Selection of air conditioning systems

Prof. M. Ramgopal
Department of Mechanical Engineering
IIT Kharagpur

Objectives

1. **List** the **criteria used** in the selection of air conditioning systems
2. **List typical constraints** to be considered for selection
3. **Compare centralized systems** with **decentralized systems**
4. **Define** zoning and **discuss** the need for zoning
5. **Classify** air conditioning systems
6. **Discuss** advantages, disadvantages and applications of different types of air conditioning systems

Selection of air conditioning systems

- Once the **required system capacity** is obtained from **load calculations**, the **next step** is **selecting a suitable system**
- **For small capacities**, **options** available are **limited**
- **For large capacity systems**, **several options** are available, hence **selection** should be done based on relevant **criteria**
- The **general selection criteria** may consist of the following factors:

1. **Capacity and performance**
2. **Spatial requirements**
3. **Initial** and **running costs**
4. Required system **reliability** and **flexibility**
5. **Maintenance**
6. **Aesthetics**

Typical constraints in system selection

- Typical **constraints** that play a role in final system selection are:

1. **Availability of buildings space**
2. **Architectural** constraints
3. **Infrastructure** availability
4. Ability of the **operators**
5. **State of the building** at the time of system installation, i.e., **occupied** or **unoccupied**
6. **Budgetary** and **project time** constraints
7. **Equipment lead times**
8. **Access** to building
9. **Structural load bearing capacity** of the building etc.

Centralized vs decentralized systems

- **In a typical centralized system**:

1. **The primary equipment** (also called as the high side) is located in a **central plant**, located inside or outside the building
2. The **secondary equipment** (or the low side) located inside the building takes care of cooling/heating needs of the space
3. If the secondary equipment is modular, then it can be turned on or off depending upon requirement, **but the central plant must be on always**
4. **Chilled water** or **air** is used to **transport heat** between the **primary and secondary equipment**

- **In a typical decentralized system**:

1. The **primary and secondary equipment**, which are **modular** and are **distributed** throughout the building
2. **Each module** caters to a **particular zone**
3. Depending upon the **zone requirement** at any particular point of time, the **individual modules** can be turned **on or off** independent of others

Centralized vs decentralized systems

Characteristics	Centralized System	Decentralized System
Conditions inside the space (DBT, W, P etc.)	Can be controlled very accurately	Can be controlled but with less accuracy compared to central systems
Installed Capacity	Can be much less than peak load due to diversity	Close to peak load due to modularity
Spatial requirements	Can be high due to need for a central plant room etc.	More favorable due to distributed nature, ducts may or may not be needed
Initial cost	Can be high compared to decentralized system	More favorable as procurement can be phased
Running cost	Favorable at peak load	Energy can be saved by switching off individual modules when not needed
Maintenance cost	Favorable due to less no. of total equipment	Can be favorable if spares are standardized
Reliability	Very high	High
Noise and vibration	Favorable as the main plant is often located away	Can be problematic as equipment may be located inside the conditioned space

A typical System Selection Matrix

Table 1 Sample HVAC System Analysis and Selection Matrix (0 to 10 Score)

Goal: Furnish and install an HVAC system that provides moderate space temperature control with minimum humidity control at an operating budget of 220 kW/m^2 per year				
Categories	**System #1**	**System #2**	**System #3**	**Remarks**
1. Criteria for Selection: • 25.6°C space temperature with ±1.7 K control during occupied cycle, with 40% rh and ±5% rh control during cooling. • 20°C space temperature with ±1 K, with 20% rh and ±5% rh control during heating season. • First cost • Equipment life cycle				
2. Important Factors: • First-class office space stature • Individual tenant utility metering				
3. Other Goals: • Engineered smoke control system • ASHRAE *Standard* 62.1 ventilation rates • Direct digital control building automation				
4. System Constraints: • No equipment on first floor • No equipment on ground adjacent to building				
5. Other Constraints: • No perimeter finned-tube radiation or other type of in-room equipment				
TOTAL SCORE				

ASHRAE Handbook, 2008

Zoning

- **Zone:** A zone is **an area of a building** that must be **provided with** a **separate control** if the **design intent** is to be met
- The **most common design intent** of an AC system is:
  - Thermal comfort and/or Indoor Air Quality
- **Each zone** in a conditioned building is controlled by **single control setting** for a suitable control parameter(s)
- The **common control parameters** are:
  - **Space Temperature**
  - **Humidity**
  - **Fresh air**
  - **Period of operation**
- **Zoning should be established before system selection**

Typical applications that require Zoning

1. **A theater** with a stage for performing arts/movie shows
2. **An Indoor stadium** with arena and gallery
3. **An academic complex** with classrooms, library, offices
4. **An office block** with interior and perimeter zones
5. **A large hospital** with in-patient and out-patient wards, ICUs, Operation theaters
6. **A chemical laboratory complex** with dry and wet labs (labs with fume hoods etc)

Classification of air conditioning systems

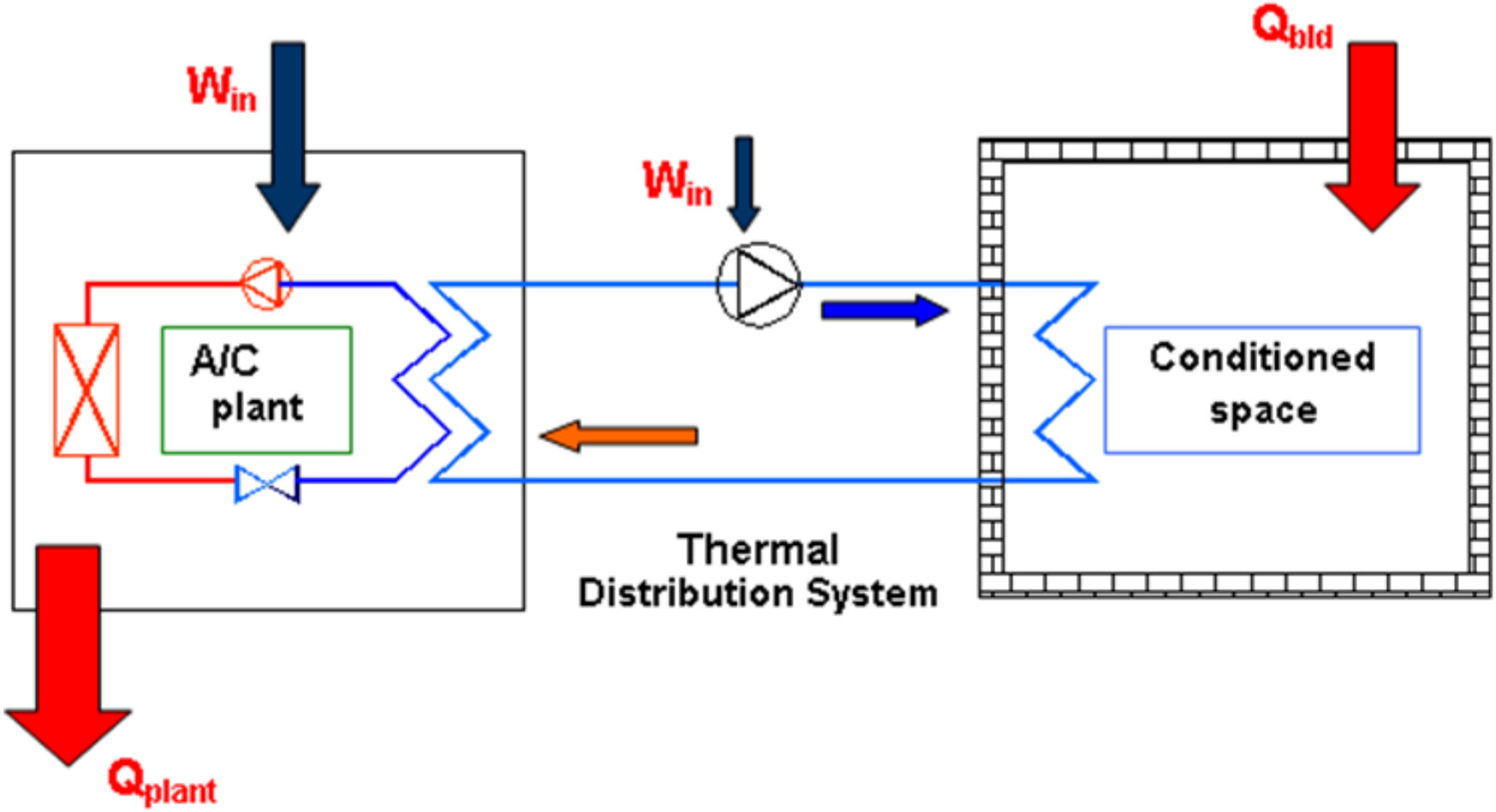
- Based on the **fluid media** used in the **thermal distribution system,** air conditioning systems classified into:

1. **All air systems**
2. **All water systems**
3. **Air water systems**
4. **Unitary refrigerant based systems**

- **Air conditioning systems can also be classified into:**

1. **Centralized systems**
2. **Decentralized systems**

Major elements of a large, central air conditioning system



All air Systems

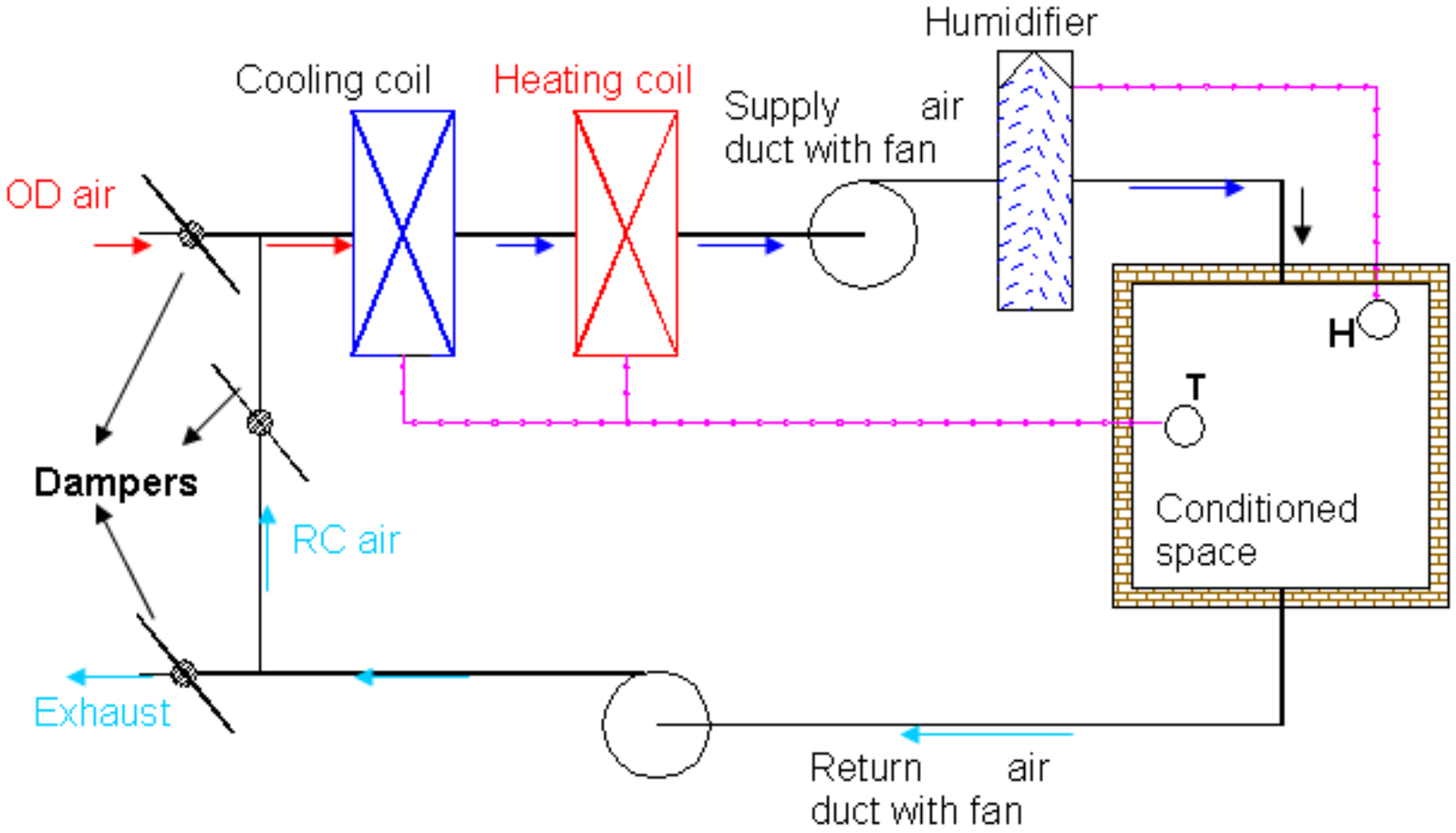
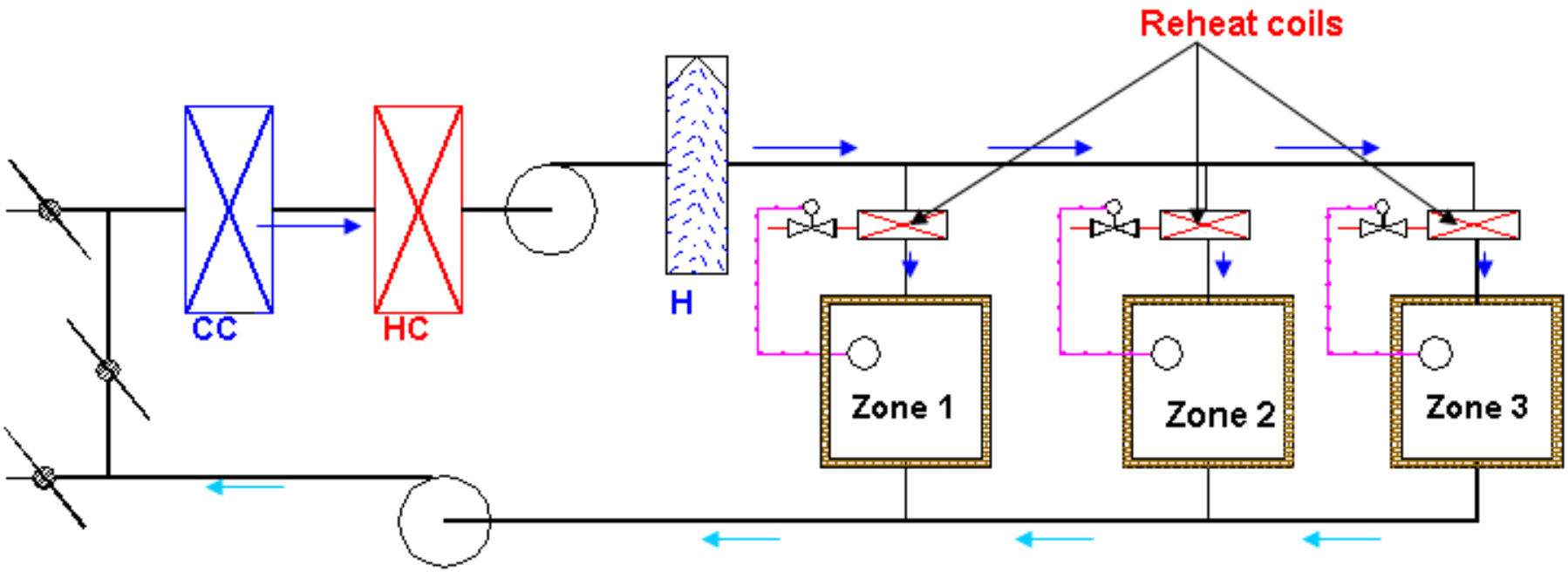


