Agenda

• End Use study
  • Methods
  • Consumption findings
  • Willingness to pay

• Potential study findings and comparison
  • Potential study
    • Sector-level results
    • 2009 vs 2015
    • 2015 vs NWPPCC 7th Plan
End-Use Study
End-Use and Load Profile Study Methodology: Objectives

• Characterize NorthWestern Energy’s current sales data by sector and end-use
  • Evaluate breakdown of existing building types
  • Calibrate load shapes to historical sales data

• Provide pertinent inputs to the demand-side management potential study including:
  • Number of residences/building stock
  • Unit energy consumption (UEC)/Energy utilization intensity (EUI)
  • Equipment saturation and fuel share
  • Baseline technology conditions
End-Use and Load Profile Study Methodology: Primary Data Collection

- On-site surveys were used as primary data source
- Site visits included rural and urban locations
End-Use and Load Profile Study Methodology: Secondary Data Collection

- **Nexant supplemented its primary research with secondary data sources**
  - NorthWestern Energy’s on-site energy audits
    - Large sample size
    - Reliable data collection protocol
    - Regionally accurate
Overall Electric and Natural Gas Consumption by End Use

### Electricity

- **Industrial**: 13.5%
- **Water Heat**: 3.6%
- **Space Heat**: 4.4%
- **Refrigeration**: 12.4%
- **Plug Load**: 17.0%
- **Other**: 8.8%
- **Cooking**: 3.8%
- **Cooling**: 6.4%
- **HVAC Auxiliary**: 6.6%
- **Heat Pump**: 0.8%
- **Lighting**: 22.6%

### Natural Gas

- **Water Heating**: 20.3%
- **Other**: 8.9%
- **Heating**: 70.7%
Overall Electric and Natural Gas Load Profile by Sector

### Electricity

- **Consumption (GWh)**
- **January**
- **February**
- **March**
- **April**
- **May**
- **June**
- **July**
- **August**
- **September**
- **October**
- **November**
- **December**

- **Commercial**
- **Residential**
- **Industrial**

### Natural Gas

- **Consumption (dKt)**
- **January**
- **February**
- **March**
- **April**
- **May**
- **June**
- **July**
- **August**
- **September**
- **October**
- **November**
- **December**

- **Commercial**
- **Residential**
- **Industrial**
Residential Electric Consumption by Segment and End Use

- Single Family, 75.8%
- Multi-Family, 11.4%
- Manufactured, 8.9%
- LI Single Family, 3.0%
- LI Multi-Family, 0.5%
- LI Manufactured, 0.4%

End Uses:
- Central AC 3.4%
- Central Heat 1.3%
- Cooking 2.5%
- Heat Pump 0.9%
- Room AC 0.8%
- Lighting 15.7%
- HVAC Auxiliary 4.0%
- Refrigerator 11.8%
- Room Heat 7.1%
- Water Heat 7.8%
- Other 5.8%
- Dryer 8.6%
- Freezer 4.9%
- Cooking Range 3.1%
Residential Natural Gas Consumption by Segment and End Use

- Single Family: 80.2%
- Multi-Family: 5.5%
- Manufactured: 10.3%
  - LI Single Family: 3.3%
  - LI Multi-Family: 0.2%
  - LI Manufactured: 0.4%

End Uses:
- Central Heat: 63.4%
- Room Heat: 10.7%
- Water Heat: 17.1%
  - Cooking Oven: 2.9%
  - Cooking Range: 2.9%
  - Dryer: 0.2%
  - Other: 2.9%
Commercial Electric Consumption by Segment and End Use

---

**Segment Contribution**
- Education: 6.9%
- Grocery: 5.9%
- Large Health: 4.7%
- Large Office: 7.3%
- Lodging: 6.1%
- Miscellaneous: 19.4%
- Restaurant: 4.3%
- Retail: 16.9%
- Small Health: 4.7%
- Small Office: 16.3%
- Warehouse: 7.4%

**End Use Breakdown**
- Lighting: 30.7%
- Refrigeration: 12.3%
- Ventilation: 10.9%
- Plug Load: 9.8%
- Cooking: 3.2%
- Water Heating: 0.9%
- Heating: 2.8%
- Cooling: 10.7%
- Ext. Lighting: 4.6%
- Other: 14.0%
Commercial Natural Gas Consumption by Segment and End Use

