EN 410
Energy Management

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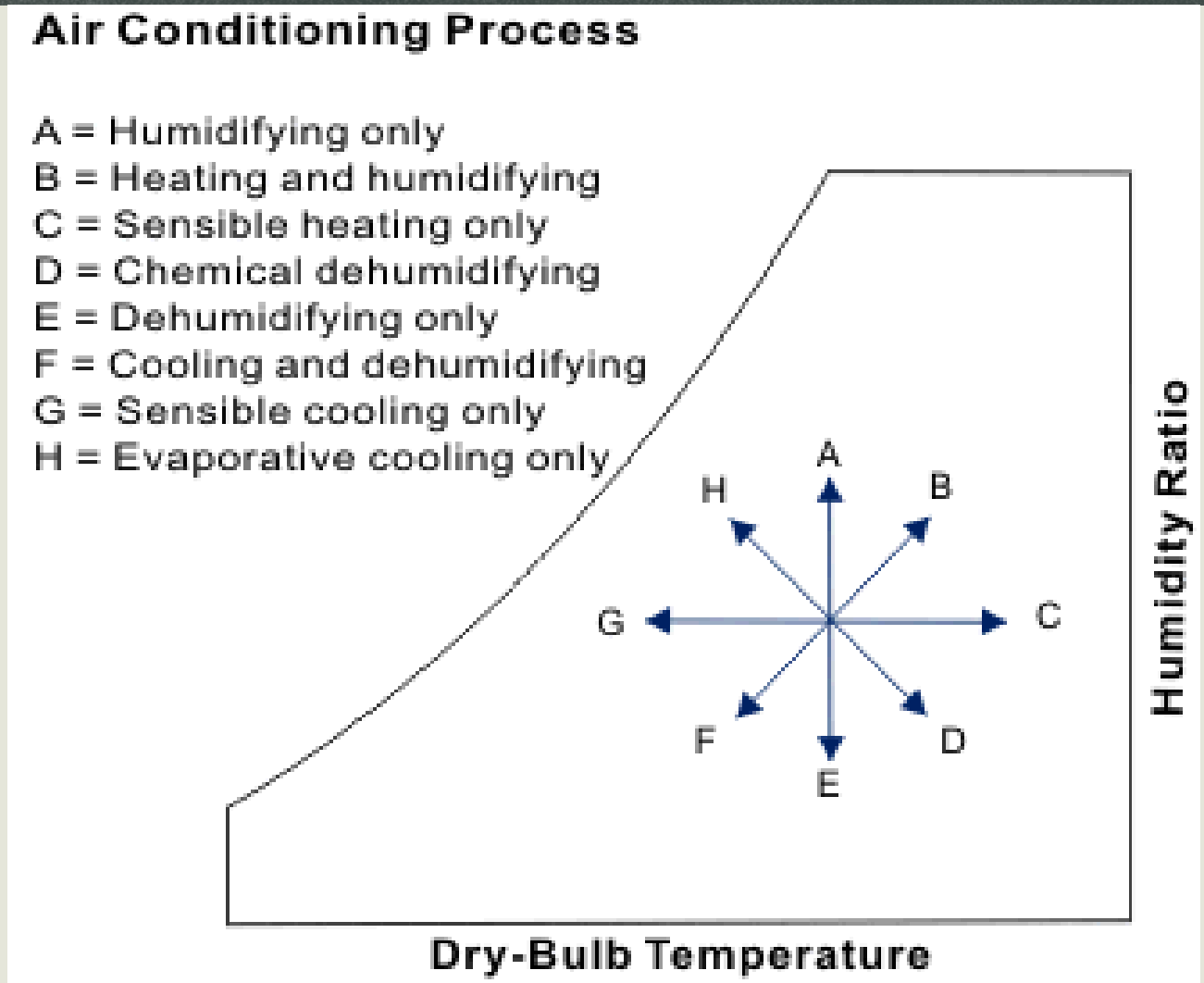
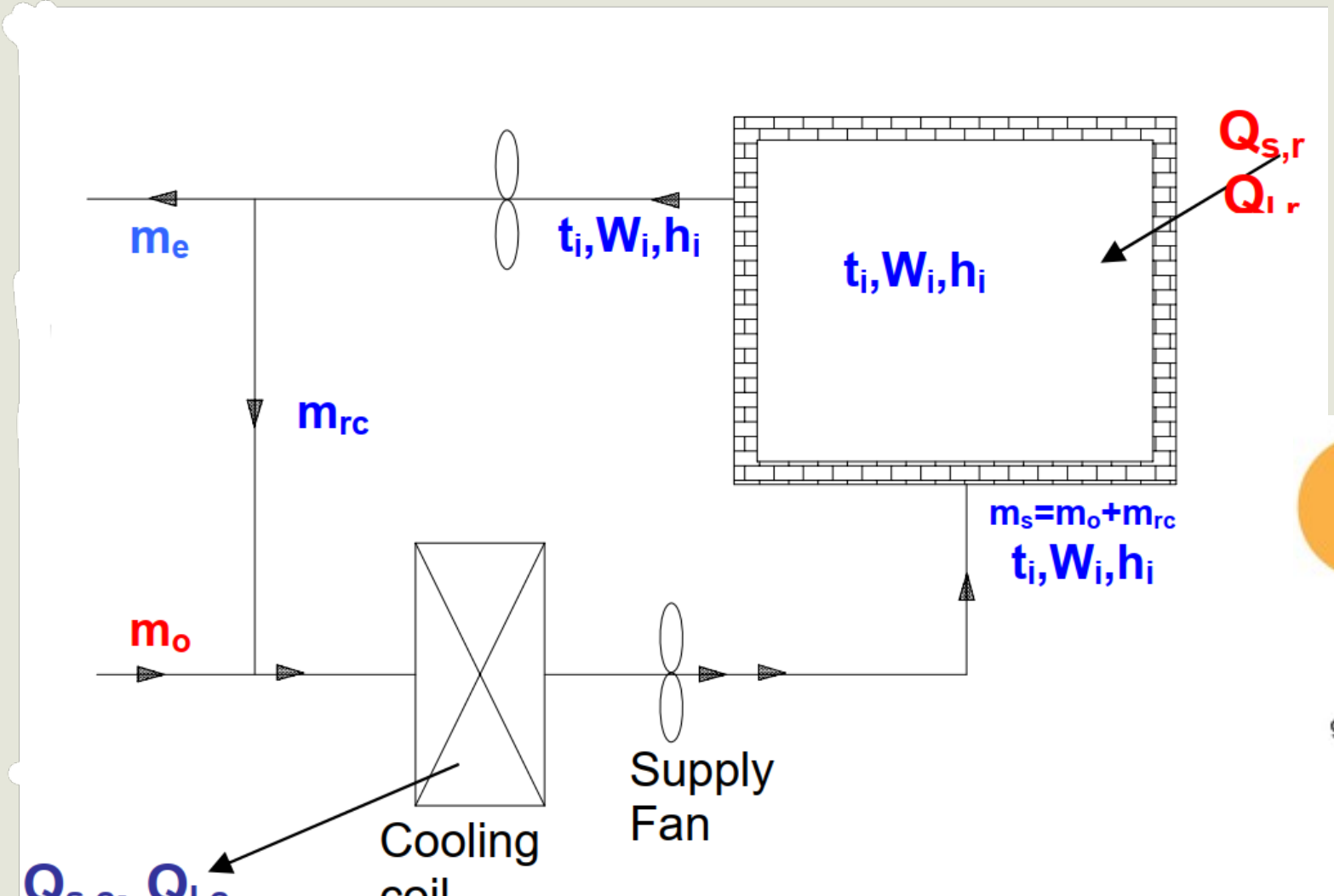
Psychometric process

