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NOTE: Today’s presentation is being recorded and will be available at http://e3tnw.org/Webinars within 48 hours
High Performance Residential Buildings

Firmware Upgrade for Ductless Heat Pumps

*Charlie Stephens – NEEA*

Reduce “Smart” Appliance Standby Loads

*Iain Walker – Lawrence Berkeley National Labs*

High-efficiency Set-top Boxes

*Gregg Hardy*

3-Function Heat Pump: Hot Water, Radiant Floors, Cooling

*Andrew Gordon – WSU Energy Program*
Firmware Upgrades for DHPs

A work in progress……..

Charlie Stephens
Northwest Energy Efficiency Alliance

June 12, 2014
Some DHP systems don’t cycle well in low-load conditions

This is a function of four interacting factors:

• Building design load, relative to the sizing of the individual system
• Outdoor temperature
• Minimum capacity of the system, or turndown ratio
• The firmware that manages the system
Every system is different

Even from the same manufacturer. Fujitsu:

<table>
<thead>
<tr>
<th>Model</th>
<th>Nominal Cooling</th>
<th>Nominal Heating</th>
<th>Cooling Range</th>
<th>Heating Range</th>
<th>Nominal Turndown Ratio</th>
<th>Maximum Turndown Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOU9RLS</td>
<td>9,000</td>
<td>12,000</td>
<td>3,600 - 12,000</td>
<td>3,000 - 22,000</td>
<td>4:1</td>
<td>7:1</td>
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<tr>
<td>AOU12RLS</td>
<td>12,000</td>
<td>16,000</td>
<td>3,800 - 14,500</td>
<td>3,100 - 24,000</td>
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<td>8:1</td>
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<tr>
<td>AOU15RLS</td>
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<td>18,000</td>
<td>3,800 - 16,000</td>
<td>3,100 - 21,000</td>
<td>6:1</td>
<td>7:1</td>
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<tr>
<td>AOU24RLX</td>
<td>24,200</td>
<td>27,600</td>
<td>9,900 - 27,300</td>
<td>7,500 - 36,200</td>
<td>Less than 4:1</td>
<td>5:1</td>
</tr>
<tr>
<td>AOU30RLX</td>
<td>30,600</td>
<td>32,000</td>
<td>9,900 - 32,400</td>
<td>7,500 - 37,500</td>
<td>A bit better than 4:1</td>
<td>5:1</td>
</tr>
</tbody>
</table>
Manufacturer Rating Points versus Rated Capacity Ranges

Note the vastly different minimum and maximum capacities

Comparison of Nominal 1-ton DHP Models

Manufacturer's Stated Heating Capacity at 47 deg F (Btu/hr)

"Rated" Capacity

E3T Energy Efficiency Emerging Technologies
Manufacturer Rating Points versus Rated Capacity Ranges

Again, note the vastly different minimum and maximum capacities

Comparison of Nominal 2-ton DHP Models

- "Rated" Capacity
Corvallis – Fujitsu AOU9RLS

Maximum power is 770W

Cycling here to about 460W

Average power is about 280W

Note that cycling worsens when outdoor temp rises above about 43F
Kennewick – Fujitsu AOU9RLS – Ducted

Maximum power is 650W

Cycling here to about 430W, every 19 minutes

Average power is about 390W

Note that after the firmware change, cycling goes to 1 to 3 hours, at 130W
Bainbridge Island – Mitsubishi MUZ12FE

Maximum power is 1,340W

Cycling here to about 1,000W

Average power is about 650W

Note that cycling worsens when outdoor temp rises above about 43F. Above 50F, the system starts to sample” return air periodically. When OAT rises to setpoint, it shuts off.
1. Fujitsu has agreed to install its new firmware in all of its new products later this year.

2. Mitsubishi is working on new firmware, to be ready for us to test, before September.

3. NEEA getting ready to monitor at least 2 systems from each of the other manufacturers in our market (quite a few).

4. Negotiating for retrofitting existing systems.
Other factors are important, too.

• Standard contractor load calculation tools are crude and don’t provide room-by-room loads
• Serious system oversizing is likely to be common
• One outdoor unit or several? Contractors go for the money, which exacerbates low-load behavior
• Ductless or ducted? The choice determines loads
• Controls. Wall controllers have issues, too, and often aren’t programmed correctly.
Reducing Appliance Standby Loads

Iain Walker
Lawrence Berkeley National Laboratory
June 12, 2014
What is standby?