Fig.36.2. A constant volume, single zone system



Single duct, constant volume system with multiple zones and reheat coils

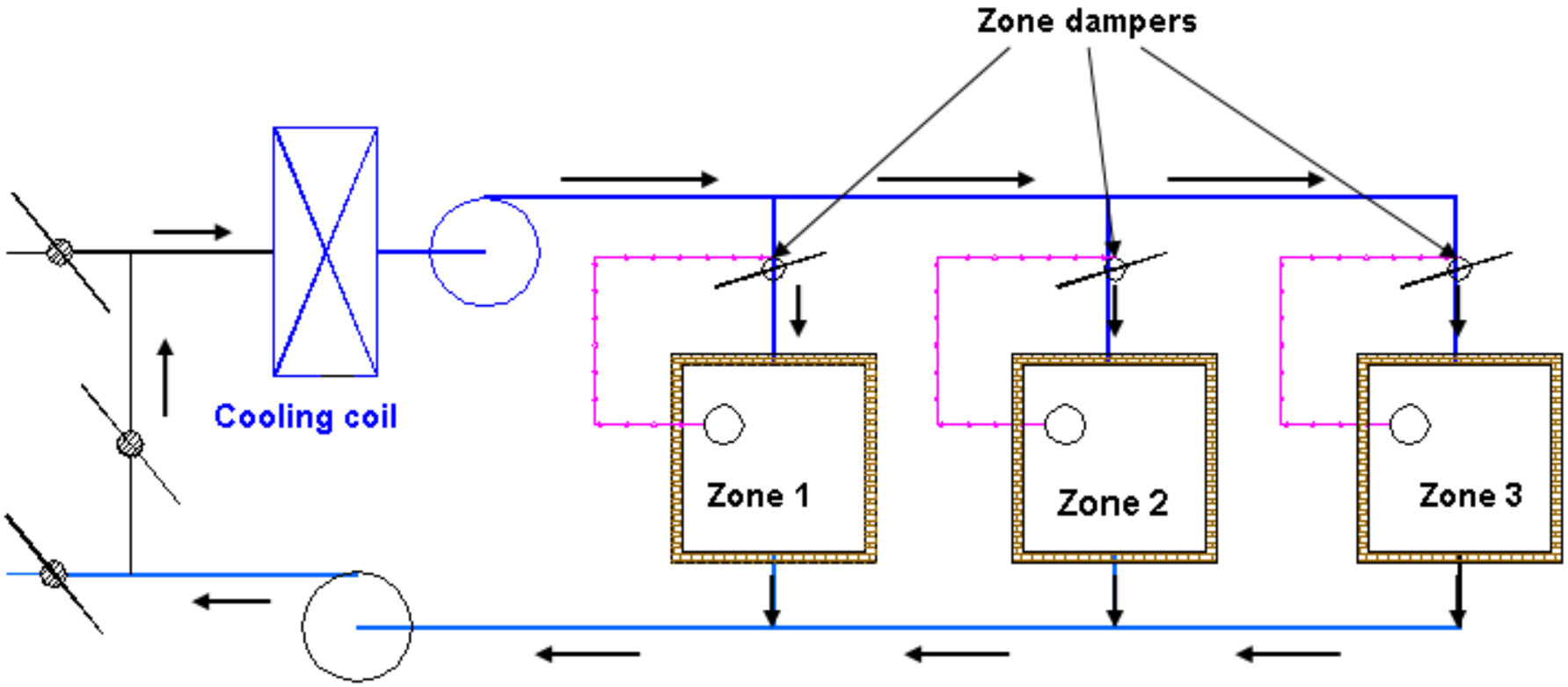


Fig.36.4: Single duct, multiple zone, variable air volume system

Dual Duct All Air Systems

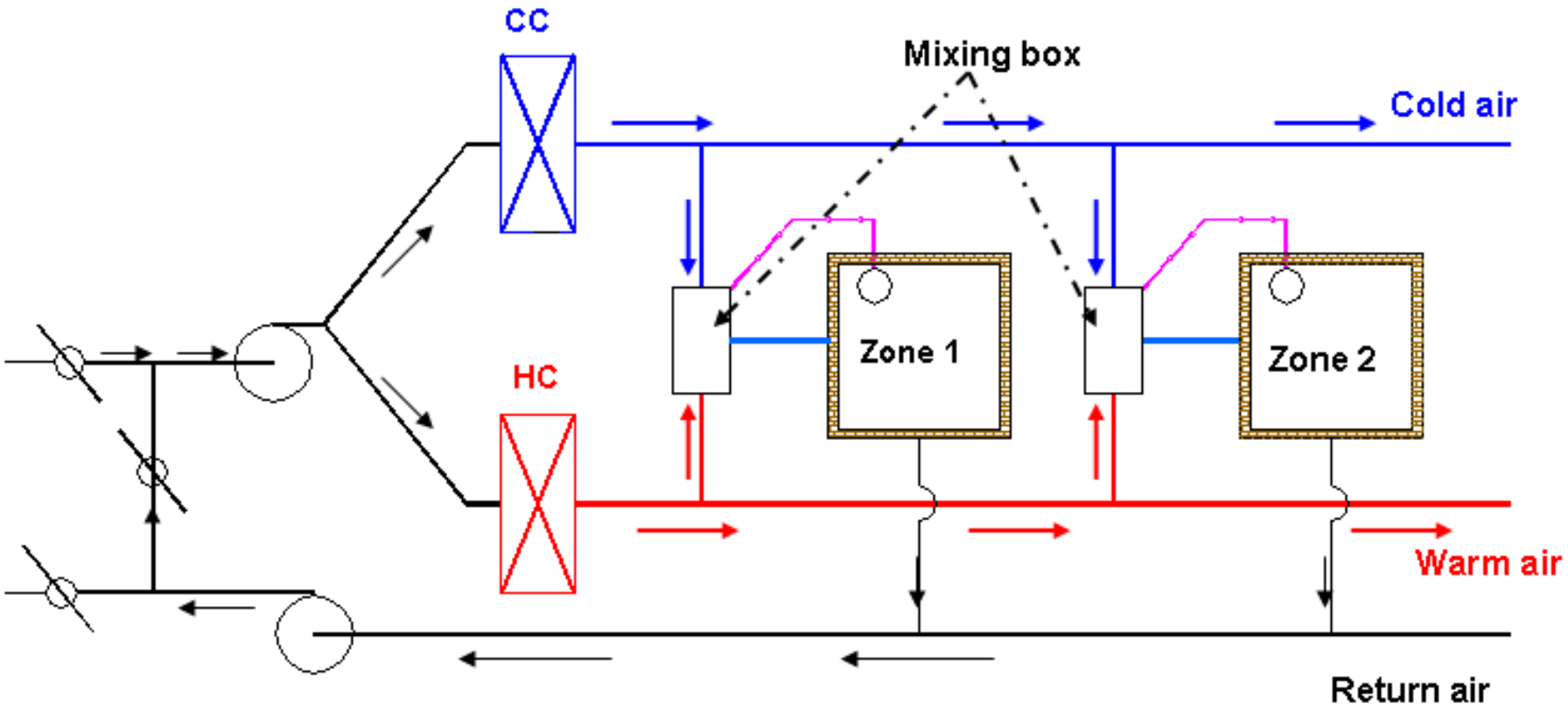


Fig.36.5: Dual duct, constant volume system

Advantages of all air systems

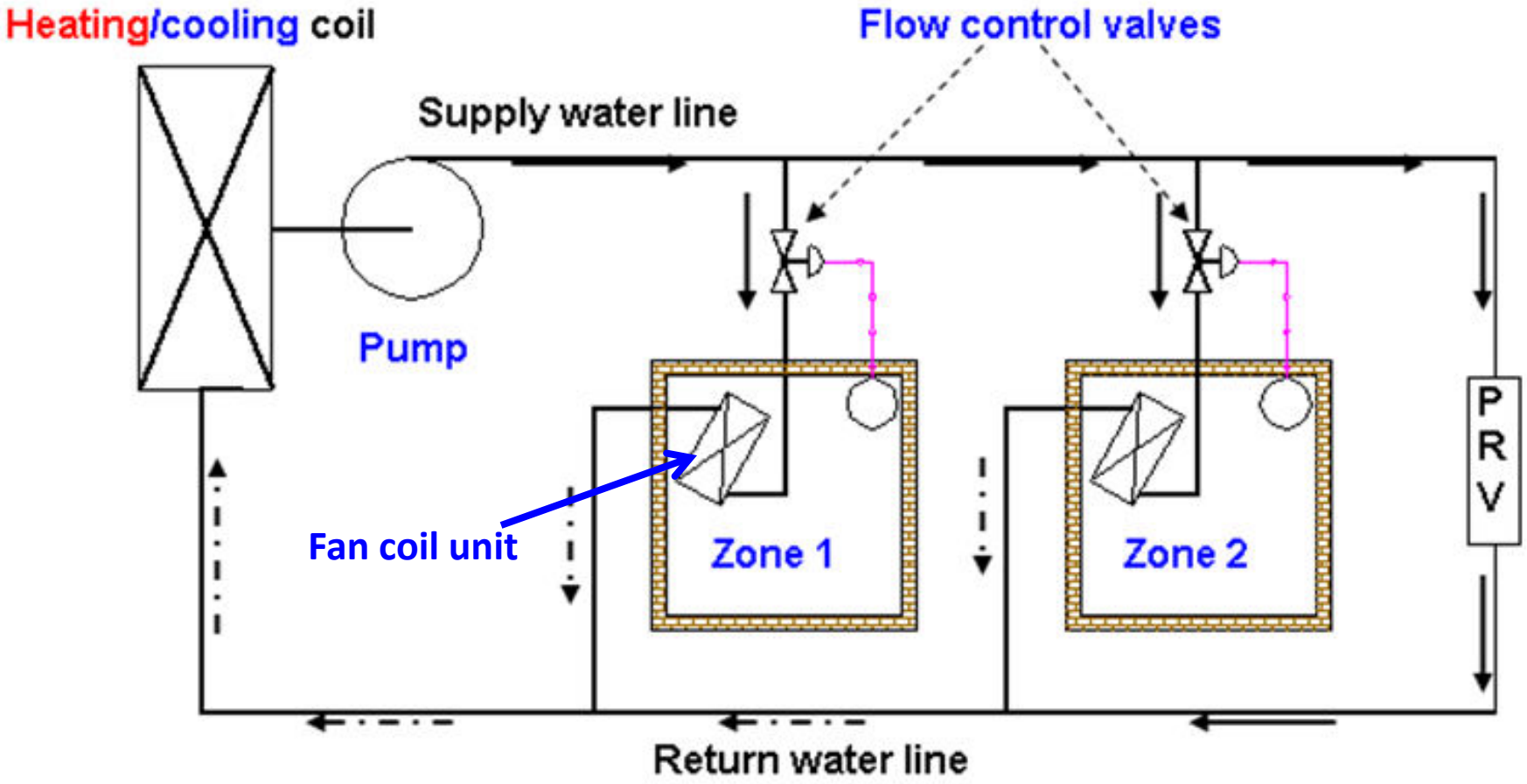
- Offer the **greatest potential for energy conservation** by utilizing the outdoor air effectively
- It is possible to **maintain** the temperature and relative humidity of the conditioned space within **± 0.15°C** and **± 0.5%**, respectively
- Using **dual duct systems**, it is possible to provide **simultaneous cooling and heating**
- Changeover from summer to winter and vice versa is relatively simple
- It is possible to provide good room air distribution and ventilation under all conditions of load
- Building pressurization can be achieved easily
- The complete air conditioning plant including the supply and return air fans can be located away from the conditioned space. Due to this it is possible to use a wide variety of air filters and **avoid noise in the conditioned space**