How do estimate the energy transfer in each process

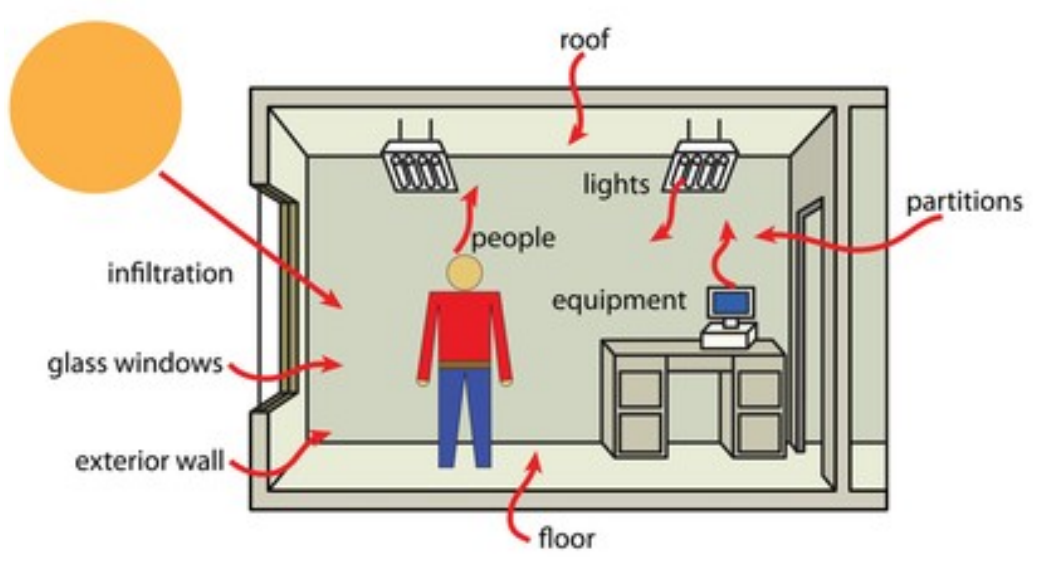
B and F are the major air conditioning process



