EUI Advisory Committee

- Discussion on EUI - Upgrade potential
About MRES

- Joint Action Agency
- Based in Sioux Falls, SD
- 60 municipal members
- Board of Directors - 13
- Average member population <5,000
  - Smallest: Pickstown, SD (215)
  - Largest: Moorhead, MN (39,400)
Minnesota Members

Adrian
Alexandria
Barnesville
Benson
Breckenridge
Detroit Lakes
Elbow Lake
Henning
Hutchinson
Jackson
Lake Park
Lakefield

Luverne
Madison
Marshall
Melrose
Moorhead
Ortonville
St. James
Sauk Centre
Staples
Wadena
Westbrook
Worthington
Residential Programs

- ENERGY STAR® Appliances
- Heating & Cooling

Commercial & Industrial Programs

- Various Prescriptive programs
- Custom Programs

Evaluation / Measurement / Verification (EM&V)

- EM&V critical to reliance on EE as resource
- Deemed savings - MN-DER
- Use consulting engineers for other custom projects
- Inspected more than 30% of C&I projects in 2015
So, What’s Missing?

- We don’t offer Infrastructure programs!

Area’s of EUI qualified savings

- Generation
- Transmission
- Distribution infrastructure
- Traditional conservation measures
Generation provided to Members

- 2015 Sources of Energy
  - 42% Renewable Resources (WAPA and Wind)
  - 23% Owned Coal Generation (Wyoming)
  - 17% Market Purchases
  - 12% Provided by Others
  - 6% Nuclear Generation
  - Less than 1% Natural Gas
Fossil Fueled Generation

- Coal - Laramie River Station
  - Located in Wheatland Wyoming.
  - Jointly Owned by 6 consumer-owned electric utilities

- N/G - Exira Station
  - Located in Brayton Iowa

- Fuel Oil - Watertown Power Plant
  - Located in Watertown South Dakota
Transmission

- Transmission is managed by MISO
  - Our members are either MISO nodes or node groups
  - Transmission upgrades are focused on N-1 philosophy's.
    - Potential upgrades focus on system reliability not efficiency.
Distribution upgrades

- Substations
  - Energy efficiency upgrades are possible

- Primary or Secondary metered customers
  - Primary metered customers take delivery at full voltage and own their own transformers

- Distribution feeders
Distribution upgrades - cont.

- Energy improvements in Ancillary equipment
  - Lighting, VFD’s, Pumps, ETC...
  - Most of these types of improvements would be covered by existing Prescriptive and Custom programs.
Delano:

- 4 square miles
- 5,800 electric meters
- 12MW load
- Double-ended substation
- 12 miles 69kV transmission
- 65 miles / 12 looped circuits
- OH to URD competed in 2012
Delano:

- 26 MW capacity
- 6 OP Diesel
- 1 12MW CT
Transformers:

- Amorphous core windings (thin foil core)
- Not new - ca. 1980
- $ premium (30%-50%)
- Higher efficiencies achieved
- Quantifiable savings? (70% @ no-load)
- Susceptible to inrush failures (brittle)
- Repair impossible
- Noisy & larger
What is Amorphous Metal?

Standard iron-silicon steel

Ferromagnetic Amorphous steel
Gen 1

Metal fragments breaks off from the core under stress

Metal fragments dropping into oil tank

CRGO steel transformer
3-phase 3-legs

Amorphous metal transformer
3-phase 5-legs
Transformers:

The test:

- Single-phase, rebuilt, pad-mount XFMR
- Various capacities & customers
- Logger installed on Primary and Secondary URD

<table>
<thead>
<tr>
<th>Transformer No-load Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watt Measured</td>
</tr>
<tr>
<td>0    50    100    150    200    250    300</td>
</tr>
<tr>
<td>kVA  5     7.5    10     25     75     100</td>
</tr>
</tbody>
</table>

- Amorphous
- Standard
Transformers:

Variables:

“Standard” (25 years old, rebuilt)

“Amorphous” (25 year old, rebuilt)

Variable load
Transformers:

Energy Savings Conclusion:

- Not worth “new” capital investment, but Amorphous-core re-tank has sound economic mojo.
- Price premium 140% of standard re-tank.
- Larger transformer loading sweet spot.
15KV URD Cable:

- Improved conductivity
- Reduce Ohmic loss
- Quantifiable savings? Consult TRM
15 KV URD Cable:

The test:

