CERTs 2018 Community Driven Clean Energy Conference

Wednesday, March 28, 2018
2:30 – 3:30 PM

Utility Efficiency Program Ideas Ready for Replication
Utility Efficiency Program Ideas Ready for Replication

Mary Sue Lobenstein
R&D Program Administrator
marysue.Lobenstein@state.mn.us

Mark Garofano
Energy Engineer
mark.garofano@state.mn.us

Conservation Improvement Program (CIP)

Responsibilities
- Regulatory Compliance
- Evaluation, Measurement & Verification
- Technical Assistance
- Conservation Applied Research & Development (CARD)

Benefits
- Conserves Energy Resources
- Reduces Harmful Emissions
- Minimizes Need for New Utility Infrastructure
- Generates Positive Economic Value
PANELISTS

Utility Efficiency Program Ideas Ready for Replication

Greg Marsicek
Energy Engineer
Seventhwave
gmarsicek@seventhwave.org

Joe Plummer
Program Manager
Franklin Energy
jplummer@franklinenergy.com

Ben Schoenbauer
Senior Research Engineer
Center for Energy & Environment
bschoenbauer@mncee.org
## AGENDA & FORMAT

**Utility Efficiency Program Ideas Ready for Replication**

<table>
<thead>
<tr>
<th>AGENDA</th>
<th>SESSION FORMAT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overview</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Presentations</strong></td>
<td><strong>33 minutes</strong></td>
</tr>
<tr>
<td>• Powering down, Powering off: Office Plug Load Strategies</td>
<td>• Each panelist introduced individually</td>
</tr>
<tr>
<td>• Turning Off T12 Lighting for Good</td>
<td>• Each panelist will give a 10 minute presentation</td>
</tr>
<tr>
<td>• Opportunities for New Cold-Climate Air Source Heat Pumps</td>
<td>• Audience uses question/comment cards</td>
</tr>
<tr>
<td><strong>Q&amp;A &amp; Discussion</strong></td>
<td><strong>20 minutes</strong></td>
</tr>
<tr>
<td><strong>Wrap-Up</strong></td>
<td></td>
</tr>
</tbody>
</table>
Powering Down, Powering Off: Office Plug Load Strategies

Application: Commercial Sector
- Office buildings
- Storefront offices

Greg Marsicek
Energy Engineer
Seventhwave
gmarsicek@seventhwave.org
ADVANCING THE LAST FRONTIER:

Reduction of commercial plug loads

Greg Marsicek, Seventhwave

Working with:
Center for Energy and Environment
LHB
PLUG LOAD ENERGY IN A TYPICAL OFFICE
CONTROLLABLE PLUG LOADS

- Over 40% of typical office plug load is controllable
- Workstations make up 53% of controllable load
- Common area is the rest
  - Office equipment 30%
  - Break room 16%

Plug Load EUI ≈ 19 kBtu/sq.ft.
TYPICAL LOADS - TRENDS

Increasing use of laptops saves energy

- **Average Desktop**: 220 kWh
- **Average Laptop**: 120 kWh

Energy consumption (kWh)
BACKGROUND AND METHOD
ENERGY SAVING STRATEGIES

Advanced power strips:
- APS – Occupancy sensor
- APS – Foot pedal

Computer power management
Behavior campaign + APS

Common area equipment: Basic timer

CREDIT: Tricklestar
SAVING ENERGY IN WORKSTATIONS
WORKSTATION SAVINGS

Computer power management saved the most

106 kWh 29.1%

67 kWh 21.7%

42 kWh 19%

70 kWh 22.4%

Other three were all variations on advanced power strips
IMPACT OF BEHAVIOR

City public works

APS savings alone: 49 kWh

... with behavior campaign: 57 kWh

Engineering

APS savings alone: 84 kWh

... with behavior campaign:
PARTICIPANT FEEDBACK

<table>
<thead>
<tr>
<th></th>
<th>Positive Response</th>
<th>Negative Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>APS OC</td>
<td>89%</td>
<td>11%</td>
</tr>
<tr>
<td>APS FP</td>
<td>91%</td>
<td>9%</td>
</tr>
<tr>
<td>CPM</td>
<td>70%</td>
<td>30%</td>
</tr>
</tbody>
</table>
SAVING ENERGY IN COMMON AREAS
COMMON AREA TIMER SAVINGS
CONTEXT, CONCLUSIONS
KEY TAKE-AWAYS

- Though some loads are moving out of the workstation, significant savings remains
- Relatively simple solutions are available to save 30% or more
- Energy efficiency advocates should make an ally in IT
- There’s value in discussing behavior
NEED MORE DETAIL?

