Building systems

Building HVAC – basic systems

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Learning Objectives

- Discuss basic HVAC equipment and system types
- Describe the control systems for these equipment and system types
- Explain a simple HVAC control logic
- Introduce modern smart packaged controls
- Know why an economizer saves energy and how multiple control loops form an economizer sequence.

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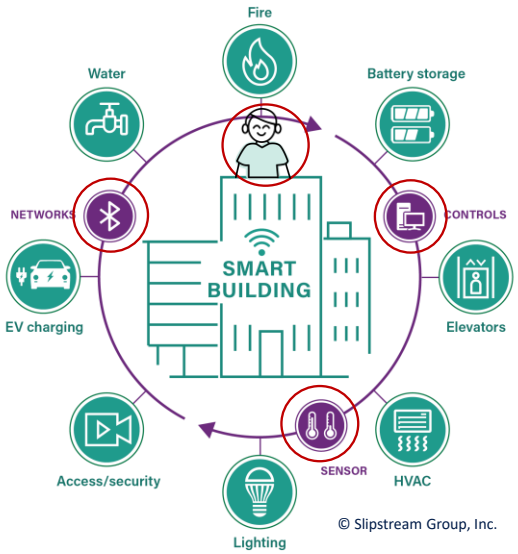
Outline

- **Basic HVAC System Types**
  - Unit Heaters and Cabinet Unit Heaters
  - Small Unitary and Split Systems
  - Packaged Rooftop Units
  - Boiler Plant
- **Basic HVAC Controls**
  - Control logic
  - Basic control loop
  - Basic control loop examples
- **Simple HVAC controls**
- **Economizer Controls**

Smart Building Elements



1) Building systems
   1) Envelope
   2) HVAC
   3) Lighting
   4) Water
   5) Solar PV + battery energy storage
   6) EV charging
   7) Other (elevator, fire, access/security)
2) Sensors
3) Controls
4) Networks
5) Occupants!

Building HVAC

HVAC, **H**eating **V**entilation and **A**ir-**C**onditioning, is a term used to define building environmental controls systems.

Heating and air-conditioning systems maintain a comfortable building temperature and humidity.

Ventilation systems ensure building occupants have clean, fresh air within air-tight modern buildings.

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Basic HVAC System Types

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Unit Heaters and Cabinet Unit Heaters

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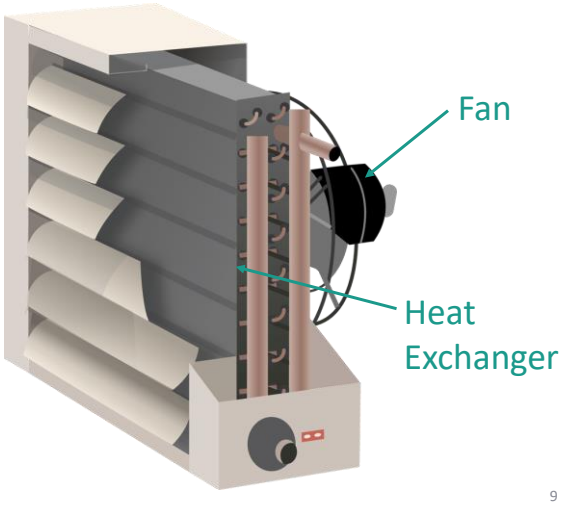
Unit Heaters and Cabinet Unit Heaters

Components

- Fan
- Heat Exchanger
  - Gas-Fired HX
  - Hot Water Coil
  - Steam Coil
  - Electric Resistance Heat



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Unit Heaters and Cabinet Unit Heaters

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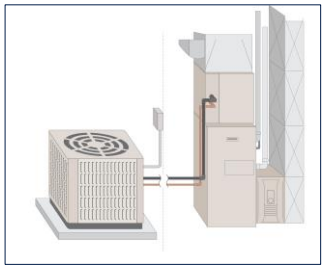
Small Unitary and Split Systems

