RME 1102: Fundamentals of Mechanical Engineering

REFRIGERATION & AIR CONDITIONING

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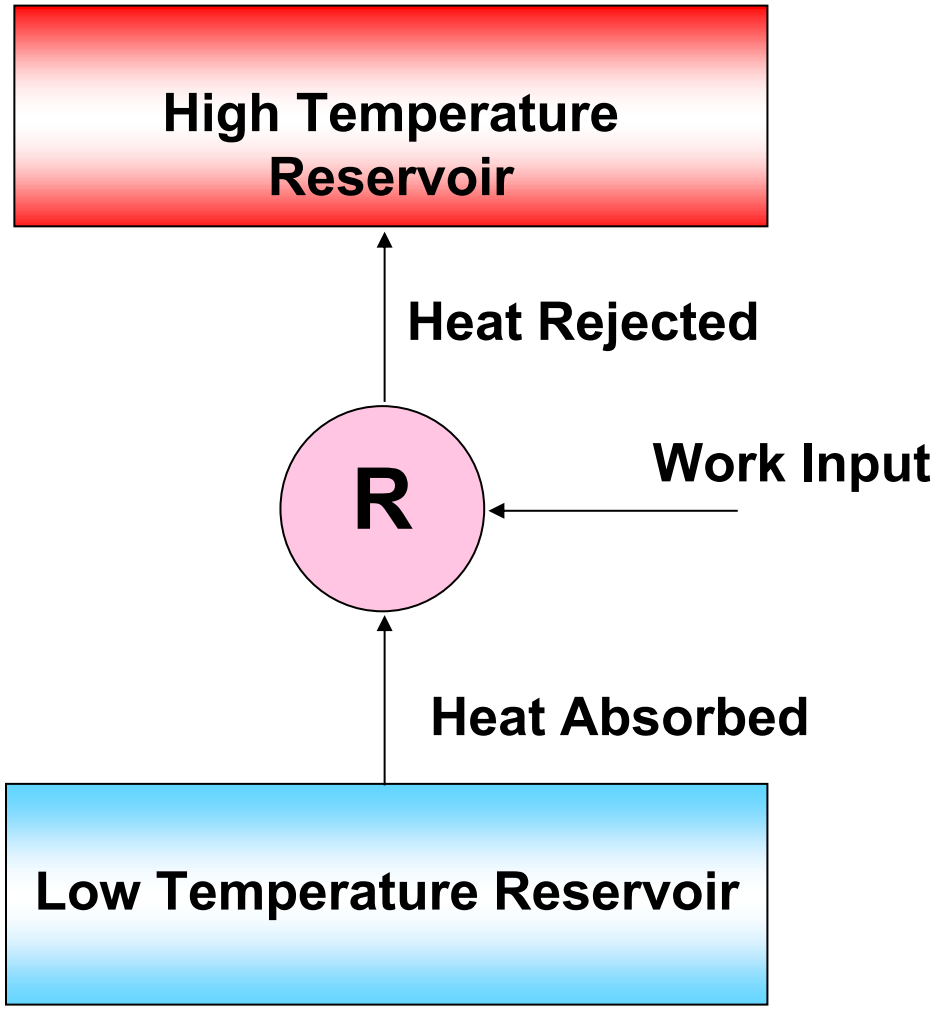
Refrigeration

What is Refrigeration??

- Refrigeration is the removal of heat from a material or space so that it's temperature is lower than that of it's surroundings.
- Heat transfer from lower temperature to higher temperature.

✓ But according to thermodynamics it is not possible until an extra work is done.

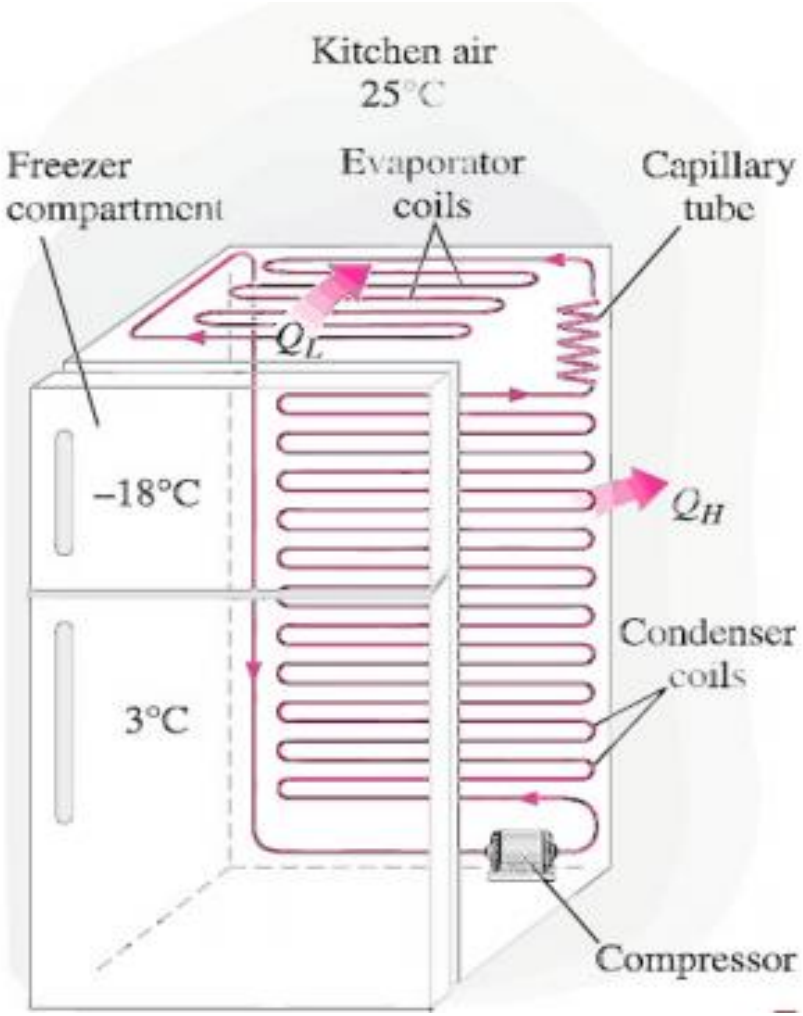
How does it work??



Applications

- Domestic Refrigeration
- Commercial Refrigeration
- Industrial Refrigeration
- Marine & Transportation Refrigeration
- Comfort Air Conditioning
- Industrial Air Conditioning

Domestic Refrigeration



Commercial Refrigeration

Commercial Refrigeration

- ✓ Meats, poultry and fish all must be kept in climate-controlled environments before being sold.

Industrial Refrigeration

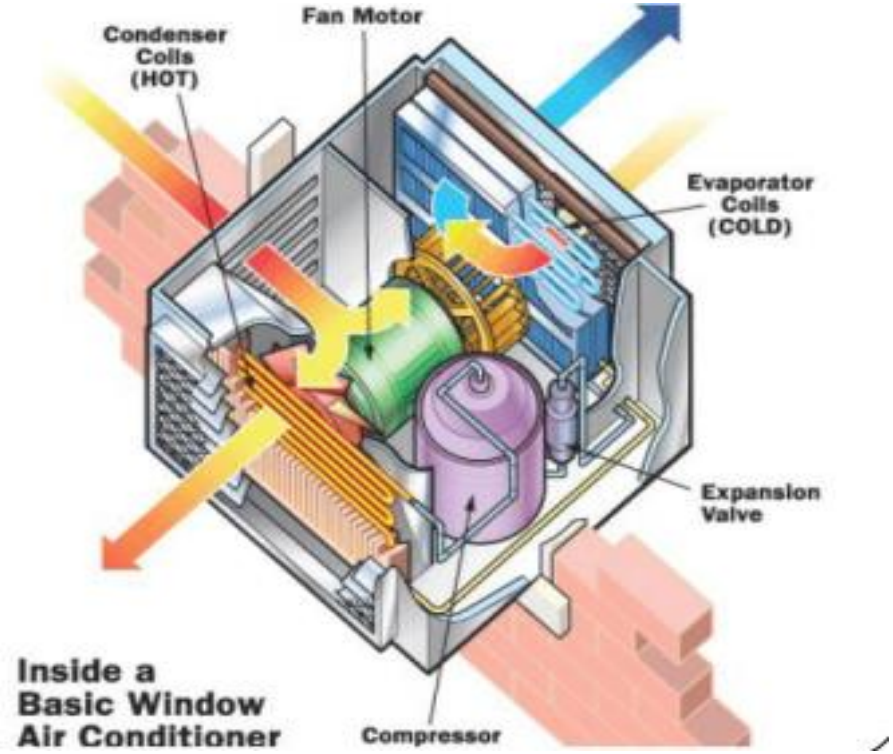
Industrial Refrigeration

- ✓ Cold storage: for Fruits, Vegetables, Fish, Meat etc.

Comfort Air-conditioning

- ✓ Comfort air-conditioning is for human comfort.
- ✓ It involves control of space temperature, humidity, ventilation and, air-motion and cleaning/filtering of air.

Window type A/C



Inside a Basic Window Air Conditioner

Industrial Air-conditioning

- ✓ Air conditioning and dust removal of the machines is extremely important in the weaving mill.

Industrial Air-conditioning

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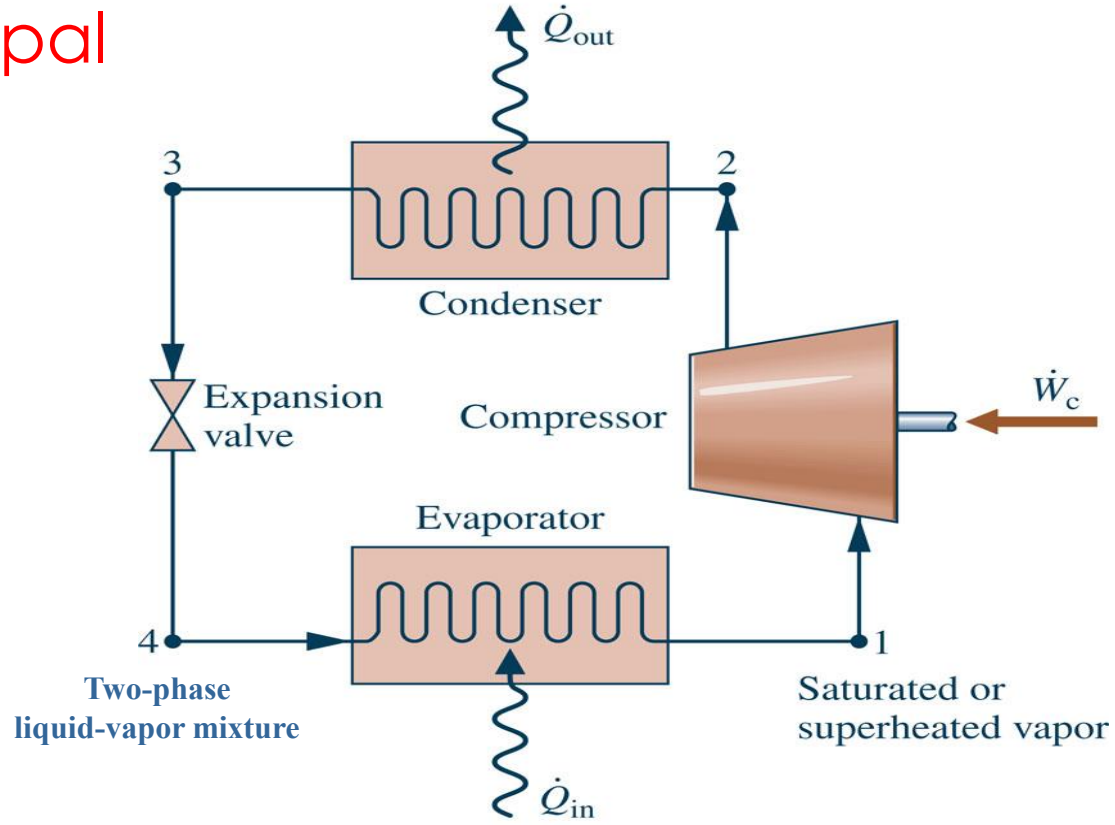
Classifications

Based on Energy Input

- Vapor-Compression Refrigeration System
- Absorption Refrigeration System

Vapor-Compression Refrigeration Cycle

- Most common refrigeration cycle in use today
- There are four principal control volumes involving these components:
  - Evaporator
  - Compressor
  - Condenser
  - Expansion valve



Vapor-Compression Refrigeration Cycle

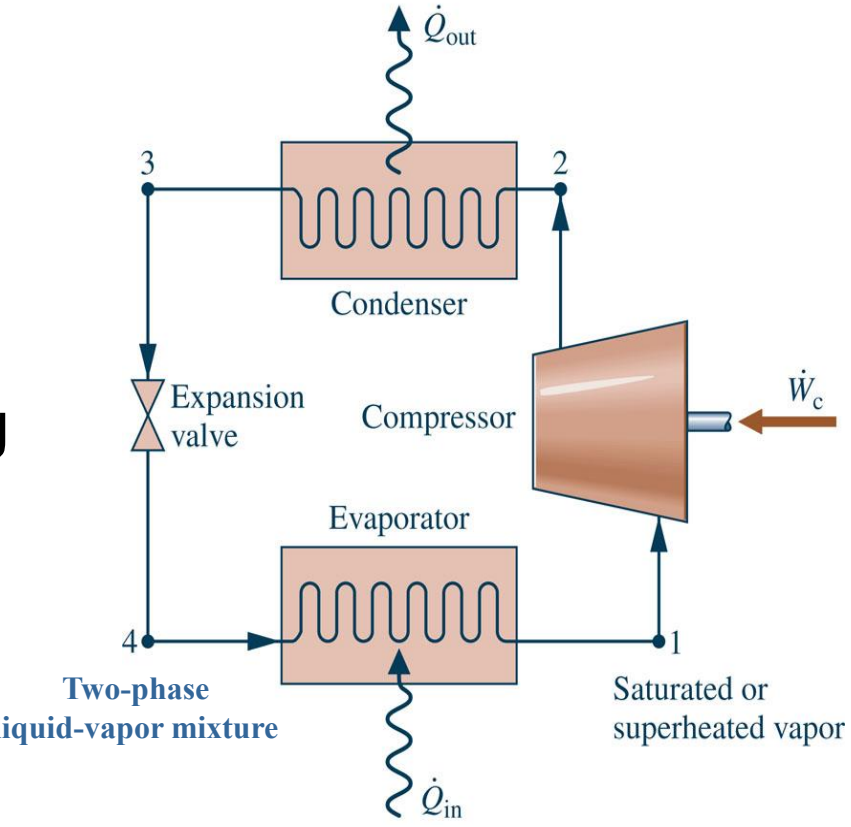
- The processes of this cycle are

Process 4-1: two-phase liquid-vapor mixture of refrigerant is evaporated through heat transfer from the refrigerated space.