Download the study
See a fact sheet and the full report: seventhwave.org/commercial-plug-load-study

Contact me:
GREG MARSICEK
Seventhwave
gmarsicek@seventhwave.org
Turning Off T12 Lighting for Good

Application: Commercial Sector

• Retail
• Small business
• Storefront offices

Joe Plummer
Program Manager
Franklin Energy
jplummer@franklinenergy.com
Turning Off T12 Lighting… For Good!

Presented at CERTs Conference
March 28, 2018

Presented by: Joe Plummer
jplummer@franklinenergy.com
Topics

1. Background
2. Methodology
3. Findings
4. Challenges and Solutions
5. Q/A
• T12s: an outdated, inefficient technology
• Manufacture and import phase-out beginning July 2010
• Utilities heavily promoted T12 change-outs through T8 bonus rebates and T12 bounties
• But… anecdotal evidence that significant quantities of T12s remain
• Research questions
  – What is the total T12 load remaining in Minnesota?
  – What is the energy savings potential?
  – How can utilities target remaining T12s?

This project was supported in part by a grant from the Minnesota Department of Commerce, Division of Energy Resources through the Conservation Applied Research and Development (CARD) program.
Methodology

• Field study – data collected from site visits
• Cluster sample design chosen to minimize travel
• Goal was to estimate MN T12 load at 90/10 confidence
  – Needed sample size of 200 businesses
  – Power analysis used to analyze different clustering options
• Sample Design
  – 10 communities x 20 businesses per community chosen
  – Businesses stratified by size
    • Small: 0-4,999 ft2
    • Medium: 5,000-9,999 ft2
    • Large: 10,000 ft2 and greater
## Methodology

<table>
<thead>
<tr>
<th>Region</th>
<th>Community</th>
<th>Business Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metro</td>
<td>Minneapolis</td>
<td>57,897</td>
</tr>
<tr>
<td></td>
<td>St. Paul</td>
<td>33,742</td>
</tr>
<tr>
<td>Northeast</td>
<td>Duluth</td>
<td>7,204</td>
</tr>
<tr>
<td></td>
<td>Nisswa</td>
<td>311</td>
</tr>
<tr>
<td>Northwest</td>
<td>Alexandria</td>
<td>1,773</td>
</tr>
<tr>
<td></td>
<td>Foley</td>
<td>243</td>
</tr>
<tr>
<td>Southeast</td>
<td>Albert Lea</td>
<td>1,135</td>
</tr>
<tr>
<td></td>
<td>Red Wing</td>
<td>1,082</td>
</tr>
<tr>
<td>Southwest</td>
<td>Morris</td>
<td>501</td>
</tr>
<tr>
<td></td>
<td>Worthington</td>
<td>860</td>
</tr>
</tbody>
</table>
Findings

T12 STATEWIDE LOAD ESTIMATED AT 242 MW
- 10% of Minnesota C/I Lighting Load (2,558 MW)

T12 ENERGY CONSUMPTION ESTIMATED AT 881 GWh/YEAR
- Average Operating Hours = 3,226 (approx. 60 hours/week)
- Equivalent to annual consumption of 77,000 US homes

TECHNICAL SAVINGS POTENTIAL ESTIMATED AT 512 GWh/YEAR
- $51,000,000 per year
- Conservative estimate (lumen equivalence)
Findings

• T12 Average Power Density
  – Small (< 5,000 ft²) buildings have highest T12 power density

<table>
<thead>
<tr>
<th>Size</th>
<th>Average ft²</th>
<th># of Businesses</th>
<th>T12 Load (kW)</th>
<th>T12 Watts/ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>2,500</td>
<td>104,639</td>
<td>74,387</td>
<td>0.284</td>
</tr>
<tr>
<td>Medium</td>
<td>7,500</td>
<td>41,905</td>
<td>36,544</td>
<td>0.116</td>
</tr>
<tr>
<td>Large</td>
<td>32,777</td>
<td>91,875</td>
<td>130,874</td>
<td>0.043</td>
</tr>
</tbody>
</table>
Challenges