- DC high-pot
- Megger
- Cables off-line

<table>
<thead>
<tr>
<th>Standard</th>
<th>Insulation</th>
<th>Acceptance</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 409</td>
<td>EPR/XLP</td>
<td>56 kV /15 Min</td>
<td>46 Kv 5-15 Min.</td>
</tr>
<tr>
<td>IEEE 576</td>
<td>EPR/XLP</td>
<td>65 kV / 15 Min</td>
<td></td>
</tr>
<tr>
<td>ICEA S-68-516</td>
<td>EPR</td>
<td>65 kV / 15 Min</td>
<td></td>
</tr>
<tr>
<td>ICEA S-66-524</td>
<td>XLP</td>
<td>65 kV / 15 Min</td>
<td></td>
</tr>
<tr>
<td>ICEA S-94-649</td>
<td>EPR/XLP</td>
<td>64 kV / 15 Min</td>
<td>20 kV 5 Min.</td>
</tr>
<tr>
<td>AEIC CS6-96</td>
<td>EPR</td>
<td>64 kV / 5 Min.</td>
<td>51 kV 5 Min.</td>
</tr>
<tr>
<td>AEIC CS5-94</td>
<td>XLP</td>
<td>64 kV / 5 Min.</td>
<td>20 kV 5 Min.</td>
</tr>
</tbody>
</table>
15 KV URD Cable:

Variables:

- **XLP** (cross linked poly) susceptible to damage from tests
- **TR-XLP** (tree resistant)
- **EPR** (ethylene poly rubber) more flexible
- Length of run
- 4/0 or 1/0 conductor
- Terminations
15 KV URD Cable:

Energy Savings Conclusion:

- Line loss negligible
- Economic mojo prevails due to other factors including:
  - Reliability
  - Simplified installation
- All electrical distribution contains loss - TRXLP contains smallest dielectric loss.

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**Table 3.4**

Properties of Cable Insulations

<table>
<thead>
<tr>
<th>Dielectric Constant 20°C</th>
<th>Loss Angle Tan δ at 20°C</th>
<th>Volume Resistivity Ω-m</th>
<th>Annual Dielectric Loss* W/1000 ft</th>
<th>Unaged Impulse Strength V/mil</th>
<th>Water Absorption ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>PILC</td>
<td>3.6</td>
<td>0.003</td>
<td>10¹⁰</td>
<td>N/A</td>
<td>1000-2000</td>
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<tr>
<td>PE</td>
<td>2.3</td>
<td>0.0002</td>
<td>10¹⁴</td>
<td>N/A</td>
<td>3300</td>
</tr>
<tr>
<td>XLPE</td>
<td>2.3</td>
<td>0.0003</td>
<td>10¹⁴</td>
<td>8</td>
<td>350</td>
</tr>
<tr>
<td>TR-XLPE</td>
<td>2.4</td>
<td>0.001</td>
<td>10¹⁴</td>
<td>10</td>
<td>3000</td>
</tr>
<tr>
<td>EPR</td>
<td>2.7-3.3</td>
<td>0.005-0.008</td>
<td>10¹²–10¹⁴</td>
<td>28-599</td>
<td>1200-2000</td>
</tr>
</tbody>
</table>

* For a typical 1/0 15-kV cable.

Distribution Voltage:

- Improved capacity
- Reduce voltage drop & line loss
- Improved reach with smaller conductor
- Quantifiable savings? (0.8% energy/year per 1%V*)

*NEMA
Distribution Voltage:

- Overhead VS. Underground

![Graph showing cost-per-mile for distribution power lines]

*EPRI*
Distribution Voltage:

- 2,400
- 4,160
- 7,200
- 12,470
Distribution Voltage:

Energy Savings Conclusion:

- Line loss negligible
- Economic **mojo prevails** due to other factors including:
  - Reliability
  - Load capacity increase
Other Delano EUI:

Load Management
kVAR control (capacitors)
Voltage regulators
Variable speed air compressor/storage
VFD / PLC controls water system
LED streetlights
Geothermal (ground-source) in plant
Energy Star office equipment / computers
The EUI bible:

Opportunities for Energy Efficiency Improvements in the U.S. Electricity Transmission and Distribution System

Roderick Jackson
Cmer C. Onar
Harold Kirkham
Emily Fisher
Klaehn Burkes
Michael Starke
Olama Mohammed
George Weeks

April 2015
CIP Conclusions:

hmm....consult TRM

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Re-occurring Issues.

- **Soft questions**
  - What is Maintenance?
  - Why quantify EUI only after DSM efforts?
  - Should we cleanup spending and kWh goals

- **Harder questions**
  - What’s next!
Rob Scott-Hovland  
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