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Introduction to Hybrid Heat Pumps

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Module 1: Hybrid Heat Pump Systems

Learning Objectives

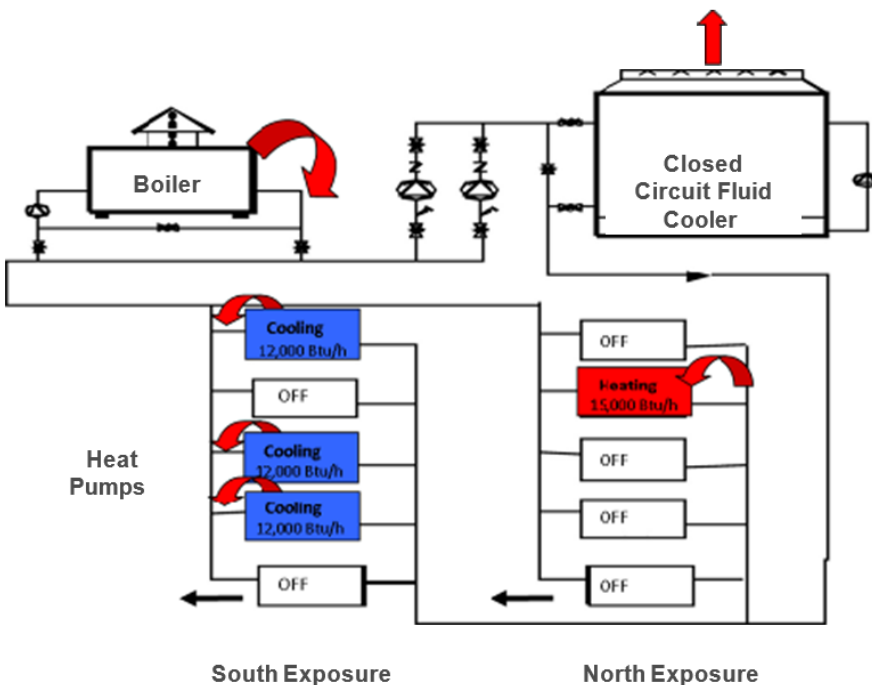
By the end of this section, you will be able to:

- **Evaluate** the mechanical differences between traditional reversing Water Source Heat Pump (WSHP) systems and hybrid heat pump configurations.
- **Calculate** air temperature rise and leaving air temperature (LAT) for hybrid hydronic heating coils.
- **Analyze** building energy compliance regarding fluid loop temperature scheduling and pipe insulation requirements.

Executive Summary: The hybrid heat pump system optimizes traditional WSHP technology by replacing compressor-based heating with a hydronic heating coil. This "fuel switching" strategy removes the 90°F loop temperature limitation, eliminates compressor electrical consumption in heating mode, and improves occupant comfort through precise load matching and reduced thermal stratification.

