• Infrastructure methodology/overview
• Smart grid demonstration project
• NorthWestern solar projects
• Smart infrastructure
• Smart meter
There are 8 significant components of the distribution system that are the focus of the plan

1. Poles
2. Underground cable
3. Overhead equipment
4. Tree trimming
5. Substations
6. Capacity margins
7. Rural reliability
8. Smart Grid
### DSIP Strategy for Smart Grid

<table>
<thead>
<tr>
<th>Establishing the foundation</th>
<th>Customer options</th>
</tr>
</thead>
<tbody>
<tr>
<td>A communications backbone</td>
<td>Metering / communications</td>
</tr>
<tr>
<td>Cost effective monitoring and control capabilities</td>
<td>Demand / efficiency initiatives</td>
</tr>
<tr>
<td>Supporting software and management systems</td>
<td>Service / rate options</td>
</tr>
</tbody>
</table>

**Deployed at the speed of value**

<table>
<thead>
<tr>
<th>The pilot</th>
<th>Distribution operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application development</td>
<td>Monitoring / automation</td>
</tr>
<tr>
<td>Concept testing</td>
<td>Outage prevention / restoration</td>
</tr>
<tr>
<td>Process education</td>
<td>Self-healing grid</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2010</th>
<th>2015</th>
</tr>
</thead>
</table>

---

*NorthWestern Energy*

*Delivering a Bright Future*
T&D Asset Management Strategy

Evaluate
Organizational Performance

Data
System information

Analyze
Asset Management & Planning & Engineering

Execute
Operations & Construction

Evaluate
Organizational Performance

Data
System information

Analyze
Asset Management & Planning & Engineering

Execute
Operations & Construction
Defining a **Common Language** for managing our delivery systems

Optimizing Investment Portfolio

- **Project Strategic Value Analysis**
- Align with Corporate Drivers
- Meet Delivery System’s Performance Targets

*Delivery systems are comprised of: Electric & Gas Transmission & Distribution and Substations & Gate/Compressor Stations*
T&D Asset Management Strategy

Manage vs. Replace/Eliminate

Prohibitively Expensive

Replacement Costs & Technology Enhancements

Maintenance and Reliability Costs

Very frequent replacement

Frequency of asset replacement and system upgrades

Replace only at failure

Unacceptable Operations

NorthWestern Energy
Delivering a Bright Future
Infrastructure CAPEX Plan Blueprint

Electric and Gas Infrastructure
Transmission, Distribution and Stations

- **Capacity (CP)**
  - The necessary delivery capabilities of the system necessary to meet operations, reliability, and growth parameters

- **Reliability (RE)**
  - Define delivery systems expectations versus actual performance

- **Asset Life (AL)**
  - Life of an asset based on a set level of performance of a delivery system

- **Compliance (CO)**
  - The adherence to established norms

*Note: Capacity is broken down into Capacity Growth (CP_G) and Capacity Reliability (CP_RE)*
1. Positive impact on **customer** service and value
2. Positive **financial** impact to net income
3. Reduced **risk** to the company
Portfolio Concept

NorthWestern Energy Portfolio
- Customers
- Finance
- Risk

System Portfolio
- Customers
- Finance
- Risk

Project Portfolio
- Customers
- Finance
- Risk

NorthWestern
- Infrastructure
- Other Business Units

- Reliability
- Capacity
- Asset Life
- Compliance

NorthWestern Energy
Delivering a Bright Future
NorthWestern Corporate Risk Categories

**Compliance**
- Federal Regulation
- State Statutes
- National Standards
- National Guidelines
- Local Ordinances
- NorthWestern Standards
- NorthWestern Guidelines
- Industry Best Practices
- Environmental

**Operational**
- Safety
- Property Loss
- Multiple Systems
- Isolated System
- Emergency Response
- System Capacity
- Impacts: Expenses, Revenues, Customers, Employees, Equipment, Obsolescence
- Utility
- Infrastructure

**Financial**
- Fines
- Litigation
- Regulatory Expenses
- Revenues
- Market/Sales

**Reputational**
- Regulatory
- Customer Satisfaction
- Corporate Image
- Community Perception
- Litigation

**Strategic**
- Emerging Technology
- Company Values
- Company Initiatives
- Growth Initiatives
- Diversification
- Governance
Scenario’s could be developed by focusing on guiding principles in different priorities.