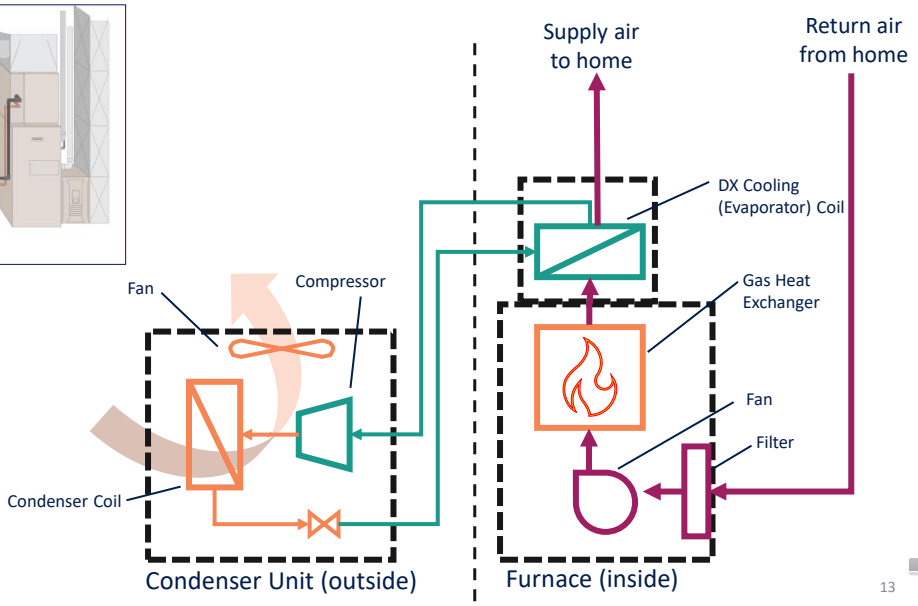
Small Unitary and Split Systems

Unitary

Split System

Split Systems





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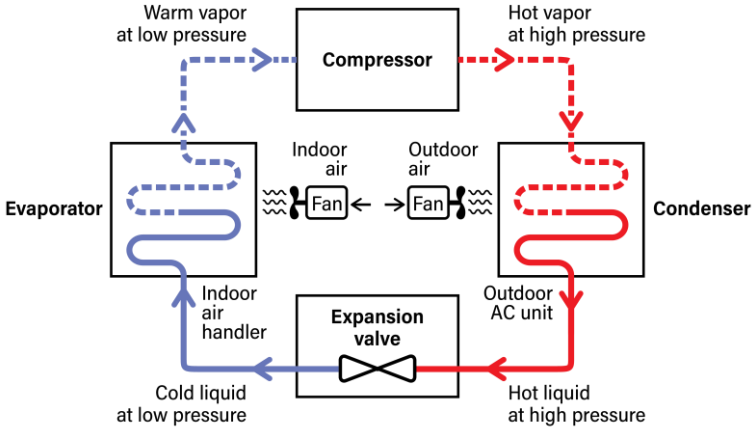
Refrigeration Cycle



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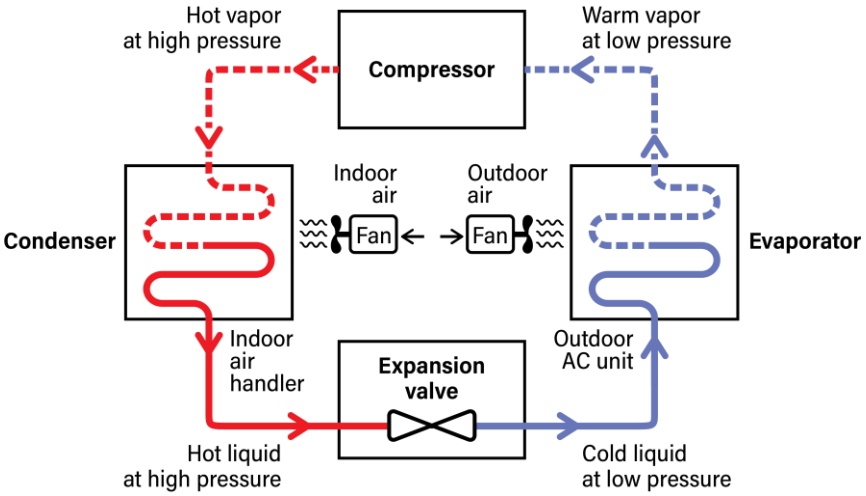
Heat Pump Refrigeration Cycle



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Small Unitary and Split System Applications

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Packaged Rooftop Units (RTU)