- Education: 6.0%
- Grocery: 3.2%
- Lodging: 4.4%
- Miscellaneous: 22.9%
- Restaurant: 5.5%
- Retail: 14.0%
- Small Health: 3.5%
- Small Office: 35.7%
- Warehouse: 4.8%
- Water Heating: 8.6%
- Heating: 77.4%
- Other: 14.0%
### Residential Sector

<table>
<thead>
<tr>
<th>Type of Bulb</th>
<th>% Sockets - 2009</th>
<th>% Sockets - 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>65.6%</td>
<td>50.0%</td>
</tr>
<tr>
<td>CFL</td>
<td>22.9%</td>
<td>33.0%</td>
</tr>
<tr>
<td>Halogen</td>
<td>3.0%</td>
<td>1.7%</td>
</tr>
<tr>
<td>LED</td>
<td>0.2%</td>
<td>8.4%</td>
</tr>
<tr>
<td>Linear Fluorescent</td>
<td>8.3%</td>
<td>6.4%</td>
</tr>
<tr>
<td>Other</td>
<td>N/A</td>
<td>0.5%</td>
</tr>
</tbody>
</table>
## Commercial Sector

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>% Fluorescent Fixtures - 2009</th>
<th>% Fluorescent Fixtures - 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>T12</td>
<td>42.9%</td>
<td>6.2%</td>
</tr>
<tr>
<td>T8</td>
<td>53.2%</td>
<td>86.4%</td>
</tr>
<tr>
<td>T10</td>
<td>1.4%</td>
<td>0.0%</td>
</tr>
<tr>
<td>T8 Plus</td>
<td>0.7%</td>
<td>0.0%</td>
</tr>
<tr>
<td>T5</td>
<td>0.8%</td>
<td>7.4%</td>
</tr>
<tr>
<td>T5HO</td>
<td>1.0%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>
End Use Study: Residential Willingness to Pay Findings

- Average Likelyhood to Purchase Percent of Incremental Cost Incented
  - Refrigerator (n=84)
  - LED (n=79)
  - CFL (n=69)
  - Furnace (n=67)
  - Central Air (n=26)
  - Insulation (n=73)

- % of Customers 'Extremely Likely' to Purchase EE Option Incremental Cost
  - LEDs
  - CFLs

- Incremental Cost
  - $19
  - $14
  - $10
  - $5
  - $0
  - $1.50
  - $1.00
  - $0.75
  - $0.50
  - $0.00
End Use Study: Commercial Willingness to Pay Findings

Graph showing the average likelihood of purchase against the percent of incremental cost incented for different scenarios:

- **T12 -> T8 (n=6)**
- **T8 -> HP T8 (n=60)**
- **HPS/MH -> T5 (n=12)**
- **CFL/Incandescent -> CFL (n=12)**
- **Occupancy Sensor (n=71)**
End Use Study: Commercial Willingness to Pay Findings

Commercial Lighting

- T12 -> T8 (n=6)
- T8 -> HP T8 (n=60)
- HPS/MH -> T5 (n=12)
- CFL/Incandescent -> CFL (n=12)
- Incandescent/CFL -> LED exit sign (n=9)
- Occupancy Sensor (n=71)
Electric Potential Study
Potential Assessment Analysis

- **Technical potential:**
  - savings available if all baseline equipment stock was replaced with the most efficient measures available

- **Economic potential:**
  - savings available if all baseline equipment stock was replaced with the most efficient measures that are cost effective
  - Economic potential constrained by measures that pass the Total Resource Cost (TRC) with a ratio of 1.0

- **Achievable potential:**
  - portion of economic potential attainable by the utility with consideration for market barriers and customers willingness to participate
## Potential Study Summary Findings

<table>
<thead>
<tr>
<th>Sector</th>
<th>aMW – 20 yr Achievable Potential</th>
<th>Percent of Baseline Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>14.1</td>
<td>4%</td>
</tr>
<tr>
<td>Commercial</td>
<td>38.5</td>
<td>10%</td>
</tr>
<tr>
<td>Industrial</td>
<td>9.1</td>
<td>8%</td>
</tr>
<tr>
<td>All Sectors</td>
<td>61.7</td>
<td>7%</td>
</tr>
</tbody>
</table>
2015 potential study key parameters

- **Avoided Energy Costs**
  - Avoided costs:
  - $40.70/MWh

- **Cost Effectiveness**
  - TRC: 1.0
  - Avoided energy costs include non-energy and environmental benefits