**Scenario One**
- Reasonable Cost
- Reliable Service
- Sustainable Future
- Customer Responsiveness

**Scenario Two**
- Reliable Service
- Reasonable Cost
- Sustainable Future
- Customer Responsiveness

**Scenario Three**
- Sustainable Future
- Customer Responsiveness
- Reliable Service
- Reasonable Cost
<table>
<thead>
<tr>
<th>Technology Category</th>
<th>Scenario One</th>
<th>Scenario Two</th>
<th>Scenario Three</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electric Systems</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission Segmentation</td>
<td>$15</td>
<td>$25</td>
<td>$30</td>
</tr>
<tr>
<td>Distribution Segmentation</td>
<td>$30</td>
<td>$30</td>
<td>$30</td>
</tr>
<tr>
<td>Volt/Var</td>
<td>$-</td>
<td>$-</td>
<td>$-</td>
</tr>
<tr>
<td>AMI Metering</td>
<td>$-</td>
<td>$-</td>
<td>$-</td>
</tr>
<tr>
<td>Circuit Coordination</td>
<td>$5</td>
<td>$15</td>
<td>$20</td>
</tr>
<tr>
<td>Bank Metering/Database</td>
<td>$-</td>
<td>$1</td>
<td>$1</td>
</tr>
<tr>
<td>Equipment Monitoring</td>
<td>$0.6</td>
<td>$5</td>
<td>$10</td>
</tr>
<tr>
<td>Breaker Monitoring</td>
<td>$-</td>
<td>$2</td>
<td>$2</td>
</tr>
<tr>
<td>Regulator Monitoring</td>
<td>$-</td>
<td>$3</td>
<td>$3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$50.6</strong></td>
<td><strong>$86</strong></td>
<td><strong>$161</strong></td>
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<tr>
<td><strong>Gas Systems</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compressor Controls</td>
<td>$-</td>
<td>$1</td>
<td>$1</td>
</tr>
<tr>
<td>Mobile Data</td>
<td>$-</td>
<td>$0.5</td>
<td>$0.5</td>
</tr>
<tr>
<td>More on-line chromatographs</td>
<td>$-</td>
<td>$1</td>
<td>$1</td>
</tr>
<tr>
<td>Bar Coding System for Materials</td>
<td>$-</td>
<td>$-</td>
<td>$1</td>
</tr>
<tr>
<td>Updated Fuel system/ Panels</td>
<td>$-</td>
<td>$-</td>
<td>$1.2</td>
</tr>
<tr>
<td>Updated Modeling Software</td>
<td>$0.1</td>
<td>$0.1</td>
<td>$0.1</td>
</tr>
<tr>
<td>Improved SCADA System</td>
<td>$2</td>
<td>$2</td>
<td>$2</td>
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<tr>
<td>SD/MT Gas Scheduling System</td>
<td>$0.8</td>
<td>$0.8</td>
<td>$0.8</td>
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<tr>
<td>Enhanced Physical Security</td>
<td>$-</td>
<td>$-</td>
<td>$2</td>
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<tr>
<td>System Pressure Monitoring</td>
<td>$2</td>
<td>$4</td>
<td>$4</td>
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<tr>
<td>Central Equipment (Valve Con)</td>
<td>$-</td>
<td>$4</td>
<td>$6</td>
</tr>
<tr>
<td>AMI Metering</td>
<td>$-</td>
<td>$-</td>
<td>$25</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$4.9</strong></td>
<td><strong>$13</strong></td>
<td><strong>$45</strong></td>
</tr>
<tr>
<td><strong>Comm</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiber Control network (Urban)</td>
<td>$4</td>
<td>$6</td>
<td>$30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$4</strong></td>
<td><strong>$6</strong></td>
<td><strong>$30</strong></td>
</tr>
<tr>
<td><strong>Customer Options</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Web Portals</td>
<td>$-</td>
<td>$1</td>
<td>$1</td>
</tr>
<tr>
<td>Customer Experience Software</td>
<td>$-</td>
<td>$-</td>
<td>$6</td>
</tr>
<tr>
<td>Demand Response</td>
<td>$-</td>
<td>$-</td>
<td>$20</td>
</tr>
<tr>
<td>LED Street lights Conversion</td>
<td>$-</td>
<td>$-</td>
<td>$16</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$1.0</strong></td>
<td><strong>$1.0</strong></td>
<td><strong>$43.0</strong></td>
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<tr>
<td><strong>Grand Total</strong></td>
<td><strong>$59.45</strong></td>
<td><strong>$106.4</strong></td>
<td><strong>$278.6</strong></td>
</tr>
</tbody>
</table>
Smart Infrastructure
What does this mean?
Deeper Dive into Technology Within Five-Year Plan

Journey Map To
Enhance Our Bright Future

Value added timely and strategically to reduce risk & prepare system
"With Digital Transformation the consumer (or PSC), rather than the technology, is in the driver’s seat, and this matters" - Forbes
A smart system has each of these components integrated together.
Fiber Communication Backbone

Montana Fiber and Microwave (MW)
137 MW/Fiber Sites
123 MW Paths
Smart Grid Pilot
• An ARRA funded project, led by Battelle in collaboration with the BPA, 11 Utilities, 2 Universities, and 5 Vendors.
• $178M, five-year cost-shared demonstration
• 60,000 metered customers in five states
• Started 2010
• Ended 2015
  – Some assets still in place throughout the Northwest region
  – NorthWestern Energy is building on concepts of FLISR and VVO
NorthWestern’s Role & Objectives in PNWSGDP

- Contributing Member in regional experiment
- Learn from regional & other utility results
- Test technologies & position ourselves for future
- Evaluate costs, benefits, impacts on system
- **Utility** “side” of our project.
  - Distribution Automation – improve reliability
  - Volt/VAR Optimization [VVO] – energy savings
- **Customer** “side” of our project.
  - Provide customers with ways to control usage
  - Time of Use pricing – energy savings
  - Demand Response & Load Control
• **Budget = $4.2M**
  – 50/50 cost share with DOE funds