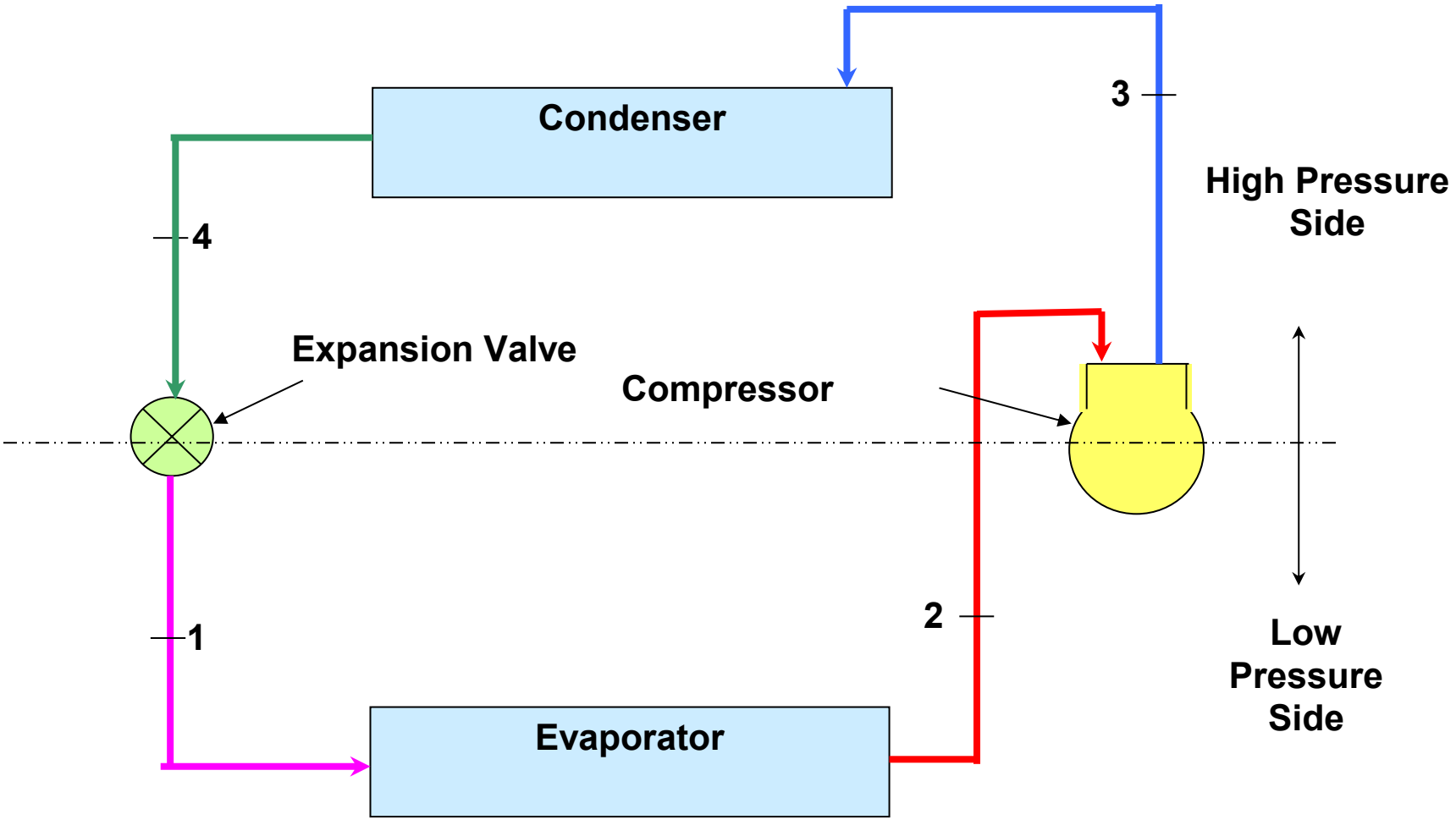
Process 1-2: vapor refrigerant is compressed to a relatively high temperature and pressure requiring work input.

Process 2-3: vapor refrigerant condenses to liquid through heat transfer to the cooler surroundings.

Process 3-4: liquid refrigerant expands to the evaporator pressure.