- **Codes and Standards**
  - Naturally occurring savings excluded from quantified potential

- **Increased Resolution**
  - Large population of measure permutations
### 2015 potential study impacts: Changes in lighting market characterization

<table>
<thead>
<tr>
<th>Reduction in commercial lighting end-use consumption of 19%</th>
<th>Reduction in residential lighting end-use consumption of 24%</th>
<th>Commercial T8 saturation increased from 53% to 86% and T5 saturation increased from 0.8% to 7%.</th>
<th>Residential CFL saturation increased from 23% to 33% and LEDs increased from 0.2% to 8%</th>
</tr>
</thead>
</table>

Lighting found to be the end use with the highest potential for savings (~37-52% per sector)
2015 potential study key drivers: residential

- 60W CFL-equivalent energy savings reduced by 69%
  - EISA efficiency requirements
  - Residential lighting hours of use modeled at 2.02 hours
- EISA backstop
  - Study assumes lighting efficiency standard similar to that of a CFL beginning in 2020
- Reduced costs of LEDs
  - Permits several LED technologies to be cost effective
- ENERGY STAR® computers
  - Incremental cost close to $0.00, therefore measure applicability significantly reduced in terms of potential
2015 potential study key drivers: commercial

- Linear lighting baseline changed from T12 to T8.
- Linear lighting saturation in 2015 creates opportunity for potential:
  - ~86% T8 saturation
  - ~8% T5 or T5HO lighting
- Reduced costs of LEDs
  - Permits several LED technologies to be cost effective
- Large population of measure permutations
  - For cost effective measures, increases opportunity for potential
Projected Potential by Sector: 2015 – 2034

- **Industrial**
- **Commercial**
- **Residential**

Potential Models: Overview
Potential Models: Residential Overview

Potential Savings as a Percentage of Sales by Scenario
(annual incremental savings)
Potential Models: Residential Overview

Economic Potential Savings by Segment

Single Family: 75.8%
Multifamily: 6.8%
Manufactured: 12.5%
Low Income Single Family: 3.9%
Low Income Multifamily: 0.4%
Low Income Manufactured: 0.7%
Potential Models: Residential Overview

Economic Potential Savings by End Use

- Interior Lighting: 27.3%
- HVAC Aux: 32.1%
- Clothes: 14.3%
- Exterior Lighting: 9.4%
- Plug Load: 12.4%
- Water Heat: 2.0%
- Central Heat: 2.3%
- Other: 0.2%
Behavioral program cost effectiveness testing

- Key assumptions:
  - 20-year levelized avoided cost of energy: $0.0407/kWh
  - Cost: $15.00/report
  - Upfront programming cost: $0.00
  - Decay rate: 20%
  - Annual forecast consumption: 1.2%
  - Annual customer consumption: 10,994 kWh
    - Average of 75% quartile
  - TRC findings:
    - 0.58
    - Average TRC over 20 years
    - EUL = 1
Potential Models: Commercial Overview

Potential Savings as a Percentage of Sales by Scenario
(annual incremental savings)
Potential Models: Commercial Overview

Economic Potential Savings by Segment

- Grocery: 26.9%
- Restaurant: 8.6%
- Retail: 13.9%
- Large Health: 5.9%
- Small Health: 4.0%
- Lodging: 5.7%
- Miscellaneous: 6.3%
- Large Office: 8.1%
- Education: 7.3%
- Warehouse: 10.2%
- Street Lighting: 0.3%
- Retail: 13.9%
- Large Office: 8.1%
- Education: 7.3%
- Warehouse: 10.2%
- Street Lighting: 0.3%
Economic Potential Savings by End Use

- Refrigeration: 31.7%
- Lighting: 16.4%
- Linear Lighting: 28.5%
- HVAC Aux: 11.6%
- Cooking: 2.9%
- Heat Pump: 1.1%
- Water Heat: 0.3%
- Cooling Chillers: 0.4%
- Exterior Lighting: 0.3%
- Miscellaneous: 2.0%
- Plug Load: 4.7%
- Space Heat: 0.1%
Potential Models: Industrial Overview

Potential Savings as a Percentage of Sales by Scenario (annual incremental savings)
Potential Models: Industrial Overview

Economic Potential Savings by End Use

- Lighting: 51.4%
- HVAC: 23.6%
- Motors Other: 17.1%
- Process Cooling: 2.5%
- Process Specific: 1.1%
- Motors Pumps: 1.1%
- Compressed Air: 0.8%
- Other: 2.4%
## 2009 Achievable Potential versus 2015 Achievable Potential