- All the electronics in a home that still draw power when not in use
- A long list that is getting longer
- Includes power used when electronics are “off”
- Should we include things that are always “on” but not always in use – router, modem, set-top-box?
Newer(ish) Appliances

Source: Calwell et al. (2011)

Much lower since 2013

Better in these modes

Note: measurements taken without network connectivity except set-top boxes
What household devices?

TVs
Monitors
Computers
Battery Chargers
Doorbells
Set-top-boxes
A/V equipment
Clocks
Radios
Lighting
Home security
Modems
Routers
Furnaces
Air Conditioners
CO Alarm

Cordless phones
Cordless tool charger
Cellphone Charger
Laptop Charger
Printer
FAX machine
External power supplies
Water heaters
DVRs
Xbox
PlayStation
Wii
Portable Stereo
Smoke Alarm

Media hub
(AppleTV, Roku, etc.)
iPad (or equivalent)
Garage Door Openers
Ovens
Microwaves
GFI outlets
Sprinkler Controls
Electric Toothbrush
Coffee Maker
Baby Alarm
Portable Heater

Photos from Alan Meier’s House
Increasing Awareness

Smart Meters Make Leaking Electricity More Visible

Why is my house using 300 W while everybody is sleeping?!!?

Courtesy of Alan Meier
How much power and energy?

About 100 W per home or 900 kWh/yr – in roughly 4m pacific northwest homes this is total of 3600 GWh/yr

More devices being added BUT new devices have much lower standby

NET effect uncertain
Low standby devices can save 75% or more of standby energy.
600-700 kWh/yr for each home or 2700 GWh/yr potential in all PACNW homes.
Ease of Adoption

- Combination of voluntary agreements: EPA (Energy Star, Set-top-boxes) & Regulations
- Most devices now limited to 1 W or less, (was 2-10W, or more) & incorporate auto-shutdown
- Low standby power options exist in almost all product categories
- Need to be vigilant about newer devices not yet covered by EnergyStar or regulation
- Add non-covered devices: HVAC?
- What about the future: networked devices?
• Much new equipment is low standby already – so there is no cost increment for many devices
• Could be worth an incentive to replace older devices?
• Invest in industry collaboration rather than end-use incentives?
• For legacy equipment: smart power strips: $25
Questions/Comments?

Iain Walker
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Alan Meier
akmeier@lbl.gov
Set-top Boxes (STB)

No simple program opportunities, but significant systems savings nearby

Gregg Hardy
June 12th, 2014
Early retirement is not economic

- The best case is a basic satellite box
  - Cost to service provider is about $60 or $10/year given 6 year expected life (DOE NODA)
  - Difference between baseline stock and ENERGY STAR (ES) 4.1 or Voluntary Agreement (VA) allowance levels is about 60 kWh or about $6/year given average PNW rates (DOE NODA, Echostar)

It’s difficult to influence new STB purchases

- Industry has already committed per STB VA to purchase 90% ES 3.0 set-top boxes, and current ES 3.0 qualified boxes are close to ES 4.1 efficiency levels.
- ENERGY STAR partners must purchase 50% ES STBs.
- Major service providers purchase nationally.
- Service providers are rapidly deploying thin clients.
Industry is Making Progress on Pay-TV STB EE

Notes:
ECOVA 2012 – G. Hardy presentation - 2012 ACEEE Summer Study on Energy Efficiency in Buildings
Source: Adapted from Gary Langille - Echostar
Mobile efficiency could lead to STB breakthroughs

- With mobile technology Aggios reduced IPTV STB power from 20W all day to 4W on and 1W sleep with quick wake
- Standards interfaces for software and tools will reduce $R&D

Source: Aggios

- power/energy controlled by CLIOS
Can utilities influence consumer choice?

• Consumers have no choice of STB once they sign-up for a Pay-TV package.

