Energy Efficiency in Buildings

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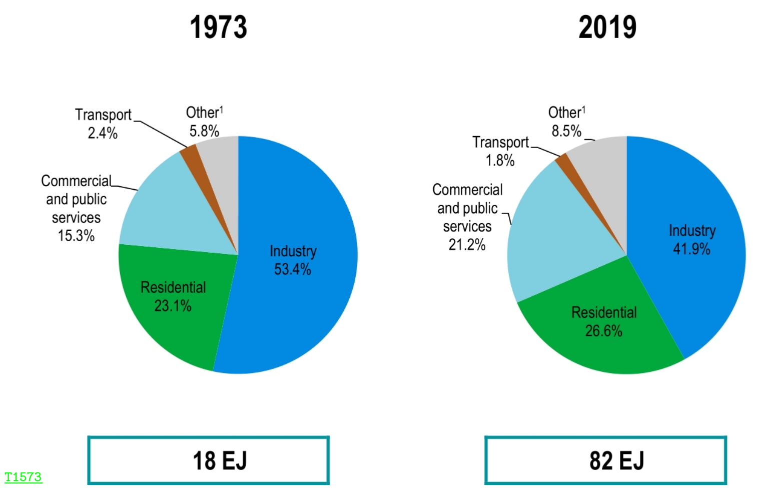
Course on Energy Fundamentals

Overview

1. Why Buidling Energy is Important?
2. Comfort Air-Conditioning: System & Components
3. HVAC Cooling Load
4. Chillers
5. Heat Pump

Share of electricity final consumption by sector, 1973 and 2019



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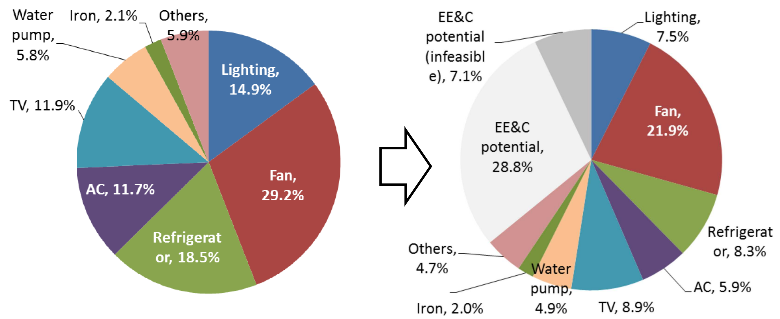
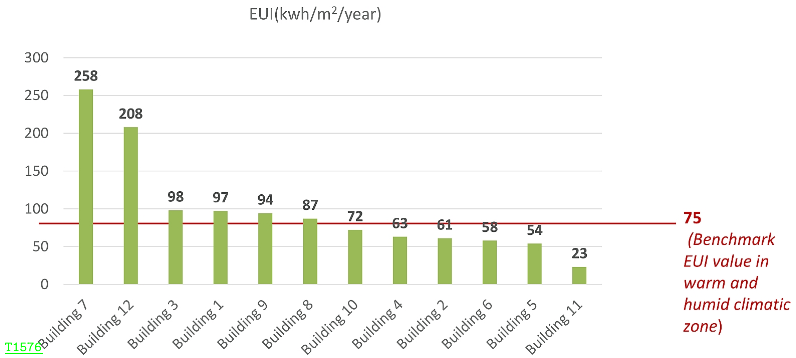
EE&C Potential of Home Appliances



T1574 A: Present Electricity Consumption   B: EE Case Electricity Consumption

EE potential in Residential Sector is estimated 28.8%.

Public Building Energy Use Intensity (EUI) analysis



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75-85 kW/m2/yr is for one star, and 45 kWh/m2/yr for five star building in India.

INDOOR AIR QUALITY

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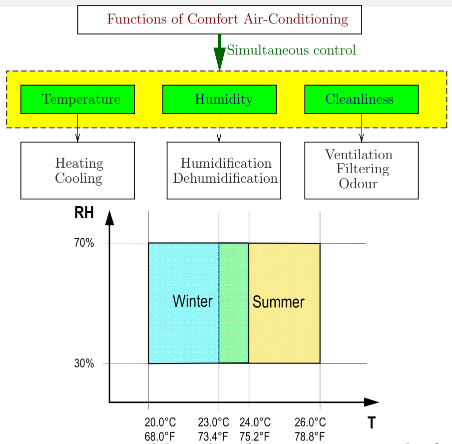
Comfort Air-Conditioning



