Welcome

Conservation Applied Research & Development (CARD) Webinar

October 20, 2020
Demystifying Stand-Alone Dehumidifiers
Webinar Basics

- Attendees in listen-only mode
- Type questions into Q&A box
- Send to “All Panelists”
- Questions addressed at end
- Webinar recorded & archived
- Slide set will also be available

Additional WebEx Controls at Bottom of Your Screen

Q&A on right side of WebEx panel

Send Questions to All Panelists

Type Questions in Q&A Box
• 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
CEE – Discover + Deploy

The most effective solutions for a healthy, low carbon economy
Agenda

• Dehumidification background

• Surveys & Findings

• Fieldwork & Results

• Takeaways & Recommendations
The Language of Humidity

• Absolute Humidity
  • How much moisture is in the air

• Relative Humidity
  • How much moisture relative to maximum moisture capacity

• Psychrometrics – study of air-water vapor mixtures
Seasonal Humidity in Minnesota

Rainforest

Indoor comfort

Antarctica
Humidity Sources – An Example

- Size: ~2000 ft²
- Occupancy: 2 – 4 people
- \( \text{ACH}_{50} = 8 \)
Moisture Removal Systems
How does a VCS dehumidifier work

- Vapor compression device
- Collocated condenser and evaporator
- Humid air passes cool coil
- Vapor condenses
- Cool air heats up across evaporator
- Dry, warm air returns to room

https://www.achooallergy.com/
Dehumidifier Cycle

- Dehumidifier runs at constant power during operation.
- Dehumidifier cycle starts when fan and compressor are on.
- Setpoint met; compressor powers off and fan runs for 3 minutes to purge moisture from coil.
- Fan powers off, unit monitors humidity level to determine next cycle.
Energy Efficiency: EnergySTAR

- EnergySTAR Ratings since 2001
- Specify efficiency (L/kWh) at capacity (Pints/day)

- EnergySTAR 5.0 as of October 2019

<table>
<thead>
<tr>
<th>Max Capacity (Pints/day)</th>
<th>Minimum Energy Factor (L/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;25</td>
<td>1.57</td>
</tr>
<tr>
<td>25.01-50</td>
<td>1.80</td>
</tr>
<tr>
<td>50.01+</td>
<td>3.30</td>
</tr>
</tbody>
</table>

- Old standard “Energy Factor” 80°F / 60% RH
- New standard “Integrated Energy Factor” 65°F / 60% RH
Survey Methods

• Goals:
  • Who, how, and why do Minnesotans dehumidify?
  • What are the characteristics of their dehumidifiers?
  • What are the characteristics of dehumidified spaces?
  • Establish representative use cases for further study

• Methods:
  • Statewide penetration survey (n = 1493)
  • Phone survey (n = 211)
  • Site visits (n = 63)
Dehumidification in MN

- 56% of Minnesota single family homes have a dehumidifier
- 43% in NE up to 59% in SW
- Renters 25% less likely to have unit than homeowners
- 95% operate in basements
  - 86% below grade / 14% walkout
  - 59% of basements are finished or partially finished
  - 70% operate in utility space
- 91% believe unit meets needs
- One person cited energy efficiency as a concern
Dehumidifiers
Energy Efficiency

![Energy Efficiency Chart]

- **Survey, n = 163**
- **Visit, n = 58**
Age

Survey, n = 159
Visit, n = 56

1.3
4.6
7.9
10.12
13.20
21.30
31+
Capacity

![Bar chart showing capacity distribution with Survey and Visit data, indicating frequency by pints/day.]
Why Dehumidify?

- General moisture concern
- Maintain comfort
- Avoid microbial growth
- Eliminate odor
- Protect goods/equipment
- Other
- Maintain building
When do occupants dehumidify?
Drainage

The diagram illustrates the frequency of emptying different types of drainage systems, based on survey data and visits. The data is split into two categories: Survey, with a sample size of 160, and Visit, with a sample size of 58.

- Daily: 50.0% (Survey) and 10.0% (Visit)
- Every few days: 20.0% (Survey) and 10.0% (Visit)
- Weekly: 20.0% (Survey) and 0.0% (Visit)
- Don't know: 10.0% (Survey) and 0.0% (Visit)

The bar chart shows a significant difference in the frequency of emptying between the survey and the visit data, with the survey data indicating a higher frequency overall.
Field Work in MN

- Identify (20) representative sites form site visit work
  - Dehumidifiers: make, age, capacity, efficiency
  - Basements: level of finish and conditioning
  - Buildings: Size, grade, gutters

- Instrument dehumidifiers to remotely monitor operations for one dehumidifier season

- Evaluate performance, efficacy, and costs

- Intervene (if necessary)

- Monitor changes in performance, efficacy, and cost over a second dehumidification season
Instrumentation

• Dehumidifiers
  • Power consumption
  • Temperature and relative humidity at outlet
  • Condensate production

• Ambient conditions
  • Temperature and relative humidity of ambient space
  • Temperature and relative humidity at main thermostat
  • Temperature and relative humidity where necessary

• AC runtime
Condensate Measurements

(a) Scale

(b) Rain gauge – Manual

(c) Rain gauge Auto
Major Interventions

- **Equipment interventions**
  - Installed (13) 30 pint EnergySTAR 4.0 dehumidifiers
  - Installed (4) 55-90 pint High Efficiency dehumidifiers