Summer Air Conditioning System



- Sensible Load
- Latent Load



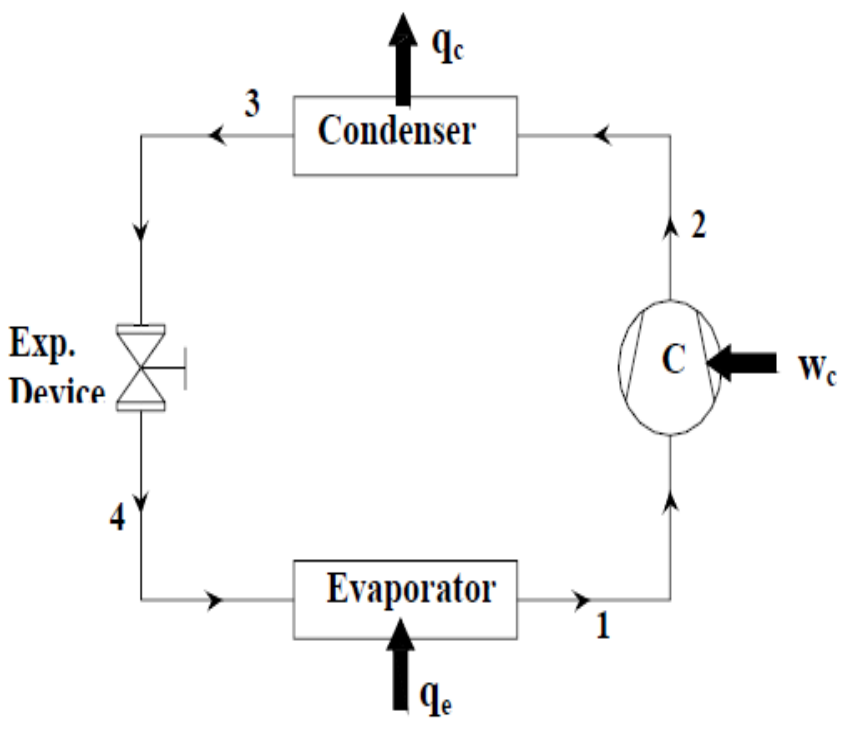
Cooling and Dehumidification

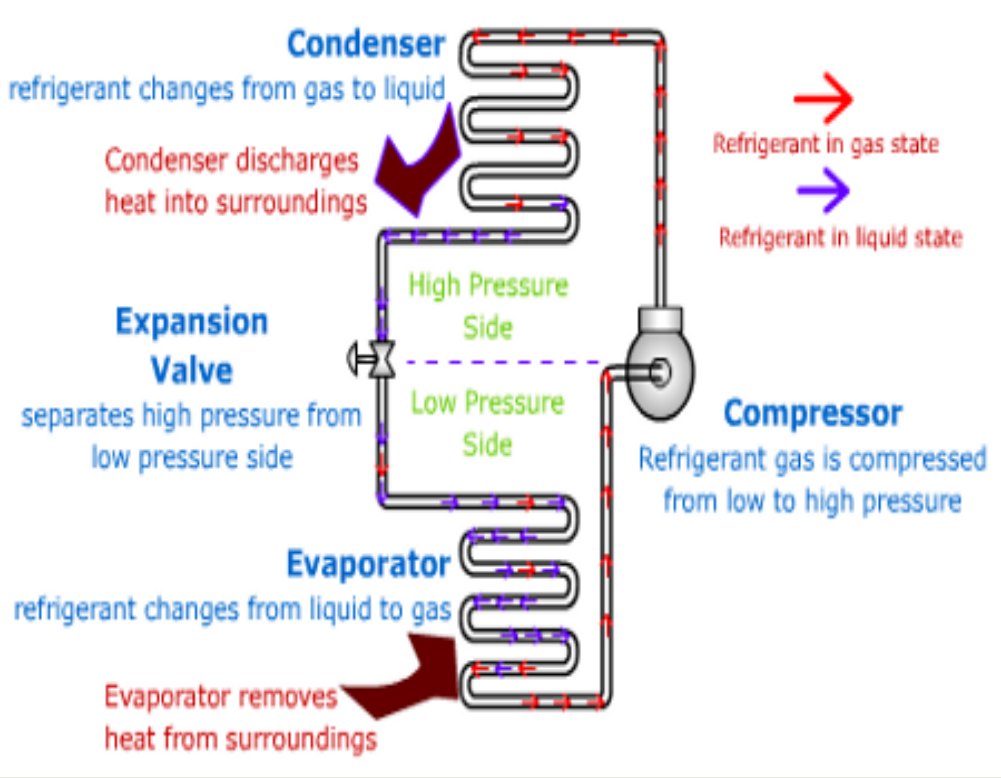
Outdoor condition is 35°C, 50% RH

Indoor condition is 24°C, 50% RH

How to design your air conditioning system?