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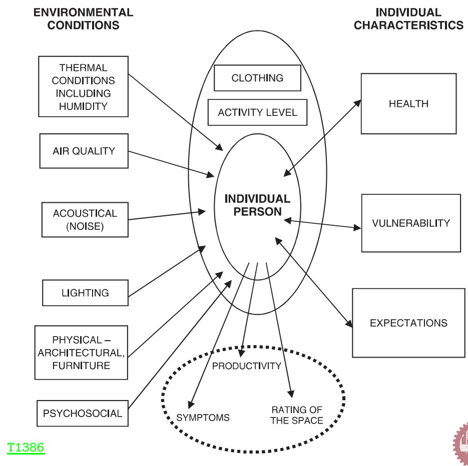
♣ Air conditioning system provides simultaneous control of temperature, humidity and cleanliness for thermal comfort. Air-cooler only cools air with reduction in moisture content of air.

Factors Influencing Thermal Comfort

1. Activity level
2. Clothing
3. Expectation
4. Air temperature
5. Radiant temperature
6. Humidity
7. Air speed



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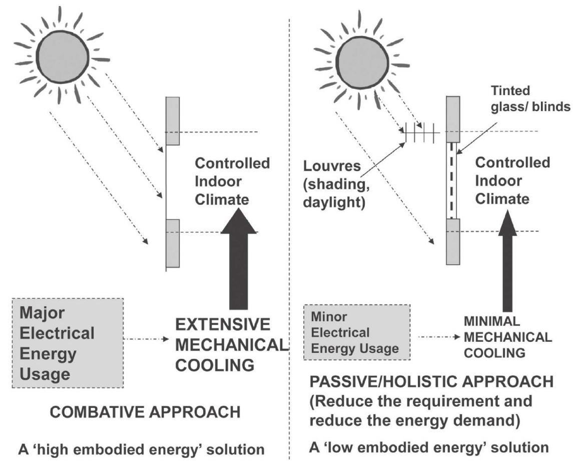
Design Strategies for Low-Carbon Buildings



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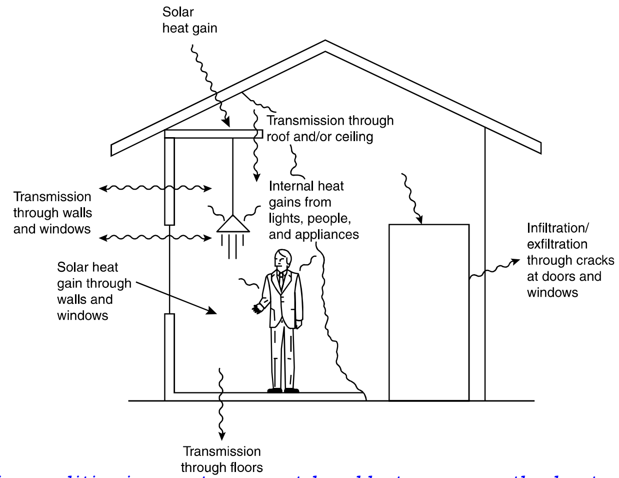
Heat Transfer to/from Building Space



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Air-conditioning system must be able to remove the heat gain

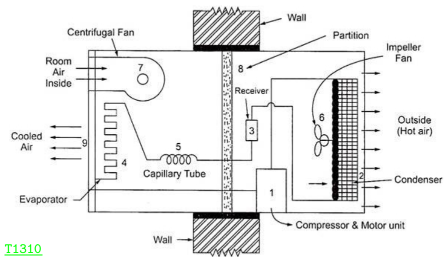
Ventilation: Outdoor Air Requirements

- to meet metabolic requirements of occupants
- to dilute the indoor air contaminants, odors and pollutants to maintain an acceptable air quality.
- to support any combustion process or replace the amount of exhaust air required in laboratories, manufacturing processes or rest rooms.
- to provide make-up of amount of ex-filtrated air required when positive pressure is to be maintained at the conditioned space.

