• 128,000 customers
• 1,000 sq. miles territory
• 44 substations
• 8,800 miles distribution
• 12.47 kV
• Wholesale supplier – Great River Energy
Planning – reacting “Reactive Planning”
- Externalities – stuff comes up not planned for
- Reactive Planning

Backfeeding – Contingency Planning
- Emergency vs Alternate Normal
- Capacity Planning

Case Example – Johnsville Transformer Failure
- Capacity Planning
- Reactive Planning
- Contingency Event
“REACTIVE PLANNING”

Events or Plans by Others – direct effect to Distribution Plant
• Road construction (road moves)
• Infrastructure failure (cable)

New “Opportunities”
• New developments (why didn’t we hear about his last year?)
• Large Load Development – ex: Data center

Other “Externalities”
• Economic changes (crash of 2008)
• Conservation (by plan, or trying reducing due to higher energy costs)

Need to plan; scan your environment; be prepared to react; adjust (re-create) the “plan”

Quote by a Senior Planning Engineer: “the forecast will never be correct”
Distribution Lines Located in Public Road Right-of-way

- Permitting required for construction
- No “easement” cost
- Risk – utility bears cost if needed due to road construction

Can We Plan for Road Work?

- Plan “road moves” capital budget
- Challenge: Entities have plan, not always executed to plan
- Often details not defined until after utility budgeting season
- Road projects often crop up during the year
ROAD MOVE “PLANNING”

Planning Year

System Analysis & Engineering Planning Complete

Contact Rd Agencies for Plans24

Receive Final Schedule / Details from Rd Agencies

Budget Plan Complete

Construction Year

Design (or redesign) time
Permitting
Construction time
Variance to “planned” budget

Rd Construction Start

Rd Construction Complete

Owned by the members we serve.
ROAD MOVE PLANNING – ANNUAL CAPITAL SPENDING

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean</th>
<th>Median</th>
<th>Std Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>1.00</td>
<td>1.01</td>
<td>0.22</td>
</tr>
<tr>
<td>2007</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 988 miles of cable installed before 1981.
- Higher than normal failure rates.
SYSTEM EXPANSION & IMPROVEMENTS – ANNUAL CAPITAL SPENDING

Capacity, Voltage, Protection

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean</th>
<th>Median</th>
<th>Std Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>1.00</td>
<td>0.98</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Owned by the members we serve.
ANNUAL SYSTEM DEMAND – PICTURE FROM 2007

Growth

- Customers
- kWhs
- Sum of Subs Pk kW

Period | Ave Growth
--- | ---
1996-2001 | 7.1%
2001-2006 | 4.2%
1996-2006 | 5.5%
TREND FOR HISTORY VS ACTUAL DEMAND

Total System Demand - MW

- **Annual Growth**: 5.00%
- **Average Annual Growth**: 0.43%

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COMPARISON – LINE CONSTRUCTION ACTIVITIES

- System Expansion
- Road Moves
- Cable Replacement

Yearly Comparison
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
TOTALIZED – LINE CONSTRUCTION ACTIVITIES

Per unit of average

<table>
<thead>
<tr>
<th>Year</th>
<th>Cable Replacement</th>
<th>Road Moves</th>
<th>System Expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>1.05</td>
<td>23%</td>
<td>34%</td>
</tr>
<tr>
<td>2007</td>
<td>1.17</td>
<td>18%</td>
<td>43%</td>
</tr>
<tr>
<td>2008</td>
<td>1.29</td>
<td>14%</td>
<td>46%</td>
</tr>
<tr>
<td>2009</td>
<td>0.95</td>
<td>7%</td>
<td>44%</td>
</tr>
<tr>
<td>2010</td>
<td>0.95</td>
<td>0%</td>
<td>37%</td>
</tr>
<tr>
<td>2011</td>
<td>0.94</td>
<td>13%</td>
<td>35%</td>
</tr>
<tr>
<td>2012</td>
<td>0.94</td>
<td>70%</td>
<td>42%</td>
</tr>
<tr>
<td>2013</td>
<td>0.98</td>
<td>41%</td>
<td>42%</td>
</tr>
</tbody>
</table>

Std Deviation 0.18

Owned by the members we serve.
KEYS TO REACTIVE PLANNING

How to react to global shift?
• Continue towards long range plan
• Shift time frame of execution

How to minimize capital costs but be ready to serve?
• Defer major investment until absolutely needed;
• Reduce lead time to complete
Almost Need a Substation???

Example Problem: Load is close to needing substation expansion, but not quite...