Disadvantages of all air systems

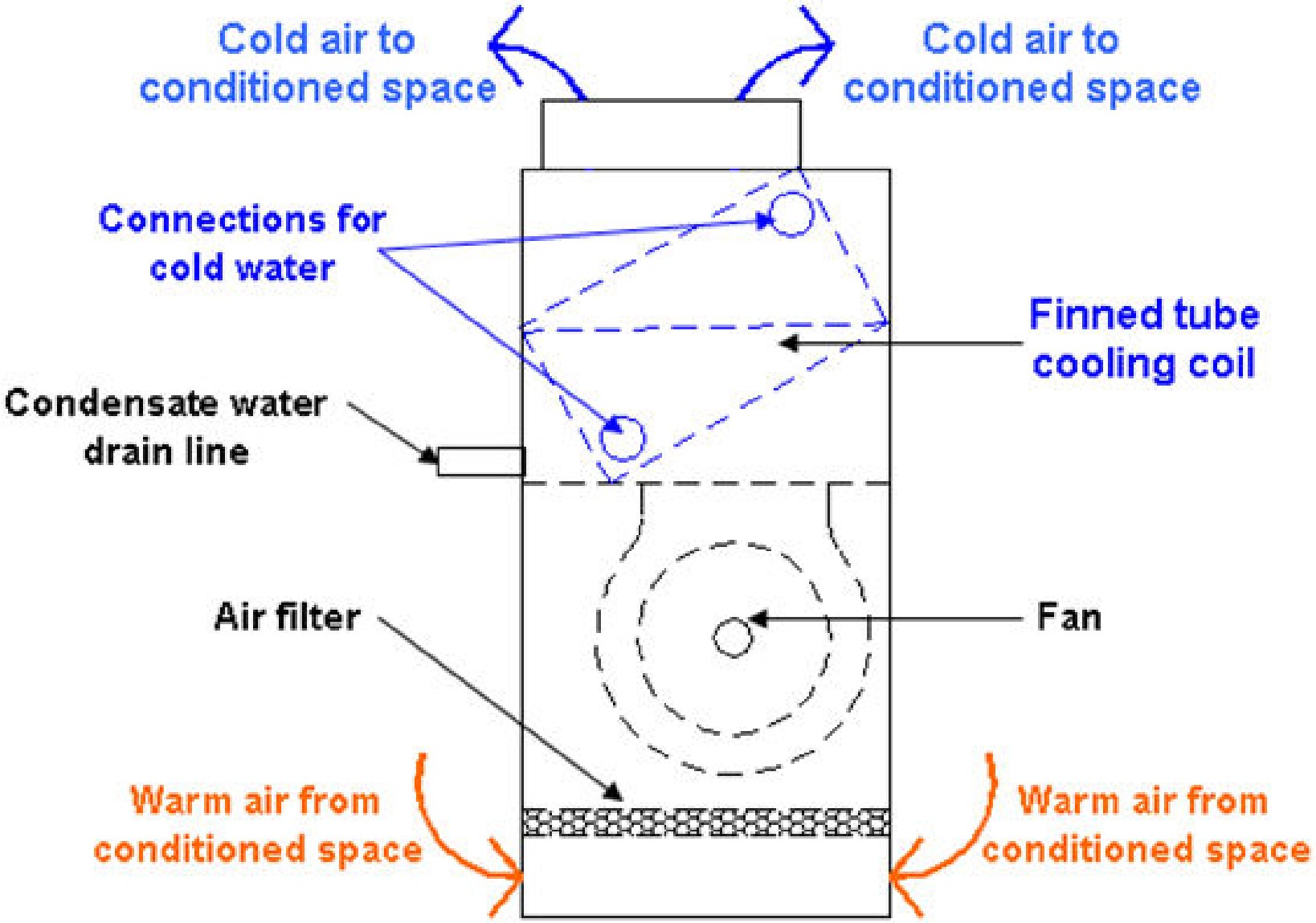
- They **occupy more space** and thus reduce the available floor space in the buildings
- It could be difficult to provide air conditioning in high-rise buildings with the plant on the ground floor or basement due to space constraints
- **Retrofitting may not** always **be possible** due to the space requirement
- **Balancing of air** in large and particularly with variable air volume systems **could be difficult**

All water Systems

A 2-pipe, All water System



A typical fan coil unit (FCU)



Different types of fan coil units

Advantages of all water systems

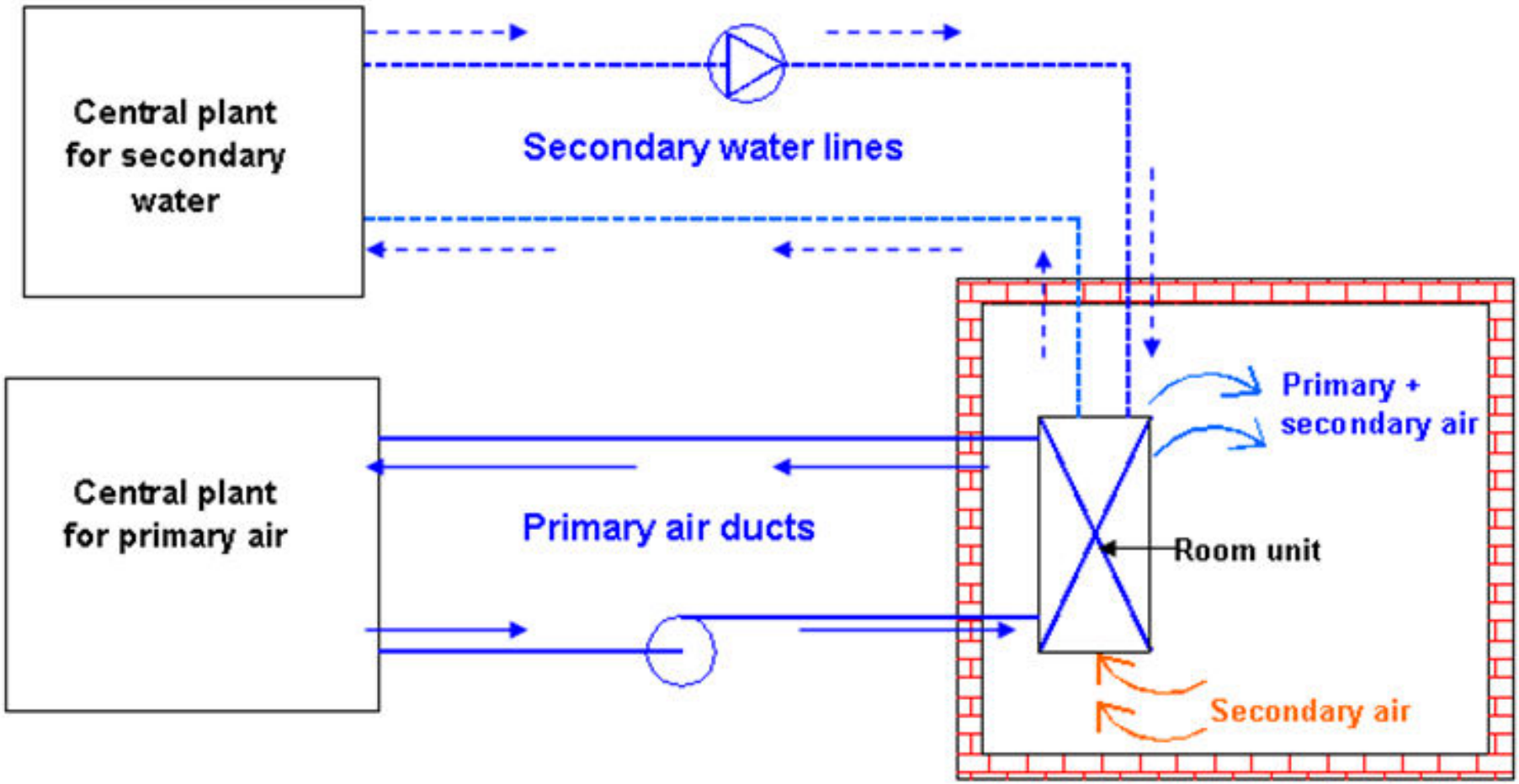
- The thermal distribution system **requires very less space** compared to all air systems. Thus there is not much penalty in terms of conditioned floor space
- Also the **plant size will be small** due to the absence of large supply air fans.
- **Individual room control** is possible, and at the same time the system offers all the benefits of a large central system.
- Since the **temperature of hot water** required for space heating is small, it is possible to use **solar or waste heat** for winter heating.
- It **can be used** for **new as well existing buildings** (retrofitting).
- **Simultaneous cooling and heating** is possible **with 4-pipe systems**.