Vapor-Compression Refrigeration Cycle



Key Components of a Refrigerator

1.Evaporator

2.Suction line

3.Vapor compressor

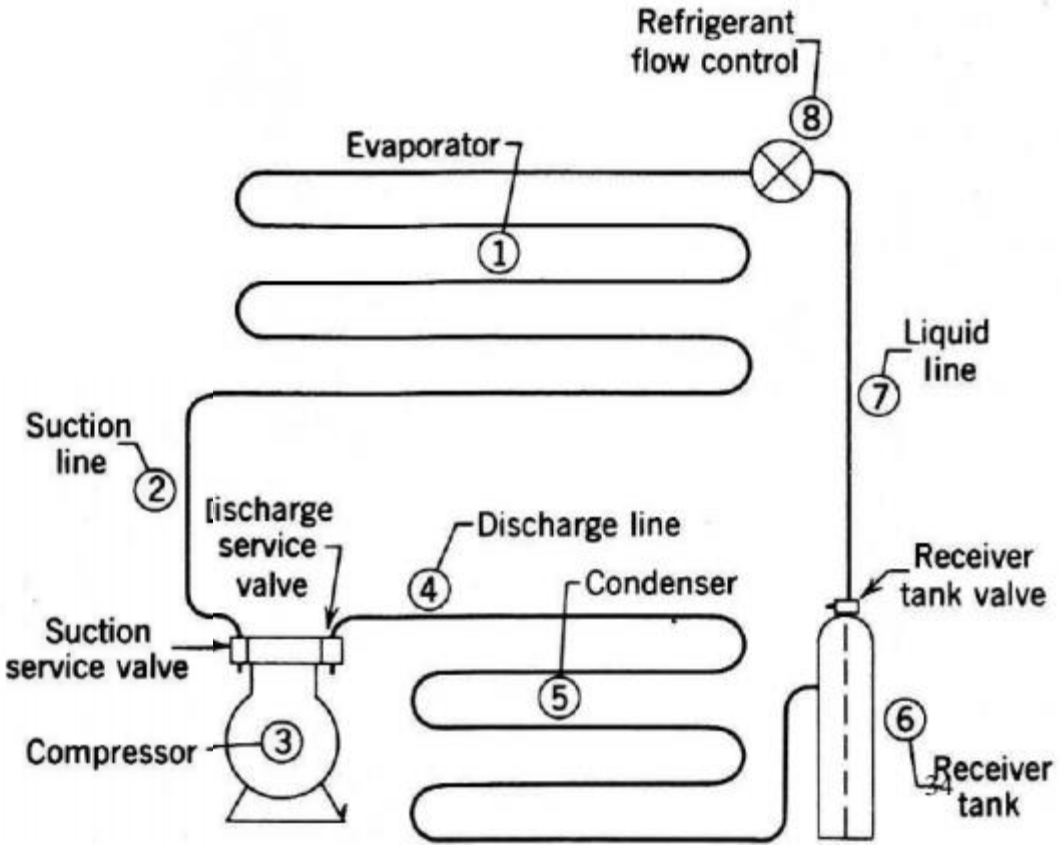
4. Hot gas/discharge line

5.Condenser

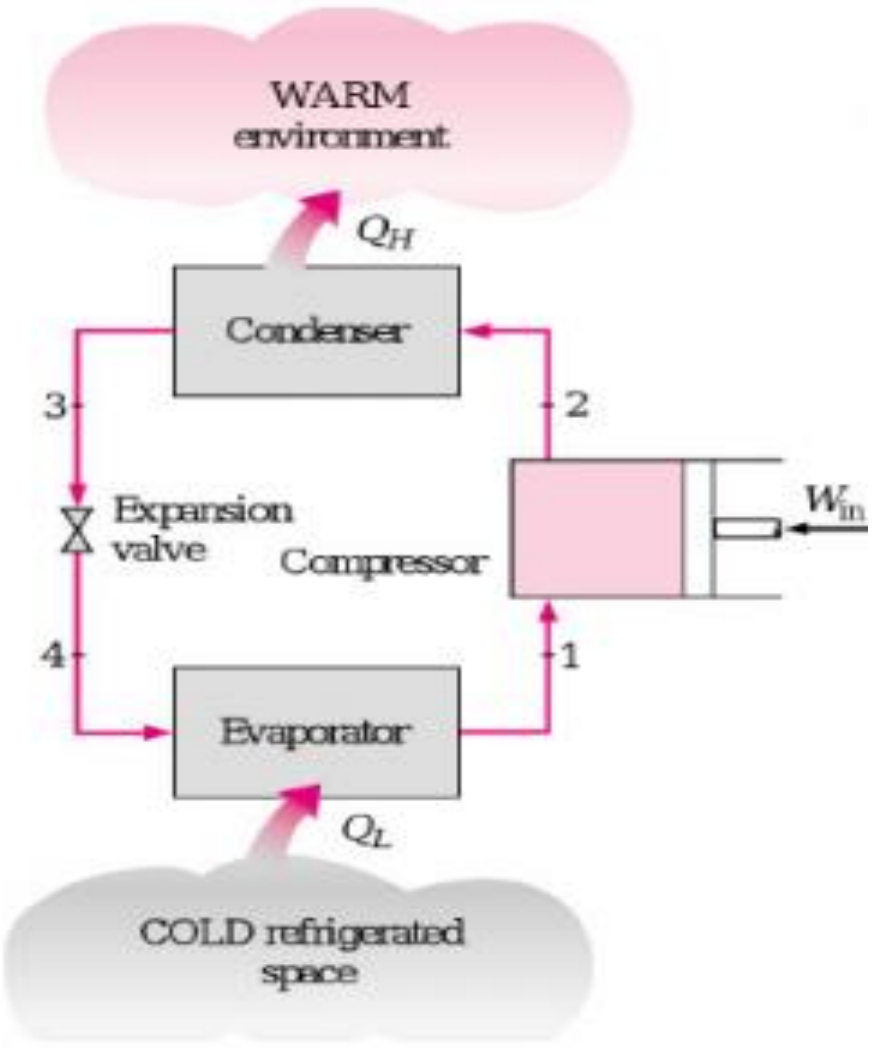
6.Receiver tank

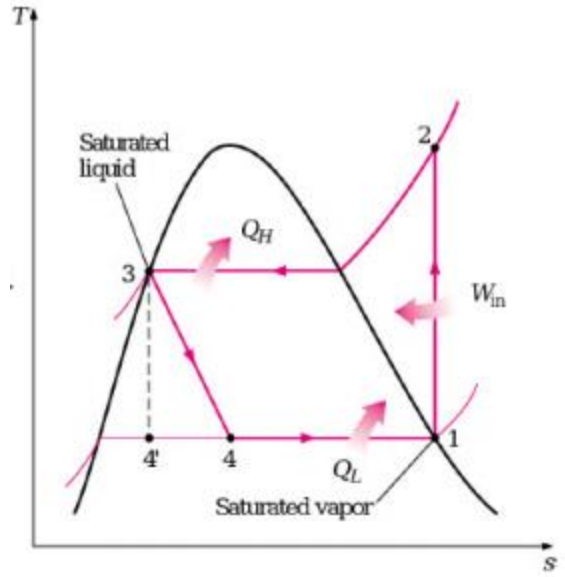
7.Liquid line

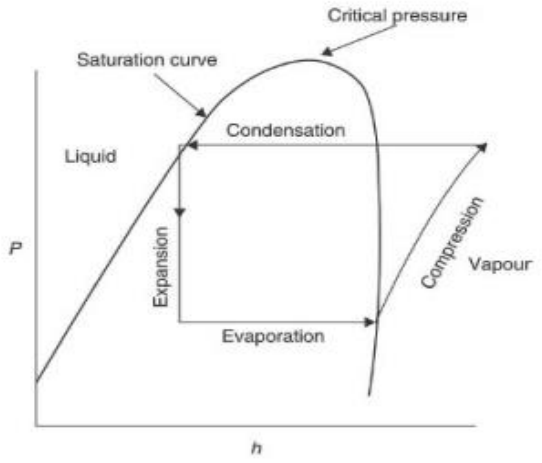
8.Refrigerant flow control device



Ideal Vapor-Compression Refrigeration Cycle



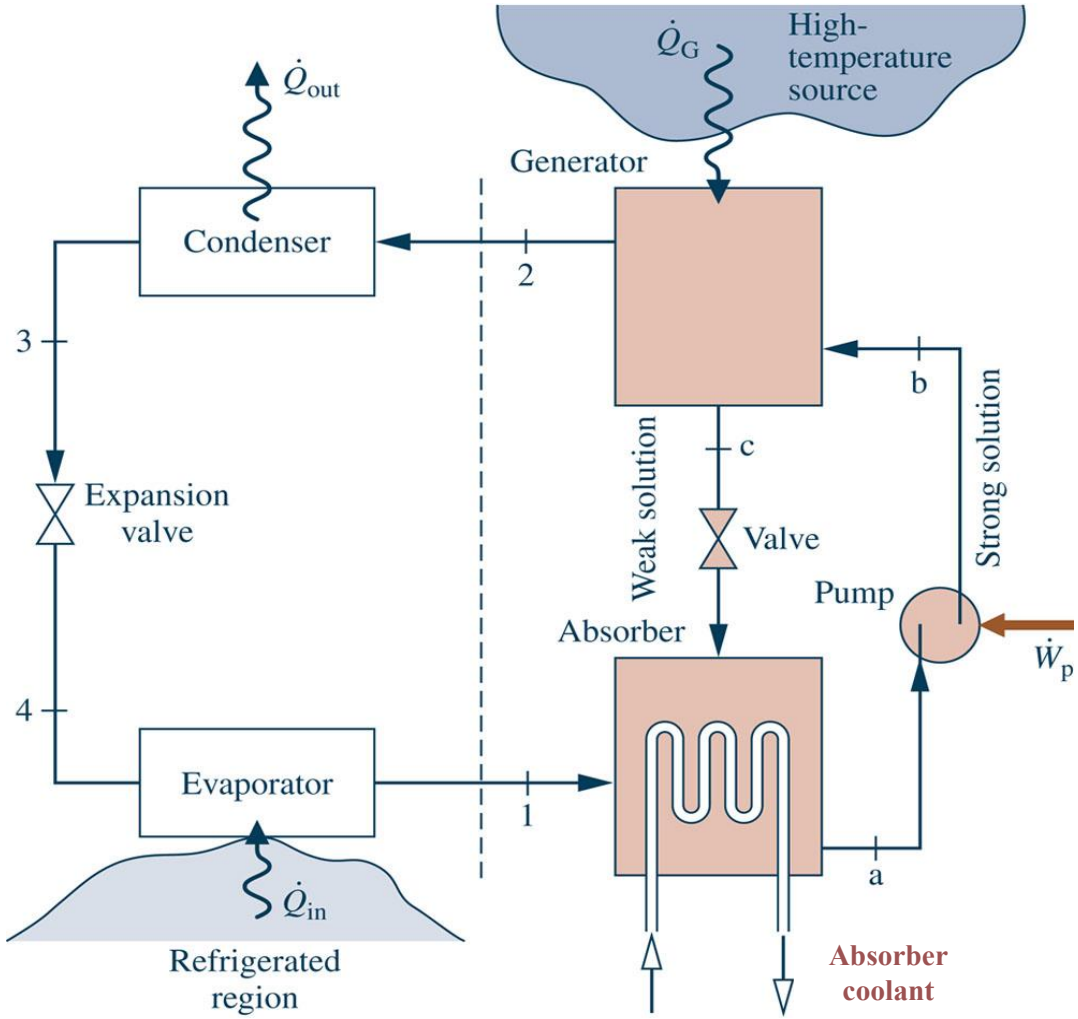




Ammonia-Water Absorption Refrigeration

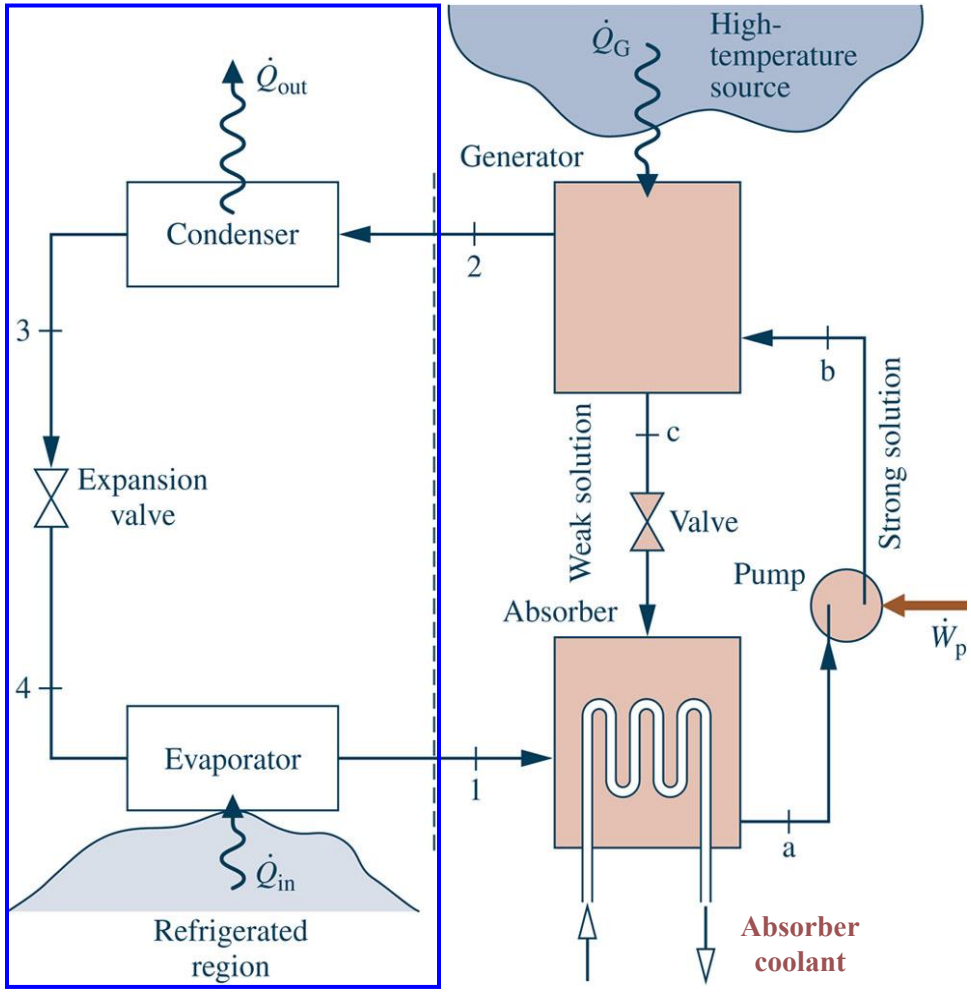
►Absorption refrigeration systems have important commercial and industrial applications.

►The principal components of an ammonia-water absorption system are shown in the figure.



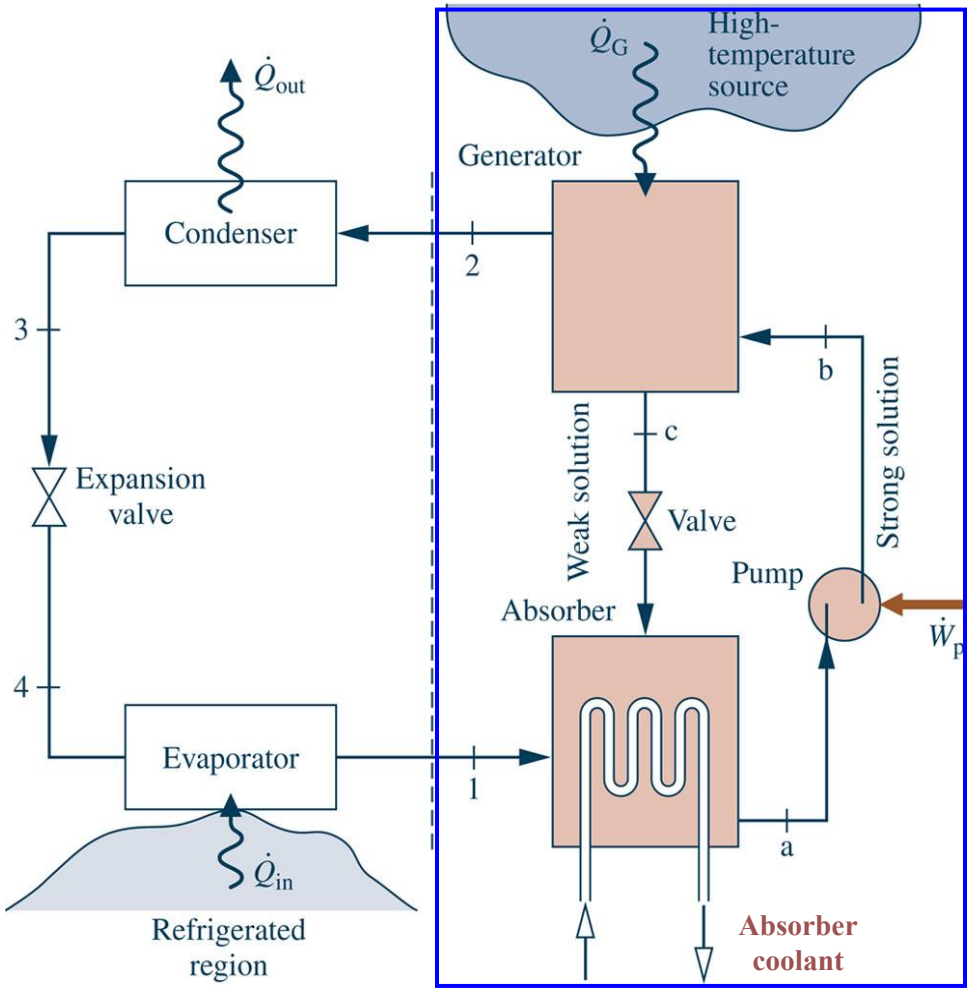
Ammonia-Water Absorption Refrigeration

►The left-side of the schematic includes components familiar from the discussion of the vapor-compression system: evaporator, condenser, and expansion valve. **Only ammonia flows** through these components.



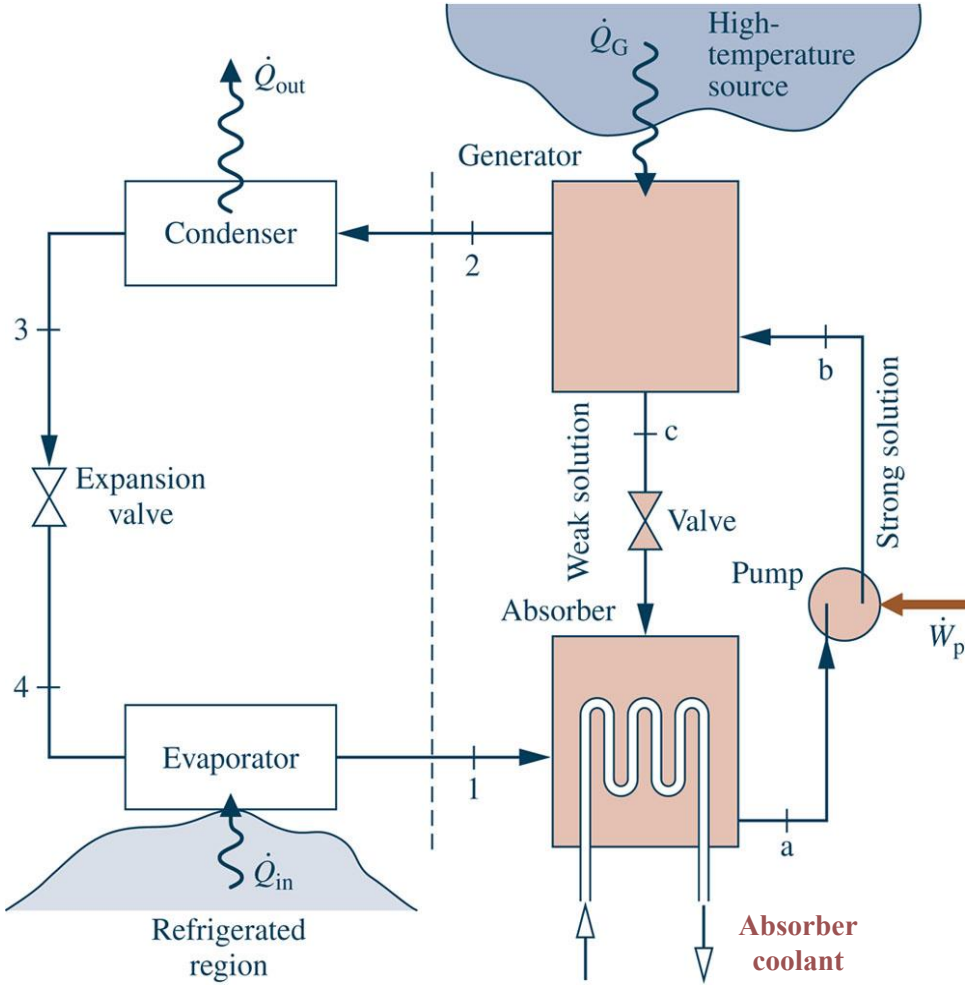
Ammonia-Water Absorption Refrigeration

►The right-side of the schematic includes components that replace the compressor of the vapor-compression refrigeration system: absorber, pump, and generator. These components involve **liquid ammonia-water solutions**.