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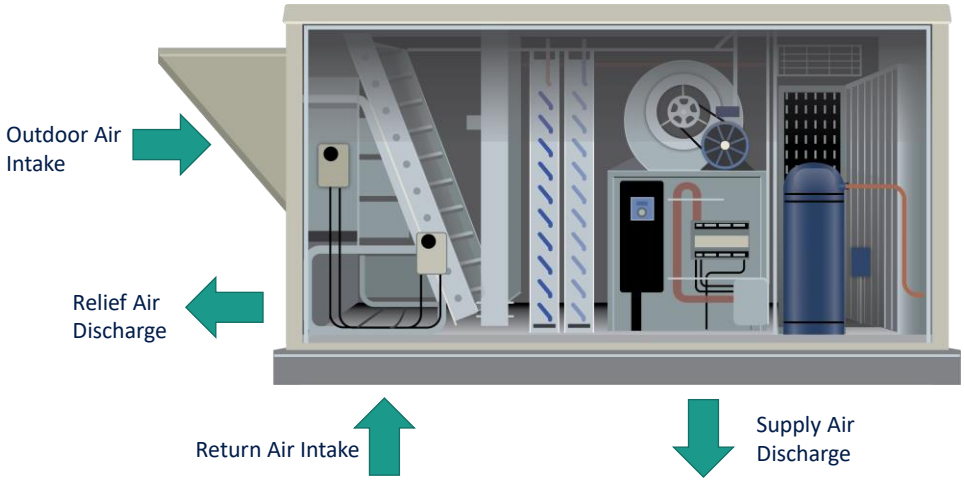
Packaged Rooftop Units (RTUs)



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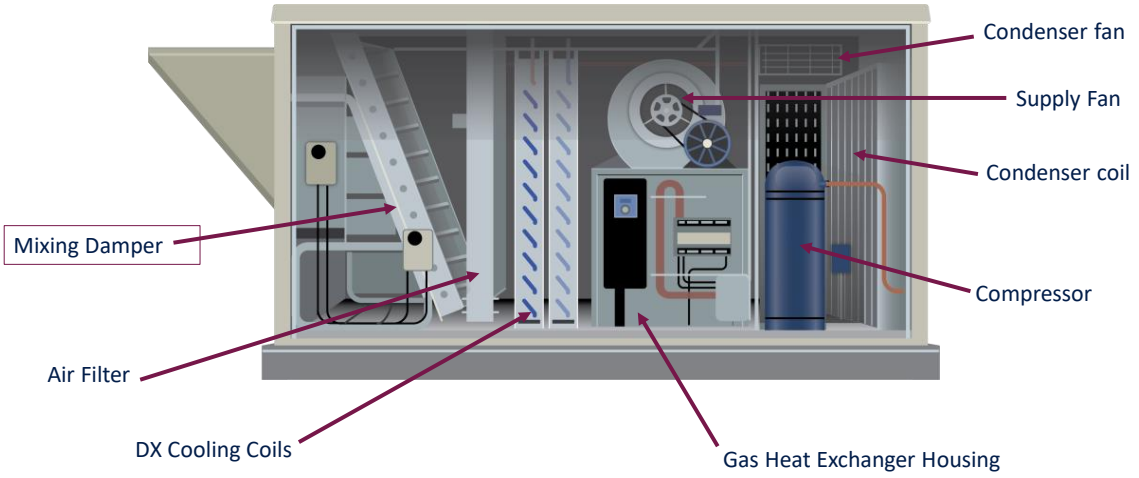
Packaged Rooftop Units (RTUs)



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Boiler Plants

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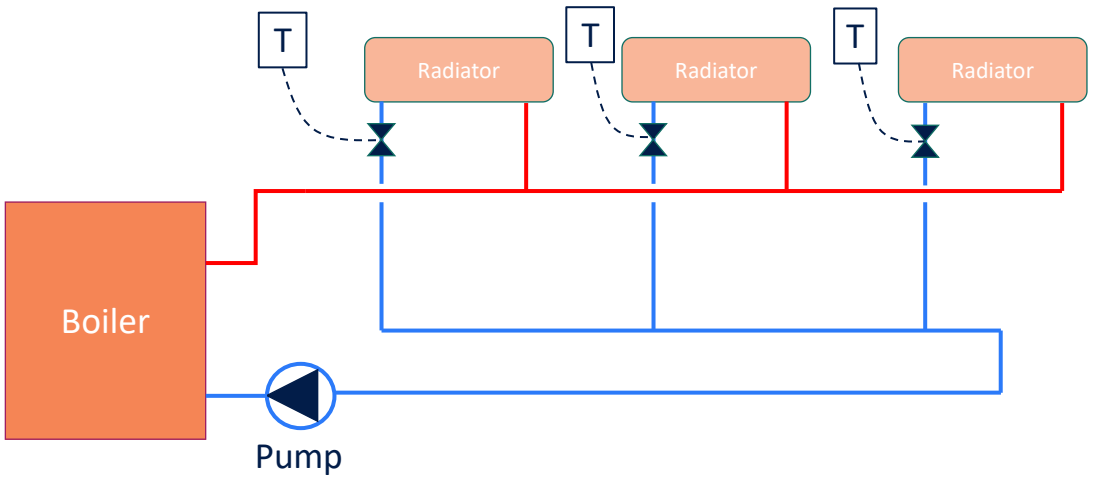
Boiler System Diagram