Traditional Reversal WSHP Systems

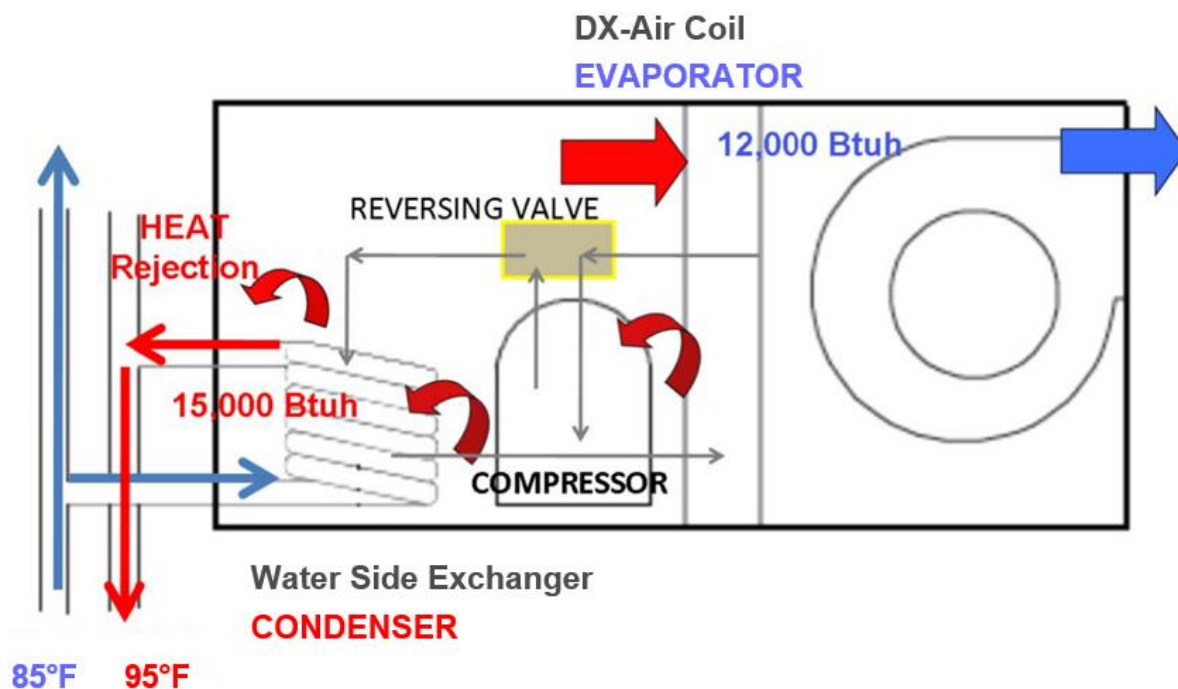
Traditional WSHP systems rely on a common fluid loop connecting multiple units that can independently heat or cool by moving energy between zones. Central boilers and fluid coolers maintain the loop within a narrow temperature band, typically 70°F to 90°F.



WSHP Cooling Mode Fundamentals

In cooling mode, the WSHP operates as a water-cooled air conditioner:

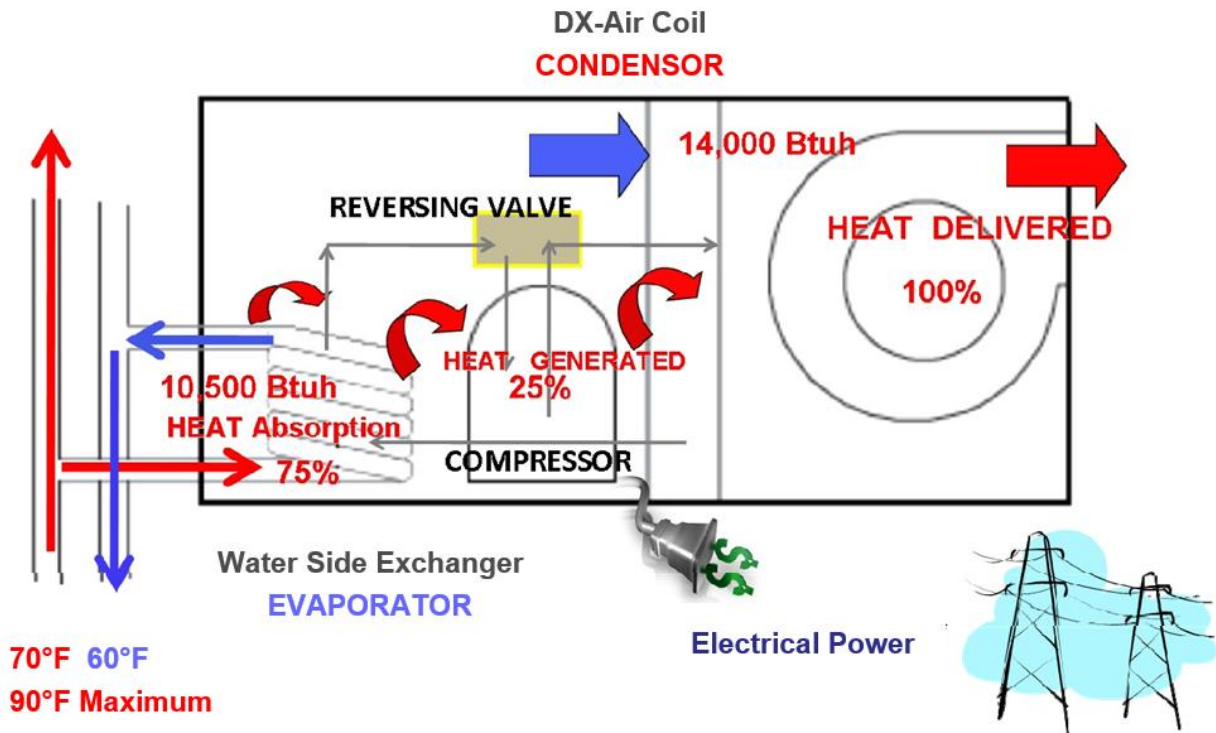
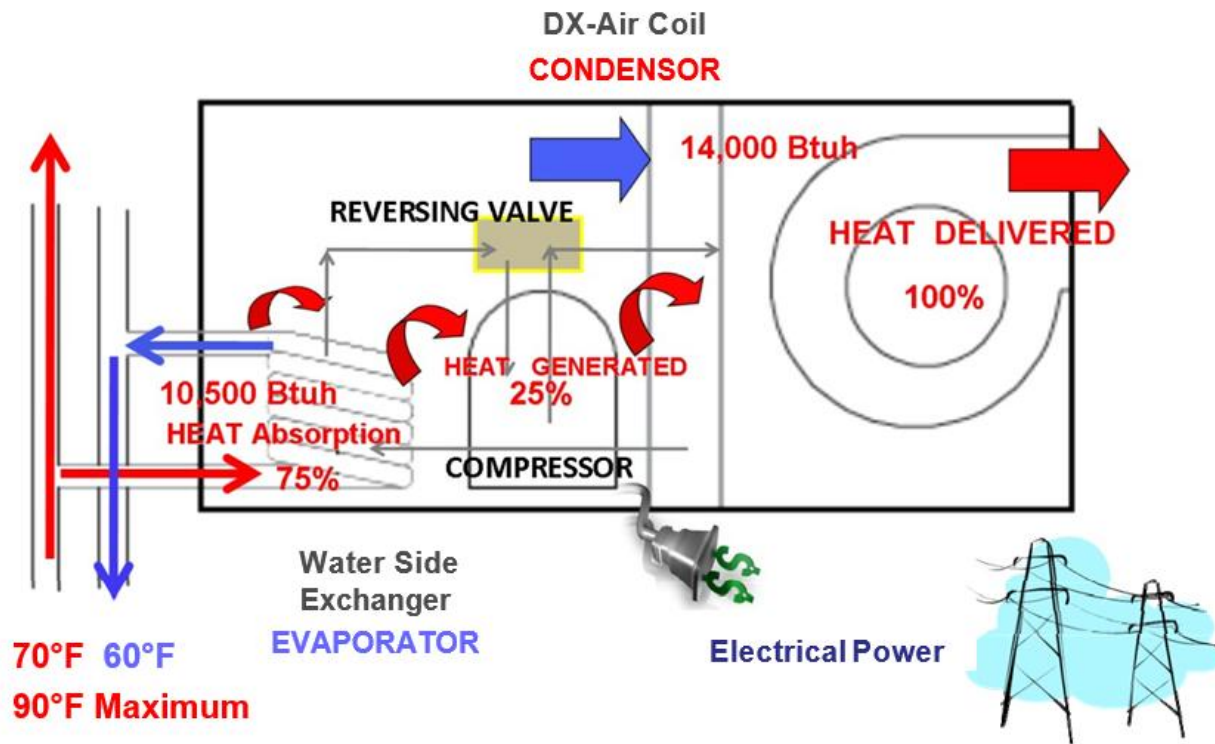
- **Heat Absorption:** The air-to-refrigerant exchanger functions as the **evaporator**, utilizing a direct-expansion (DX) coil to absorb heat from the airstream.
- **Heat Rejection:** The compressor transfers hot refrigerant gas to the water-side **condenser**.
- **System Capacity:** A 1-ton unit typically delivers 12,000 Btuh of cooling but rejects approximately 15,000 Btuh to the loop, as the condenser must handle both the absorbed heat and the heat of compression.



WSHP Heating Mode Limitations

When switched to heating via a reversing valve, the roles of the exchangers flip: the water coil becomes the evaporator and the air coil becomes the condenser.