Outdoor Air as per ASHRAE 62-1992

Application	L/s per person
Dining/conference room, office spaces, lounges	10
Retail stores, transport waiting rooms, class rooms	7
Hospital patient rooms, residences	15
Smoking lounges	30

Window Air-Conditioner



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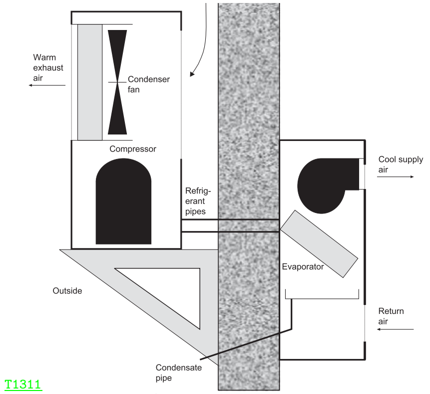
Split System



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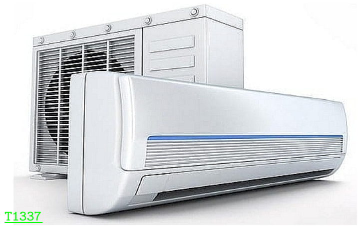

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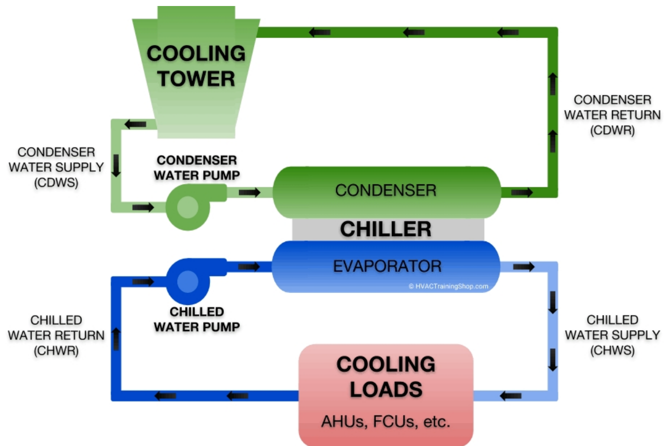
Compressor/condenser part of the refrigeration system separate from the evaporator coil and connected by the refrigerant lines to the air system, which includes the evaporator.

Central Air-conditioning System



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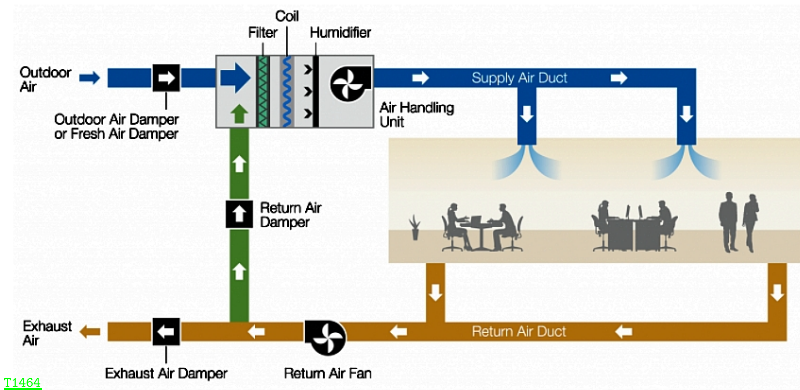
Chiller *is a complete refrigeration system and produces chilled water (6-10°C) for FCU and AHU.*



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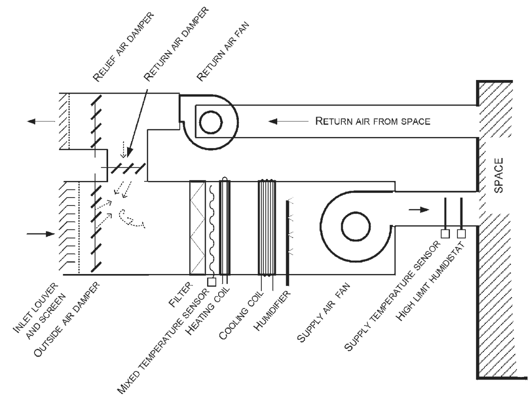
Air Handling Unit (AHU)



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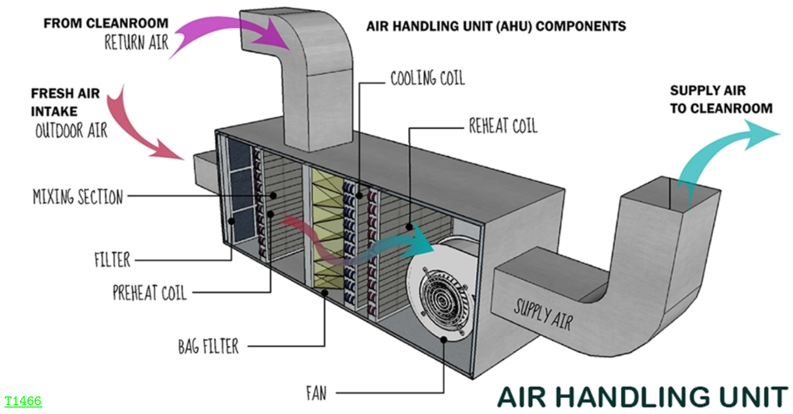
The functions of the air-handler are to draw in outside air and return air, mix them, condition the mixed air, blow the air into the space and exhaust any excess air to outside.