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Basic HVAC Control Sequences

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Why do we have building controls?

- Turn on or modulate equipment to maintain occupant comfort or specific environmental conditions.
- Allow equipment to operate at part load or shut down automatically when not in use - saving energy and reducing equipment wear.
- Make sure equipment is operated safely.

Control Logic

- Control Sequences are a list of instructions for how the system should operate at different inputs.
- Its most basic building block is control logic:

IF → THEN

IF SENSOR INPUT → THEN CONTROLLER OUTPUT

Control Logic

If input → Then output

If “Temperature is below is setpoint” → Then “Enable unit heater”

If “Low limit temperature switch is enabled” → Then “Close dampers and open hot water heating valve”

If “Outside air temperature is below 70 degrees” → Then “Enable economizer”

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Basic Control Loop

Sensor

Controller

Controlled Device

Process

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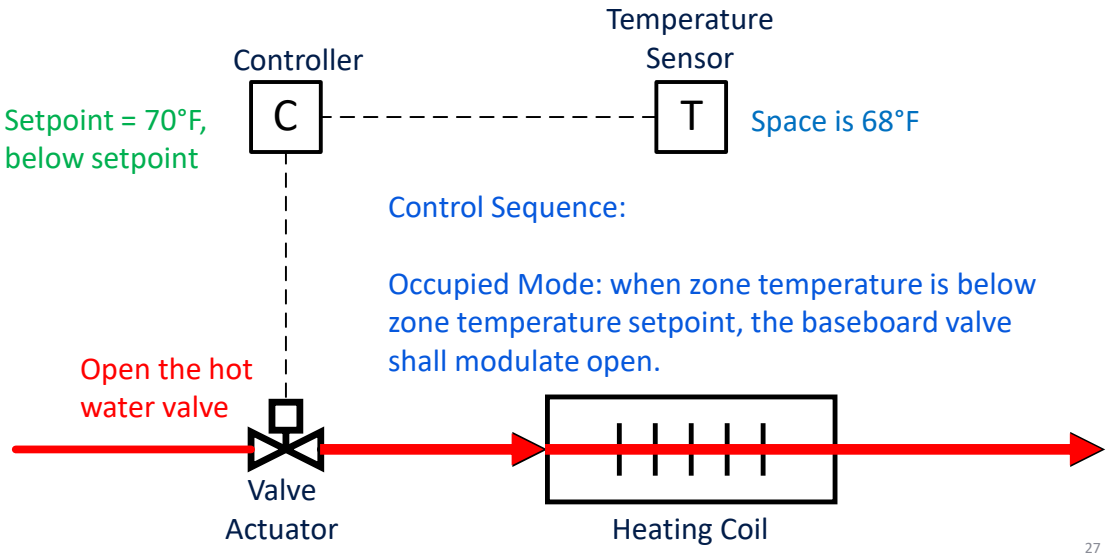
Control Sequence Example - Baseboard Heater



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Simple HVAC Controls

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Unit Heater and Cabinet Unit Heater Controls

Controls

- Simple on/off control through manual on/off switch
- Thermostat
- Standalone controllers

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Unitary and Split System Air Conditioner Controls

- Thermostat or unitary controller.
- A thermostat is a sensor and controller.
- A unitary equipment can also have a separate controller that can control temperature, humidity, and airflow one zone.