• **Scope: A Distribution Project in two locations**
  – City of Helena (urban area)
    o 3 Substations (out of 7)
    o 8 Distribution Circuits
    o Approx 200 homes, and 2 state government buildings
  – Philipsburg (rural area)
    o 1 Substation
    o 1 Distribution Circuit (240 line miles)
Let’s begin with the utility system side of the project.
Fault Location Isolation and Service Restoration (FLISR)
June 12, 2013 @ 10:23 PM SS #11
   – Tree in line
   • 1506 Customers Out of Power
   • 1250 Customers Restored in 51 Seconds by Automation
   • Remaining 256 Restored in 119 Min after tree removal

September 5, 2013 @ 7:50 AM ES #44 & #46
   – “Rocky” the Squirrel on equipment
   • ES #44 serves 492 Customers
   • ES #46 serves 1007
   • 780 Customers Restored in 41 Seconds by Automation
   • Remaining 715 Restored in 30 Min after squirrel removal
FLISR Example – Auto Accident

1100 Customers Out of Power

Golf Course Sub

Eastside Sub

Southside Sub

42
46
800 Customers Restored
300 Customers Still Out

FLISR– Intelligent Auto Restoration

Golf Course Sub

Eastside Sub

Southside Sub

51

42
46
• FLISR
  – Helena pilot project resulted in 53% reduction in customer minutes interrupted (CMI) on feeder/recloser outages.

- Billings Estimated Savings:

<table>
<thead>
<tr>
<th>Year</th>
<th>Outage Counts</th>
<th>CMI Saved</th>
<th>MT SAIDI Saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>23</td>
<td>1,325,940</td>
<td>3.79</td>
</tr>
<tr>
<td>2013</td>
<td>24</td>
<td>2,218,719</td>
<td>6.34</td>
</tr>
<tr>
<td>2012</td>
<td>18</td>
<td>1,054,303</td>
<td>3.01</td>
</tr>
<tr>
<td>2011</td>
<td>14</td>
<td>538,404</td>
<td>1.54</td>
</tr>
<tr>
<td>Average</td>
<td>19.75</td>
<td>1,284,341</td>
<td>3.67</td>
</tr>
</tbody>
</table>
Lessons Learned:

- Devices were not “plug and play out of the box”
- A robust communications system is paramount for the system to operate properly.
- Email notifications were difficult to decode, usually requiring the personnel to view the on-line system in real time to understand how it reconfigured.

Future Plans:

- We are currently evaluating the business case for YFA.
- DA is remaining active in Helena
Conservation Voltage Reduction / Volt Var Optimization (CVR/VVO)
Historical Range (118V-124V) – Maintains highest reliability by ensuring adequate voltage under most loading conditions.

Intelligent Volt/VAR Control Range (114.5V – 120V)
Increased device sophistication and controls to operate within lower portion of nominal range while continuing to deliver safe, reliable power.
Substation bus voltage reduced by an average of 1.21 volts in December 2013 when system enabled. Preliminary results indicate energy savings.
VVO – Where do the savings come from?

<table>
<thead>
<tr>
<th>% Reduction</th>
<th>16.66%</th>
<th>12.50%</th>
<th>8.33%</th>
<th>4.16%</th>
<th>0.00%</th>
<th>-4.16%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volt Range</td>
<td>100/200</td>
<td>105/210</td>
<td>110/220</td>
<td>115/230</td>
<td>120/240</td>
<td>125/250</td>
</tr>
<tr>
<td>Air Cond</td>
<td>1.028</td>
<td>1.002</td>
<td>0.989</td>
<td>0.985</td>
<td>1.000</td>
<td>1.034</td>
</tr>
<tr>
<td>L - Lighting</td>
<td>0.764</td>
<td>0.815</td>
<td>0.876</td>
<td>0.937</td>
<td>1.000</td>
<td>1.074</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>0.790</td>
<td>0.821</td>
<td>0.846</td>
<td><strong>0.905</strong></td>
<td><strong>1.000</strong></td>
<td>1.107</td>
</tr>
<tr>
<td>F - Lighting</td>
<td>0.842</td>
<td>0.898</td>
<td>0.937</td>
<td>0.970</td>
<td>1.000</td>
<td>1.033</td>
</tr>
<tr>
<td>Motor 3ph</td>
<td>1.012</td>
<td>1.004</td>
<td>1.003</td>
<td>0.996</td>
<td>1.000</td>
<td>1.007</td>
</tr>
<tr>
<td>Microwave</td>
<td>1.029</td>
<td>0.996</td>
<td>0.989</td>
<td>0.996</td>
<td>1.000</td>
<td>1.027</td>
</tr>
<tr>
<td>Heat Pumps</td>
<td>1.095</td>
<td>1.040</td>
<td>1.019</td>
<td>1.014</td>
<td>1.000</td>
<td>1.017</td>
</tr>
<tr>
<td>Electronics</td>
<td>0.717</td>
<td>0.783</td>
<td>0.861</td>
<td>0.924</td>
<td>1.000</td>
<td>1.080</td>
</tr>
<tr>
<td>Resistive</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

From: *Effects of Reduced Voltage on the Operation and Efficiency of Electric Loads*, Volume 1 and 2, Electric Power Research Institute, Palo Alto, California, Sep 1981.
Value of CVR/VVO as Demonstrated in the PNSWG Pilot

- CVR/VVO
  - 1% reduction in voltage resulted in approximately 0.8% energy savings.