Vapor Compression Refrigeration system

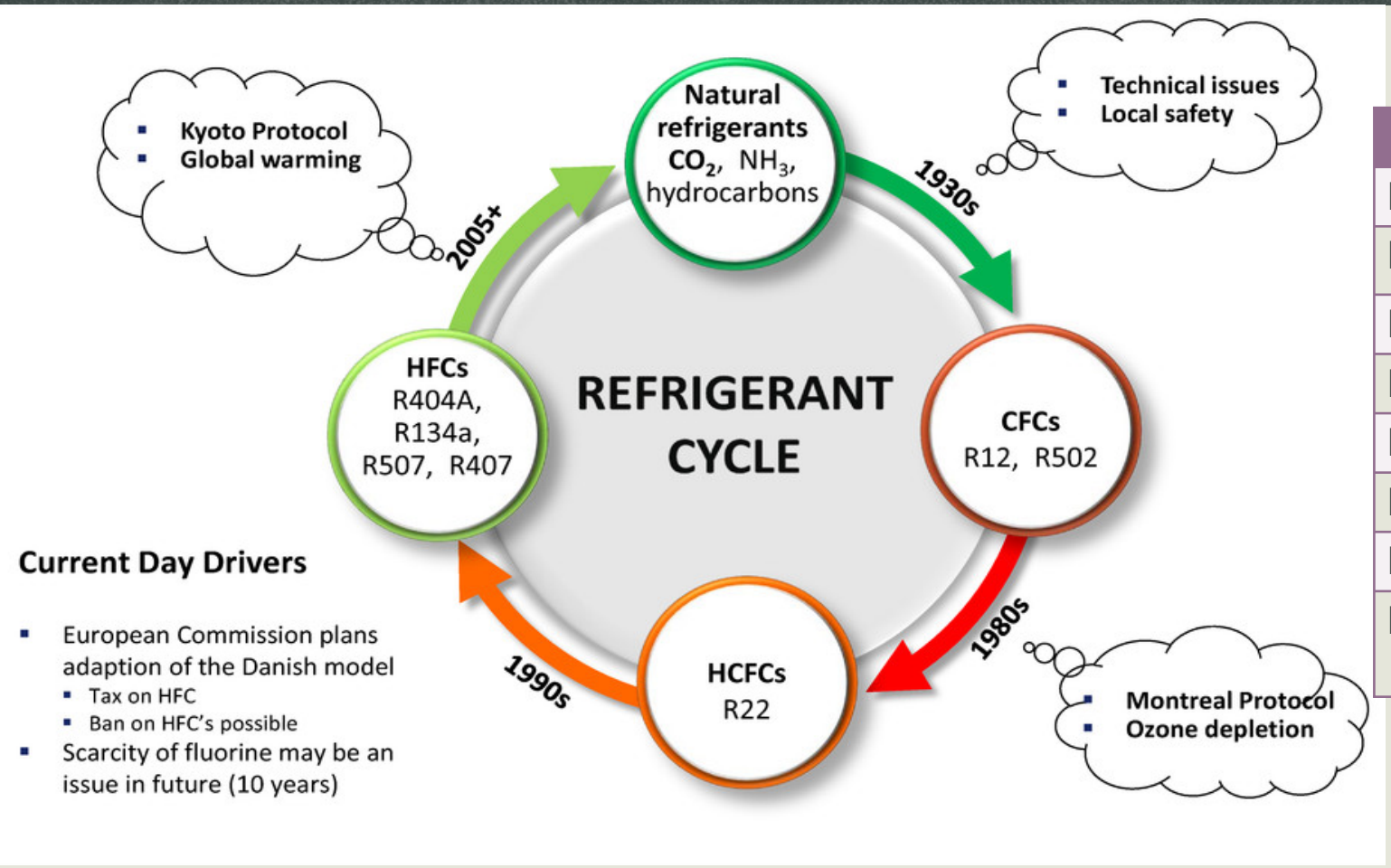




A ton of refrigeration (1 TR) is defined as the amount of heat, which is to be extracted from one tonne of water at 0℃ in order to convert into ice at 0℃ in 24 hours (1 day).

1 TR = 210 kJ/min = 3.5 kW.

Refrigerants



REFRIGERANT	TYPE	ODP*	GWP*
R-12	CFC	0.820	10,600
R-22	HCFC	0.034	1,700
R-404A	HFC	0	3,800
R-410A	HFC	0	2,000
R-134a	HFC	0	1,300
R-290 (Propane)	Natural	0	~20
R-717 (Ammonia)	Natural	0	<1
R-1234yf	Unsaturated HFC	0	4

Estimate the energy demand (EER) of an air-conditioner

Inlet condition: DBT=20°C, WBT=14°C

Outlet condition: DBT=12.7°C, WBT=11.3°C

Capacity = 10 TR

Air flow rate = 4751 m^3/hr

Power consumption = 4300 W

(Valid from the 1st July, 2023 to30th June, 2025)

Indian Seasonal Energy Efficiency Ratio(kWh/kWh)		
Star Rating	**Minimum**	**Maximum**
1 Star	2.70	3.09
2 Star	3.10	3.39
3 Star	3.40	3.69
4 Star	3.70	3.99
5 Star	>=4.00	

Strategies of Net Zero Buildings - Space Cooling

- Reduce the room load
- Reduce the system load
- Meet the load by passive cooling methods

Insulation

Reduce the room load

Reasons to provide insulation.

