a Final IIP Resources Report, which is intended to enable more efficient preparation of environmental review documents

‣ Process is voluntary
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