Primary barriers to upgrading T12s

1. Lack of awareness/knowledge
2. T12 lamps still available
3. Tenant/landlord split incentives
4. Cost/Return on Investment
   - Labor costs
   - Recycling costs
   - Lower operating hours
   - Small businesses often struggling financially
Solutions

- Community-based small business campaigns
  - Walk-through energy assessments coupled with targeted incentives for T12 upgrades and/or low cost supplier option with instant rebate
  - Customer education on efficiency and utility programs
  - Combine with Direct Install measures to increase cost-effectiveness

- Trade-ally incentive program
  - Small businesses often have trusted relationships with local contractors
  - Leverage local contractors to promote upgrades
  - Requires trusted allies, outreach and education
Thank You
Opportunities for New Cold-Climate Air Source Heat Pumps (ccASHP)

Application: Residential Sector

• Single family homes
• Two- to four- unit residences

Ben Schoenbauer
Senior Research Engineer
Center for Energy & Environment
bschoenbauer@mncee.org
Field Assessment of Cold-Climate Air-Source Heat Pumps

March 2018

Ben Schoenbauer, Senior Research Engineer
Center for Energy and Environment
Cold Climate Air-Source Heat Pump?

• An ASHP uses a refrigerant system involving a compressor, condenser, and evaporator to absorb heat at one place and release it at another.

• New generation systems can operate as low as -13 °F

• ASHPs have the potential to deliver energy and peak saving as well as reduce reliance on delivered fuels.
Opportunity

• Winter of 2013/2014 saw delivered fuel shortages in MN
  • Delivered fuel expensive or unavailable
  • Compensation with electric resistance space heaters

• Market:
  • Delivered fuel are the primary space heating fuel for more than 40% of homes in MN, IA, SD, ND (RECS, 2009)
  • Over 25% of Midwest homes rely on fuels other than natural gas for space heating (RECS, 2009)
  • Over 47% of homes in the US rely on fuels other than natural gas for space heating (RECS, 2009)
ccASHP System Types

Ducted Flex Fuel

Ductless Mini-Split
Study Overview

- Field Study
  - 6 ccASHP in a variety of MN residences
  - Monitor installed field performance of ASHP & backup

- Install was very important
  - Equipment
  - Sizing
  - Operation
  - Integration with back-up systems
System Design: Sizing for Ducted Systems

Typically systems sized for heating are 1-ton larger than the same system that if sized for cooling.

The OAT for the systems to switch to back up:
- 4 ton ~ 3°F
- 3 ton ~ 10°F
- 2 ton ~ 19°F

Percentage of heating load meet by ASHP:
- 4 ton ~ 86%
- 3 ton ~ 77%
- 2 ton ~ 60%

*Targeted a maximum change-over temp of 10°F
Ductless: Install Location
- Without propane:
  - COPs 1.5 to 3.5
- Furnace SS Efficiency
  - 90% +
- Defrost reduces COP to < 0.5
- ASHP lockout at 10 F
System Performance

Annual COP: ductless ~1.9 to 2.1
Flex Fuel ~1.2 to 1.3
### Annual Characteristics and Savings

<table>
<thead>
<tr>
<th>Site</th>
<th>Annual COP</th>
<th>Heating Design Load [Btu/hr]</th>
<th>Site Energy Reduction</th>
<th>Cost Reduction</th>
<th>Propane Reduction</th>
<th>Savings [$/yr]</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_1_ducted</td>
<td>1.3</td>
<td>35,468</td>
<td>37%</td>
<td>28%</td>
<td>56%</td>
<td>$469</td>
</tr>
<tr>
<td>S_2_ducted</td>
<td>1.4</td>
<td>30,046</td>
<td>46%</td>
<td>32%</td>
<td>73%</td>
<td>$497</td>
</tr>
<tr>
<td>S_3_ducted</td>
<td>1.1</td>
<td>24,923</td>
<td>49%</td>
<td>40%</td>
<td>67%</td>
<td>$767</td>
</tr>
<tr>
<td>S_4_ducted</td>
<td>1.3</td>
<td>22,778</td>
<td>40%</td>
<td>30%</td>
<td>60%</td>
<td>$358</td>
</tr>
<tr>
<td>S_6_ductless</td>
<td>2.1</td>
<td>14,200*</td>
<td>52%</td>
<td>52%</td>
<td>NA</td>
<td>$610</td>
</tr>
<tr>
<td>S_8_ductless</td>
<td>2.2</td>
<td>9,400*</td>
<td>54%</td>
<td>54%</td>
<td>NA</td>
<td>$349</td>
</tr>
</tbody>
</table>