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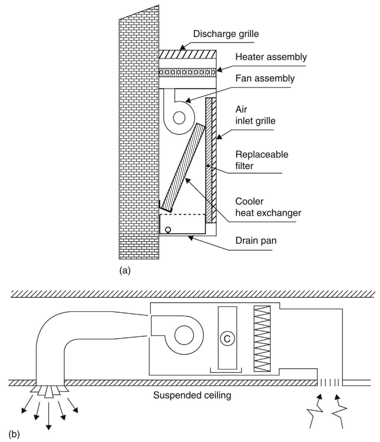
AHU prepares clean air at a required temperature and humidity.

Fan Coil Unit (FCU)



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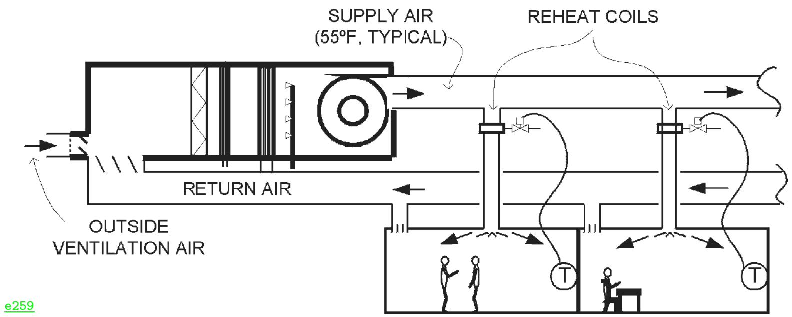
T1306 *Fan coil units.* (a) Wall mounted, (b) ceiling mounted.

FCU: Fan Coil Units, FCU receives air from room and cools it using

All-Air System with Reheat



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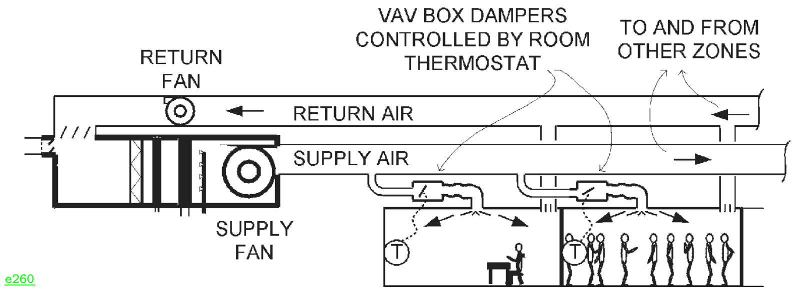
Reheat is the simplest system, known for both its reliability and the down side, its high energy wastage.

All-Air System with Variable Air Volume (VAV)



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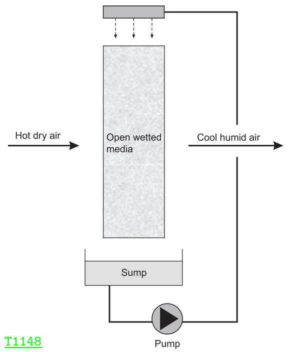
More energy efficient than reheat, VAV is a very flexible system with many virtues. When there is a low load, however, it does offer challenges for maintaining adequate ventilation air and good room air distribution.