“Plan - Defer - React”

Substation Elements:

Plan: Do Up Front (Preparation)
- Engineering
- Land Acquisition
- Site Preparation

Defer – React: Do when absolutely needed
- Structures
- Bus work / switchgear
- Transformer

1. Risk high dollar expenditure and the load doesn’t come?
2. Risk deferring the substation, load comes and cannot build fast enough to meet demand?

Economic Risk
Reliability / customer service risk
CONTINGENCY PLANNING (AND REACTING...)

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Build plant to handle loss / failure / needed alternate source of power

Issues to address:

- **Investment made** → **Reliability**; **Revenue**
  - Duration of backfeed
    - Emergency only?
    - Extended? (“alternate normal”)
  - Design contingency operation;
    - ANSI A  (110 volts at meter)
    - ANSI B  (114 volts at meter)
  - Use emergency equipment ratings, or normal load ratings?

To what level of capacity to you build additional plant for contingency operations?

- 100% of peak load
- Less than 100%
  - Need plan for a 100% peak event
  - Need operational plan to execute

Use N-1? What do you do if event becomes N-2?
LOAD DURATION CURVE – PEAK LOAD

- Peak without AC
- Controllable AC potential - 100% penetration
  - 93% peak -> >20 hrs/yr (0.22%)
- Total residential central AC demand
- Peaking Load - 330 hrs
### Reliability Risk Based on % of Backfeed Capability

<table>
<thead>
<tr>
<th>Backfeed Capacity (% of peak load)</th>
<th>Exposure</th>
<th>Cost Impact 10 yr NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>No backfeed design</td>
<td>Days / Year: 81 - 140</td>
<td>Hours / Day: 14 - 16</td>
</tr>
<tr>
<td>70</td>
<td>Days / Year: 25 - 30</td>
<td>Hours / Day: 12 - 14</td>
</tr>
<tr>
<td>80</td>
<td>Days / Year: 10 - 14</td>
<td>Hours / Day: 10 - 12</td>
</tr>
<tr>
<td>90</td>
<td>Days / Year: 3 - 7</td>
<td>Hours / Day: 6 - 10</td>
</tr>
<tr>
<td>100</td>
<td>Days / Year: 0</td>
<td>Hours / Day: 0</td>
</tr>
</tbody>
</table>
## EQUIPMENT LOADING – “NORMAL” VS “EMERGENCY”

<table>
<thead>
<tr>
<th>Plant Equipment</th>
<th>“Normal”</th>
<th>“Emergency”</th>
<th>Incremental capacity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable (750 MCM Al)</td>
<td>475</td>
<td>532</td>
<td>12%</td>
</tr>
<tr>
<td>OH Wire (4/0 ACSR)</td>
<td>330</td>
<td>440</td>
<td>33%</td>
</tr>
<tr>
<td>Substation Transformer</td>
<td>28 MVA</td>
<td>35 MVA</td>
<td>25%</td>
</tr>
</tbody>
</table>
**Planning & Design Strategy:**
- Design feeders into multiple sections – backfeed per section
- Shift load to 2nd tier substation – leverage existing transformer capacity
- High probability of extended backfeed? Consider “normal load ratings” for contingency plan
- Quantify and understand the risk (voltage, capacity, degree of shortfall)
- Have spare equipment (i.e., transformer) ready to roll

**Operational Strategy:**
- Plan for placing emergency transformer in service in 24 hours.
- Have a plan for contingency system operation
- Have a plan to execute the plan!
JOHNSVILLE SUBSTATION – FEEDER TIES TO 1ST TIER SUBS