Thermost

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Packaged Rooftop Unit Controls – Single Zone

- Often come with packaged controls
- Specify enable sequence
- Schedule: Occupied, Unoccupied, Morning Warmup, and Failure
- Safeties
  - Heating coil discharge low limit switch (freeze stat)
  - Static pressure safeties
  - Supply air smoke
  - Return air smoke
- Heating control
  - Zone thermostat starts gas heater when below setpoint.
- Cooling control
  - Zone thermostat starts DX compressor sequence when above setpoint.
- Fan control
  - Generally constant volume.
- Economizer control

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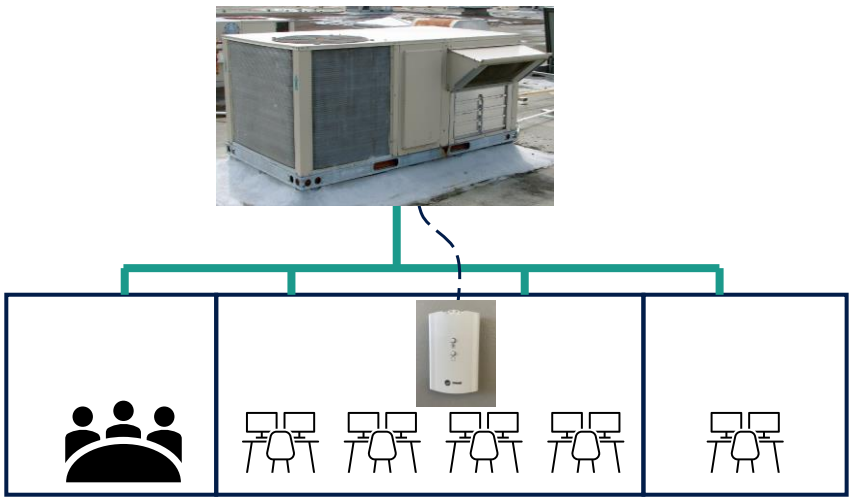
Packaged Rooftop Units (RTUs) – Single Zone



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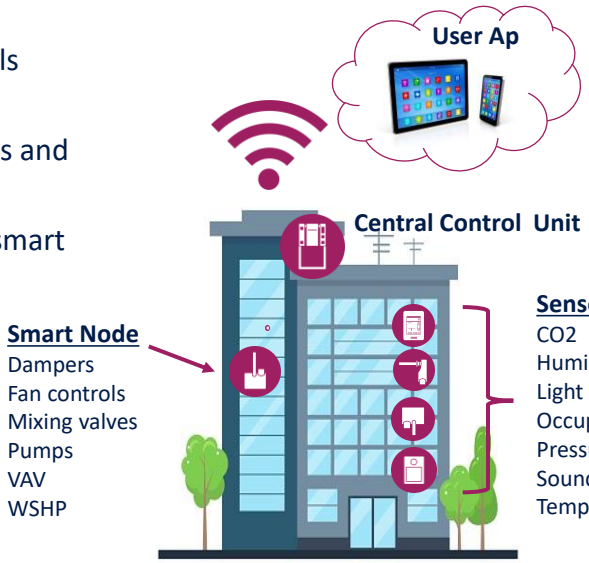
Smart Packaged Controls

- Modern smart packaged controls
- Smart thermostats are already common for single family homes and multifamily homes.
- Packaged RTUs have emerging smart controllers.



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Control Sequence Example - Boiler Control

Simple variable-primary boiler system:

- Radiator or coil valves open or close based on air temperature detected by the thermostat.
- Water pump maintains pressure in the pipe system as detected by the pipe static pressure sensor.
- Boiler maintains the temperature of the hot water loop return temperatures

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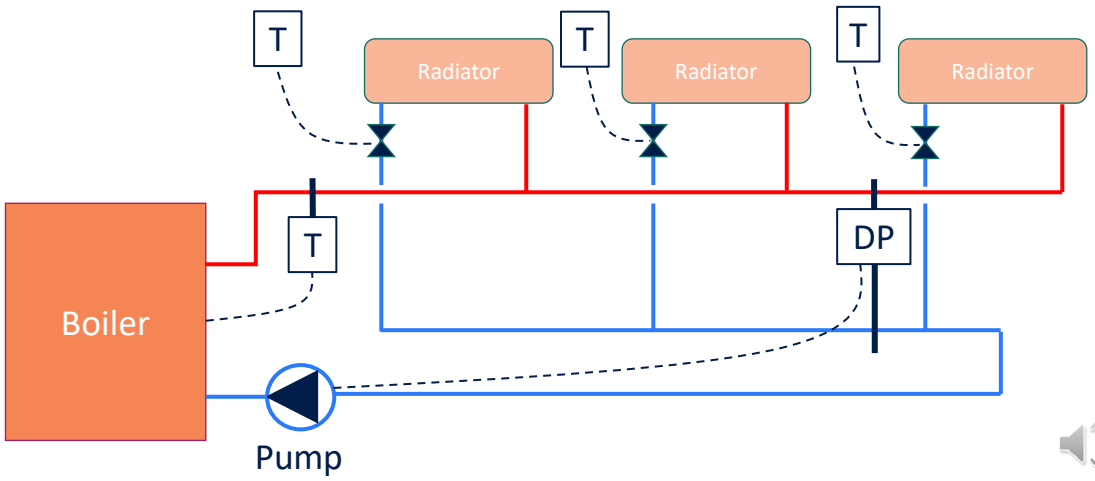
Boiler System Diagram