Evaporative Cooling



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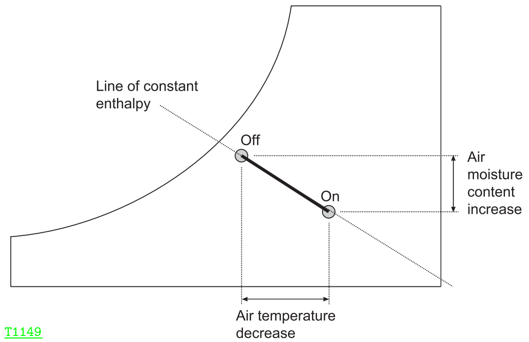

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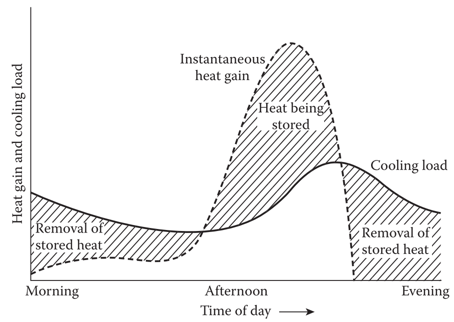
Heat Gain & Cooling Load



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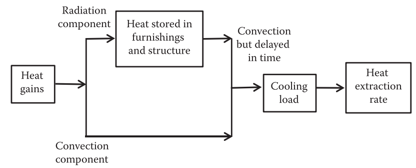

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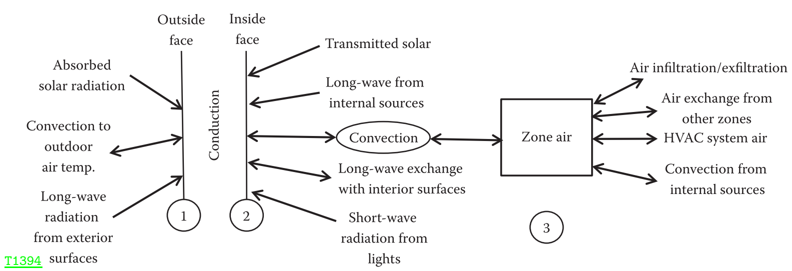
Cooling Load Components



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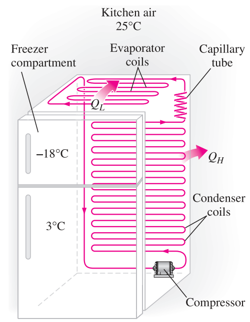
Basic Vapour Compression Refrigeration System



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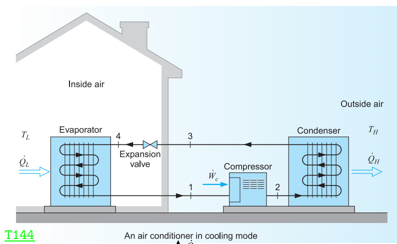

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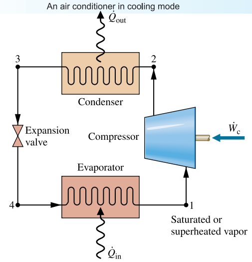

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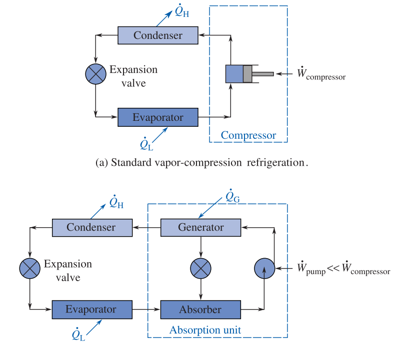
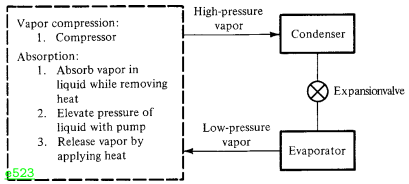
- $\dot{Q}_H = \dot{Q}_L + \dot{W}_C$
- $COP_R = \frac{\text{Desired Output}}{\text{Required Input}} = \frac{Q_L}{W_{net,in}}$
- $COP_{HP} = \frac{\text{Desired Output}}{\text{Required Input}} = \frac{Q_H}{W_{net,in}}$

Vapour Absorption Refrigeration System



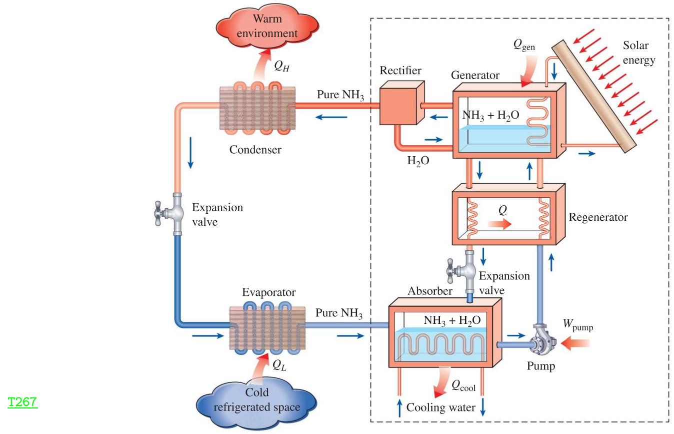
(a) Standard vapor-compression refrigeration.