Owned by the members we serve.
SCADA TRACE – TRANSFORMER TEMPERATURE

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TRANSFORMER DAMAGE
<table>
<thead>
<tr>
<th>Feeder</th>
<th>BF Source</th>
<th>Details (Range B requirement is 114 v.)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>JON01</td>
<td>HAM04</td>
<td>106.9 v.</td>
<td>6.1 MW un-served</td>
</tr>
<tr>
<td>JON06</td>
<td>&gt; 114 v.</td>
<td></td>
<td>not applicable</td>
</tr>
<tr>
<td>SLP02</td>
<td>109.6 v.</td>
<td></td>
<td>6.1 MW un-served</td>
</tr>
<tr>
<td>JON01 Sec 1</td>
<td>SLP02</td>
<td>&quot;Section Switch&quot; is TP disconnects 2170-S: 111.7 v.; 4/0 ACSR 102%</td>
<td>4.7 MW un-served</td>
</tr>
<tr>
<td>JON01 Sec 2</td>
<td>HAM04</td>
<td>&gt; 114 v.; ALSO &gt; 114 v. if HAM04 BF JON02 with JON01 Sec 2; BUT 110.5 v. &amp; 4/0 ACSR 114% if HAM04 BF JON02 &amp; 03 with JON01 Sec 2</td>
<td>1.8 MW OK</td>
</tr>
<tr>
<td>JON02</td>
<td>HAM04</td>
<td>&gt; 114 v.</td>
<td>2.8 MW OK</td>
</tr>
<tr>
<td>JON03</td>
<td>&gt; 114 v.</td>
<td></td>
<td>not applicable</td>
</tr>
<tr>
<td>JON03</td>
<td>JON02</td>
<td>&gt; 114 v.</td>
<td>not applicable</td>
</tr>
<tr>
<td>JON02 -HAM04</td>
<td>112.2 v.</td>
<td></td>
<td>2.2 MW un-served</td>
</tr>
<tr>
<td>JON04</td>
<td>BLN05</td>
<td>110.1 v.</td>
<td>4.4 MW un-served</td>
</tr>
<tr>
<td>HAM02</td>
<td>112.2 v.; 4/0 ACSR 109%</td>
<td></td>
<td>4.4 MW un-served</td>
</tr>
<tr>
<td>JON04 Sec 1</td>
<td>BLN05</td>
<td>&quot;Section Switch&quot; is disconnects 475-S: 113.6 v.</td>
<td>1.3 MW un-served</td>
</tr>
<tr>
<td>JON04 Sec 2</td>
<td>HAM02</td>
<td>&gt; 114 v.</td>
<td>3.1 MW OK</td>
</tr>
<tr>
<td>JON05</td>
<td>APT05</td>
<td>&gt; 114 v.</td>
<td>4.6 MW OK</td>
</tr>
<tr>
<td>JON06</td>
<td>&gt; 114 v.</td>
<td></td>
<td>not applicable</td>
</tr>
<tr>
<td>JON06</td>
<td>JON01</td>
<td>&gt; 114 v.</td>
<td>not applicable</td>
</tr>
<tr>
<td>JON05</td>
<td>JON01</td>
<td>&gt; 114 v.</td>
<td>not applicable</td>
</tr>
<tr>
<td>SLP06</td>
<td>113.8 v.</td>
<td></td>
<td>5.0 MW un-served</td>
</tr>
</tbody>
</table>
LOADING SUMMARY

Projected peak: 24.8 MVA
Backfeed ability through distribution: 12.3 MW (~50%)
• System as is
• Plant normal load ratings

Feeder sectionalizing enhancement 5 MW

Remaining shortfall: ~7.5 MW (~30%)
"ALTERNATE NORMAL" - PLAN

- 14 MVA “Spare” transformer
- Feeder section switches
- Tap phase changes
- LDC settings changes
With 14 MVA spare transformer, backfeed to OTHER subs still short by 8 MW

<table>
<thead>
<tr>
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<th>BF Source</th>
<th>Details (Range B requirement is 114 v.)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAM04</td>
<td>JON01</td>
<td>111.2 v.</td>
<td>4.4 MW un-served</td>
</tr>
<tr>
<td>SLP02</td>
<td>JON01</td>
<td>&gt; 114 v.</td>
<td>4.8 MW OK</td>
</tr>
<tr>
<td>HAM04</td>
<td>JON02</td>
<td>&gt; 114 v.</td>
<td>4.4 MW OK</td>
</tr>
<tr>
<td>BLN05</td>
<td>JON04</td>
<td>112.7 v., 4/0 ACSR 107%</td>
<td>6.7 MW un-served</td>
</tr>
<tr>
<td>HAM02</td>
<td>JON04</td>
<td>111.0 v., 4/0 ACSR 105%</td>
<td>6.1 MW un-served</td>
</tr>
<tr>
<td>APT05</td>
<td>JON05</td>
<td>&gt; 114 v.</td>
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<tr>
<td>SLP06</td>
<td>JON06</td>
<td>&gt; 114 v.</td>
<td>3.6 MW OK</td>
</tr>
</tbody>
</table>
CONTINUING CHANGE / EVOLUTION

**Business Drivers:**
- Grid efficiency
- Conservation
- Reliability

**Tools & Strategies:**
- IVVC – Integrated Volt/VAR Control
- CVR – Conservation Voltage Reduction
- FLISR – Fault Detection, Isolation, System Restoration
- Line Sensors
- AMI

DMS – Demand Management System

Communications System
Questions

Owned by the members we serve.