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Controls Example: Economizer

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What is an Economizer?

- An economizer is a means to use outside air to provide “free” cooling to a building.
- International Energy Conservation Code (IECC) and ASHRAE-90.1 have prescriptive requirements to include either an air-side or water-side economizer for most cooling systems.

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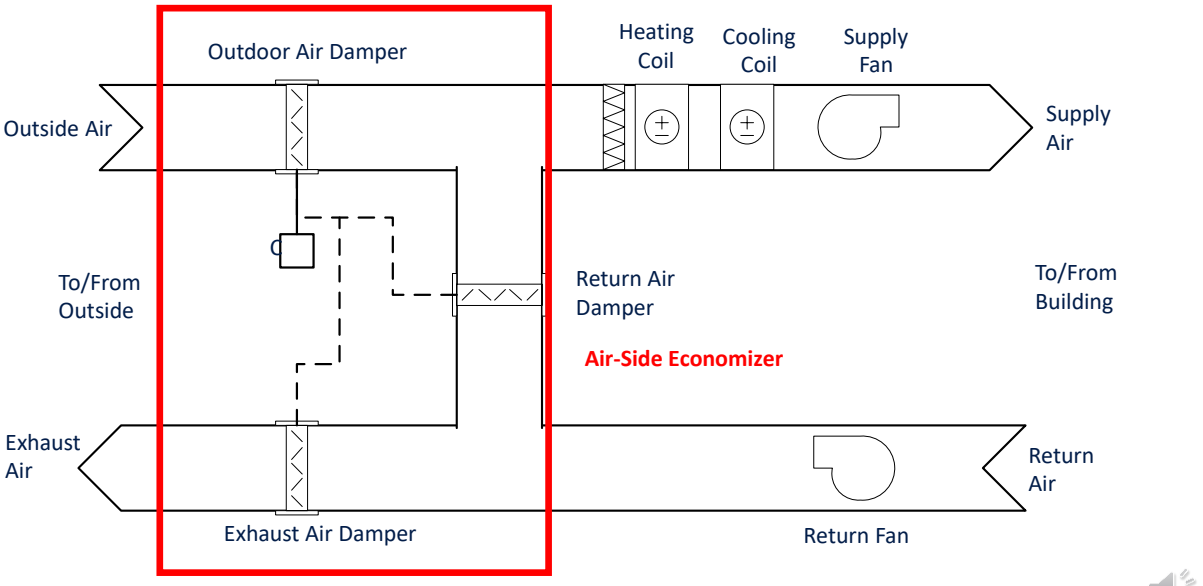

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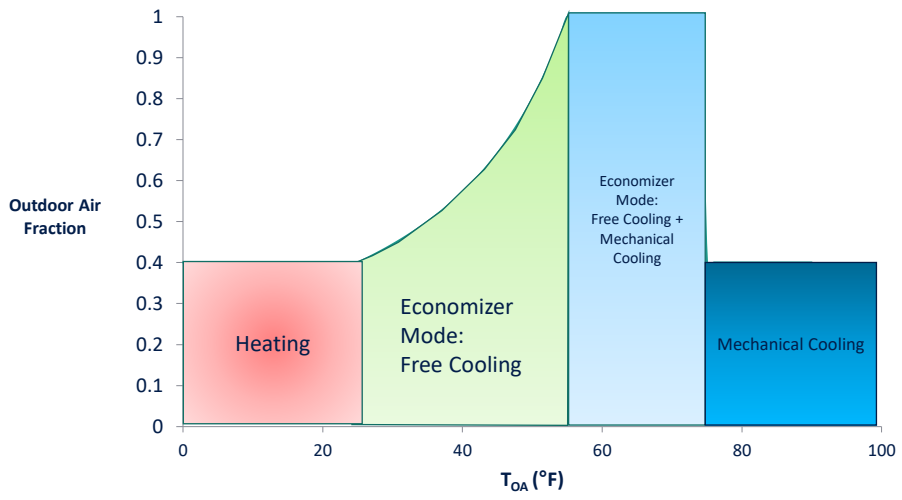
Concept