But …

• Consumers can choose a more efficient service provider and content viewing options if they have the right information
  – There is little information available; we do know that IPTV (Telco) STBs and fiber to the home typically use less energy than the alternatives.
  – Consumers can choose to use less energy intensive or fewer STBs
    • Network DVR vs. in-home DVR (savings expected but not quantified)
    • Stream missed pay-TV shows using laptop vs. in-home DVR
    • Over the Top (OTT) video streaming with an AppleTV, iPad, smart TV or laptop. Be wary of using your game console for video streaming.

• Consumers can watch less video content on smart phones during peak cellular service hours
Some networks use more power than others

- For 10 Mbps service
  - **Cable**: about **8W** all day, dominated by modem
  - **Cellular**: about **20W** all day, mostly cell tower
- For 100 Mbps service
  - **Cable**: about **15W** all day, access network becomes an important factor
  - **Optical Network**: **7W** all day, mostly modem

Source: CEET
Global Study by Greentouch Consortium Reveals How Communications Networks Could Reduce Energy Consumption by 90 Percent by 2020
CEET and GreenTouch are making progress analyzing and reducing internet energy consumption.
Needed Action

• Encourage ENERGY STAR and/or others to develop a service provider rating system and consumer information about the most efficient ways to stream media
  – I have engaged with EPA in preparation for June 26th meeting in DC on systems energy efficiency

• Monitor development of breakthrough mobile efficiency and internet communications technologies
Thank You!

Gregg Hardy
hardygregg@gmail.com
503.975.3641c
## VA Tier 2 Energy Goals Comparison (Typical STBs):

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Cable</td>
<td>US: AVP, HD, CC, D2</td>
<td>132</td>
<td>95</td>
<td>145</td>
<td>95</td>
<td>132</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>EU: AVP, HD, RTP, D2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Sat</td>
<td>US: AVP, HD</td>
<td>107</td>
<td>65</td>
<td>145</td>
<td>65</td>
<td>107</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>EU: AVP, HD, RTP</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic IP</td>
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<td>87</td>
<td>65</td>
<td>140</td>
<td>60</td>
<td>87</td>
<td>60</td>
</tr>
<tr>
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<td>EU: AVP, HD, RTP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WH DVR Cable (6 channels)</td>
<td>US: AVP, HD, CC, D2, M5, DVR, MR</td>
<td>233</td>
<td>212</td>
<td>303</td>
<td>227</td>
<td>233</td>
<td>213</td>
</tr>
<tr>
<td>(MoCA)</td>
<td>EU: AVP, HD, RTP, D2, MD, RFx5, HNI, DVR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>WH DVR Sat (6 channels)</td>
<td>US: AVP, HD, CC, D2, M5, DVR, MR</td>
<td>208</td>
<td>182</td>
<td>303</td>
<td>197</td>
<td>208</td>
<td>183</td>
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<tr>
<td>(MoCA)</td>
<td>EU: AVP, HD, RTP, MD, RFx5, HNI, DVR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WH DVR IP (6 channels)</td>
<td>US: AVP, HD, CC, D2, M5, DVR, MR</td>
<td>180</td>
<td>172</td>
<td>198</td>
<td>117</td>
<td>180</td>
<td>148</td>
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<tr>
<td>(HPNA)</td>
<td>EU: AVP, HD, RTP, MD, HNI, DVR</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Thin Client</td>
<td>US: AVP, HD, HNI</td>
<td>82</td>
<td>47</td>
<td>80</td>
<td>47</td>
<td>82</td>
<td>54</td>
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<tr>
<td>(MoCA)</td>
<td>EU: AVP, HD, HNI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
- EU VA allows 20/channel (T1) and 15/channel (T2) per additional RF channels.
- EU VA allows 38 (T1) and 25 (T2) for multi-decode to support PIP capability present on most WH DVRs.
- EU VA effective date is the date a new model STB is “placed into the market” by the manufacturer. A STB placed into the market before the effective date may continue to be sold by the service provider but the service provider must report progress against the goal of >80% compliance.
- The ES (50% of service provider purchases) and USVA (90% of service provider purchases) effective dates apply to STB purchases.