![Graph showing kWh savings potential based on % voltage reduction]

The equation for the graph is:

\[ y = 0.8086x - 0.0004 \]

\[ R^2 = 0.9815 \]
• **Sourdough Feeder #1**
  - Customers: 4,730
  - Modeled avg. customer savings: 1.12%
  - Avg. customer kWh/yr (before): 16,213
  - Avg. customer kWh/yr (after): 16,032
  - Total kWh Savings per Customer 181 kWh/yr

Requires investment into DMS control system and infrastructure upgrades.

It is balance between the cost to the consumer and its potential savings. The goal is to reduce the customers utility bill as a whole.
Lessons Learned:

- Devices were not “plug and play out of the box”
- A robust communications system is paramount for the system to operate properly.
- Difficult to validate S&C’s powerflow model.
- Difficult to perform Measure and Verification without industry standard protocols.
  - A newer verification process through sister feeder comparison is gaining traction, and may be used as another tool to validate savings in the future.
- Estimating the % voltage saved is more difficult than originally anticipated.
- Controlling equipment based EOL tends to increase its tap operations. This additional wear and tear is still being evaluated.
- Savings tend to be controlled by select amount of low voltage control points.
Questions still being evaluated:
- How to optimize a VVO deployment:
  - i.e.. Weigh the investment of feeder and secondary improvements to achieve additional voltage reduction for more savings.
- What is the best control scheme to minimize equipment operations and gain both energy savings and system savings?

Future Plans:
- Volt/VAr testing will continue in Helena.
- Currently working to better understand savings and peak energy reduction to develop business model.
What about the customer side of the project?
The Customer Side of Project

200 Residential Customers –
  – Meter Collector Wireless “Footprint”

1 Commercial Building –
  – (MT State Government Campus)
Objective: Leveraging AMR in a Smart Meter World

Asset Systems:

• 200 Meters read at 15 minute intervals
  • Installed new meters and communication backbone
  • Used existing billing system
Objective: Smart Home

Asset Systems:
- Smart Thermostat
- 240 V and/or 120 V Control Switches
- In-Home Display
- Web Portal
- Broadband Gateway
- ERT to Zigbee Gateway
Project Goals for Residential Customers

• Provide Customers more information and ways to control their usage.
• Utilize WEB based services via in-home displays
  • Energy Use Profiles
  • Load control
• Offer Time Variable Pricing
• Observe Customer Response to Price Signals
• Evaluate performance of technology
“How am I doing” messages sent here to residential participants.
Asset Systems:

- Lockheed Martin
  - Demand response software
- Energy management software

Objective: Transactive Control & Demand Response

- Battelle EIOC
- NorthWestern Node (MDCC)
- Customer HAN system
- VVO System
- Transactive Incentive Signal (TIS)
- Transactive Feedback Signal (TFS)
- Load/capacity
- Translate regional price to local TOU prices
- Tendril
3-Level Time of Use Energy Pricing
(Red – Yellow - Green traffic signal color scheme)

- On Peak $0.08/kWh
- Mid $0.05/kWh
- Off Peak $0.03/kWh

<table>
<thead>
<tr>
<th>Mountain</th>
<th>Time - Hour Ending</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 0.03</td>
<td>0.03 0.03 0.03 0.03 0.03 0.05 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.08 0.08 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.03</td>
</tr>
<tr>
<td>Feb 0.03</td>
<td>0.03 0.03 0.03 0.03 0.03 0.05 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.08 0.08 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.03</td>
</tr>
<tr>
<td>Mar 0.03</td>
<td>0.03 0.03 0.03 0.03 0.03 0.05 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.08 0.08 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.03</td>
</tr>
<tr>
<td>Apr 0.03</td>
<td>0.03 0.03 0.03 0.03 0.03 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.08 0.08 0.08 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.03</td>
</tr>
<tr>
<td>May 0.03</td>
<td>0.03 0.03 0.03 0.03 0.03 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.08 0.08 0.08 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.03</td>
</tr>
<tr>
<td>Jun 0.03</td>
<td>0.03 0.03 0.03 0.03 0.03 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.08 0.08 0.08 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.03</td>
</tr>
<tr>
<td>Jul 0.03</td>
<td>0.03 0.03 0.03 0.03 0.03 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.08 0.08 0.08 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.03</td>
</tr>
<tr>
<td>Aug 0.03</td>
<td>0.03 0.03 0.03 0.03 0.03 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.08 0.08 0.08 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.03</td>
</tr>
<tr>
<td>Sep 0.03</td>
<td>0.03 0.03 0.03 0.03 0.03 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.08 0.08 0.08 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.03</td>
</tr>
<tr>
<td>Oct 0.03</td>
<td>0.03 0.03 0.03 0.03 0.03 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.08 0.08 0.08 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.03</td>
</tr>
<tr>
<td>Nov 0.03</td>
<td>0.03 0.03 0.03 0.03 0.03 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.08 0.08 0.08 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.03</td>
</tr>
<tr>
<td>Dec 0.03</td>
<td>0.03 0.03 0.03 0.03 0.03 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.08 0.08 0.08 0.08 0.08 0.08 0.05 0.05 0.05 0.05 0.03</td>
</tr>
</tbody>
</table>
Time-of-use results (Sept 2012 thru Aug 2014)