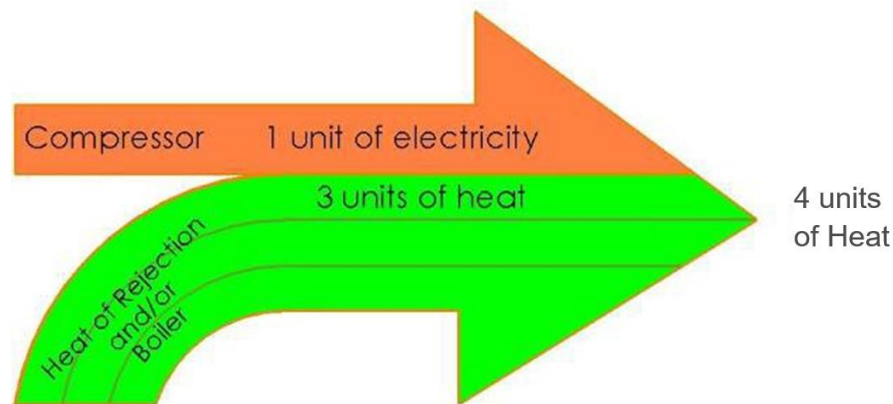
- **Energy Sourcing:** Approximately **75%** of the delivered heat is extracted from the fluid loop, while **25%** is derived from electrical power used by the compressor.
- **Operating Constraints:** Manufacturers generally prohibit operation if the fluid loop exceeds **90°F**.
- **Efficiency Metric:** The Coefficient of Performance (COP) typically reflects a ratio where 1.15 units of energy input (compressor + fan) yield 3.5 units of heat.



Heat Sources

The heat delivered by a traditional WSHP unit is derived from two distinct sources:


- **Fluid Loop Heat (75%):** Approximately three-quarters of the delivered heat is moved from the common fluid loop.
- **Heat Origin:** This loop heat is sourced from cooling unit rejection, boiler-supplied heat, or a combination of both.
- **Electrical Energy (25%):** Approximately one-quarter of the heat is derived from the electricity used to power the compressor.
- **Compressor Requirement:** Because compressors are always required to move heat from the loop to the air stream, a portion of the delivered heat is always derived from electricity.



Coefficient of Performance (COP)

The Coefficient of Performance (COP) is a term used to quantify the efficiency of a heat pump by comparing the heat delivered to the energy consumed.

- **Basic Ratio:** The COP is a ratio of the useful energy delivered as heat divided by the amount of energy used to deliver that heat.
- **System Efficiency:** In a typical WSHP, a COP of 3.5 indicates that the system produces 3.5 units of heat with only 1.15 units of energy input.
- **Role of the Fluid Loop:** This high level of performance is possible because 3 units of heat are moved from the fluid loop, rather than being generated entirely by electricity.

 **Calculation Note:** When determining the COP for a traditional WSHP, ensure you account for both the compressor energy and the fan motor energy in the input denominator.



Equation:

$$COP = \frac{\text{heating capacity}_{\text{Btuh/hr}}}{\text{watts} \times 3.413}$$

Where:

- **heating capacityBtuh/hr** = Heating capacity output
- **watts** = Amount of energy input
- **3.413** = Conversion factor for Btuh per watt-hour

Checkpoint Quiz

1. In a hybrid heat pump system operating in heating mode, which component is responsible for extracting heat from the fluid loop?

- a) The compressor
- b) A coaxial evaporator
- c) A hydronic heating coil
- d) A reversing valve

Answer: (c). Unlike traditional WSHPs that use a compressor and evaporator, the hybrid unit utilizes a hydronic heating coil to extract heat directly from the loop.

2. What is the primary reason the maximum fluid loop temperature can be increased to 125°F in a hybrid system compared to 90°F in a traditional WSHP?

- a) Hybrid units use high-pressure R-410A refrigerant.
- b) The compressor does not operate during the heating cycle.
- c) The outdoor air sensor overrides manufacturer safety limits.
- d) Hybrid systems use thicker pipe insulation.

Answer: (b). The 90°F limit in traditional systems is a compressor/refrigeration cycle constraint; by removing the compressor from the heating process, the hybrid system can safely utilize warmer loop water.

3. Using the standard sizing for a hybrid hydronic coil (70% extraction), what is the Leaving Air Temperature (LAT) if the Entering Air Temperature is 70°F and the Entering Water Temperature is 100°F?

- a) 70°F
- b) 91°F
- c) 100°F
- d) 115°F

Answer: (b). LAT = 70 + 0.70 * (100 - 70) = 70 + 21 = 91°F.



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