Heat Pump Sizing and Design – Course Curriculum Guide

NYSERDA presents this outline of recommended training content as a reference for organizations who provide training for cold climate heat pump installers and technicians.

The content includes air source heat pump application details for specifying cold climate heat pumps that will optimize energy and thermal comfort performance for the home, apartment, or small business.

Trainings that contain this content will address recommended practices and informed application of design load calculations, system capacity, system type (ducted/ductless/compact-ducted), indoor and outdoor unit location(s), and duct design.

Course Curriculum: (target 4-8hrs)
Part 1: Basic Principles of Heat Pump Operation and Energy-Use (target 60-90 minutes)
1. **Learning Objectives (Required):**
    a. Explain standard air-source heat pump (ASHP) technology, functions, and energy use.
    b. Describe at least 3 major differences inherent in the technology used in variable-capacity heat pump (VCHP) vs. standard ASHP.
    c. Understand how, using expanded performance data and design recommended practices (or equivalent product selection tools), to select VCHP equipment to optimize performance for comfort and energy use in a cold climate.
    d. Describe impacts on performance, efficiency, and comfort of poorly designed/sized ASHP equipment
2. Example Course Sections Matched to Learning Objectives:
    a. Standard ASHP operation and terminology –
        i. Vapor compression cycle, compressor/expansion valve/reversible refrigerant pump
        ii. Heat exchangers (indoor and outdoor units), indoor blower fan
        iii. Defrost mode, ancillary loads (crank case heater, drain pan heater, on board electronics, indoor fan air sampling (ducted), electric resistance strip heat modes (backup/emergency/defrost-comfort support.)
    b. Differences with inverter driven, variable capacity heat pumps, particularly cold-climate rated heat pumps –
        i. Modulating performance
        ii. Variable speed compression
        iii. Variable speed fans – via ECM motor or similar – to vary heat/cool extraction
        iv. Expansion valve firing control (refrigerant flow control)
        v. Variable capacity by temperature
            • Explanation of capacity ratings
        vi. Variable efficiency by temperature
            • Explanation of AHRI's SEER/EER/HSPF ratings. Fixed speed test basis, extrapolated performance off a few data points matched to climate

zone IV bins, not the full picture, not always indicative of actual performance

      vii.   Energy penalty of auto-changeover and continuous fan modes.

  c. Expanded data performance curves: existence and how to read/interpret

      i.   Introduction to NEEP cc heat pump specification

      ii.   VCHP Goldilocks sizing/operation principle (recommended practice)

- Load-Capacity matching at heating design temp(s)
- Minimize oversizing for mild-temperature partial loads and cooling
- Spends majority of run-hours in a sweet spot of capacity and efficiency

      iii.   Cold climate ASHP specific differences and rating (recommended practice)

- VCHP system where operations are optimized to perform at low outdoor ambient conditions
- NEEP rating criteria and process

Part 2: Using Load Calculations (target 45-60 minutes)

1. **Learning Objectives (Required):**
   a. Describe the relationship between a home's heat loss/gain and ambient temperature
   b. Describe the purpose of using accurate ACCA Manual J, or equivalent, block and room/zone load calculations when designing a comfortable and efficient VCHP system.
   c. Describe differences in partial-load (displacement) versus full-load (whole house) approaches.
   d. Define appropriate balance points, set points, and electric resistance strip heater lockouts for VCHP systems installed cold climates.

2. Example Course Sections Matched to Learning Objectives:
   a. Overview/Review of ACCA Manuals J, D, S, and T
      i. Conservative in nature
      ii. How/when to use each
      iii. Correct use of climactic design temperatures
   b. Design considerations
      i. Heat-pump balance points and set points
      ii. Use of backup heating source to assure confidence in sizing heat pump conservatively to the full calculated heating load;
         - Methods to disable/enable backup heating source (e.g. ER strip lockout, manual control)'
   c. Alternative sizing tools for heat pumps
      i. Manufacturer specific tools
      ii. NEEP's *Guide To Sizing & Selecting Air-Source Heat Pumps in Cold Climates*
      iii. NEEA's HVAC-ST
      iv. Rules of thumb such as NEEA ccDHP Recommendations
   d. Zonal calculations, isolated rooms

  e. Reading and interpreting the full spectrum of outputs (across varying outdoor conditions)

Part 3: System Sizing and Specification (target 30-45 minutes)
  1. Learning Objectives (Required):
    a. Understand load-matching best practices for VCHP system specification.
  2. Example Course Sections Matched to Learning Objectives:
    a. Specifying AHRI matched systems
    b. Using temperature bins by climate (linking back to goldilocks principle)
    c. Ensure capacity at design load (minimize need for supplemental back up, when available)
    d. Ensure turn-down ratio is sufficient to not short-cycle at partial load
      i. Multi-split exacerbation issue with individual heads
    e. Aim for high-performance at dominant temperature bins
    f. Designing primarily for heating vs. cooling mode
    g. Charting house load lines vs. minimum and maximum heat pump capacities
    h. Importance of part-load humidity control
    i. Use of manufacturer-specific product selection tools in light of these same principles

Part 4: System Design Options/Considerations (target 30-60 minutes)
  1. Learning Objectives (Required):
    a. Understand system design best practices for a variety of distribution, displacement/replacement, and outdoor unit location challenges.
  2. Example Course Sections Matched to Learning Objectives:
    a. Displacement vs. replacement
      i. Strategies for full-house replacement (or new construction) and multi-system (including back-up/emergency/supplemental heat)
      ii. Percent load served
      iii. Integrated controls options (see also thermostats and controls, below)
    b. System design options - distribution considerations
      i. Ducted
      ii. Compact-ducted
      iii. Ductless
      iv. Combination (e.g. small multi-zone with ductless for 1-2 main zones and one compact-ducted for bedrooms – better load matching)
      v. Benefits of using multiple smaller compressors vs. fewer (or one) bigger compressor: higher efficiency, shorter line sets, avoid branch boxes, and reduce emergency no-heat calls if a unit fails.
    c. Equipment location choices
      i. Indoor head location choices –
        • Avoid installing 2-3" from ceiling (heating efficiency penalty)

- Install at lower level to better deliver heating
- Use of floor-mounted units on lower floors/open spaces
            ii. Line set considerations
            iii. Condensate drain planning
            iv. Duct design requirements (static pressure limits)
    d. Design nuances in particular home and zone-types
            i. Low-load homes
            ii. Zonally segmented homes

Part 5: Thermostats and controls (target 25-35 mins)

1. **Learning Objectives (Required):**
    a. Define appropriate control strategies for VCHP applications
2. Example Course Sections Matched to Learning Objectives:
    a. Integrated controls option with or without complimentary systems
    b. Pairing 3rd party controls (NEST, Ecobee, etc.): State of the industry and considerations moving forward
    c. Thermostat settings when integrated controls aren't offered
    d. Value of "set and forget": consistent setting vs. "on-off" or heavy temperature setbacks that push system to less-efficient modes during pickup load
    e. Reducing use of deep daily setbacks with VCHPs

Part 6: Recommended Practice Design Examples (target 30-45 minutes)

1. **Learning Objectives (Required):**
    a. Design a basic VCHP system for an entire house with multiple zones and varied loads.
2. Example Course Sections Matched to Learning Objectives:
    a. Two example homes
    b. Common design failures/errors
    c. Recommended practices