- Lower monthly bills - shift load to lower cost time of day
- Started with 195 participants ended with 190
  - Some dropouts and some new recruits
- Bill Credit
  - Maximum bill credit achieved $31.15 (January 2013)
  - Highest average savings $8.88 (Jan 2013)
  - Lowest average savings $1.33 (Oct 2013)
- No “penalty” if TOU bill exceeds standard rate calculated bill
Time-of-use results (Sept 2012 thru Aug 2014)
Quarterly contests with prizes
  – Compare usage over last year – top 3 reducers receive prize $
  – First contest results (April – June 2013)
  – Second contest results (Oct – Dec 2013)

<table>
<thead>
<tr>
<th>Contest #</th>
<th>Place</th>
<th>kWh Saved</th>
<th>Cost Savings</th>
<th>Prize</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1st</td>
<td>2,176</td>
<td>$131.84</td>
<td>$100</td>
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<tr>
<td>2nd</td>
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<td>1,459</td>
<td>$135.56</td>
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<td>3rd</td>
<td></td>
<td>1,440</td>
<td>$193.10</td>
<td>$25</td>
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</table>
Demand Response Events

• Residential Homes
  – Some quarterly residential home events – multiple phases of load reduction
  – Customer can opt out using home equipment
  – Lockheed Software calculated load reduction capability based on input from supplied customer data
Metcalf Building Tasks

- DR to Building Management System
  - Lighting Control
    - Along Outside Windows
    - Overhead Lights
    - Diming Controls
  - HVAC Control
Proposed Demand Response Events
– Capital Building
  • Quarterly events – multiple phases of lighting & HVAC

<table>
<thead>
<tr>
<th></th>
<th>Estimated Summer kW Demand Reduction</th>
<th>Estimated Winter kW Demand Reduction</th>
<th>Notes:</th>
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<tbody>
<tr>
<td></td>
<td>Phase 1</td>
<td>Phase 2</td>
<td>Phase 3</td>
</tr>
<tr>
<td>Lighting Controls</td>
<td>6.7</td>
<td>10.8</td>
<td>16.0</td>
</tr>
<tr>
<td>AC-1 VFD Speed Control</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>AC-3 VFD Speed Control</td>
<td>0.0</td>
<td>6.7</td>
<td>10.4</td>
</tr>
<tr>
<td>Atrium and Solar Street</td>
<td>0.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Cooling Tower Fan Electric Reheat Coils</td>
<td>8.0</td>
<td>8.0</td>
<td>10.0</td>
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<tr>
<td>Heat Pump Cycling</td>
<td>0.0</td>
<td>20.0</td>
<td>30.0</td>
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<tr>
<td>Totals</td>
<td>14.7</td>
<td>49.5</td>
<td>70.4</td>
</tr>
</tbody>
</table>
Demand Response Events

- Capital Building
  - Estimated seasonal savings
  - 3 levels of reduction
    » Phase 1, 2 or 3
  - Lockheed software to set level based on operator input and send signal to BMS
Demand Response Results

- Residential Homes
  - Calculated savings and actual measured savings very different

- Capital Building
  - Never able to test system

<table>
<thead>
<tr>
<th>DR Event #</th>
<th>Calculated Savings</th>
<th>Measured Saving</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>0.663 MW</td>
<td>0.00882 MW</td>
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<tr>
<td>2</td>
<td>0.408 MW</td>
<td>0.005908 MW</td>
</tr>
<tr>
<td>3</td>
<td>1.624 MW</td>
<td>0.005578 MW</td>
</tr>
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</table>
End of 2 year test period business case development

– Does the technology work?
– Is it reliable?
– What does it cost?
– What is the ROI?
– Is there a business case to carry any of these forward?
– Additional questions on the consumer side:
  • Will consumers accept and use the technology?
  • Will they be willing to pay for it?
  • Will price signals work to change/improve the current pattern of demand?
  • Time-of-use energy pricing?
Lessons Learned

- Lack of sufficient “plug and play” between systems and technology
  - Capital Building
- Will consumers accept and use the technology?
  - Exit Survey Results
- Will they be willing to pay for it?
  - Cost Recovery
- Will price signals work to change/improve the current pattern of demand?
  - Contest Results
- Time-of-use energy pricing?
  - TOU Results
Future Plans

– Keep eye on
  • load growth (MT and regional)
  • peak demand changes (MT and regional)
  • renewable energy integration
  • state of smart grid technology

– Wait
  • Finish smart grid ready substations and communications
Advanced Distribution Management System (ADMS)

NorthWestern Energy
Delivering a Bright Future
What is an ADMS?