(b) Absorption vapor-compression refrigeration.



- Pump consumes significantly less electricity than compressor.
- A large amount of heat is required in the generator to release the dissolved vapour to result in low COP.
- Low grade heat (waste heat,solar energy etc.) can be used in the generator, and the system can be economic.

Solar Refrigeration System



Integrated Part-Load Value (IPLV)

- COP or EER:

$$IPLV = 0.01A + 0.42B + 0.45C + 0.12D$$

- kW/ton:

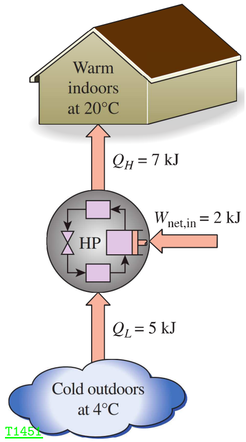
$$IPLV = \frac{1}{\frac{0.01}{A} + \frac{0.42}{B} + \frac{0.45}{C} + \frac{0.12}{D}}$$

A ≡ COP or EER or kW at 100% capacity
B ≡ COP or EER or kW at 75% capacity
C ≡ COP or EER or kW at 50% capacity
D ≡ COP or EER or kW at 25% capacity

Minimum Performance (ASHRAE 90.1)

type	COP	IPLV
Vapour Compression System:		
Air cooled, with condenser, capacity < 150 ton	2.7	2.8
Air cooled, with condenser, capacity > 150 ton	2.5	2.5
Air cooled, condenserless, all capacity	3.1	3.2
Water cooled, reciprocating, all capacity	3.8	3.9
Water cooled (screw & centrifugal) < 150 ton	3.8	3.9
Water cooled (screw & centrifugal) 150< < 300 ton	4.2	4.5
Water cooled (screw & centrifugal) > 300 ton	5.2	5.3
Vapour Absorption System:		
Air-cooled, single-effect	0.45	-
Water-cooled, single effect	0.60	-
Double-effect	0.95	1.0

Heat Pump



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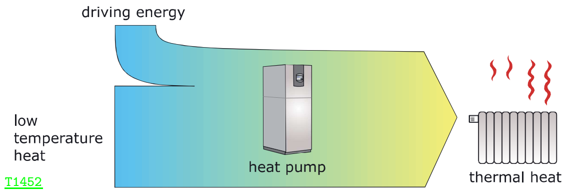

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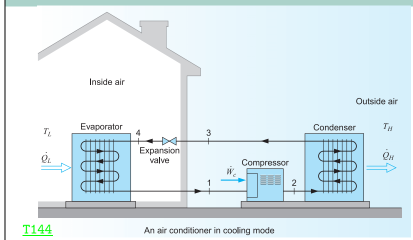
- $COP_R = \frac{Q_L}{W_{net,in}} = \frac{5}{2} = 2.5$
- $COP_{HP} = \frac{Q_H}{W_{net,in}} = \frac{7}{2} = 3.5$
- 7 kW electrical heating needs 7 kW electricity.
- 2 kW electricity is needed using heat pump.



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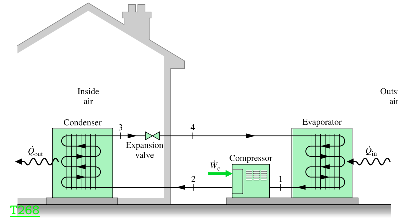
Cooling mode



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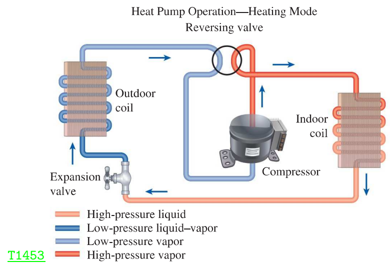
Heating mode



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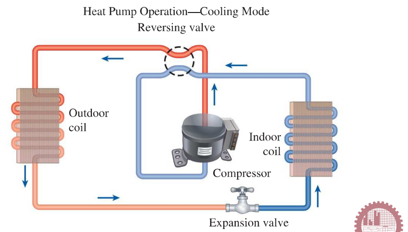

Thanks a Lot