- Thermal Protection
- Roof Load Distribution
- Building Codes and Standards (IS 3792-1978)

Types of Wall Insulation Materials

- Fiberglass
- Mineral wool
- Cellulose
- Natural fibers
- Polystyrene
- Insulation facings

- Polyisocyanurate
- Polyurethane
- Perlite
- Cementitious foam
- Phenolic foam

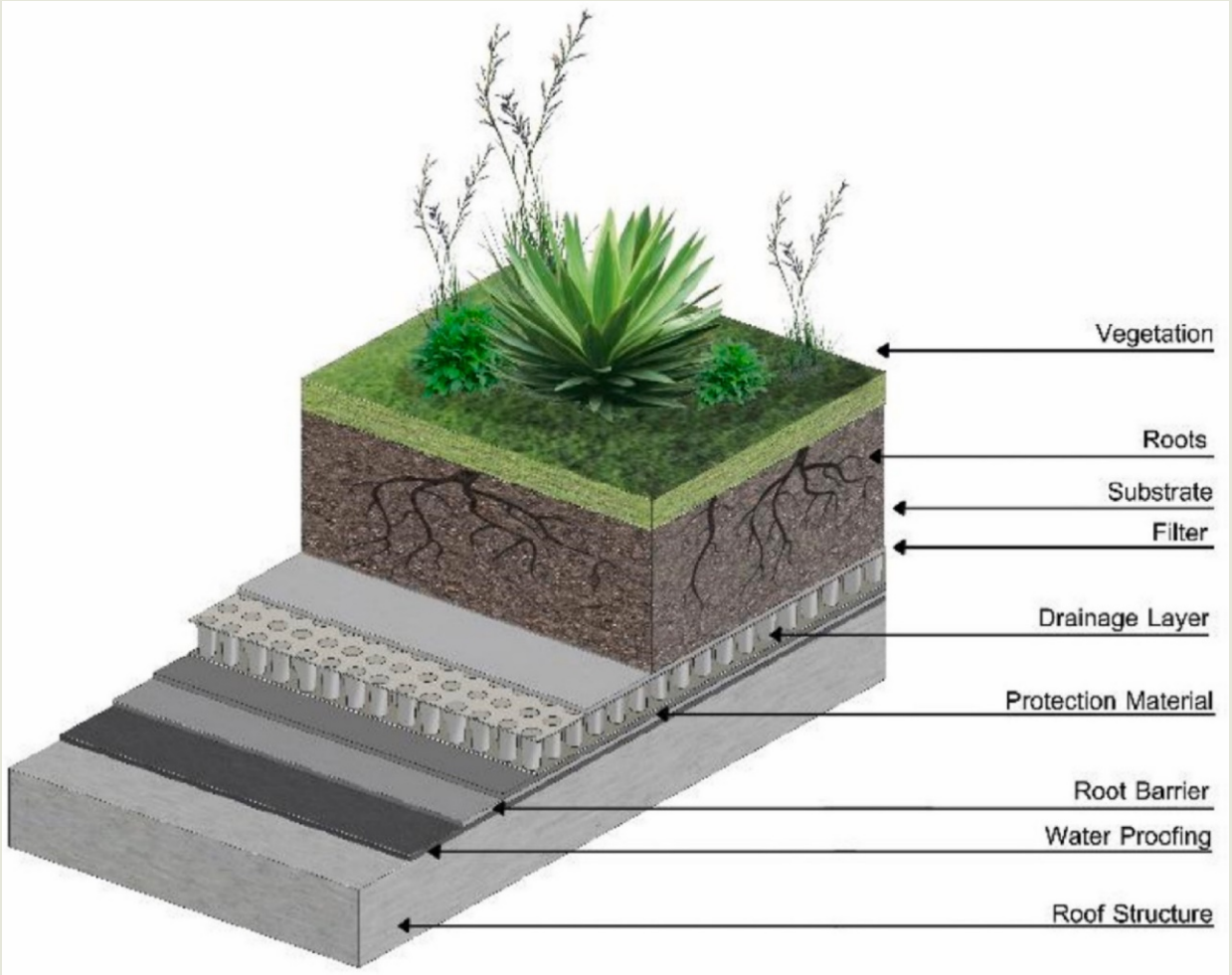
Green Roof

Reduce the room load

Green roof or living roof or Eco roof is a roof which is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane.