Ammonia-Water Absorption Refrigeration

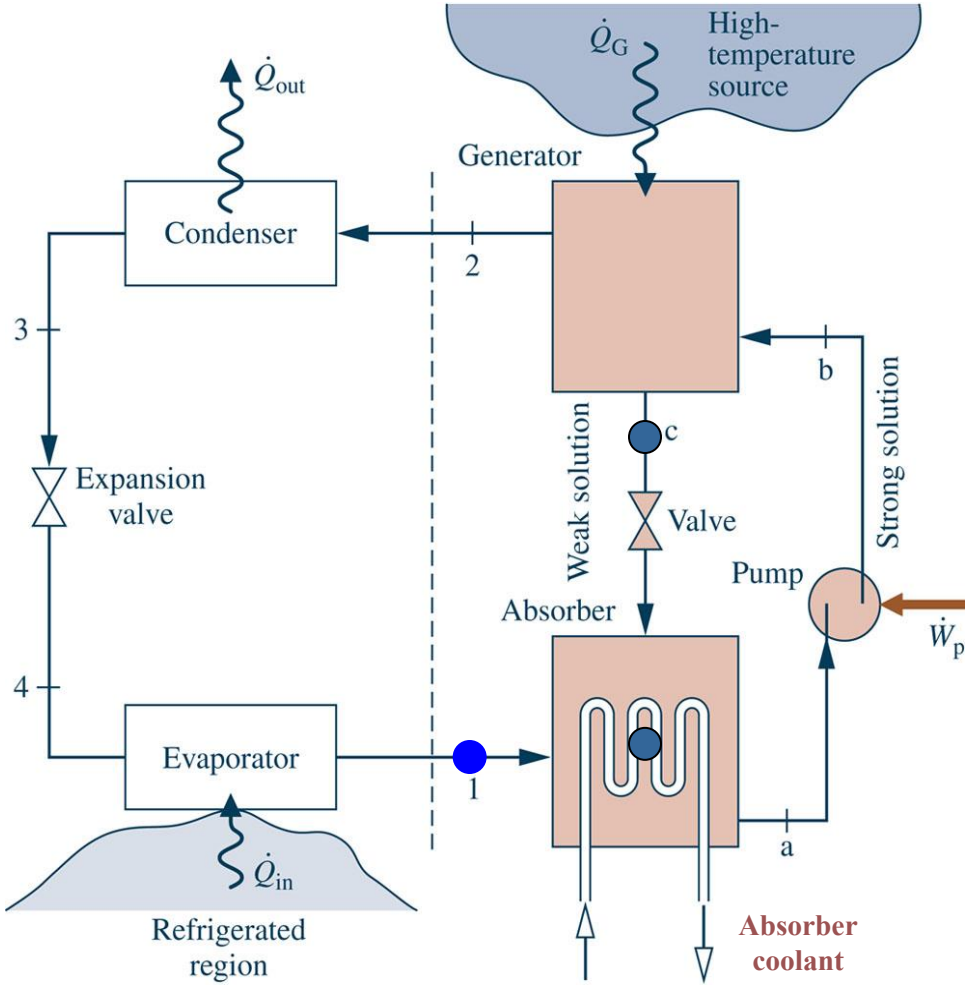
► A principal advantage of the absorption system is that – for comparable refrigeration duty – the pump work input required is much less than for the compressor of a vapor-compression system.



Ammonia-Water Absorption Refrigeration

►Specifically, in the absorption system ammonia vapor coming from the evaporator is absorbed in liquid water to form a liquid ammonia-water solution.

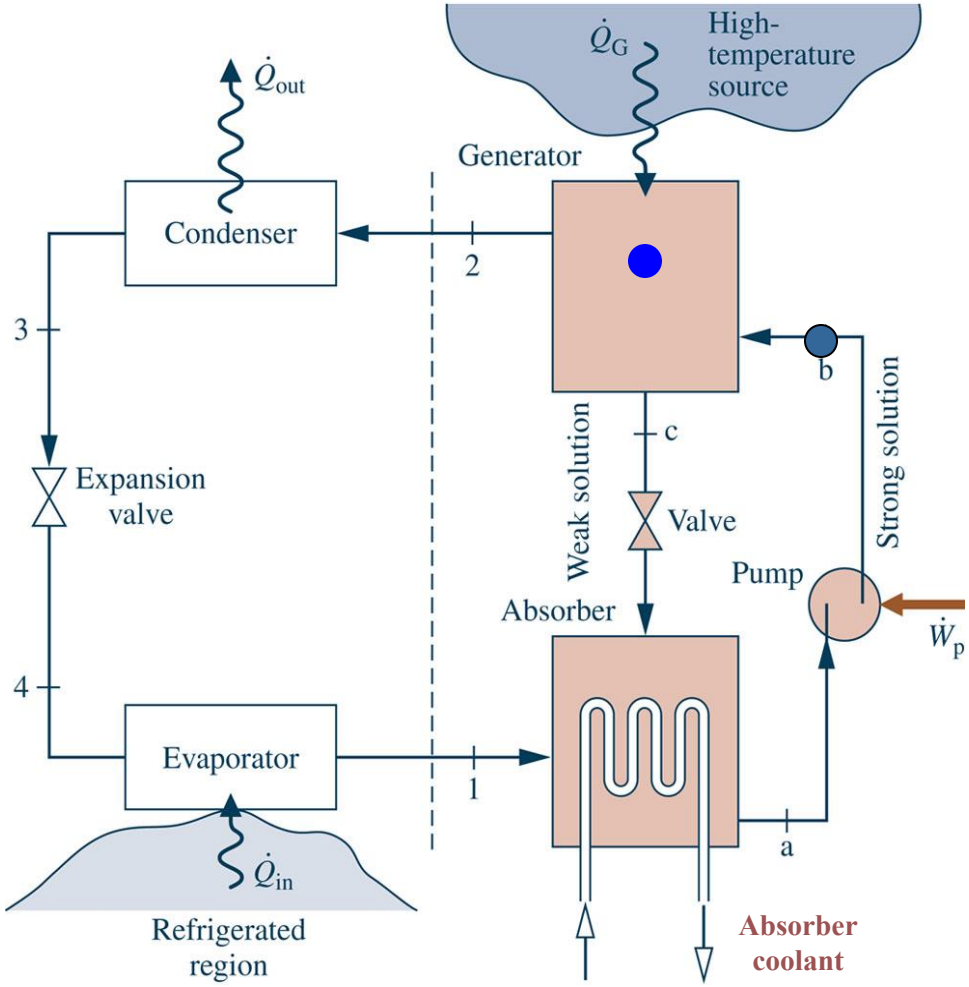
►The liquid solution is then ***pumped*** to the higher operating pressure. For the same pressure range, significantly less work is required to pump a liquid solution than to compress a vapor.



Ammonia-Water Absorption Refrigeration

►However, since only ammonia vapor is allowed to enter the condenser, a means must be provided to retrieve ammonia vapor from the liquid solution.

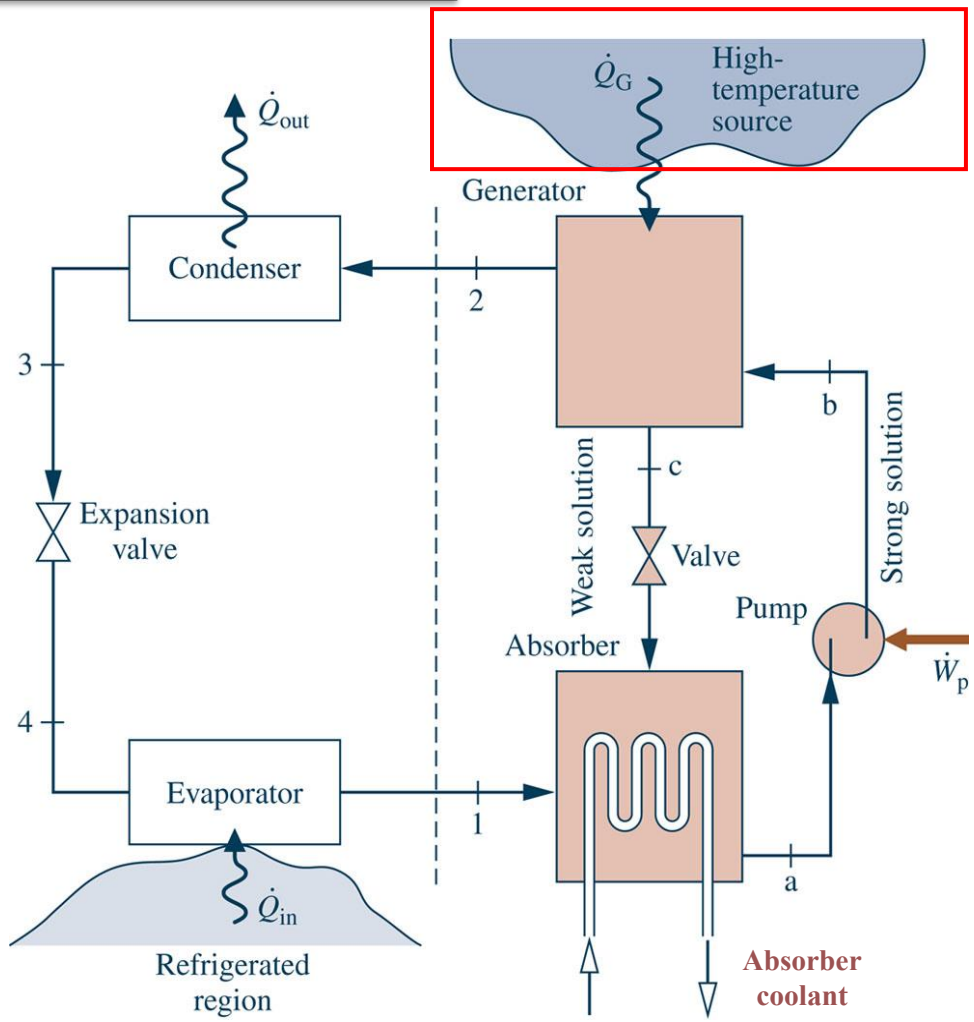
►This is accomplished by the ***generator*** using heat transfer from a relatively high-temperature source.



Ammonia-Water Absorption Refrigeration

►Steam or waste heat that otherwise might go unused can be a cost-effective choice for the heat transfer to the generator.

►Alternatively, the heat transfer can be provided by solar thermal energy, burning natural gas or other combustibles, and in other ways.



Refrigerant

- Desirable properties:
  - High latent heat of vaporization - max cooling
  - Non-toxicity (no health hazard)
  - Desirable saturation temp (for operating pressure)
  - Chemical stability (non-flammable/non-explosive)
  - Ease of leak detection
  - Low cost
  - Readily available
- Commonly use FREON (R-12, R-114, etc.)

Performance Parameter

- **1 ton refrigeration**: heat absorbed by 1 ton (2000 lb) of ice melting at 0°C in 24 hours.
- 1 ton ref. = 3.516 kW = 12000 BTU/hr = 200 BTU/min
- Coefficient of Performance, $COP = \frac{Refrigeration\ Effect}{Net\ Work\ Required}$

Problem-1. A vapor compression refrigeration system has to handle a cooling load of 2 ton. Find the power of the compressor in kW if the COP of the refrigeration system is given as 3.5.

Solution: $\mathbf{COP = Q_R/W_c}$ here, Q_R = Refrigerating capacity
W_c = Work input to the Compressor

Therefore, we get,

$3.5 = 2\ ton / W_c$

or, $W_c = (2\ ton) / 3.5 = (2\ ton) \times (3.5\ kW/1\ ton)/3.5 =$ **2 kW Ans.**

Air Conditioning

Introduction to Air Conditioning

- The process of controlling & maintaining the properties of air like temperature, humidity , purity , direction of flow etc. in a closed space.
- Refrigeration system is at heart of AC system

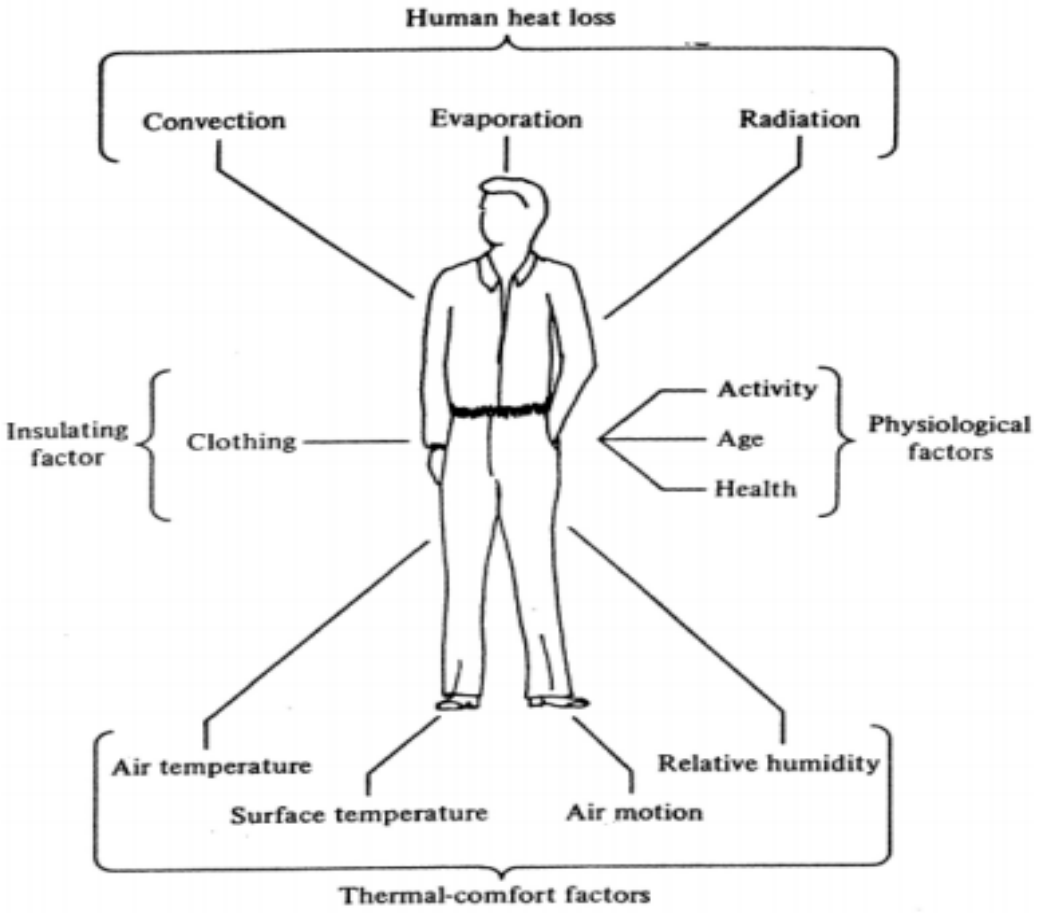
HVAC = Heating, Ventilation and Air Conditioning