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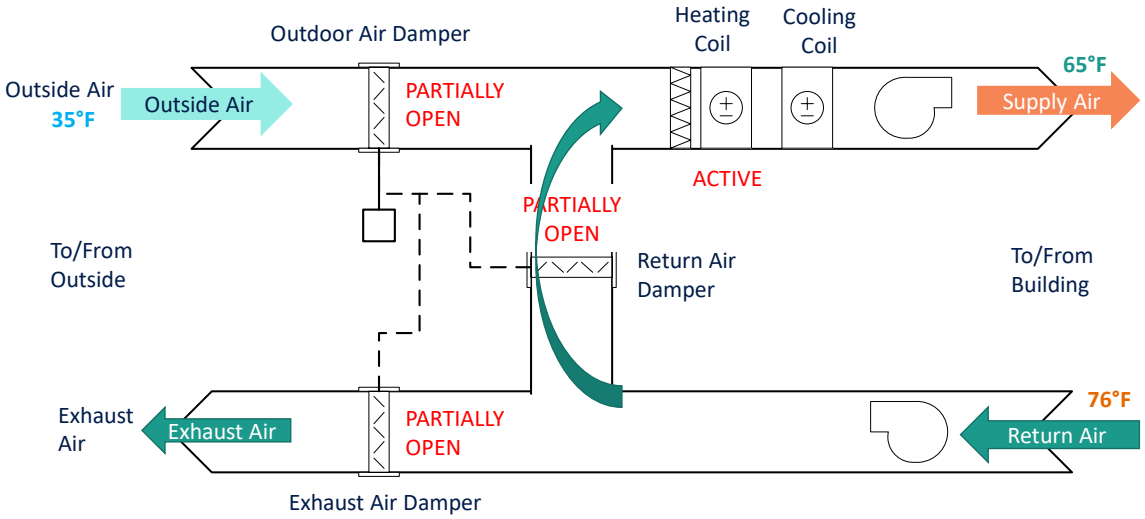
Heating



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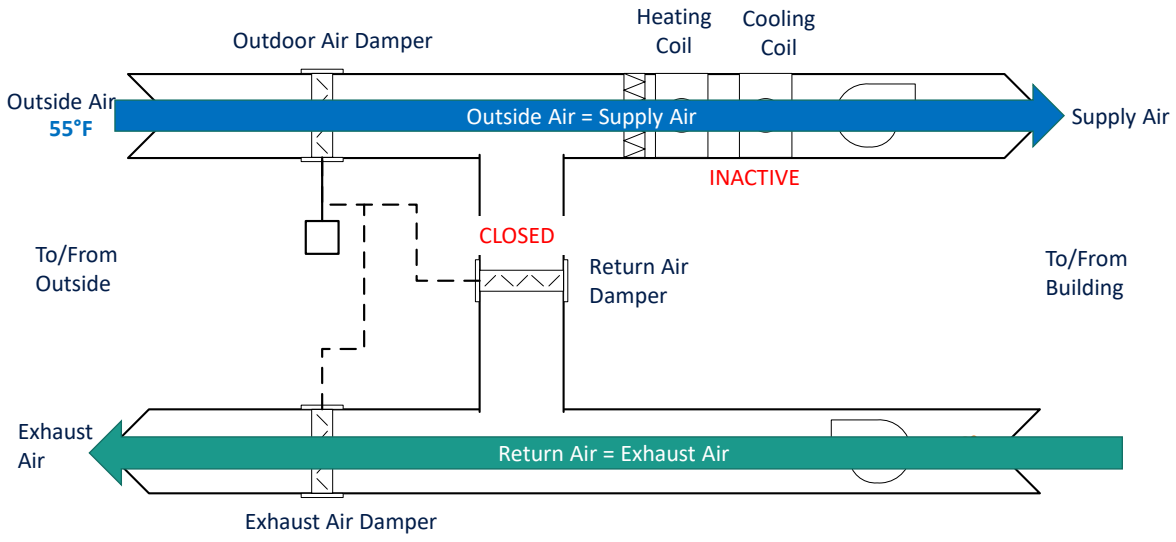
Economizer Mode