Types of green roof systems

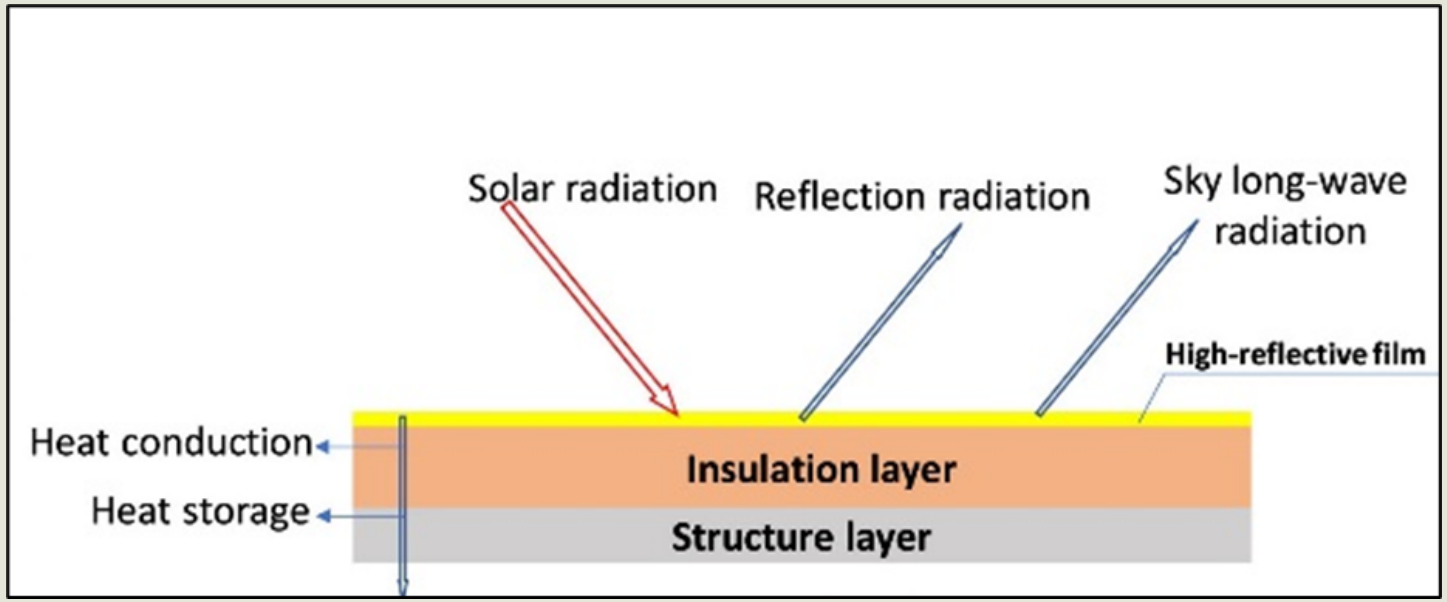
- Single Course Extensive
- Multi- Course Extensive
- Semi Intensive
- Intensive



Cool Roof

Reduce the room load

Cool roofs are the roofs that can deliver high solar reflectance and high thermal emittance



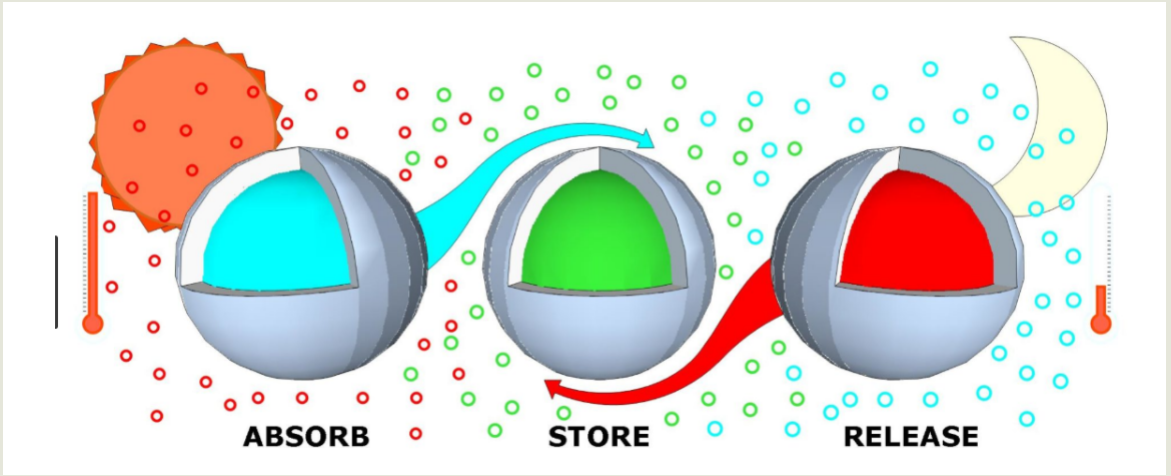
Coatings Types

- Acrylic based cool coats
- Spray polyurethane cool coats
- Polymer cool coats
- Fiber Filled liquid cool coats