ADMS = OMS + SCADA + Software
ADMS foundation = Power-Flow Model
(Power-Flow Model = GIS Extract w/Connectivity + CIS Data + Equipment & Conductor Attributes)
Reliability & Customer Satisfaction:
- **Fault Location**: Quicker restoration time
- **Switch Orders**: Less errors, consistency in process
- **Fault Location Isolation and Service Restoration (FLISR)**: Automated switching & restoration
- **Enhanced OMS**: SCADA enabled, and future AMI

System Capacity:
- **Engineering Analysis**: increased capacity utilization allowing capital investment deferral
- **Network Reconfigure**: Optimizing loading & producing switching plans.
Asset Life:
- Conditioned based and alarm monitoring: reduce unexpected failures
- Extend Asset Life: adjust operations, monitor equipment

Regulatory/Risks:
- Data—historical information for detailed engineering analysis and future rate cases
- Safety—greater situational awareness, move towards centralized control
Leveraging the DSIP Communications Assets:
• Remote programming of field devices
• Monitoring & Control of system assets

Additional Business Opportunities
• Volt/VAR Optimization (VVO)
• Distributed Energy Resource Management (DERM)
ADMS Benefits

**Increase Reliability**
- Automated switching orders from real time loading information
- A cost effective platform for Fault Location Isolation & Service Restoration (FLISR)
- Near real time awareness of interruptions
- Identify momentary interruptions perform early diagnoses

**Optimize Capacity**
- Optimum system configuration based on real time information
- Encourage reliable distributed energy resource (DER) integration

**Asset Life**
- A cost effective platform for conditioned based monitoring (transformers/LTCs)
- Awareness of compromised assets before failure

**Reduced Risk**
- Safety/Centralized Control

**Additional Business Opportunities**
- Volt VAR Optimization (VVO)
- Distributed Energy Resources (DER) Integration

**Increase Customer Satisfaction**
- Response to breaker and recloser outages before a customer calls.
- Improve estimated time of restoration through increased situational awareness.

**Operational Benefits**
- Modeling improvements
- Automated switching plans
- Situational awareness
ADMS Integrations, Functionality, GIS, & Project Time Line
ADMS Interfaces & Functions

Red Lines
- Electric Outage Orders
- “System Related” Orders/Items
  - CIS: Lines Down, Car Hit Pole, etc.
  - SCADA: Alarms, Events, etc.
  - AMI: Outage Notifications
GIS & Data Items

- Distribution Generator Database
- Line Conductor & Transformer Data
- Primary Meter & Customer Association
- Switch Data (Ganged/Un-ganged, consistency in data, SCADA control, etc.)
- Looped Systems (GF Pasta & Waterworks, SD 34.5kV, etc.)
- Transmission in GIS
- Substation one-lines in GIS
- Switchgear one-lines in GIS
**System Segmentation**

**Customer Count**

- **Golf Course Sub**
  - 51
  - 400
  - 350
  - 900
  - 250
  - 400
  - 700
  - 400

- **Eastside Sub**
  - 300
  - 42
  - 46
  - 20

- **Southside Sub**
  - 300
  - 450
  - 300
  - 1
Utility Supported Solar Projects Overview
NorthWestern Distribution Solar Projects

- 4 Locations
  - Deer Lodge (Beck Hill)
  - Bozeman
  - Missoula
  - Helena
- Result of Community Sustainable Energy Working Group meetings in 2015 and 2016
Solar Project Overview

- **Beck Hill Rural Microgrid**
  - Operational November 2015
  - Pilot test of Rural Reliability

- **Bozeman Community Solar Project**
  - Operational November 2016
  - Pilot test of utility owned PV with Smart Inverters
• **Missoula Community Solar Project**
  – Estimated Completion Date – Q3 2018
  – Pilot test of Holistic Schools Program

• **Helena Solar Project**
  – Estimated Completion Date – TBD
  – Pilot test of Utility Owned Rooftop
Locations: Beck Hill Rural Microgrid
Location: Bozeman Community Solar Project
Location: Missoula Community Solar Project

Missoula Community Solar Project
Proposed Locations

Legend
- High School
Location: Helena Solar Project
NorthWestern’s Definitions:

“Microgrid” - Powers a medium voltage line without a utility source.

“Utility Supported Microgrid” - Benefits the utility system when the utility source is available and has the ability to intentionally island to form a microgrid.
NorthWestern is investigating:
- How to safely integrate Microgrids
- A market based deployment of Microgrids
  - Increased reliability
  - Better load management
  - Asset deferral opportunities
  - Greater system efficiency

For Our Customers:
- Increased reliability
  - 2 - 4 hours of additional power during outages.
### Beck Hill: Rural Microgrid Project

**Target Customers:** Customers with rural reliability issues

**Location:** Beck Hill (~7 miles north of Deer Lodge, MT)

### Description

~160 kWh of battery storage paired with 40 kW of Solar. Configure the Microgrid to automatically disconnect from the utility and re-power 16 customers during outages. Re-connect customers to utility automatically when power is restored.