Source: Gary Langille - Echostar
US STB VA Reporting

CableLabs

COMCAST STB ENERGY INFORMATION

This site provides information about the energy efficiency of STB models that have been purchased by Comcast since January 1, 2014. This site will be updated as Comcast adds new devices to its inventory. Note that STBs deployed by cable operators are specific to such cable operator’s particular network, system configuration, headend, and software; contact your local cable operator to determine the STBs available for service in your location. The power measurements herein represent the STBs generally configured as they are deployed in the cable operators’ networks, running the operators’ software, and measured in accordance with the test procedures as specified in the Voluntary Agreement.

<table>
<thead>
<tr>
<th>MAKE</th>
<th>MODEL</th>
<th>TYPE</th>
<th>FEATURES</th>
<th>ON POWER (W)</th>
<th>SLEEP POWER (W)</th>
<th>APD POWER (W)</th>
<th>TEC (KWh/Yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco</td>
<td>RNG-200N</td>
<td>Cable</td>
<td>AVP, CC, DVR, HD, MS, MS</td>
<td>25.7</td>
<td>19.9</td>
<td>-</td>
<td>202</td>
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<td>Cisco</td>
<td>RNG-150N</td>
<td>Cable</td>
<td>AVP, CC, HD, HNI</td>
<td>14.4</td>
<td>12.8</td>
<td>-</td>
<td>121</td>
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<td>Samsung</td>
<td>SRNG150B/NM</td>
<td>Cable</td>
<td>AVP, CC, D2, HD, HNI</td>
<td>15.1</td>
<td>13.9</td>
<td>-</td>
<td>129</td>
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<tr>
<td>Samsung</td>
<td>SRNG150BNC</td>
<td>Cable</td>
<td>AVP, CC, D2, HD, HNI</td>
<td>15.6</td>
<td>14.9</td>
<td>-</td>
<td>129</td>
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<td>Pace</td>
<td>RNG-150N</td>
<td>Cable</td>
<td>AVP, CC, D2, HD, HNI</td>
<td>13.3</td>
<td>12.6</td>
<td>-</td>
<td>114</td>
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<tr>
<td>Aris</td>
<td>M0001L001</td>
<td>Cable</td>
<td>AVP, CC, DVR, D9, HD, MS, MS, XCD</td>
<td>25.2</td>
<td>20.8</td>
<td>-</td>
<td>212</td>
</tr>
</tbody>
</table>
Daikin Altherma

Air to Water Heat Pump System

- Hydronic Heating
- Hydronic Cooling
- Domestic Hot Water
- Solar Hot Water Option
Altherma Performance

- Operates without Electric Strip heat at Low Ambient Temperatures (-4F)
- Operates at COPs estimated between 2.7 – 3.1 in NW Coastal region.
- COPs between 2.1 – 2.4 East of the Mountains
  - Estimates from Daikin’s Altherma Simulator software
- Provides same annual COP, less standby losses, for Domestic Hot water
- Can provide heat through radiant floor system, radiators or through an air handler
Savings Estimate

- Manufacturer claims installed costs of $10,000, and equipment is available online for ~$11,000.
- Realistic installed system costs currently appear to be in the region of $18,000 (one Olympia installation) – $14,000 for equipment, $4000 for labor
- Installations in Snohomish back in 2010 were over $22,000 for a single family home.
## Savings Estimate

<table>
<thead>
<tr>
<th>City</th>
<th>COP</th>
<th>Annual Savings</th>
<th>Simple Payback</th>
<th>C/B ratio</th>
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</thead>
<tbody>
<tr>
<td>Olympia</td>
<td>2.8</td>
<td>$1,230</td>
<td>12.2</td>
<td>1.23</td>
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<tr>
<td>Seattle</td>
<td>3.1</td>
<td>$1,211</td>
<td>12.4</td>
<td>1.21</td>
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<tr>
<td>Medford</td>
<td>2.7</td>
<td>$1,068</td>
<td>14.0</td>
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<tr>
<td>Portland</td>
<td>2.9</td>
<td>$1,048</td>
<td>14.3</td>
<td>1.05</td>
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<td>Spokane</td>
<td>2.4</td>
<td>$1,335</td>
<td>11.2</td>
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<tr>
<td>Boise</td>
<td>2.4</td>
<td>$1,156</td>
<td>13.0</td>
<td>1.16</td>
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<tr>
<td>Kalispell</td>
<td>2.1</td>
<td>$1,418</td>
<td>10.6</td>
<td>1.42</td>
</tr>
</tbody>
</table>