* Design loads for ductless systems are estimated and intended as metric to gauge magnitude of heating load.
Summary of Results

- Cold Climate ASHPs:
  - **Energy Reduced**: 37% and 54% of site energy consumption
  - **Cost Reduced**: total heating costs 28% to 54%
  - **Heating Load Served**: on average ducted ccASHP met 84% of the homes heating loads
  - **Propane Reduction**: propane consumption down by 64%
    - Less than 500 gallons per year at each house

- Percentage of heating load for ductless largely dependent on usage & install location
- Provided more efficient space heating
  - Ducted ccASHP COP of 1.4 & ductless COP of 2.3.
  - Compared to a COP 1.0 for ER
Recommendations for Programs

• Installation is very important for ccASHP
  • Integration, sizing, operation, etc

• Training is needed
  • Equipment and install are very similar to past generations and baseline equipment. Need ccASHP specific set up

• Vast majority of MN installs require back-up heating
  • Savings estimates need to account for that

• Equipment, operation and controls can impact savings.
  • Tiered programs may be an option
THANK you!

Ben Schoenbauer: bschoenbauer@mncee.org
Utility Efficiency Program Ideas Ready for Replication

Greg Marsicek  
Energy Engineer  
Seventhwave  
gmarsicek@seventhwave.org

Joe Plummer  
Program Manager  
Franklin Energy  
jplummer@franklinenergy.com

Ben Schoenbauer  
Senior Research Engineer  
Center for Energy & Environment  
bschoenbauer@mncee.org

QUESTIONS & Discussion
Thanks for Participating!

Check out our Website for details on CARD projects

If you have questions or feedback on CARD contact:
Mary Sue Lobenstein
marysue.Lobenstein@state.mn.us
651-539-1872
Operation

- Switchover set point:
  - Primary ccASHP meets load at temps greater than switchover
  - Secondary heating system meets load below switchover
- Primary is priority
  - Runs primary system whenever possible
  - Back up as boost or when primary cannot operate
- Dynamic
  - Considers estimates efficiency and energy costs chooses primary/secondary control based on estimated performance
    - Typically based on operating costs
- Controls:
  - Ducted Systems: automated controls to bring up backup
  - Ductless Systems: manual action by homeowner
- Interaction with back-up systems
  - Ducted Systems: Integrated installs with shared controls
  - Ductless Systems: Separate systems
Furnace Integration – Keep or Replace?

• Issues:
  • Air handler requires a multi-stage fan to achieve the full capability of the ccASHPs
  • Furnace and heat pump require integrated controls

• Proposed Solutions:
  • New condensing furnace with control integration
  • New 80% AFUE with multi-stage fan with control integration
  • Retrofit existing system (future?)
  • Plenum electric resistance heater

• Several manufacturers are working on solutions to pair new ASHPs with existing furnaces
## Site Equipment

<table>
<thead>
<tr>
<th>Site Number</th>
<th>ASHP System</th>
<th>ASHP Size</th>
<th>ASHP Type</th>
<th>Backup</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carrier Infinity with Greenspeed [2SVNA048A003]</td>
<td>4 ton</td>
<td>Ducted</td>
<td>LP Cond. Furnace</td>
</tr>
<tr>
<td>2</td>
<td>Bryant Extreme Heat Pump [280ANV048]</td>
<td>4 ton</td>
<td>Ducted</td>
<td>LP Cond. Furnace</td>
</tr>
<tr>
<td>3</td>
<td>Carrier Infinity with Greenspeed [2SVNA036A003]</td>
<td>3 ton</td>
<td>Ducted</td>
<td>LP 80% Furnace</td>
</tr>
<tr>
<td>4</td>
<td>Trane XV20i [4TWV0036A]</td>
<td>3 ton</td>
<td>Ducted</td>
<td>LP Cond. Furnace</td>
</tr>
<tr>
<td>5</td>
<td>Mitsubishi Ductless Hyper Heat [MUZ-FH18NAH]</td>
<td>1.5 ton</td>
<td>Ductless</td>
<td>Electric Resistance</td>
</tr>
<tr>
<td>6</td>
<td>Mitsubishi Ductless Hyper Heat [MSZ-FH12NA]</td>
<td>1 ton</td>
<td>Ductless</td>
<td>Electric Resistance</td>
</tr>
<tr>
<td>7</td>
<td>Mitsubishi Hyper Heat System [PVA-A30AA7]</td>
<td>3 ton</td>
<td>Ducted</td>
<td>Electric Booster</td>
</tr>
<tr>
<td>8</td>
<td>Mitsubishi Hyper Heat System [PVA-A30AA7]</td>
<td>3 ton</td>
<td>Ducted</td>
<td>Electric Booster</td>
</tr>
</tbody>
</table>