### Technologies Deployed

- Lead Acid Battery Storage
- DC Coupled Solar
- AC Coupled Solar (string inverter)
- AC Coupled Solar (Micro-inverters)
- Communications
- Electronic Relcosers

### Desired Learnings

- Value of storage in rural applications
- Storage optimization
- Benefits of solar in Microgrid applications
- Development cost models
- Controls needed for Microgrids, including ancillary services provided by storage
• **Purpose:**
  – Review the conceptual design of a Microgrid

• **Takeaways:**
  – High level understanding of a Microgrid
  – Talking points for the proposed Microgrid

• **Next Steps:**
  – Review operating procedures and commissioning steps with Butte Division Operations
How Does it Work?

Utility Source

Recloser
Closed

Fused Disconnect

17 Residential Customers

Microgrid:
Battery Storage & Solar PV

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How Does it Work – Grid Connected

PV charges batteries and excess energy supports the grid.

Batteries can be discharged to support grid, as needed.
How Does it Work – Microgrid

1. Loss of Source Power
2. IEEE 1547 trips A/C coupled inverters
3. Safety Checks:
   - Microgrid Recloser did **not** lock out
   - Microgrid Recloser is **not** in hot line hold
   - Microgrid is **not** disabled
4. Microgrid Recloser Opens
5. Microgrid is energized
1. Source power is available
2. Safety Checks:
   - Microgrid Recloser is not in hot line hold
   - Microgrid is not disabled
   - Microgrid is energized
3. Microgrid is then de-energized
4. Microgrid Recloser is closed in to restore utility power
Microgrid Results
• Operations
  – 5 in 2016
  – 5 in 2017
    o November 1 approximately 2 hours 30 minutes
  – Longest islanded operation: 4 hours and 22 minutes
• MSU Senior Design Project
  – Improvements of Microgrid inverters (inverter ramping, voltage angle controls, etc.)
• Last Operation 11/1/17
  – Cause was an open fuse on distribution feeder
<table>
<thead>
<tr>
<th>Time</th>
<th>Power used</th>
<th>Energy from grid</th>
<th>Power generated</th>
<th>Energy to grid</th>
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<tbody>
<tr>
<td>10:00 AM</td>
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<td>11:00 AM</td>
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<td>12:00 PM</td>
<td></td>
<td></td>
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<tr>
<td>1:00 PM</td>
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</tr>
<tr>
<td>2:00 PM</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- Power used
- Energy from grid
- Power generated
- Energy to grid

NorthWestern Energy
Delivering a Bright Future
Bozeman Community Solar
<table>
<thead>
<tr>
<th><strong>Target Customers:</strong></th>
<th>Diversity of Residential, Commercial, &amp; Industrial Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potential Location(s):</strong></td>
<td>Bozeman Water Treatment Facility</td>
</tr>
</tbody>
</table>

**Description**

380 kW PV array with smart inverters and 40-50 volunteer customers w/advanced metering (5-min interval data)

**Technologies Deployed**

- Utility-scale solar
- Smart Inverters
- AMI
  - Virtual net-metering
  - West facing panels

**Desired Learnings**

- Peak shaving
- Educational component MSU
- Community Solar Rate Modeling
  - Development process/cost
  - Integrating solar to grid
  - Distribution mgmt. sys
  - Data on PV production & user consumption
Bozeman Solar Project – Site Overview

System:
- 1,152 Suniva Solar Modules (US Manufactured)
- 11 SMA Inverters with Advanced Inverter Controls
- 330 kW AC Output
- 2.5 Acres in Partnership with City of Bozeman
- 40 Residential Customers & 20 Commercial Customers with Advanced Meters
- 2 Montana State University Senior Design Projects
Bozeman Solar Project
Community Solar Study

Real Time Look

Current Solar Production

Kilowatt Hours (kWh)
187

Residential Load

Kilowatt Hours (kWh)
48

Total Energy Production

9,740
Kilowatt Hours (kWh)

Chart - Data

9,740
Kilowatt Hours (kWh)
PRODUCED

7,836
Kilowatt Hours (kWh)
RESIDENTIAL LOAD

Legend

- Solar Production
- Customer Usage

Historic Site Data

Solar Profile = Yellow | Residential Profile = Blue

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Missoula Schools
### Target Customers: School in Missoula, families

### Potential Location(s): School property: Big Sky, Sentinel, Hellgate, Willard

#### Description
Locate solar on a school to learn how to maximize education benefits while gathering data, knowledge and experience related to solar installations.

