Central Heat Pump
Water Heating
Q2 2020

BDC Presents Series
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Agenda

• Heat Pump Water Heating
• Technology Innovation Roadmap
• Advanced Water Heating Initiative (AWHI)
• Heat Pump Water Heating Tool Development
• Prescriptive Heat Pump Water Heater Design California T24 Approved
• Packaged Plug and Play Water Heater Skids
• On the Horizon
Heat Pump
Water Heating
Background
Multi-Family DHW Energy End Use %

- DHW Temp Maintenance: 10%
- DHW Heating: 15%
- Common Heating: 13%
- Unit Heating: 12%
- Unit Plugs and Lights: 25%
- Common Plugs and Lights: 25%
GWP limits of 700 will be required in 3-5 years. Manufacturer’s are already working on this transformation.

CO2, Propane, R-1234yf and R-32 are the leading refrigerants replacements.
Single Pass
Heats up water to working temp in single pass

Multi-Pass
Heats up water to working temp in multiple pass
Loop or Swing Tank with Single Pass

- **DHW** (120°F)
- **HWC** (110°F)
- **Primary** (170°F)
- **Temp. Swing** (165-125°F)
- **HP**
- **CW**
Swing Tank with Single Pass

- Low overnight hot water use
- High (enough) overnight hot water use
- Swing temperature drops
- Helps keep temperature up
2 Loads in any Central HPWH system

• **Primary Heating:**
  • Heating water for use
  • Making cold water hot
  • 16-22 gal DHW/pp/day

• **Temperature Maintenance:**
  • Reheating water due to energy losses in the distribution system
  • Keeping hot pipe hot.
  • 40-120 W/Apt.
Heat Pumps are Standard Practice in New Construction and Retrofit

Deliver COP of 3.0 for HPWH

Use Low-GWP Refrigerants (GWP<10)

Plug-and-Play

Cost Effective

Reliable and Redundant systems

Ability to Load Shift
Advanced Water Heating Initiative (AWHI)
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Current Advanced Water Heating Initiative Members:
1. Association for Energy Affordability
2. BC Hydro
3. Beyond Efficiency
4. Bonneville Power Administration (BPA)
5. Bradford White Water Heaters
6. Building Decarbonization Coalition
7. California Energy Commission (CEC)
8. Carbon Free Silicon Valley
9. California Public Utilities Commission (CPUC)
10. East Bay Community Energy
11. Ecotopia
12. Efficiency First CA
13. Energy Solutions
14. Electric Power Research Institute (EPRI)
15. GE Appliances
16. Grasten Associates
17. Guttmann & Blaavand’s
18. HTF Comfort Solutions LLC
19. HWR
20. Lairs Heating Systems
21. Larson Energy Research
22. Los Angeles Dept. of Water & Power (LADWP)
23. New Buildings Institute (NBI)
24. Northwest Energy Efficiency Alliance (NEEA)
25. National Renewable Energy Lab (NREL)
26. National Resources Defense Council (NRDC)
27. Nyle
28. Pacific Gas & Electric (PG&E)
29. People’s Self Help Housing Corp
30. Redwood Energy
31. Repor Plumbing
32. Rheem
33. Sacramento Municipal Utility District (SMUD)
34. Sanden
35. Silicon Valley Clean Energy
36. Southern California Edison (SCE)
37. StopWaste
38. Skycentrics
39. Turnbull Energy

AWHI’S Market Transformation Approach

The collaborators on the Advanced Water Heating Initiative range from manufacturers, to efficiency advocates to utilities and others interested in increasing the market share for these products. They are working to build better awareness among consumers and understanding of the product value. In addition, AWHI is helping installers and builders understand the opportunities for specifying HPWHs and is supporting the supply chain to break down the barriers preventing HPWHs from market adoption.

Specific objectives of the AWHI include:
• Provide alignment in the design, marketing and messaging efforts for a coordinated effort surrounding HPWHs which will assure the manufacturing industry to invest more in this technology.
• Support utilities with efficiency program offerings. Programs will provide strategic utility investments in heat pump water heating market chain development and program incentives in order to catalyze overall market transformation.
• Bring all the key stakeholders i.e. policy makers, program administrators, utilities, manufacturers, installers, industry experts, etc. together to share their experience and learn from each other in order to move the market in the same direction.