Whole house ducted systems
Install Costs

- For the 4 ducted flex fuel systems:
  - Our average cost was ~$14,000*

- NREL Residential equipment install database:
  - $6,340 for ducted 3ton ccASHP
  - $4,000 for a new condensing propane furnace ($3,000 for an 80%).
  - $5,540 for a new comparable SEER A/C

- If furnace or A/C needs replacement
  - Incremental cost ~$3,000 will results in paybacks around 6 years

- Hard to calculate paybacks for ductless systems.
  - Costs have high variance.
  - Systems are often not direct replacements
### Annual Characteristics and Savings

<table>
<thead>
<tr>
<th>Site</th>
<th>Annual COP</th>
<th>Heating Design Load [Btu/hr]</th>
<th>Site Energy Reduction</th>
<th>Cost Reduction</th>
<th>Propane Reduction</th>
<th>Savings [$/yr]</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_1_ducted</td>
<td>1.3</td>
<td>35,468</td>
<td>37%</td>
<td>28%</td>
<td>56%</td>
<td>$469</td>
</tr>
<tr>
<td>S_2_ducted</td>
<td>1.4</td>
<td>30,046</td>
<td>46%</td>
<td>32%</td>
<td>73%</td>
<td>$497</td>
</tr>
<tr>
<td>S_3_ducted</td>
<td>1.1</td>
<td>24,923</td>
<td>49%</td>
<td>40%</td>
<td>67%</td>
<td>$767</td>
</tr>
<tr>
<td>S_4_ducted</td>
<td>1.3</td>
<td>22,778</td>
<td>40%</td>
<td>30%</td>
<td>60%</td>
<td>$358</td>
</tr>
<tr>
<td>S_6_ductless</td>
<td>2.1</td>
<td>14,200*</td>
<td>52%</td>
<td>52%</td>
<td>NA</td>
<td>$610</td>
</tr>
<tr>
<td>S_8_ductless</td>
<td>2.2</td>
<td>9,400*</td>
<td>54%</td>
<td>54%</td>
<td>NA</td>
<td>$349</td>
</tr>
<tr>
<td>S_10_elec</td>
<td>1.8</td>
<td>15,150</td>
<td>47%</td>
<td>47%</td>
<td>NA</td>
<td>$496</td>
</tr>
<tr>
<td>S_12_elec</td>
<td>1.9</td>
<td>26,446</td>
<td>48%</td>
<td>48%</td>
<td>NA</td>
<td>$833</td>
</tr>
</tbody>
</table>

* Design loads for ductless systems are estimated and intended as metric to gauge magnitude of heating load.
Example: Capacity on a 17 °F day

At 18:45
OAT = 15 F
House load = 15,300 Btu/hr
ASHP Output = 16,700 Btu/hr
ASHP Sup Temp = 89 F
Airflow = 734 CFM
Cold Temperature Performance of ASHPs

- Ducted ASHPs were capable of delivering heat at outdoor temps from 5 to 10°F.
- Ductless systems operated below -13°F.
  - Homeowner in WI has removed several ER baseboards.
Cold Temperature Performance of ASHPs

- Ducted ASHPs were capable of delivering heat at outdoor temps from 5 to 10 F
- Ductless systems operated below -13 F.
  - Homeowner in WI has removed several ER baseboards
Future Needs – Metrics and Programs

- How should ASHPs be evaluated?
  - Site energy
  - Source energy
  - Carbon reductions
  - Efficiency
  - Homeowner cost

- Impacts of improving equipment
- Impacts of the grid

- Stay tuned for future CEE work