ASHRAE = American Society of Heating, Refrigerating, and Air-Conditioning Engineers

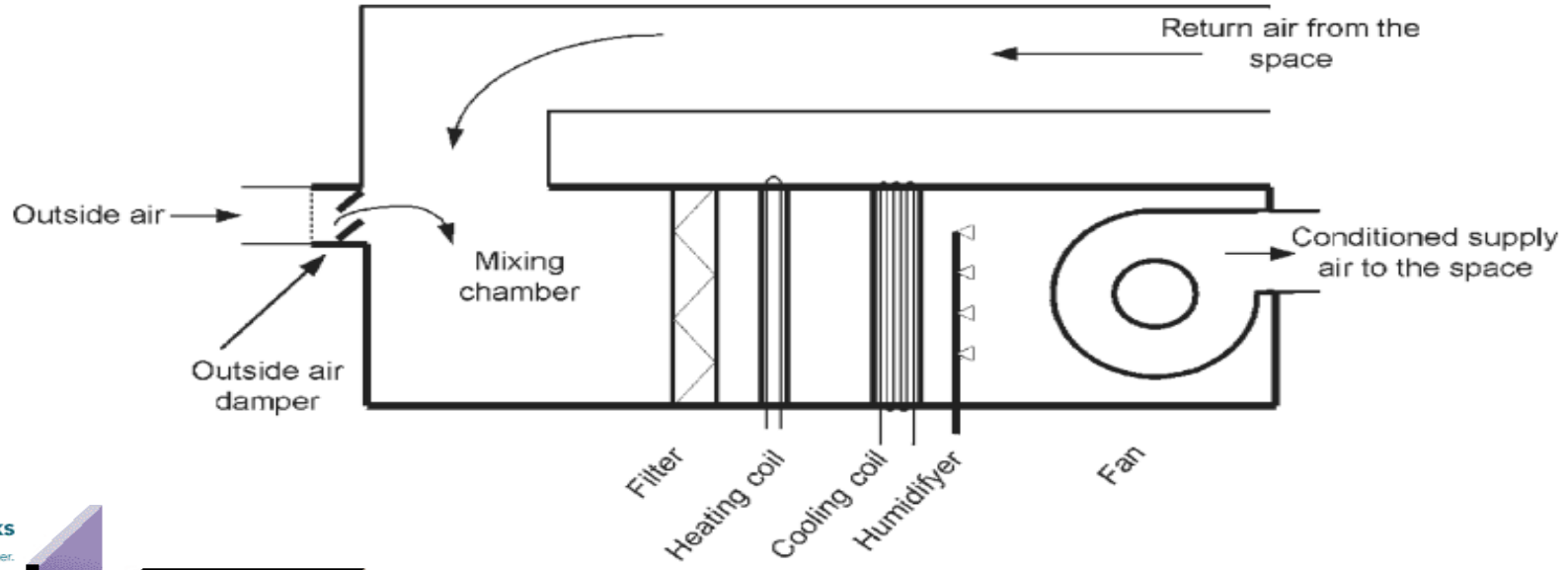
Factors Influencing Thermal Comfort

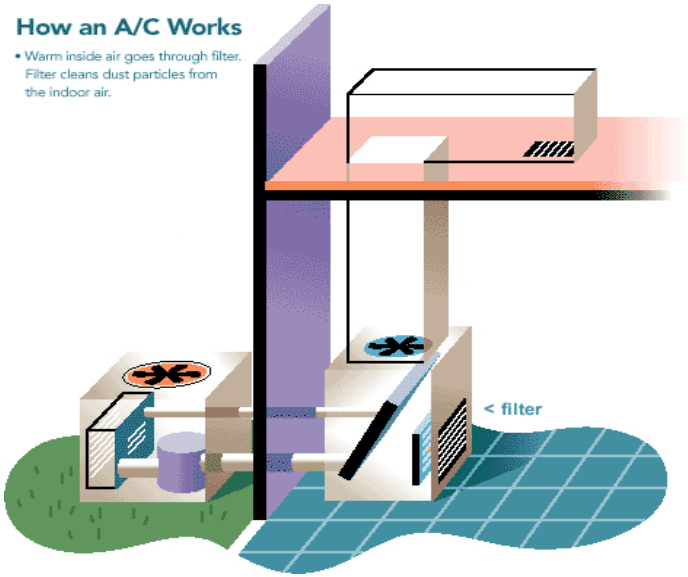
Seven Factors Influencing Thermal Comfort

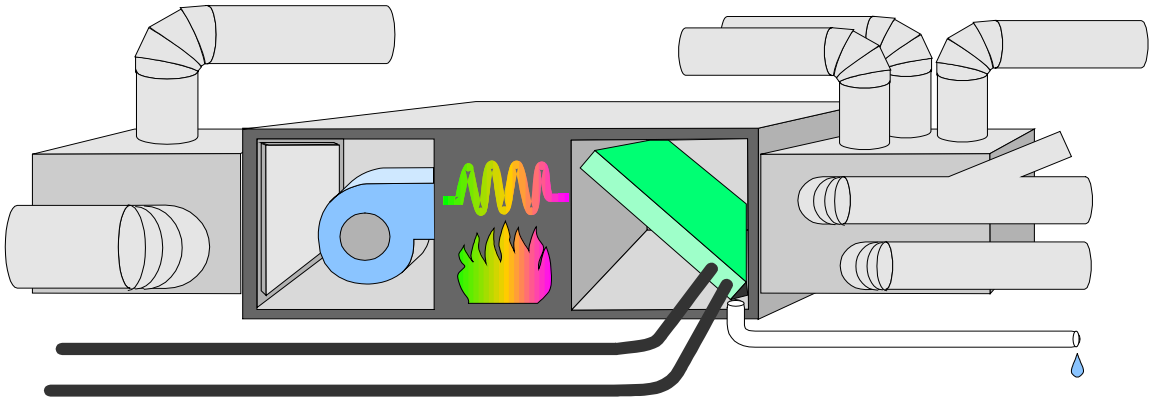
1. Activity level
2. Clothing
3. Expectation
4. Air temperature
5. Radiant temperature
6. Humidity
7. Air speed