To achieve these ends, the AWHI consortium has established four working groups that are focused on market deployment of 120V unitary HPWHs, 240V unitary HPWHs, Central HPWHs, and connectivity and controls of all units.

The initiative and the working groups rely on the support and contributions from our members. How can heat pump water heaters support your service territory, project, or jurisdiction? Join the initiative, participate in a working group, or support the initiative directly to help us shape the future of the heat pump water heater market.

Join us! To learn more, or to join the Advanced Water Heating Initiative or a working group, contact Amruta Khandolkar, NBI project manager, at amruta@newbuildings.org. Sign up to get the latest news by email.
The shorter term tactical goals are:

- Use Technology Innovation Model to support development of new products, support incorporation of existing products in the market, and push industry to fully integrated plug-and-play solutions – away from custom engineering to support rapid wide-scale adoption.
- Expand communication between all parties working in this field and improve coordination, standardization of language and metrics, and coordinated funding for priorities.
- Expand CBECC-RES simulation tool to allow for additional available HPWH technologies (Colmac and Nyle single-pass are next)
- Expand CBECC-RES tool to allow for multi-pass configurations and equipment
- Use existing high GWP refrigerant equipment as bridge while low GWP equipment is developed and brought into the market.
- Use PG&E test lab to test impact of wide range of installation variables – especially associated with handling of hot water recirculation and controls settings
- Create open source free sizing tool for HPWHs with support for designing for load shifting
- Advocate for expanded research on temperature maintenance system losses and load shapes for range of commercial applications.
Technical Information is Critical to Adoption Pathways

System Metrics
Predictable and Specific Outcomes

Policy

Utility Programs

Market Adoption
### Technology Innovation Model (TIM)

#### Feasibility Study
- Outreach
- Development Assistance
- Market Criteria

#### Application Testing
- System Specifications
- Performance Parameters
- Performance Testing

#### Demonstration
- Temperature Maintenance Module
- Load Shift Module
- Temperature Maintenance Best Practice

#### M&V
- Sizing Tool
- Research / Data Analysis
- Application Guidelines

#### System Metrics
- Component Descriptions
- Performance Map

#### Supporting Research
- Tool Development
- Research / Data Analysis

#### Manufacturer Engagement
- Outreach
- Development Assistance

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**Technology Innovation Model (TIM)**

- **Feasibility Study**
  - Outreach
  - Development Assistance
  - Market Criteria

- **Application Testing**
  - System Specifications
  - Performance Parameters
  - Performance Testing

- **Demonstration**
  - Temperature Maintenance Module
  - Load Shift Module
  - Temperature Maintenance Best Practice

- **M&V**
  - Sizing Tool
  - Research / Data Analysis
  - Application Guidelines

- **System Metrics**
  - Component Descriptions
  - Performance Map
Current Heat Pump Options for Central Hot Water Heating

- Ganged up 134a Integrated Res. Units (Rheem, AO Smith, etc.)
- Sanden CO2 Ganged Up Prescriptive Design
- Colmac 134a Single Pass Central HPWH and Controls
- Nyle 134a Single Pass Central HPWH and Controls
- Multi-Pass 410a Products (Colmac, Nyle, Aermec)
- Mitsubishi CO2 in pilot testing phase of the TIM
HPWH Tool Development
Central HPWH Sizing Tool - “HPWHuLater”

Expected September, 2020

Select the Demand Type
- Market Rate with Low Flow Fixtures (20 GPD per person)
- Or Input GPD per Person
  - 22, Range: 18 - 46 GPD Per Person

Are the Apartments Individually Metered?
- Yes

Choose Input Method:
- Number of People and Number of Apartments

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<th>Unit</th>
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<th>Number of People</th>
<th>Number of Apartments</th>
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Enter Design Temperatures
- 150 °F Primary Storage Temperature
- 50 °F Minimum Cold Water Supply Temperature
- 120 °F Hot Water Supply Temperature to Occupants
- 24 °F Design Air Temperature (Coldest Air Temperature Expected for the Sanden to Experience)

Primary Storage Size
- Minimum Storage: 688 Gal
- Storage Tank Size: 209 Gal
- Number of Storage Tanks: 3
- Total Storage: 750 Gal
- Look up by primary storage volume [Gal):

Primary Heating Size
- Heating Capacity: 6.1 Tons
- Number of Sandens: 6

Temperature Maintenance
- Storage Volume: 412 Gal
- Heating Capacity: 1.7 Tons or 5.9 kW
Figure 2: The duck curve shows steep ramping needs and overgeneration risk.