Disadvantages of all water systems

- Requires **higher maintenance** compared to all air systems, particularly **in the conditioned space**
- **Draining of condensate water** can be messy and may also create health problems if water stagnates in the drain tray. This problem can be eliminated, if dehumidification is provided by a central ventilation system, and the cooling coil is used only for sensible cooling of room air.
- If ventilation is provided by opening windows or wall apertures, then, it is **difficult to ensure positive ventilation** under all circumstances, as this depends on wind and stack effects.
- **Control of humidity**, particularly during summer is difficult using chilled water control valves.

Air-water Systems

A basic Air-water Systems



Advantages of Air-Water systems

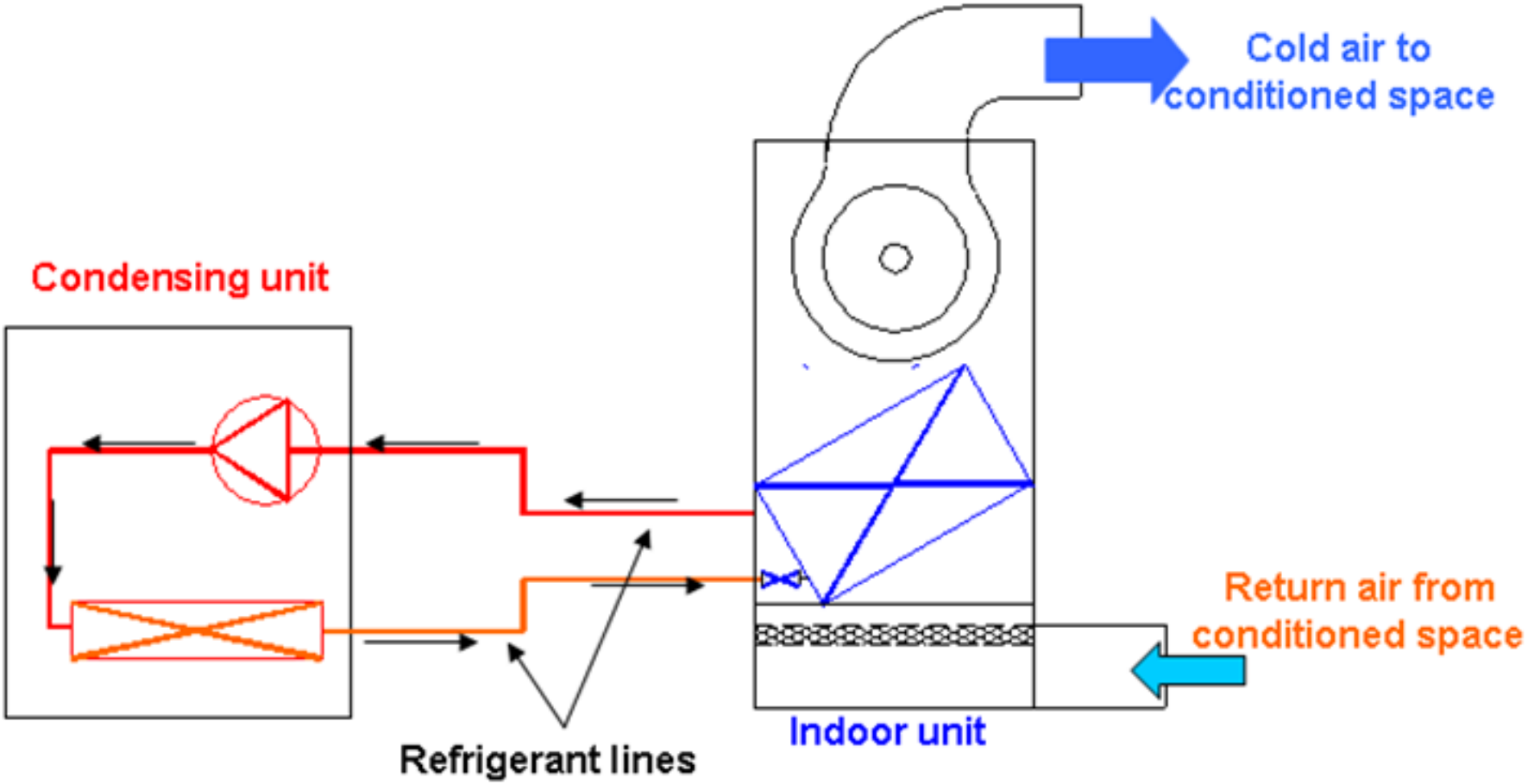
- Individual zone control is possible in an economic manner using room thermostats, which control either the secondary water flow rate or the secondary air (in fan coil units) or both
- It is **possible to provide simultaneous cooling and heating** using primary air and secondary water
- **Space requirement is reduced**, as the amount of primary supplied is less than that of an all air systems
- **Positive ventilation** can be ensured under all conditions
- Since no latent heat transfer is required in the cooling coil kept in the conditioned space, the **coil operates dry** and its life thereby increases and problems related to odours or fungal growth in conditioned space is avoided
- The conditioned space can sometimes be heated with the help of the heating coil and secondary air, thus avoiding supply of primary air during winter
- **Service of indoor units** is relatively simpler compared to all water systems

Disadvantages of Air-Water systems

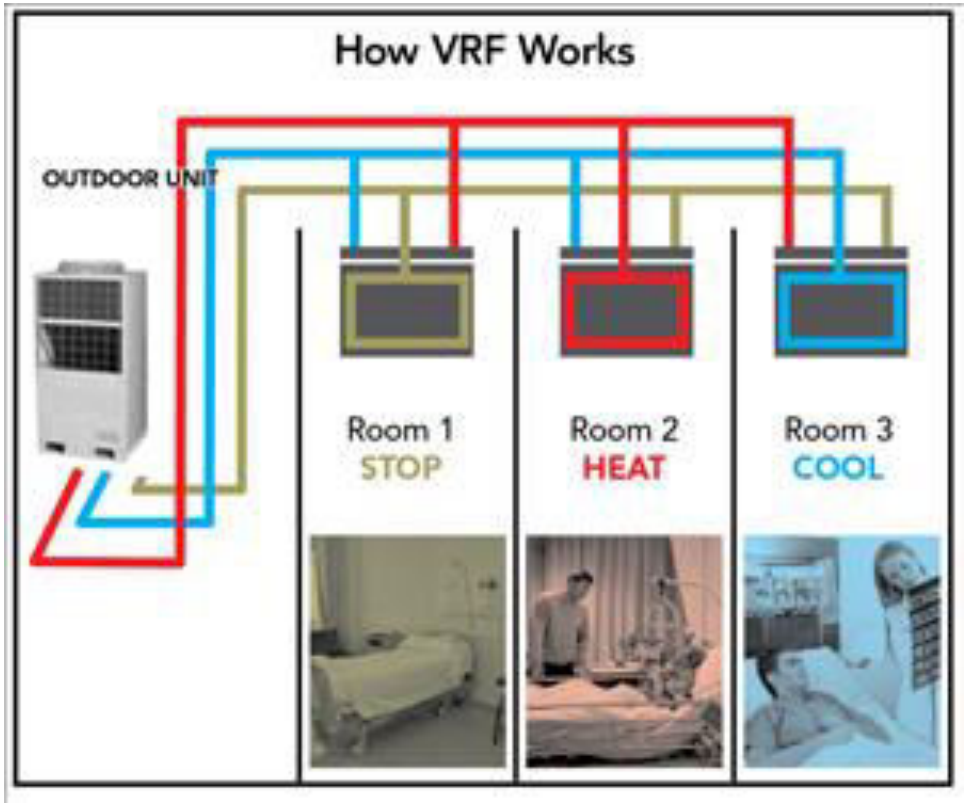
- **Operation and control** are **complicated** due to the need for handling and controlling both primary air and secondary water
- In general these systems are **limited to perimeter zones**
- The secondary water coils in the conditioned space can become dirty if the quality of filters used in the room units is not good
- Since a constant amount of primary air is supplied to conditioned space, and room control is only through the control of room cooling/heating coils, **shutting down the supply of primary air** to **unoccupied spaces** is **not possible**
- If there is **abnormally high latent load** on the building, then **condensation** may take place on the cooling coil of secondary water
- **Initial cost** could be **high** compared to all air systems