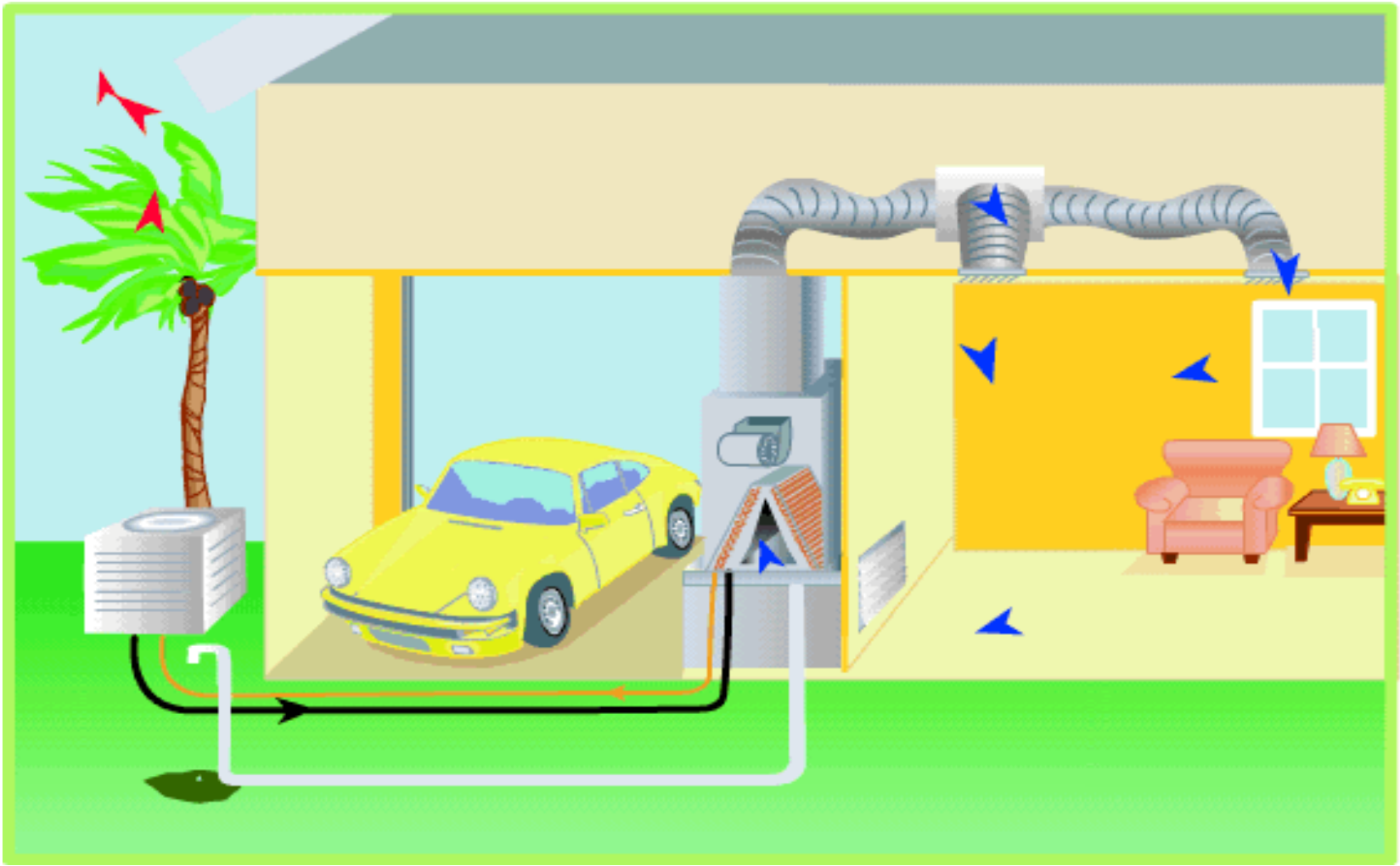
Basic Air Conditioning System



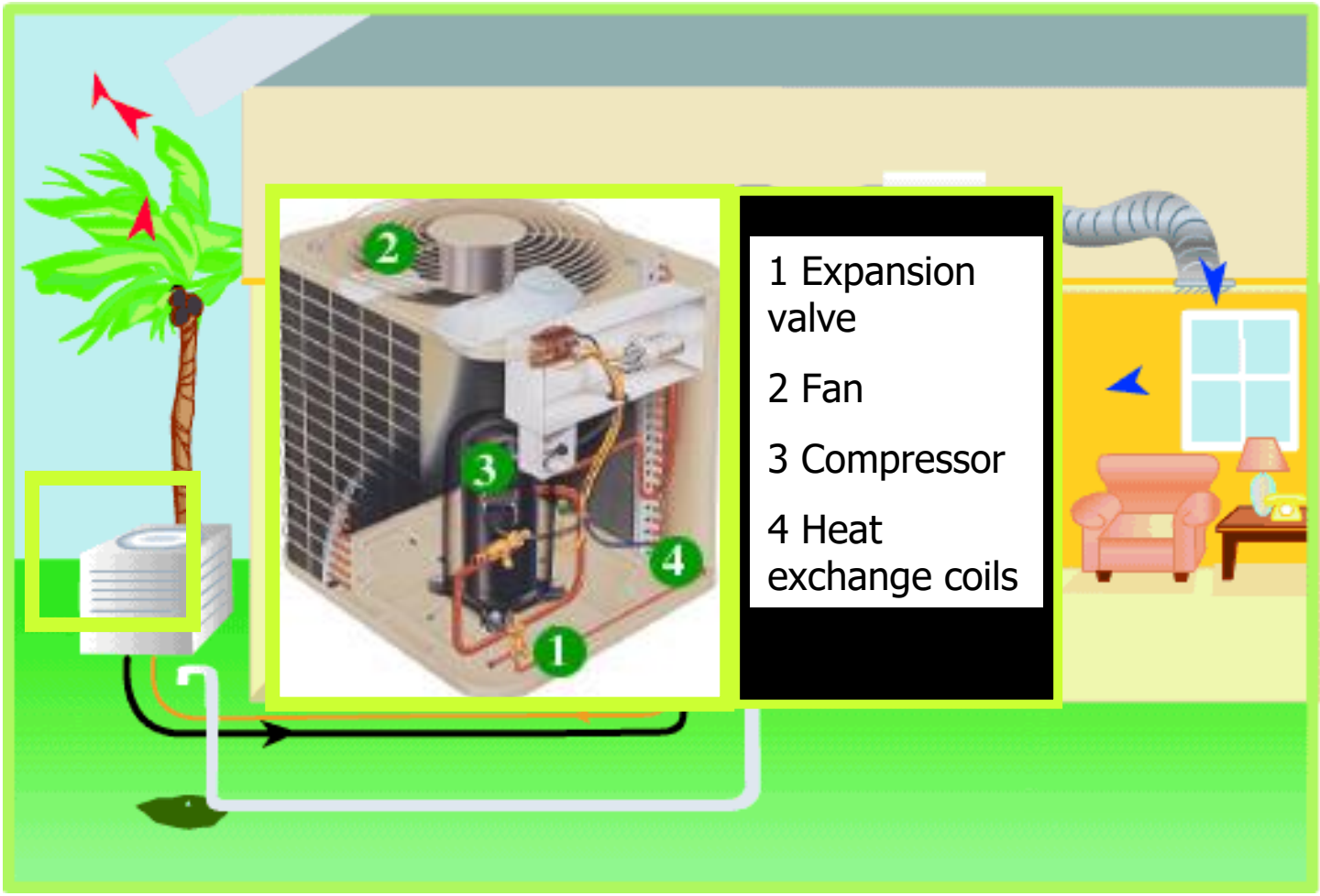




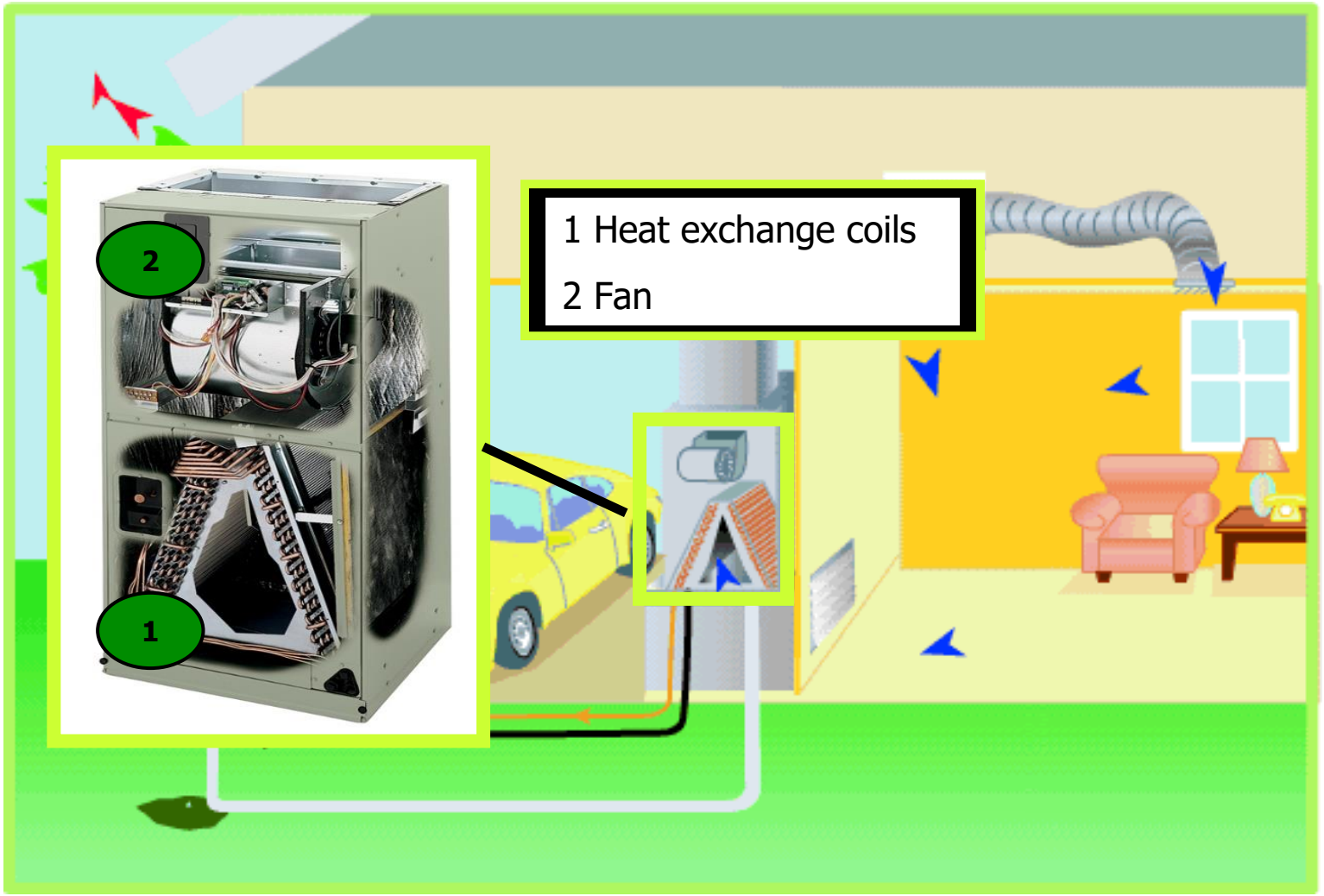
HVAC Components



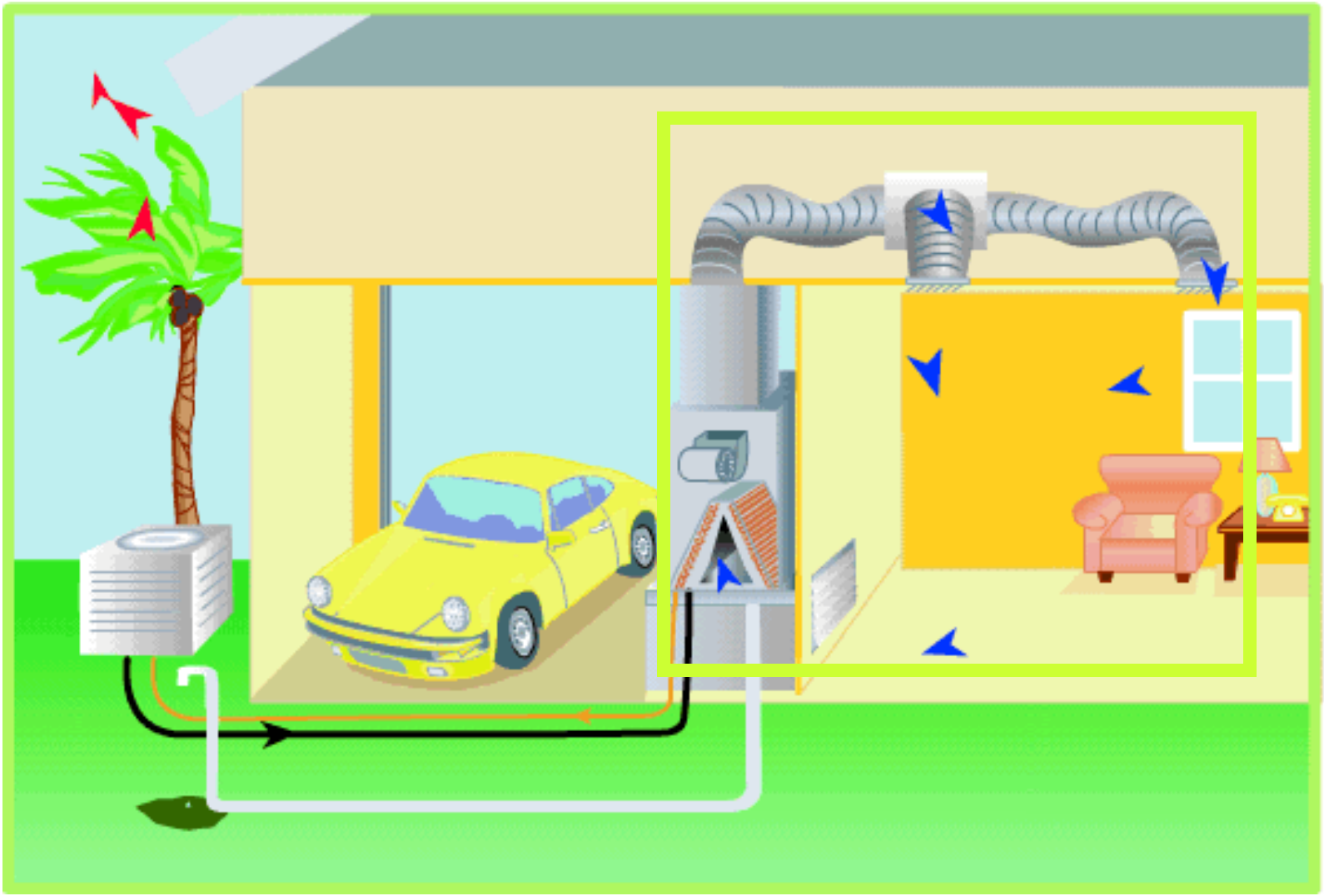
HVAC Components - Condenser



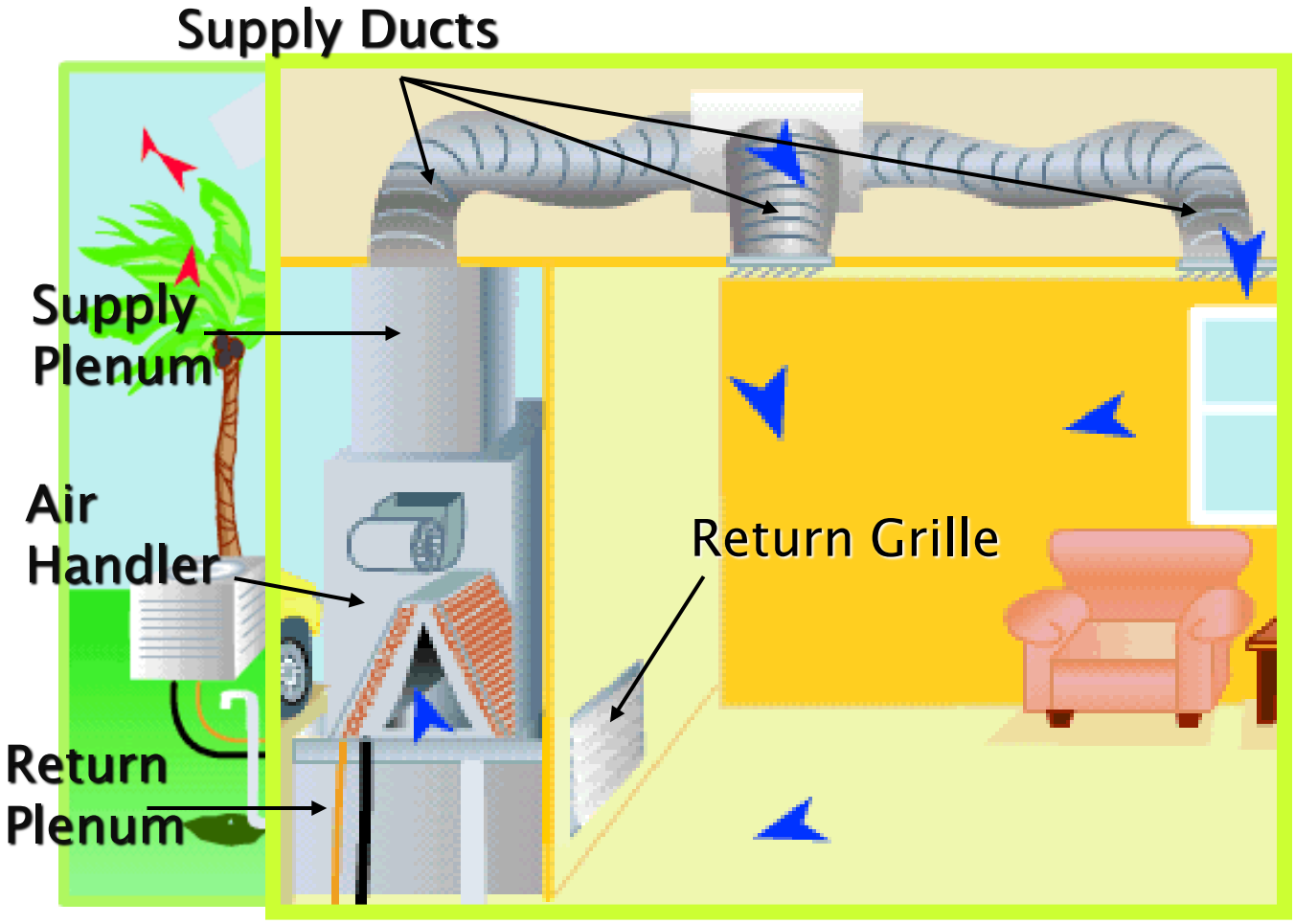
HVAC Components – Air Handler



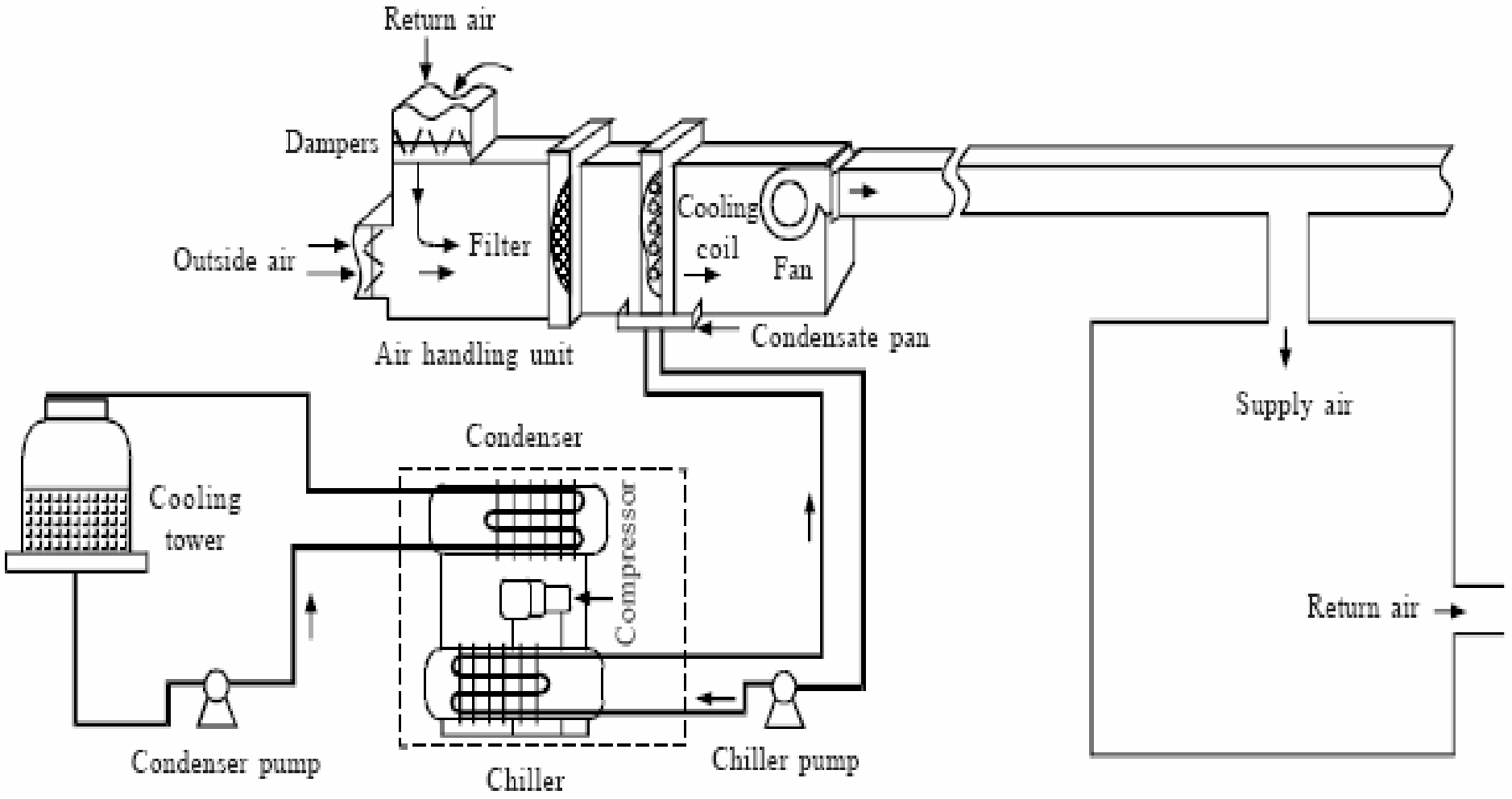