Net load - March 31

- Overgeneration risk
- Ramp need: ~13,000 MW in three hours

New Max. Gen. = 21,740 MW
Min. Gen. = 15 GW
Load Shift Sizing and Modeling

Forecast 2021 WeekDAY Monthly Net Load Distribution

Load Shift Sizing and Modeling

Multifamily Heat Pump
100 Person Skid - 16 Hour Runtime

Multifamily Heat Pump
100 Person Skid - 8 Hour Runtime

16 Hour Runtime - Cumulative Hot Water in Storage

8 Hour Cumulative Hot Water in Storage

- Heating Rate From 16 Hours
- Heating Rate From 8 Hours

- 620/0.8 = 775 Gallons
- 1230/0.8 = 1538 Gallons

Grid Harmonization
Load Shift Sizing and Modeling

### Multifamily Heat Pump 100 Person Skid - 16 Hour Runtime

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<th>Tons</th>
<th>Storage</th>
<th>kW</th>
<th>Watts/apt</th>
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<td>6.1</td>
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<td>120</td>
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<tr>
<td>8 Hrs</td>
<td>12.1</td>
<td>13.2</td>
<td>240</td>
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**SINGLE-PASS HPWH SYSTEM WITH SWING TANK**
Prescriptive Central Heat Pump Water Heating Design
Temporary solution to allow central heat pump water heaters in Title 24 compliance software while the policy/software changes in CBEC RES/COMM are being developed.
Controls Required to Power on/off heat pumps and send alarms on failure

Filter Incoming Water to Remove Particulates

Electronic Thermostatic Mixing Valve

Swing Tank or Loop Tank sizing critical to system performance

Well Insulated Storage (R-22) on R-10 Pad

Follow Manufacturer Recommendations for Heat Pump Installation
5. System Sizing

a. The number of HPWH compressors shall be no less than calculated by Equation 6.1. (Each compressor heating capacity assumed to provide 15,400 BTU/hr)

\[ \text{Compressor(s)} = (0.037 \times \text{Bedrooms}) + (0.106 \times \text{Dwelling Units}) \]

b. The primary storage capacity shall be no less than shown by Equation 6.2.

\[ \text{Primary Storage} = 80 \text{ gallons} \times \text{number of compressors} \]

**Example Prescriptive Sizing: Market Rate – 60 Units, 90 Bedrooms**

**Heat Pump Sizing**

\[ (0.037) \times 90 + (0.106) \times 60 = 9.7 \text{ compressors} \]

9.7 compressors \( \times 15,400 \text{ btu/hr} = 149,226 \text{ btu/hr} = 12.1 \text{ Tons} \]

**Primary Storage**

\[ 9.7 \times 80 \text{ gal} = 775 \text{ gallons at 120F} \]
\[ = 620 \text{ gallons at 150F} \]

**Loop “Swing” Tank Storage:**

60 units from table is 288 Gallons of storage

**Loop “Swing” Tank Backup Heat:**

Temperature Maintenance Load \( \sim 100\text{W/Apt} = 6\text{kW} \)

System Backup Power – (TM Load \( \times 2.5\)) = 15\text{kW}
Plug and Play
DHW Skid Development
• Working with Manufacturer to develop standardized packages around number of people served (25, 50, 75, 100 people)

• Crane up to roof, mount to stanchions plug in water lines, electrical lines, internet and ready to go.

• System will be configured around a skid of storage and a skid of heat pumps and controls.

• Controls add on for Monitoring, M&V systems and DDC connection

• Load Shift Capable

• COP 3.5 (Annual)
Manufacturer Plug and Play Packages Development

Multifamily Heat Pump
100 Person Skid - 16 Hour Runtime

<table>
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<tr>
<th>Time</th>
<th>Tons</th>
<th>Storage</th>
<th>kW</th>
<th>Watts/apt</th>
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Ecotope counteracts the climate crisis with research-proven engineering and visionary leadership; we drive the building industry toward transformative and scalable low-carbon solutions, informed by four decades of learning and technical innovation. Our clients seek holistic designs that optimize energy efficiency and are in harmony with the future grid.