Reduce the room load

Phase Change Material

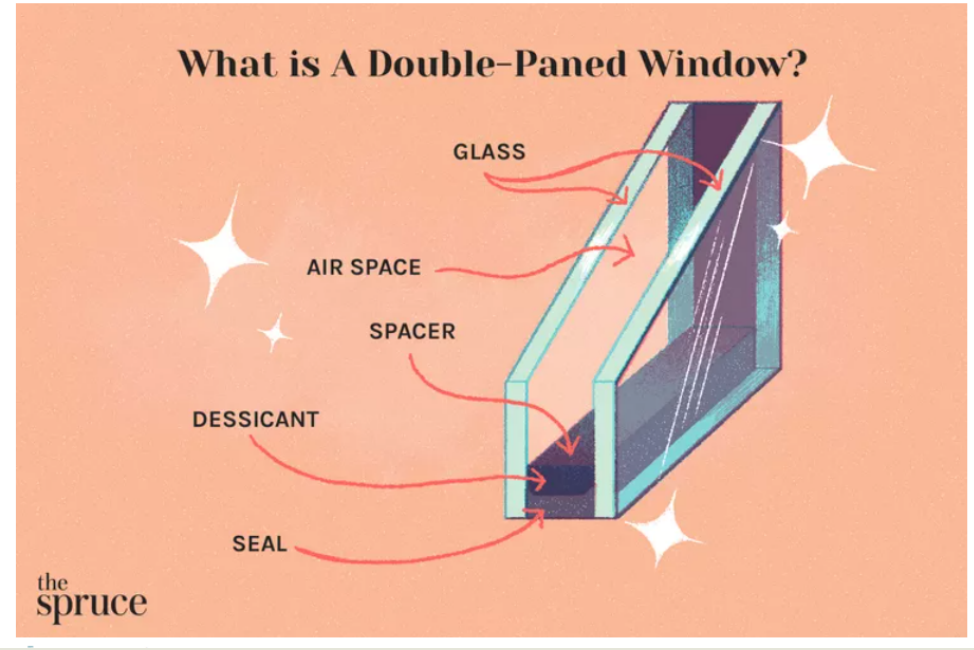
- PCMs absorb and release heat, stabilizing indoor temperatures
- Benefits include energy savings, improved comfort, and reduced emissions



Reduce the room load

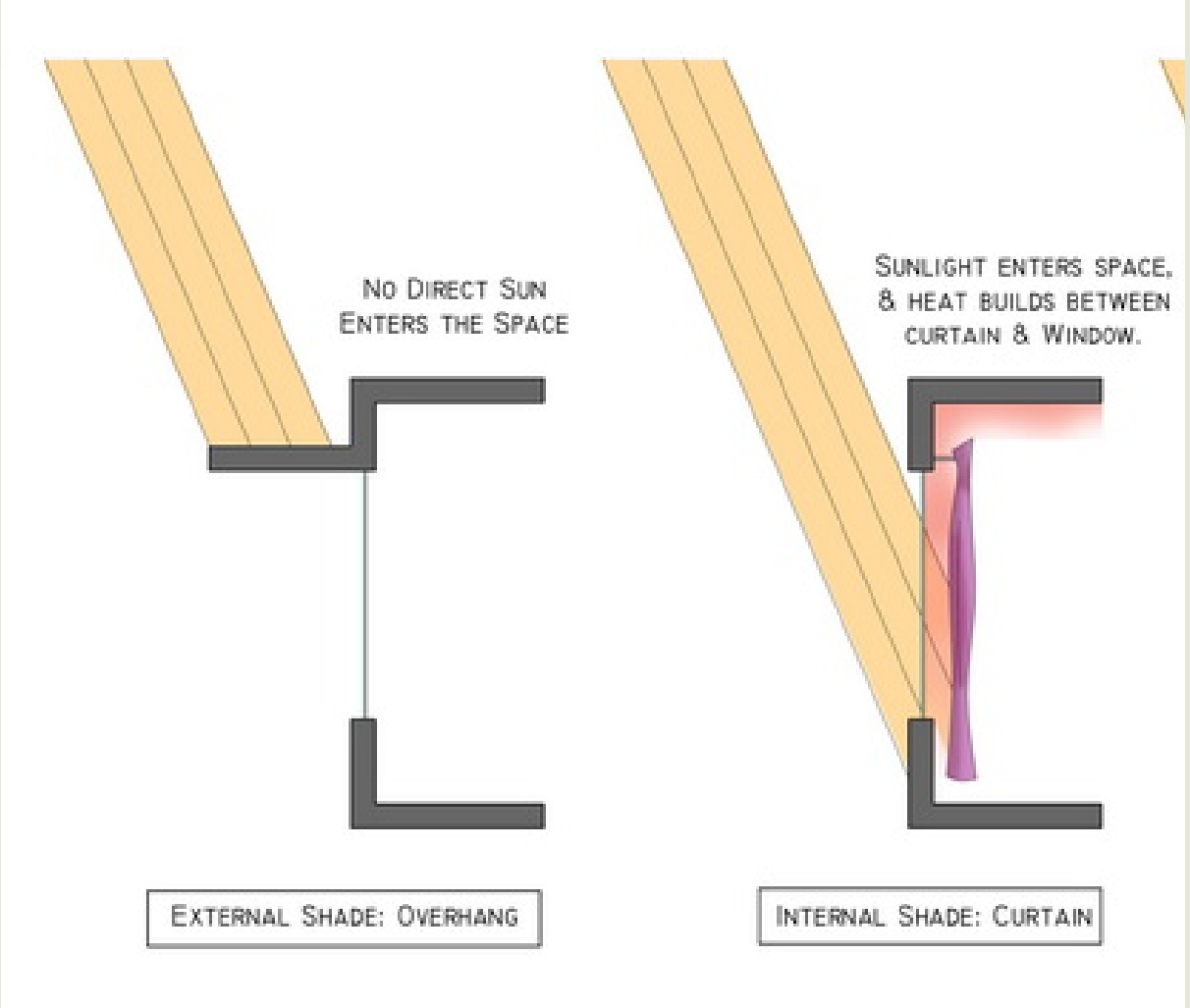
Double-Paned/Glazed Window

A double-paned window has two panes of glass set into a frame. Between the glass is an intervening gas or air pocket to better insulate a room.