HVAC Components – Duct System



HVAC Components – Duct System



Conventional Air Conditioning System



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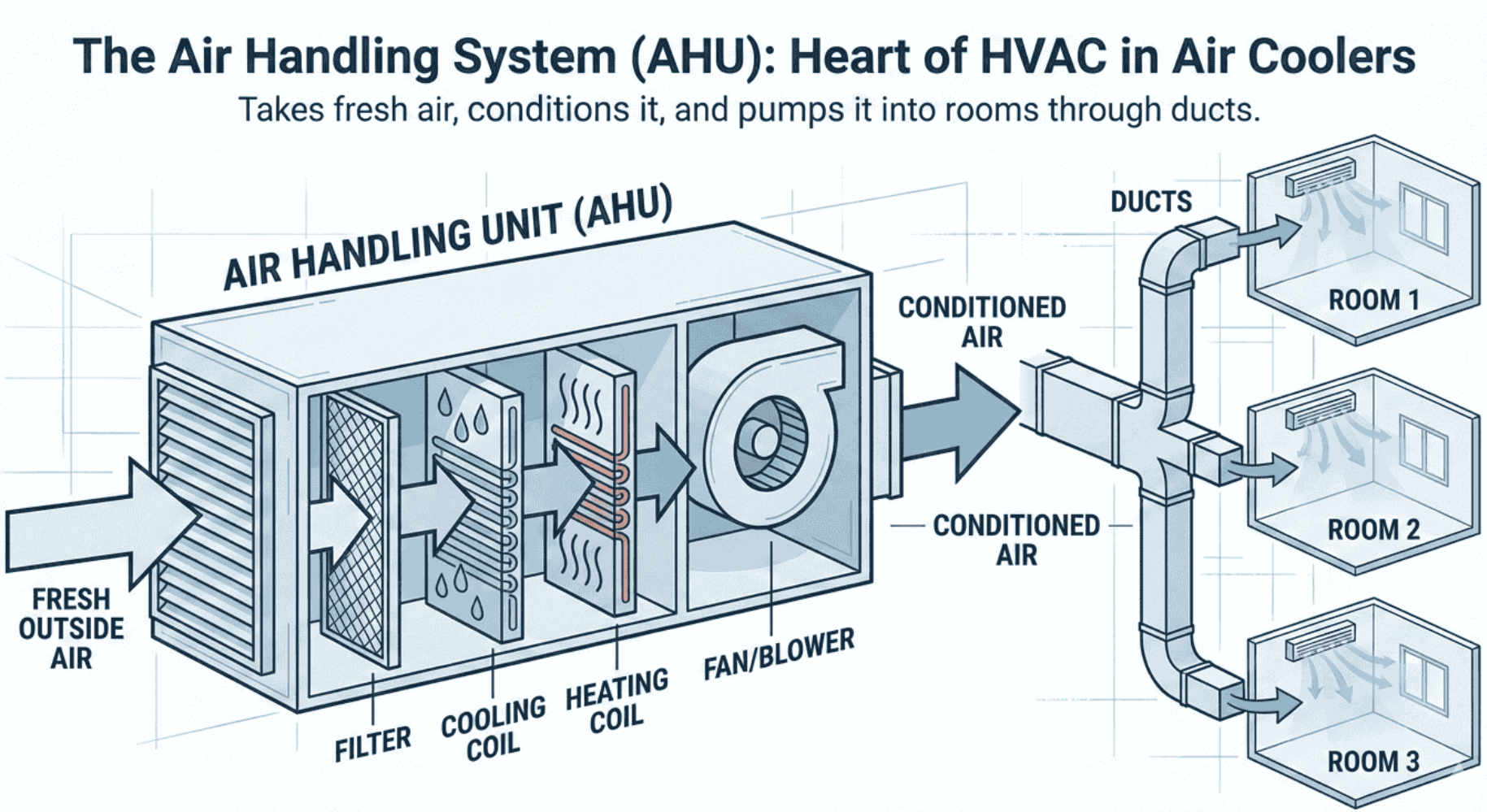

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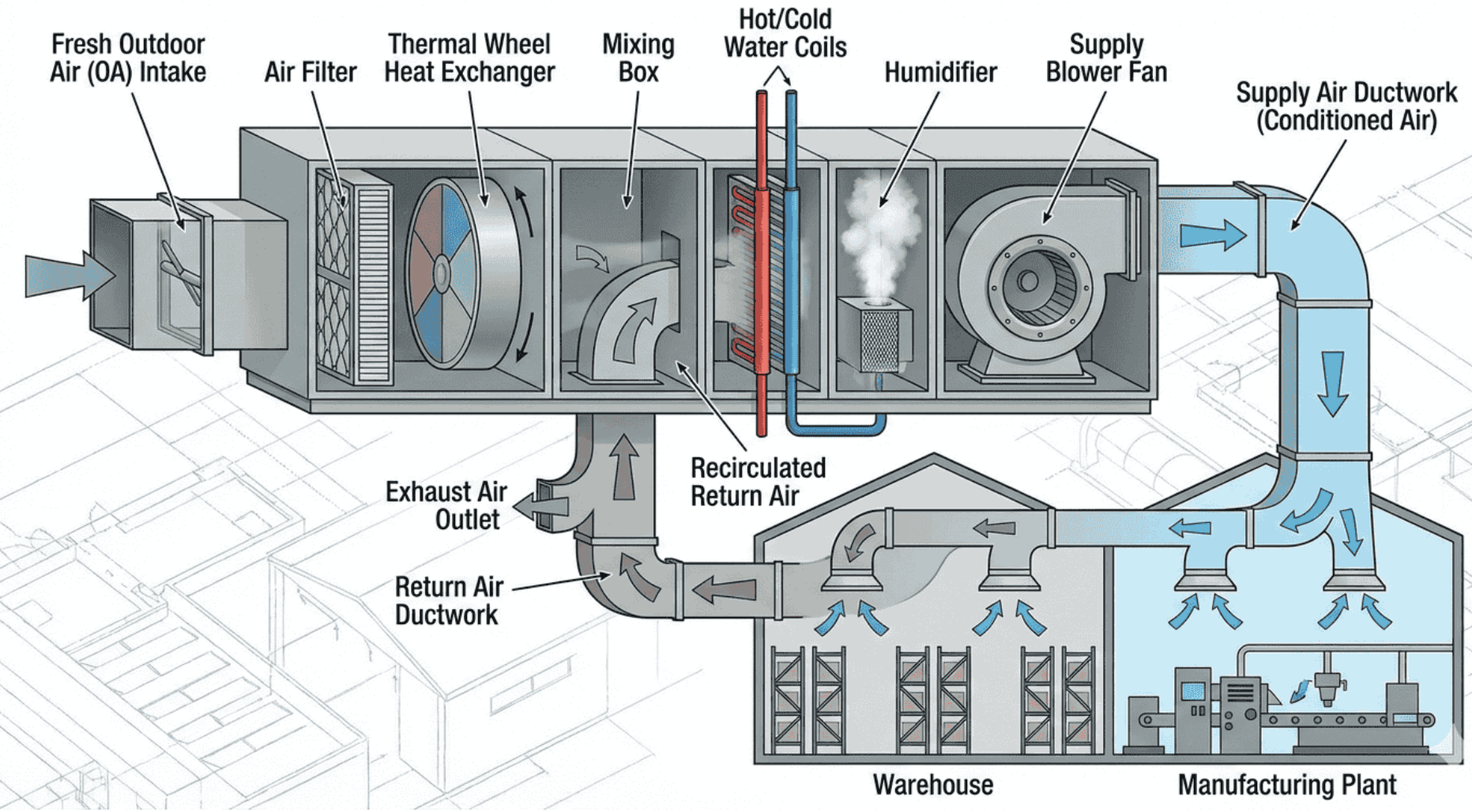
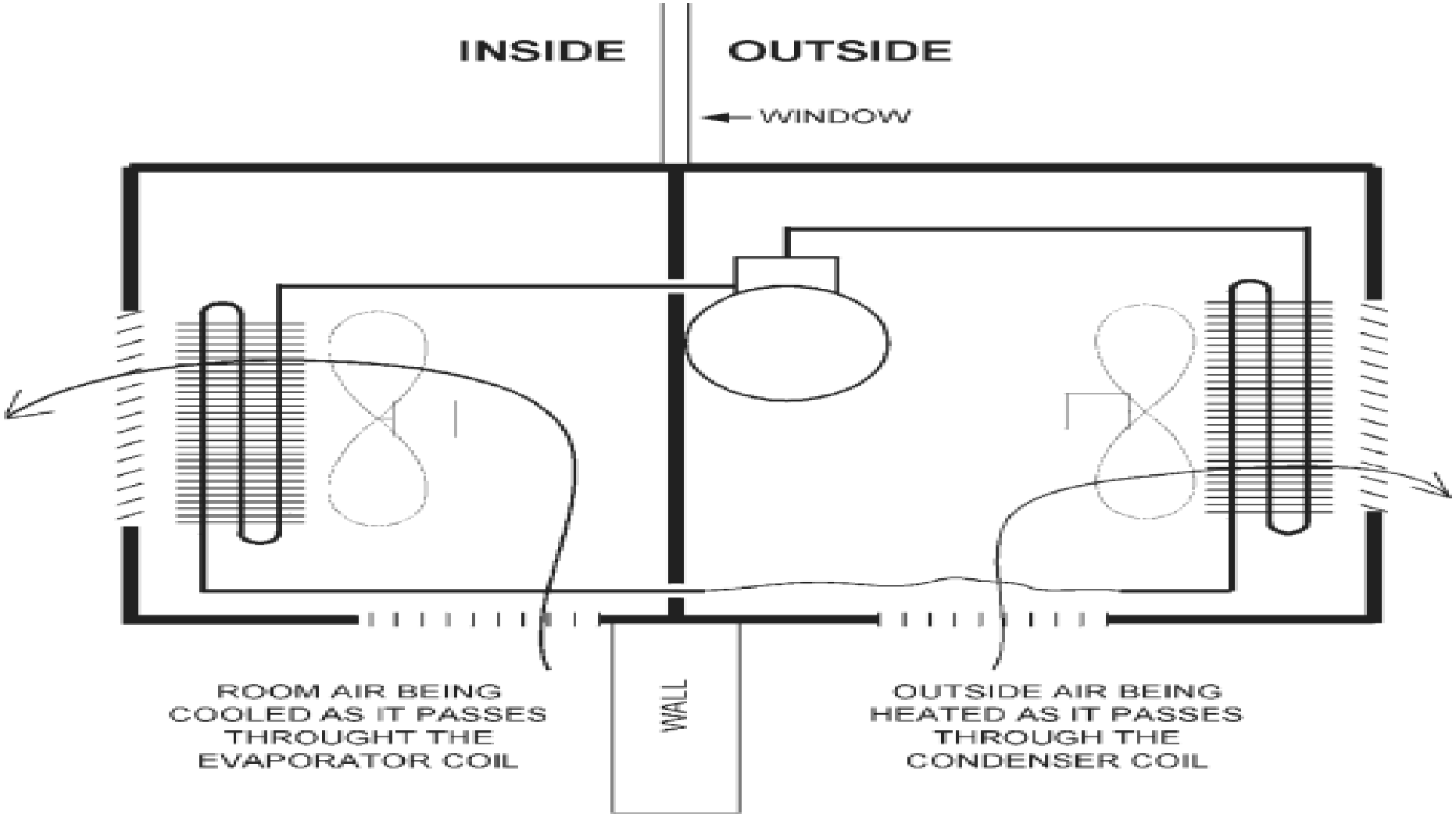