Unitary Package Systems

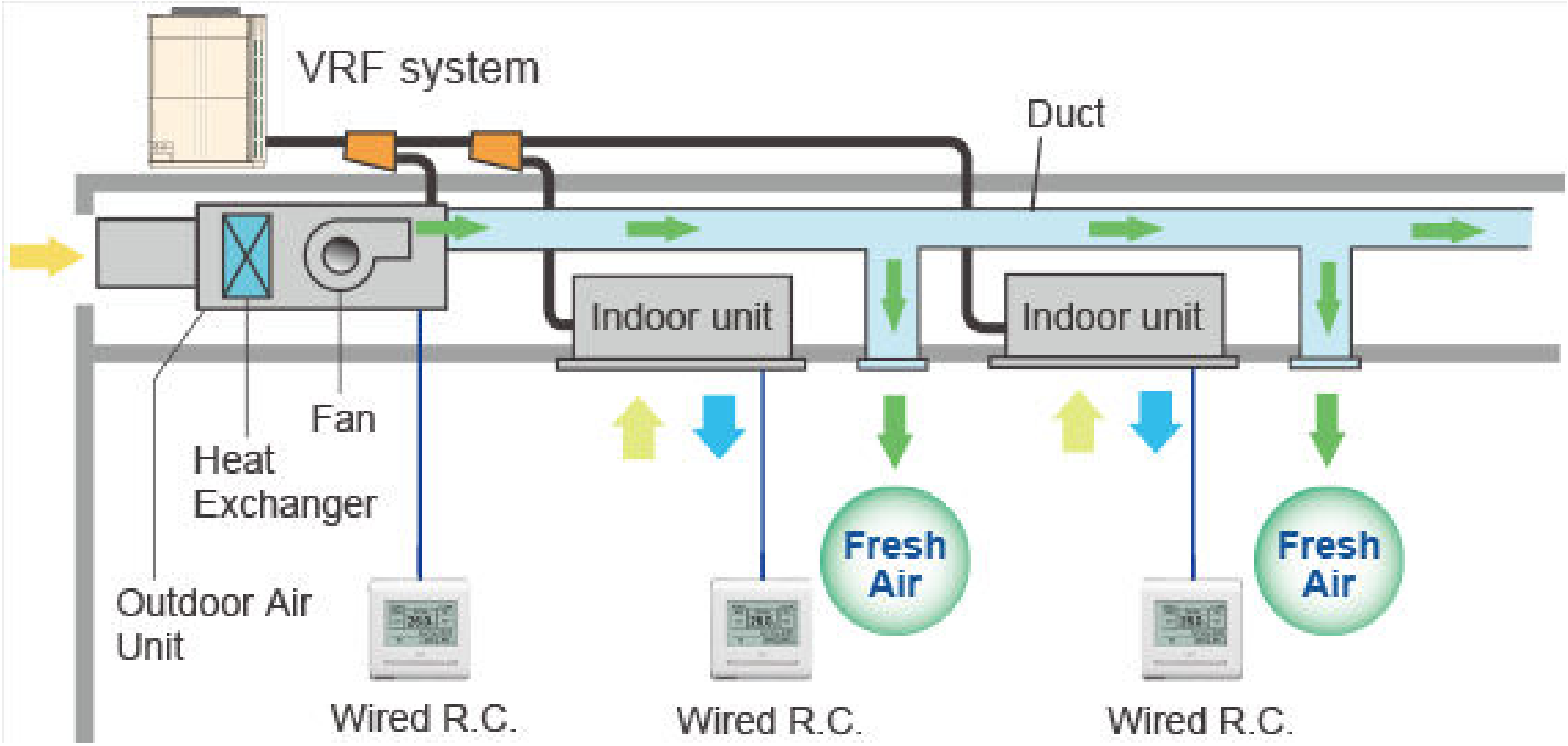
A ductable, Package Unit with remote condenser



