Welcome

Conservation Applied Research & Development (CARD) Webinar

May 6, 2021

Heat Pump Clothes Dryer – Minnesota Field and Consumer Research Findings
Webinar Basics

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  - Dial in and enter your access code
  - Enter your audio pin and press #

You will be joined into the webinar on mute.

Participation
Type in a question and hit “send” to ask a question.
• Purpose to help Minnesota utilities achieve 1.5% energy savings goal by:
  • *Identifying new technologies or strategies to maximize energy savings;*
  • *Improving effectiveness of energy conservation programs;*
  • *Documenting CO₂ reductions from energy conservation programs.*

  *Minnesota Statutes §216B.241, Subd. 1e*

• Utility may reach its energy savings goal
  • Directly through its Conservation Improvement Program (CIP)
  • Indirectly through energy codes, appliance standards, behavior, and other market transformation programs
CARD RFP Spending by Sector thru FY2019

RFP Summary

- 10 Funding Cycles
- 472 proposals
- 121 projects funded
- $27.4 million in research
Clothes Dryers in Minnesota

1.6 million single-family homes with clothes dryers

- 10,000 homes
- 1.01 million electric dryers
- 540,000 gas dryers
- 50,000 propane dryers
- 28,000 homes with no dryer

156,000 multifamily units with in-unit clothes dryers

- 151,000 electric dryers
- 5,000 gas dryers

310,000 multifamily units in buildings with central laundry facilities

Source: 2018 Minnesota Energy Efficiency Potential Study
Dryer Types

- **Compact (Unvented)**: 4 - 4.5 ft³
- **Full-size (Vented)**: 7 - 7.5 ft³
Conventional vs Heat Pump Dryer

Conventional Dryer

- Hot, dry air enters back of drum
- Heating coils
- Cool air enters at back
- Warms, moist air exhausted to outdoors
- Lint trap
- Blower

Some ducting omitted for clarity

Heat Pump Dryer

- Hot, dry air enters back of drum
- Warm, moist air exits drum
- Lint trap
- Blower
- Compression and refrigerant lines
- Heat pump condenser coils (hot)
- Moisture condenses out and is collected or drained away
- Heat pump evaporator coils (cold)
- Secondary filter

Some ducting omitted for clarity
The Guts of a Heat Pump Dryer
Heat Pump Dryers in North America

**Compact**
- Miele
- Bosch
- Blomberg
- LG
- Samsung
- Whirlpool
- Beko
- Asko

**Full-Size**
- Whirlpool (hybrid)

All are Ventless
Study Overview – What We Did

- Gave full-size Whirlpool hybrid heat pump clothes dryers to 11 households
  - Collected dryer journals and interviewed participants
  - Monitored before/after dryer energy and laundry weights for a year, split between:
    - Pre-existing dryer
    - Heat pump dryer
- Bench-tested 5 different make/model heat pump dryers
- Modeled indirect effects of dryers on space heating and cooling
  - Single-family homes
  - Multifamily new construction
What did participants know about the dryers?

• What is a heat pump dryer, anyway?

  • Only one participant recruited via social media advertisements had heard of heat pump technology

  • Most would not have considered a heat pump dryer without more information (and expected a price premium of $100 to $200)

  • They would be unlikely to run into one during the shopping process
What did participants say about dryer characteristics?

<table>
<thead>
<tr>
<th>Metric</th>
<th>Conventional dryer average score</th>
<th>Heat pump dryer average score</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of use</td>
<td>3.83</td>
<td>4.33</td>
<td>+0.50</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>2.67</td>
<td>3.00</td>
<td>+0.33</td>
</tr>
<tr>
<td>Features</td>
<td>2.83</td>
<td>4.50</td>
<td>+1.67</td>
</tr>
<tr>
<td>Feel of clothes</td>
<td>3.33</td>
<td>3.50</td>
<td>+0.17</td>
</tr>
<tr>
<td>Gentleness on clothes</td>
<td>3.33</td>
<td>3.67</td>
<td>+0.34</td>
</tr>
<tr>
<td>Time to dry</td>
<td>3.00</td>
<td>2.67</td>
<td>-0.33</td>
</tr>
</tbody>
</table>
What did participants say about the drying times?

- Half of participants did not care about drying time at all
  - Zero loads over 8-week span
- Half cared ... some of the time
  - Range: 14 to 44 percent of loads dried
  - Either needed the items or the dryer
What did participants reveal about their preferences?

7 of 10* kept the heat pump dryer
- Higher end appliance (3)
- Energy savings / reduced costs (3)
- Ventless provides more options (2)
- Better performance (than their pre-existing dryer)

3 kept their pre-existing dryer
- Matched the washer (2)
- Shorter drying times (2)
- Disliked the second lint filter (1)

*excludes the dryer that malfunctioned, which was also returned
Real-World Laundry Habits

• Complicated!
  • Some people did lots of separating and touch-up cycles
  • up to 770 dryer cycles per year
  • up to 430 laundry loads per year

• 2 ways of assessing savings
  • kWh per load
  • kWh per pound removed moisture

Average dryer load

8-10 lbs laundry + 2.5 quarts of water

1 Quart 1 Quart 1 Pint
Electricity Savings for Full-Size Hybrid (Whirlpool)

Dryer percent electricity savings

-33%  -12%  4%  2%  18%  19%  22%  23%  29%  39%  40%

Based on kWh per-load

Average: ~20%

This HP dryer malfunctioned

Based on kWh per pound of removed moisture
(insufficient data for some sites)