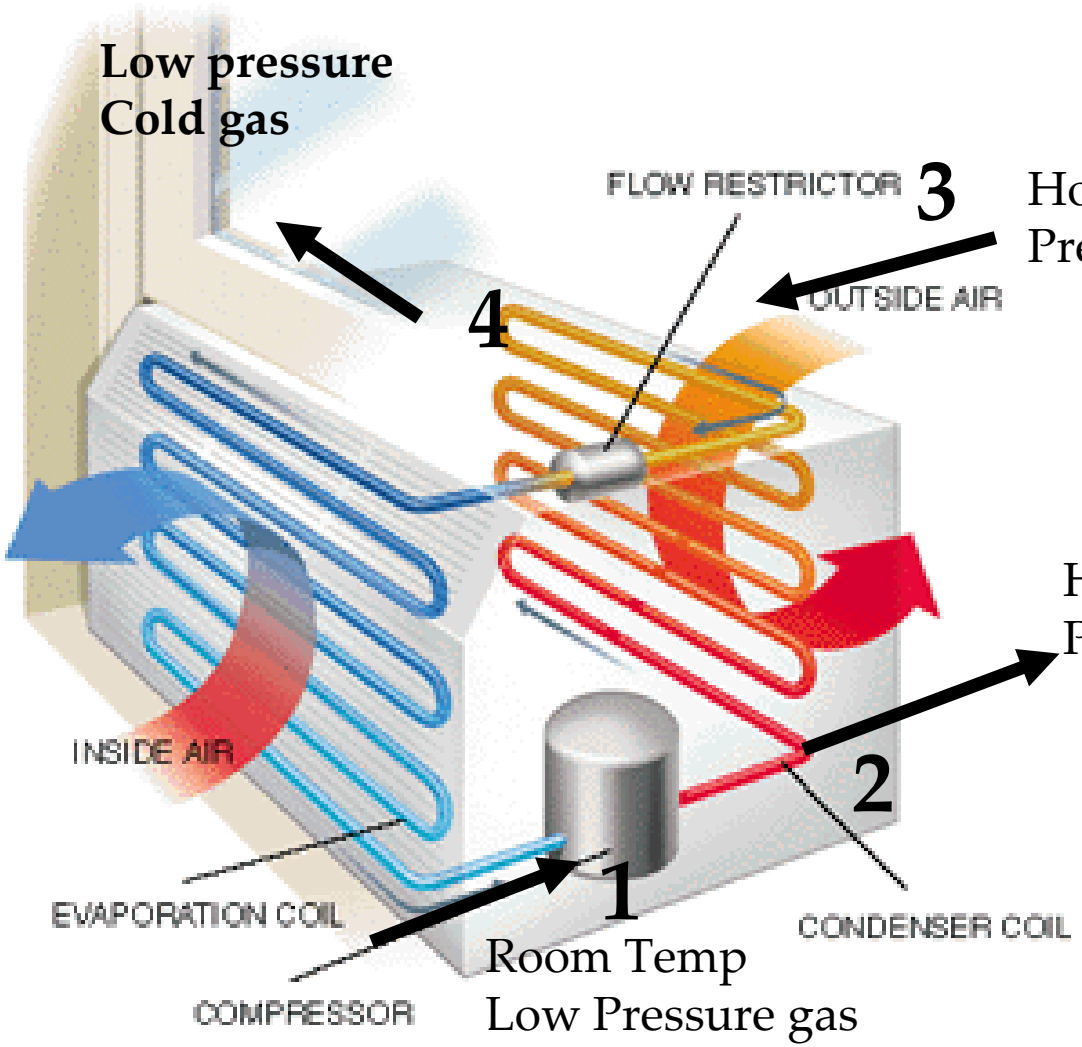
Window type Air Conditioner



Anatomy of a Window type A/C

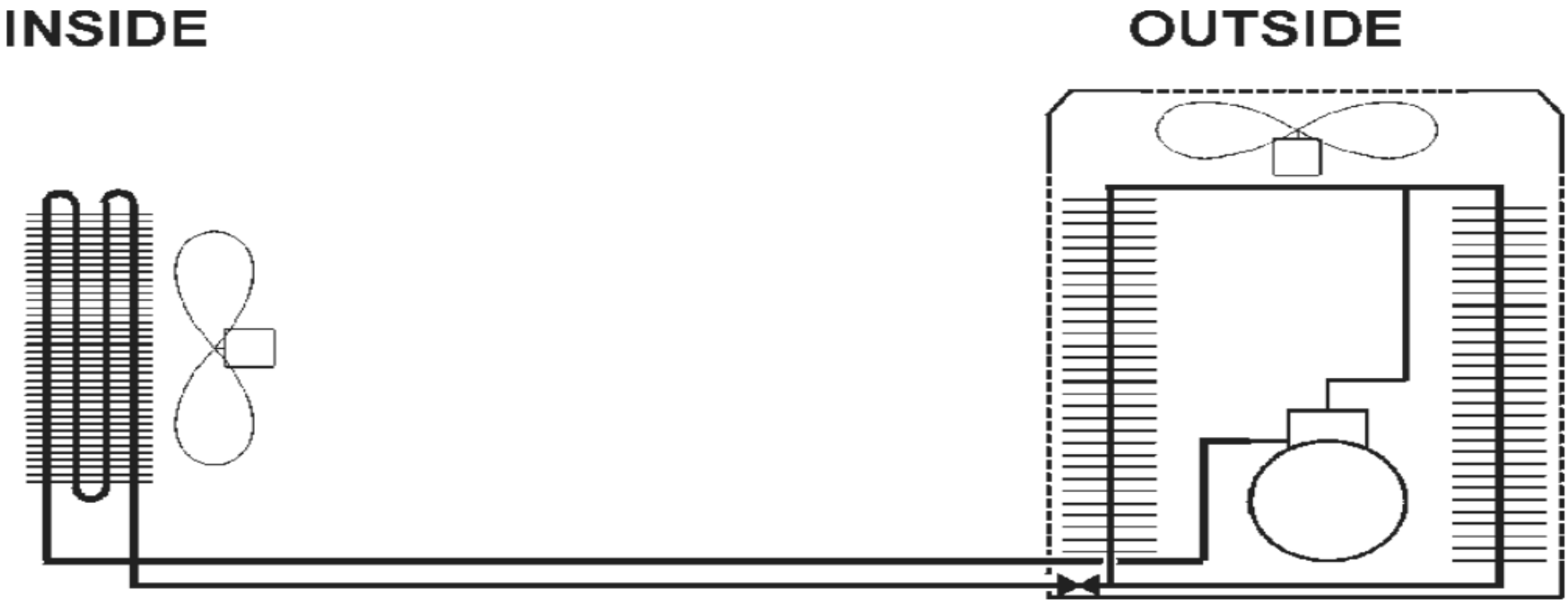
Outside Building

Inside Building



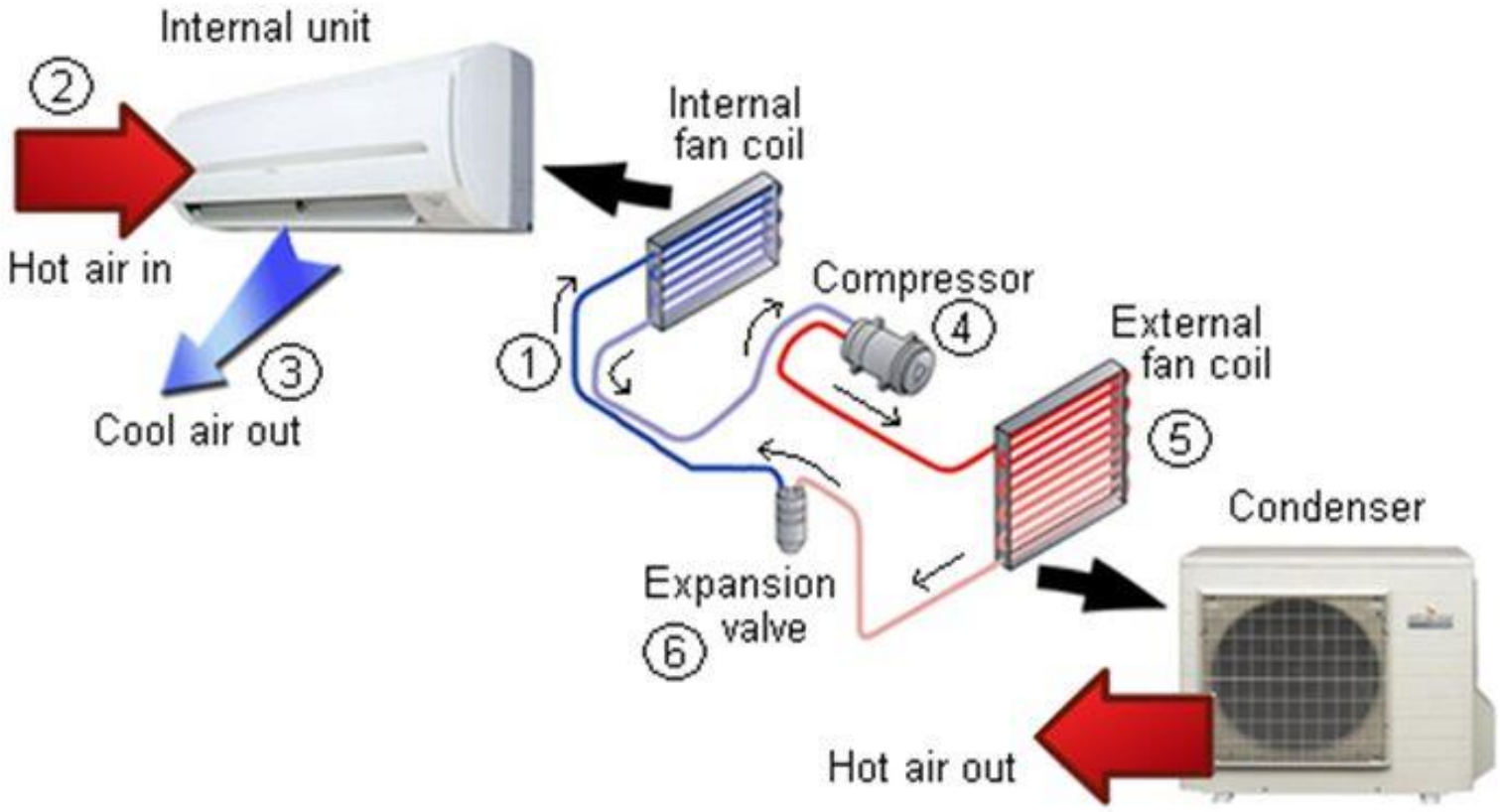
Split System A/C

- Condenser separates from the evaporator.

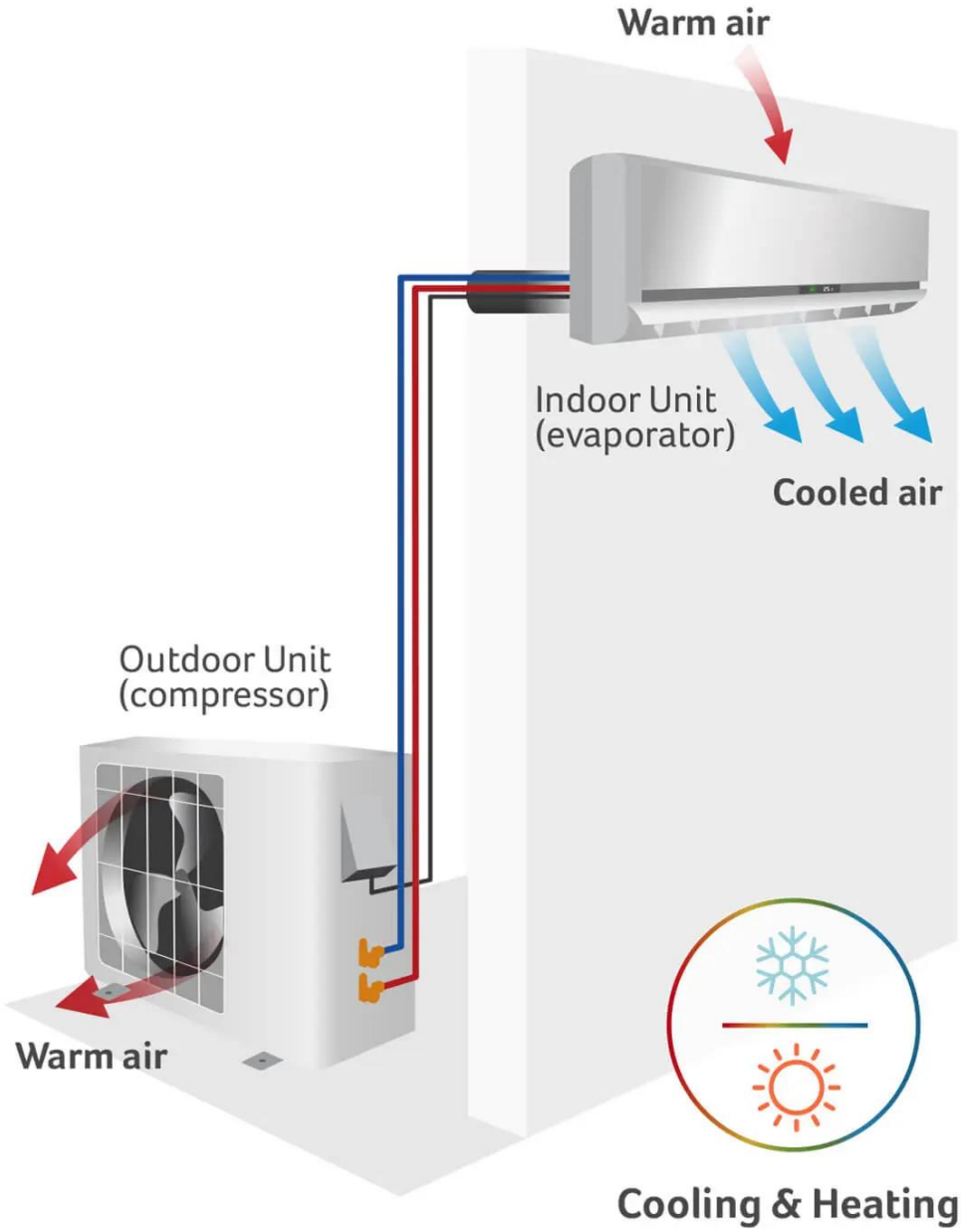


- It enables to locate the condenser elsewhere.

Split System A/C



Split System A/C



Enough for today.