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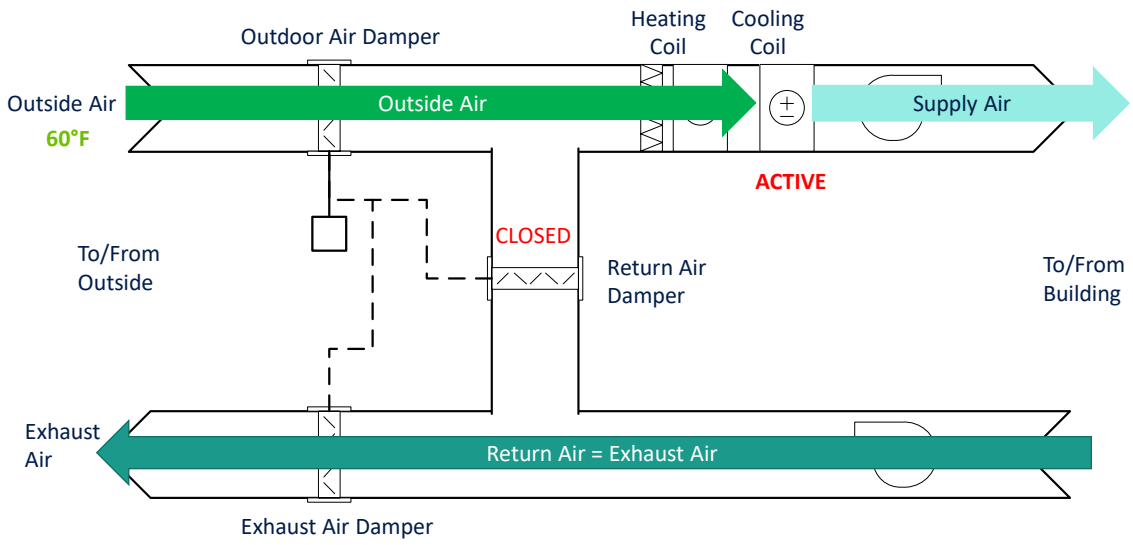
Integrated Economizer



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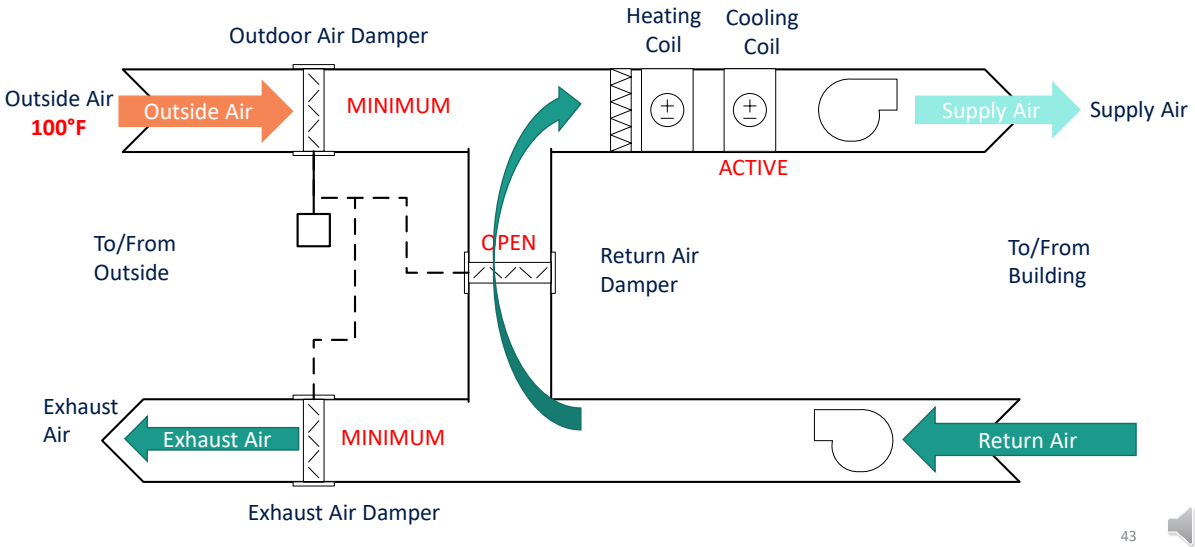
Mechanical Cooling



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This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE), Building Technologies Office (BTO) Award Number DE-EE0009703.

Thank you!