(sorted by percent savings)
## For Typical Hybrid Dryer Electricity Savings of 20%

<table>
<thead>
<tr>
<th>Number of people in household</th>
<th>Annual dryer loads*</th>
<th>Annual dryer kWh savings</th>
<th>Annual $ savings**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>110</td>
<td>75</td>
<td>$8</td>
</tr>
<tr>
<td>2</td>
<td>220</td>
<td>150</td>
<td>$17</td>
</tr>
<tr>
<td><strong>Average household</strong>* (2.6)</td>
<td><strong>285</strong></td>
<td><strong>195</strong></td>
<td><strong>$22</strong></td>
</tr>
<tr>
<td>3</td>
<td>330</td>
<td>225</td>
<td>$25</td>
</tr>
<tr>
<td>4</td>
<td>440</td>
<td>300</td>
<td>$33</td>
</tr>
<tr>
<td>5</td>
<td>550</td>
<td>375</td>
<td>$41</td>
</tr>
<tr>
<td>6</td>
<td>655</td>
<td>450</td>
<td>$50</td>
</tr>
</tbody>
</table>

*2.1 loads per person per week
**11 cents per kWh
***for Minnesota single-family and small multifamily
Drying Time Almost Doubled

Minutes per load

Existing conventional dryer

Heat pump dryer

*Load-weighted. Excludes Site 1
Bench Testing – Compact HP dryers about 2X more efficient

- Settings and load composition didn’t seem to matter much...

<table>
<thead>
<tr>
<th>kWh per pound of removed moisture</th>
<th>Field Monitoring</th>
<th>Bench Testing</th>
</tr>
</thead>
</table>

- **Bench-testing loads**
  - (A) 7 lbs
  - (B) 10 lbs
  - (C) 10 lbs
  - (D) 10 lbs
  - (E) 17 lbs
  - Non-repeated load—weight and composition varies
Whirlpool hybrid affected by filter maintenance

**kWh per pound of removed moisture**

![Bar charts comparing Whirlpool hybrid, Blomberg (compact HP), Whirlpool (compact HP), and Miele (compact HP) energy consumption across different load numbers and filter maintenance conditions.](chart.png)

- **Whirlpool (hybrid) - Site 4**
- **Whirlpool (hybrid) - Site 6**
- **Blomberg (compact HP)**
- **Whirlpool (compact HP)**
- **Miele (compact HP)**

An image of a Whirlpool hybrid appliance is also included in the document.
95% of loads dried in a full-size dryer would fit in a compact dryer.

(n=1,027 loads dried in pre-existing or full-size HP dryer by field-study participants)
Indirect Space-Conditioning Effects

• MN Single-family home w/ full-size hybrid HP
  • -13 therms/yr
  • +26 kWh/yr
  $22/yr dryer electricity savings
  $6/yr HVAC savings
  $28/yr total savings

• MN Multifamily unit w/ compact HP-only
  • -15 therms/yr
  • +28 kWh/yr
  $45/yr dryer electricity savings
  $7/yr HVAC savings
  $52/yr total savings
Heat Pump Clothes Dryers for Multifamily New Construction

- Most MF new construction has in-unit laundry
  - 16 of 19 mid-rise projects reviewed for a recent code-related study

- Ventless dryers avoid the cost of installing dryer venting
  - ...but a “listed and labeled” condensing dryer must then be installed per code
  - Currently rare in MN (1 of 16 reviewed projects)

- Conventional condensing ventless is an option, but will have long dry times and no electricity savings

- Incentivizing ventless heat pump dryers could yield significant electricity (and some gas) savings
  - **375 kWh/unit per year** (400 kWh dryer savings, less 25 kWh space-cooling penalty)
  - **15 therms/unit per year** space-heating savings
• MN TRM relies of federal energy rating – Combined Energy Factor (CEF)

• Full-size dryers
  • CEF underestimates actual dryer energy use per lb of moisture by about 30%
  • Also recommend adjusting estimated loads per year to reflect MN households
  • Overall impact on savings would be to increase savings by 60 to 100%

• Compact dryers
  • CEF overestimates performance per lb removed moisture...
  • ...but also relies on an unrealistically small load size (3 lbs)
  • Overall impact of recommended adjustments would be to increase savings by 75-80%
Key take-aways

• HP Clothes dryers do save energy
  - Compacts save more than full-size hybrid

• Co-benefits
  - Gentler drying
  - Dryer location flexibility

• HP dryers are not for everyone
  - Longer drying time
  - More maintenance
  - Energy payback not there for small HHs

• Could be a viable option for multifamily new construction
  - ...avoid cost for dryer vents
  - ...but have to provide the dryers

• MN TRM currently underestimates savings from efficient dryers
Questions?

HP Clothes Dryer Field and Consumer Research Findings

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Send us your questions using the Q&A panel
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Webinar Recording & Final Report available in couple months
Thanks for Participating!

Upcoming CARD Webinars:

• June 8, 2021: MnTAP – Energy Efficiency Opportunities at Minnesota Water Utilities
• TBD: Center for Energy and Environment – Expanded Scope of Boiler Tune-ups

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