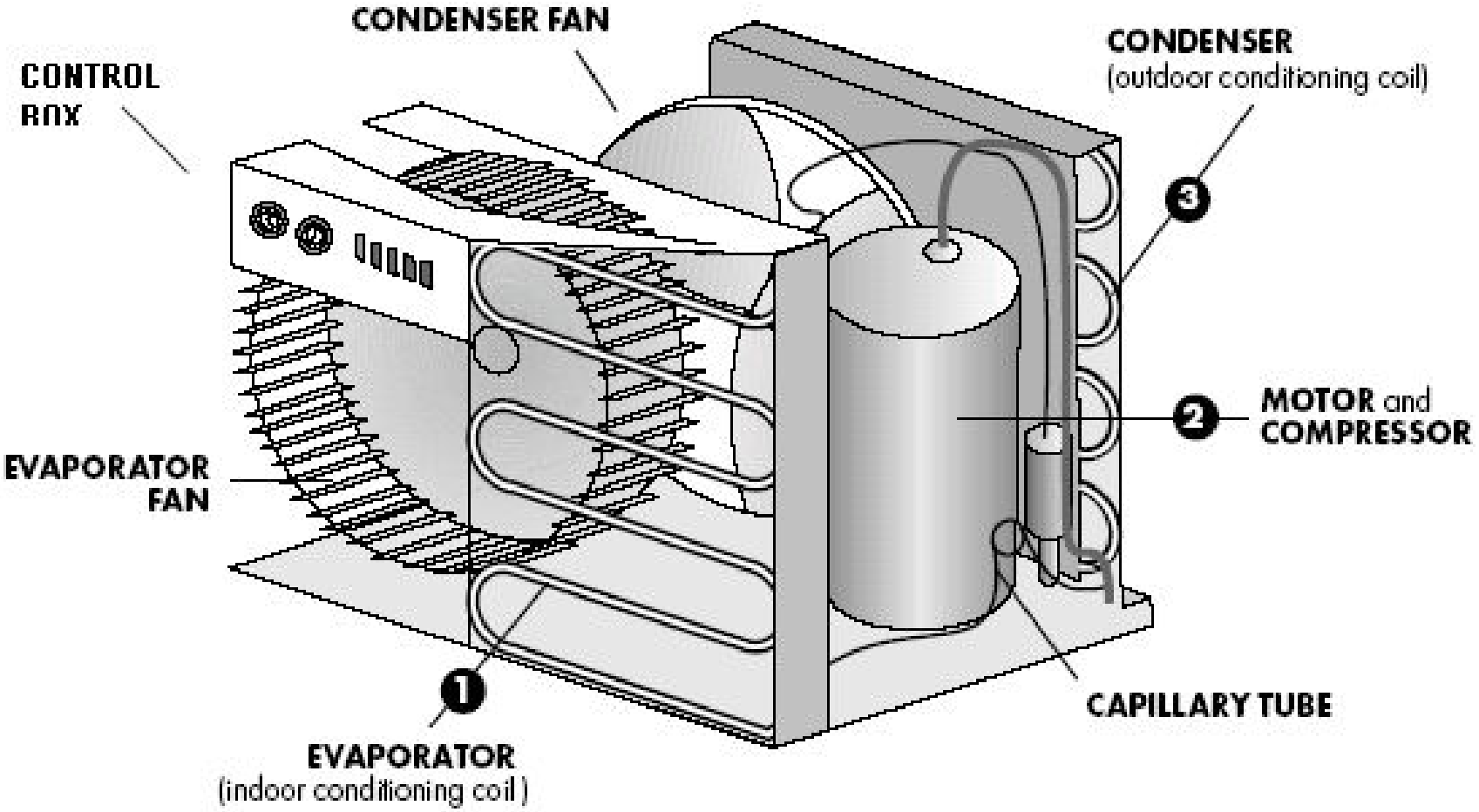
Variable Refrigerant Flow (VRF) Systems



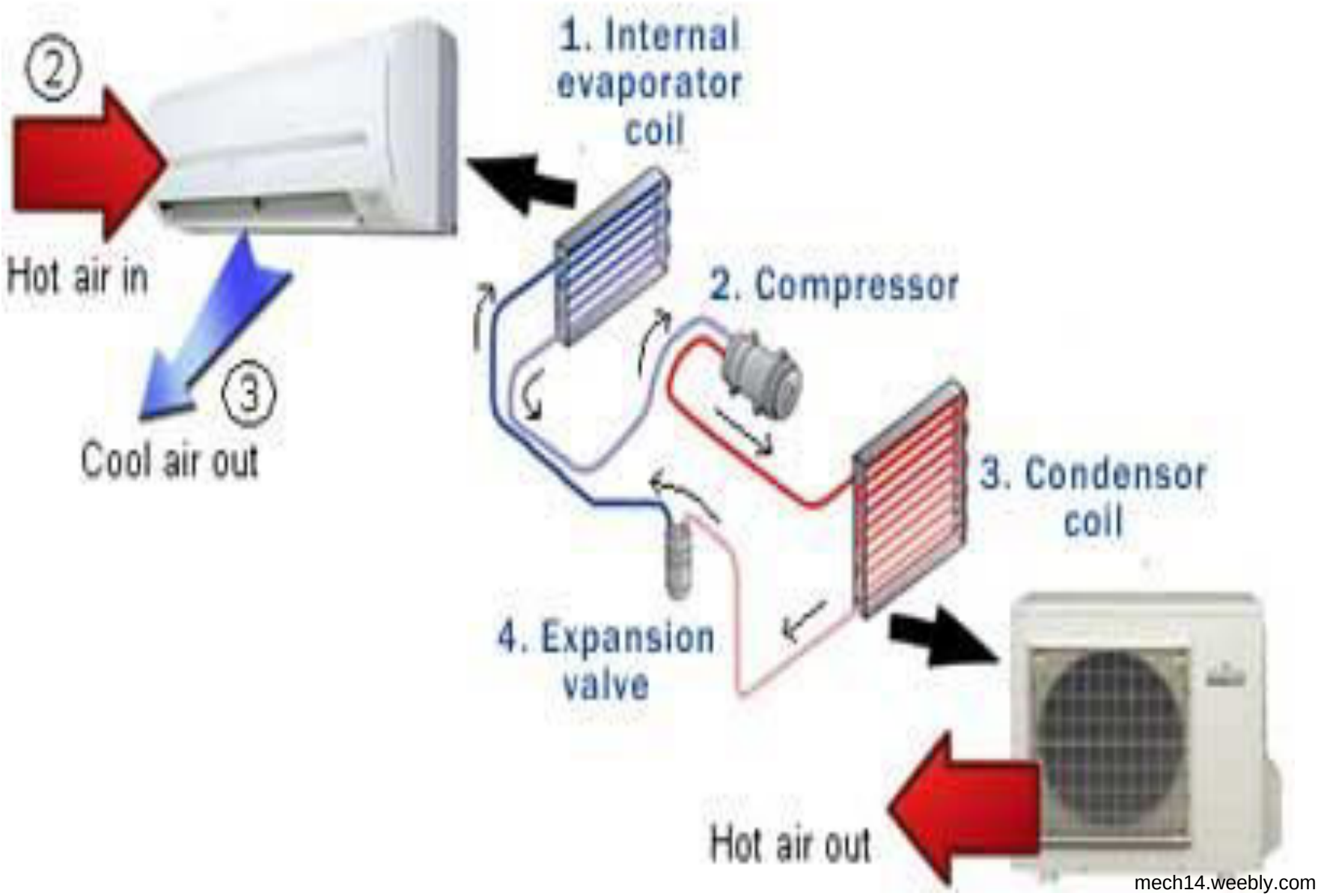
VRF System with a dedicated treated fresh air (TFA) system



A window type, room air conditioner



A split type, room air conditioner



Advantages of Unitary systems

- **Individual room control** is simple and inexpensive.
- Each conditioned space has **individual air distribution** with simple adjustment by the occupants.
- **Performance** of the system is **guaranteed by the manufacturer**.
- **System installation is simple** and takes very less time.
- **Operation of the system is simple** and there is no need for a trained operator.
- **Initial cost is normally low** compared to central systems.
- **Retrofitting is easy** as the required floor space is small.

Disadvantages of Unitary systems

- As the components are selected and matched by the manufacturer, the system is **less flexible** in terms of **air flow rate**, condenser and evaporator sizes.
- **Power consumption per TR could be higher** compared to central systems.
- **Close control of space humidity** is generally difficult.
- **Noise level** in the conditioned space could be higher.
- **Limited ventilation** capabilities.
- **Systems** are generally **designed** to meet the **appliance standards**, rather than the building standards
- **May not be appealing** aesthetically
- The **space temperature** may **experience a swing** if on-off control is used as in room air conditioners.
- **Limited options** for controlling **room air distribution**
- **Equipment life** is **relatively short**

Precautions to be taken while selecting air conditioning systems

1. **Customer requirements and constraints** should be identified clearly before selection
2. **Future expansion and future requirements** must be taken into account
3. **Oversizing** of the system should be avoided as this will lead to unnecessary investment and possibly poor humidity control
4. Should refer to **latest developments** for best results

End of Lecture