- **Operational Interventions: Goal to maintain 50% RH across basement space**
  - (3) increase set points
  - (7) decrease set points
  - (4) increase fan speeds
  - (11) conversions from manual to automatic drain
  - (6) units moved locations
- Energy Use

- Large range in annual energy across representative sites

- Averages:
  - 824 kWh pre-intervention
  - 644 kWh post intervention

- 4-7 kWh/day June – September

- <2 kWh April, May, October
Condensate Production

- July/Aug average up to 8 pints/day
- Not correlated with unit size (25 – 75 pint/day units)
- Correlated with outside absolute humidity
- Few homes with high loads, most home with low loads
  - 99% of daily loads less than 31 pints/day
Energy Efficiency

Field Energy Factor (L/kWh)

As found  EnergySTAR 4  High Efficiency

Relative Field Energy Factor (%)

As found  EnergySTAR 4  High Efficiency
Operating Conditions

• 2012 Efficiency ratings: 80°F / 60% RH

• 2019 Efficiency ratings: 65°F / 60% RH

• Basement conditions: 68°F / 48% RH
  • 48% drier than 2012 standard
  • 12% drier than 2019 standard
Performance Ranges

Performance Issues

• Short Cycling
  • Fan Energy
    • Higher proportion of fan energy at end of each cycle
  • Transient operation
    • Higher proportion for dehumidifier to reach steady-state operating conditions
  • Re evaporation
    • Evaporation of moisture off the coil reintroduces condensed moisture back into the space

• Filter and heat exchanger fouling

• Loss off refrigerant & component failure
Cost Effectiveness

• Average annual cost of dehumidification was $115 across 20 representative sites

• EnergySTAR 4 rated units can meet the same load at $62 yielding a 4 year payback

• High Efficiency units at just $46, but high initial cost yield long, 14 year payback
Capital Costs

- Dehumidifiers are similar cost or cheaper than 2018
- No added cost for EnergySTAR 4 or EnergySTAR 5 ratings
- No reason to choose minimum efficiency units
Additional Observations

• Dehumidifiers are substantial plug loads, units in this study are >10% of average MN residential electric load

• Digital controls (RH display) are reliable

• Humidity control can be maintained throughout multi-room basements through open doorways

• Automatic draining units maintain better humidity control than manual drained units

• ACs do not provide consistent basement dehumidification
Dehumidifiers underperform ratings

- Average dehumidifier energy use is 824 kWh/yr, about three times more than anticipated from 2012 performance ratings and two times more than 2019 performance ratings.
  - About 70% to 90% of the increased energy occurs because dehumidifiers operate less efficiently in cool and dry basement conditions.
  - The remaining 10% to 30% of the increased energy use is due to poor partial load performance and unit deterioration.

- Efficiency Ratings don’t consider basement conditions
  - Standard rating units at 80 °F / 60% RH while average basement conditions in study are 68 °F / 50% RH

- Short cycles greatly reduce performance
  - Fan operation at end of operation re-evaporates water off coil
  - Units take ~5+ minutes to reach steady state

- Age
  - Very old units (1970 & 1992) precede efficiency standards
  - Somewhat old units (1999 & 2003) subject to early efficiency standards
Dehumidifiers are effective

- Dehumidification season runs April – October, but surveys, measurements, and outside conditions all suggest 90%+ of moisture is removed between June and September.

- Typical loads are much smaller than commonly assumed from ratings-based calculations; average peak loads range between 5 and 8 pints/day during June – September.

- Units are usually oversized, which enables them to overcome performance challenges to maintain adequate humidity levels.
• Encourage dehumidifier replacement programs or incentives that remove older (especially pre-EnergySTAR 3) units from service
• Prefer smaller (≤ 30 pints/day) capacity units unless loads are consistently greater than 10 pints/day
• Buy an EnergySTAR 5 unit; there are no cost savings by purchasing minimum efficiency units
• Setup units to automatically drain where possible to maintain better humidity control
• Measure relative humidity levels using remote hygrometers
• Relative humidity levels should be set at 50 - 55% and increased or decreased based on specific needs
EnergySTAR 5

• Temporary confusion in the retail space

• EnergySTAR 4 units still available

• Some marketing that recognizes both old and new capacity ratings

• Ambiguity about capacity and performance

• https://www.energystar.gov/
THANK you!

Josh Quinnell
jquinnell@mncee.org
612.244.2437
Questions?

Demystifying Stand-Alone Dehumidifiers

Josh Quinell, Ph.D.  
jquinnell@mncee.org

Mary Sue Lobenstein  
marysue.Lobenstein@state.mn.us

Laura Silver  
laura.silver@state.mn.us

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Webinar Recording & Final Report available in couple months

R&D Web Page (https://mn.gov/commerce/industries/energy/utilities/cip/applied-research-development/)
Thanks for Participating!

Upcoming CARD Webinars:

• **November 10** - Market Potential for Saving Energy and CO2 with Load Shifting Measures (Slipstream)
• **December 4 (New Date)** – Reconsidering MN Cooling Loads (Center for Energy and Environment)
• **December 16** – Codes and Standards Roadmap (2050 Partners)

Commerce Division of Energy Resources e-mail list sign-up

If you have questions or feedback on the CARD program contact:
Mary Sue Lobenstein
R&D Program Administrator
marysue.Lobenstein@state.mn.us
651-539-1872
Short Cycling Consequences

- Outlet temperature
- Ambient humidity level
- Moisture re-evaporated
- Outlet humidity level
- Moisture removed
- Short cycles