Assumes $15,000 incremental installed cost, 2% discount rate Compared to all-electric baseline.
Potential Benefits and Pitfalls

• Benefit - Generates delivered system temperatures of 120° or higher, comparable to furnace delivery temperatures – cold blow not an issue

• Benefit – COPs are competitive with GSHP technology, without the need (and cost) for extensive well system

• Pitfall – installer inexperience with technology may drive up installation costs
Ken Eklund
Washington State University Energy Program
Research Supported by Bonneville Power Administration
Partners include: Sanden, Northwest Energy Efficiency Alliance, Energy Trust of Oregon, Avista, Ravalli Electric and Tacoma Power

Sanden Split System Water Heater
Lab Summary

Performance vs. Outside Temperature

\[ y = 0.033x + 1.196 \]

<table>
<thead>
<tr>
<th>Climate</th>
<th>Annual EF</th>
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</tr>
<tr>
<td>Portland</td>
<td>3.0</td>
</tr>
<tr>
<td>Seattle</td>
<td>2.9</td>
</tr>
<tr>
<td>Spokane</td>
<td>2.8</td>
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</table>

<table>
<thead>
<tr>
<th>Climate</th>
<th>Annual EF</th>
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<tr>
<td>Minneapolis</td>
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<td>Raleigh</td>
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<tr>
<td>Boston</td>
<td>2.9</td>
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<td>Chicago</td>
<td>2.9</td>
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<tr>
<td>Houston</td>
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Field Research

<table>
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<th>Site Location</th>
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<th>Climate Area</th>
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<tr>
<td>Portland, OR</td>
<td>4,461</td>
<td>Western Oregon</td>
</tr>
<tr>
<td>Tacoma, WA</td>
<td>4,696</td>
<td>Puget Sound</td>
</tr>
<tr>
<td>Addy, WA</td>
<td>6,842</td>
<td>Inland Washington</td>
</tr>
<tr>
<td>Above Corvallis, MT</td>
<td>8,156</td>
<td>Mountain Region</td>
</tr>
</tbody>
</table>

- Each site has at least 4 occupants.
- At least 3 years of electric hot water use.
- Represents a climate within the Pacific Northwest.
Field Energy Factor

• Is the Energy Contained in Total Useful Hot Water / Total Energy In
• Contains all the invested energy including compressor and freeze protection
• Also includes the energy losses from the tank and the piping
• Plus variables such as the ground water temperature—which vary significantly
Field Energy Factor & Outside Air Temp.

Weekly Field Energy Factor (including Freeze Protection) and Temperature

Performance vs. Outside Temperature

$y = 0.033x + 1.196$

E3T Energy Efficiency Emerging Technologies
Savings & Advantages

• Savings over electric resistance = 2,000 kWh/yr. for water heating; for water and space = 11,000 kWh/yr.
• Savings over standard HPWH = 1,200 kWh/yr.
• Non energy benefit = 1 Global Warming Potential unit vs 2,000 for HFC + Demand Response value
• Life Cycle Cost/Benefit at $3,000 incremental, 2% discount over electricity increase, and 15 year life = 1.00 if used solely as water heater and 5.6 if used as space and water heater.
Contacts

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Next Webinar

Reverse Cycle Chillers

• Presented by Seattle City Light

Wednesday, June 18

Information and registration at www.e3tnw.org/webinars

More information about emerging technologies:

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E3T Program: www.bpa.gov/energy/n/emerging_technology/
Conduit: www.ConduitNW.org
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• Click on the hand icon when you want to ask a question
• Please use question pane to ask questions during Q & A or if you have any technical issues
Criteria

• How significant and reliable are the energy savings per unit?
• How great are the non-energy advantages for the end user for adopting this technology?
• How ready are the products(s) and providers to scale up for widespread use in the Pacific Northwest?
• How easy is it for the end user to change to the proposed technology?
• Considering all costs and all benefits, how good of a buy is this technology for the owner?