<table>
<thead>
<tr>
<th>Sector</th>
<th>2009 - 2028</th>
<th>(Percent of Baseline Sales)</th>
<th>2015 - 2034</th>
<th>(Percent of Baseline Sales)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>42.5</td>
<td>12%</td>
<td>14.1</td>
<td>4%</td>
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<tr>
<td>Commercial</td>
<td>33.1</td>
<td>8%</td>
<td>38.5</td>
<td>10%</td>
</tr>
<tr>
<td>Industrial</td>
<td>8.7</td>
<td>12%</td>
<td>9.1</td>
<td>8%</td>
</tr>
<tr>
<td>All Sectors</td>
<td>84.3</td>
<td>10%</td>
<td>61.7</td>
<td>7%</td>
</tr>
</tbody>
</table>
### 2009 vs 2015 potential study key differences: codes & standards

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Modeled 2012 IECC</td>
<td>• Modeled impact of EISA 2020 lighting “backstop” provision</td>
<td>• Minimal incremental costs</td>
</tr>
<tr>
<td>• Previous study modeled 2009 IECC</td>
<td>• EISA standards set higher baseline</td>
<td>• Reduced applicability</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>General Service Fluorescent Lamp Standards</th>
<th>Motor Efficiencies</th>
<th>High Intensity Discharge Lamps</th>
</tr>
</thead>
<tbody>
<tr>
<td>• T8 considered baseline technology</td>
<td>• Modeled 2011 federal efficiency standard</td>
<td>• Pulse start and electronic ballasts considered baseline technology</td>
</tr>
<tr>
<td>• Previous study modeled T12 as baseline technology</td>
<td>• Set premium efficiency motors as baseline</td>
<td></td>
</tr>
</tbody>
</table>
## 2015 Achievable Potential vs NWPPCC 7th Plan Achievable Potential

<table>
<thead>
<tr>
<th>Sector</th>
<th>NWPPC 7th Plan Percentage of Sales @ $40/MWh – Technical Achievable Potential - Estimated</th>
<th>NorthWestern Energy Percentage of Sales @ $40/MWh – Achievable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>13%</td>
<td>4%</td>
</tr>
<tr>
<td>Non-Residential</td>
<td>18%</td>
<td>10%</td>
</tr>
<tr>
<td>Utility Distribution</td>
<td>1%</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15%</strong></td>
<td><strong>7%</strong></td>
</tr>
</tbody>
</table>
Questions?
NorthWestern Energy Potential Study ETAC Presentation Glossary of Terms:

**NWPC – Northwest Power & Conservation Council**
Regional organization that develops and maintains a regional power plan and a fish and wildlife program to balance the Northwest’s environment and energy needs.

**RBSA – Residential Building Stock Assessment**
Comprehensive residential end-use study conducted across the Northwest region by the Northwest Energy Efficiency Alliance.

**CBSA – Residential Building Stock Assessment**
Comprehensive residential end-use study conducted across the Northwest region by the Northwest Energy Efficiency Alliance.

**Lighting Technologies:**
- T12, T10, T8, T5 – Fluorescent tubular lamp; numeric value corresponds to the tube diameter size (per 1/8\(^{th}\) inch).
- HPT8 – T8 lighting system comprised of a long life T8 lamp and low watt electronic ballast that results in reduced energy consumption with the same lumen output as a standard T8 lighting system.
- T5HO – T5 high output lamp, which deliver more lumens than a standard T5 lamp.
- HPS – High pressure sodium lamp, (a type of high-intensity discharge lamp)
- MH – Metal halide lamp, (a type of high-intensity discharge lamp)
- CFL – Compact fluorescent lamp
- LED – Light emitting diode lamp

**IECC – International Energy Conservation Code**
Building code which provides energy performance standards for residential and commercial buildings

**EISA – Energy Independence and Security Act**
Federal act passed in 2007 which addressed US energy policy including energy efficiency standards.

**TRC – Total Resource Cost test**
Cost-effectiveness ratio used to assess the economic viability of measures, programs, or portfolios. This test compares the benefits of the energy efficiency measures to their costs using its own unique perspectives and definitions in terms of net present value of future cash flows.

**EUL – Expected useful life**
The amount of time in years a specific measure is expected to operate.