#### Technologies Deployed
- Solar PV
- Automated metering
- Storage?
- EDI dashboard - usage

#### Desired Learnings
- I.D. of customers and data collection
- Ability to establish school utility solar partnerships
- Student involvement / education
- Is Missoula good for solar production?
- Scalability

#### Go / No-Go Decision Points
- Size
- Cost
- Location/structure
Missoula - Sentinel: Vertical Wall Option
Missoula - Willard

Parking Lot: 26.4 kW 33,374 kWh/yr

Fence: 42.9 kW 35,397 kWh/yr
Solar Fence Concept

See through = enhanced security
Missoula - Big Sky School

2 Panel Racking
50 kW
63,202 kWh/yr
Helena
### Target Customers:
Existing footprint of Smart Grid demo, 6th ward

### Potential Location(s):
Expanded footprint focused on low-income?

### Description
Utility owned / controlled solar paired with AMI, advanced inverters, and storage
- Test Utility owned distributed solar / inverters
- Tipping point of circuits capacity
- Customer interest / engagement

### Technologies Deployed
- Advanced inverters
- Solar
- AMI
- Storage
- Communication

### Desired Learnings
- Conservation savings through VOLT/Var
- Ride through capabilities of inverters
- Value of storage utilization of storage at different points on the grid

### Go / No-Go Decision Points
- How do we get recovery
- Clear understanding of data
- Participation
Smart Meters at a Glance

76 MILLION
The number of SMART METERS deployed in the United States through end of 2017

Smart meters enable TWO-WAY power and information flows to improve visibility into the HEALTH OF THE ENERGY GRID

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Smart Meters at a Glance

**NUMBER OF SMART METERS DEPLOYED** (millions)

- 2009: 13M
- 2011: 27M
- 2013: 46M
- 2015: 65M
- 2016: 72M
- 2017: 26M
- 2020: 90M

- 60% of U.S. households have a smart meter

- Smart meters provide customers with control and flexibility over their energy use

- Smart meters connect distributed energy resources to the energy grid

For the full report, see: Electric Company Smart Meter Deployments: Foundation for a Smart Energy Grid
Today’s Meter Reading Process - SD/NE

- Manual meter reading process
- Data use is only for Billing functions
Future AMI Processes – SD/NE

- Remote meter reading
- Two-way capabilities reduce truck rolls
- Improved outage management
- Enables future capabilities: customer portals, etc.
AMI Field Network

Central Base Station

Neighborhood Collector/Router

End-points
New Network Equipment – SD Example

- CGRs Mesh Network (Electric & Combo)
- Mesh Range Extender (Electric & Combo)
- CGRs Star Network (Gas Only)

111,500 Electric Meters & Gas Modules
220 Network Devices
Nebraska Overview

CGRs Star Network
(Gas Only)

North Platte

43,800 Gas Modules
48 Network Devices
46 New Backhauls

Kearney

Grand Island

41,500 Electric Meters & Gas Modules
220 Network Devices
160 New Backhauls

Up to 150 towers/poles, for backhaul etc.
The project consists of the following:

- Replacing ~ 365,000 Montana electric meters with smart meters.
- Replacing ~ 190,000 Montana gas meter modules/registers with AMI modules.
- Install communication infrastructure required.
- Enhance AMI Head End software (needed to operate the Smart Metering Infrastructure).
- The Meter Data Management (MDM) system to manage and verify the data.
- Upgrade integration to the Customer Information System (CIS).
AMI Integration

SD Operations & Meter Dept.  BT Comms & Networking  BT Security/Network

IFDM Tools (Client)  IFDM Tools (Hosted)

Electric Meters  CGR (MESH)  NWE Backhaul (700 MHz)

Routing Node  CGR (STAR)  Verizon Backhaul (Cell)

Gas Meters  ISP Backhaul

900 MHz Mesh  900 MHz Star

Comms & Network Diagnose Issues Field to Install Devices

AMI Head End

OWOC-Collection Manager (Meter Dept.)
OWOC-Performance Manager (Meter Dept.)
Cisco IoT-FND (BT Comms/Network)
Itron Security Manager (BT Security)

Customer Care

MDM

CSR Portal
CIS
CIS-FDM

ESB
ADMS Engineers

BT Analysts to oversee all applications
## Change Management Strategy Document Communications Work Plan Spreadsheet

### South Dakota & Nebraska
AMI Project
Change Management Communication Work plan

<table>
<thead>
<tr>
<th>Topic/Name</th>
<th>Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recurring Events</td>
<td></td>
</tr>
<tr>
<td>Project Team Meeting</td>
<td>Phone/Skype</td>
</tr>
<tr>
<td>Change Management meeting</td>
<td>Phone/Skype</td>
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<tr>
<td>Executive Status Report</td>
<td>Brightwork</td>
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<tr>
<td>Steering Committee Meeting</td>
<td>Meeting</td>
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<tr>
<td>One-time Events</td>
<td></td>
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<tr>
<td>Meetings with local government agencies</td>
<td>Meeting/handouts</td>
</tr>
<tr>
<td>AMI - ADMS announcement</td>
<td>Teleconference</td>
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</tbody>
</table>

2017

**Advanced metering infrastructure upgrade – change management strategy**

*This document outlines the change management strategy for an upgrade project, emphasizing effective communication with stakeholders.*
Deeper Dive into Technology Within Five-Year Plan

Journey Map To Enhance Our Bright Future

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Value added timely and strategically to reduce risk & prepare system

"With Digital Transformation the consumer (or PSC), rather than the technology, is in the driver’s seat, and this matters" - Forbes
QUESTIONS?
Delivering a bright future

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