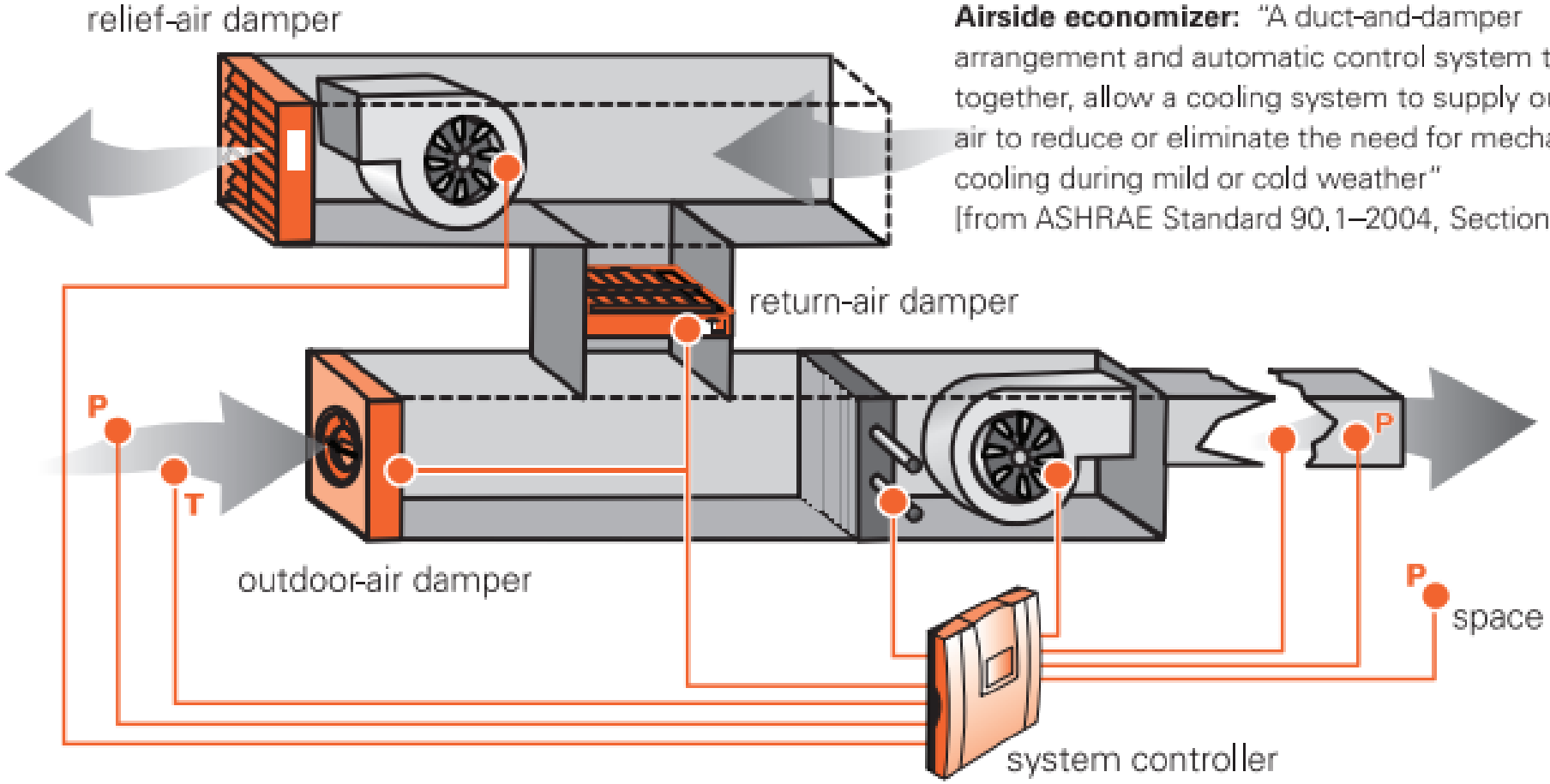


Reduce the room load

Shading

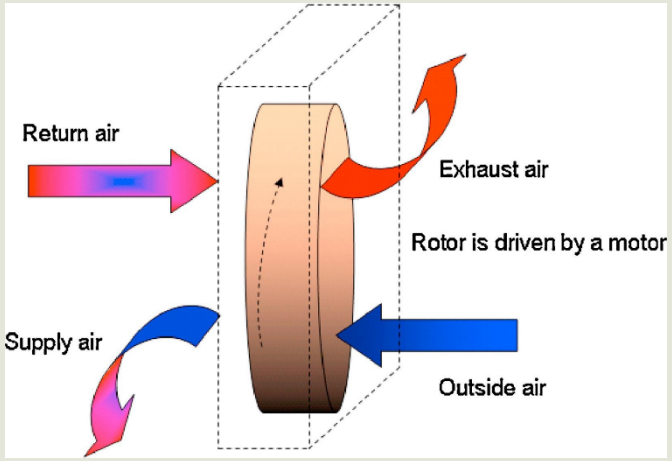


Economizer

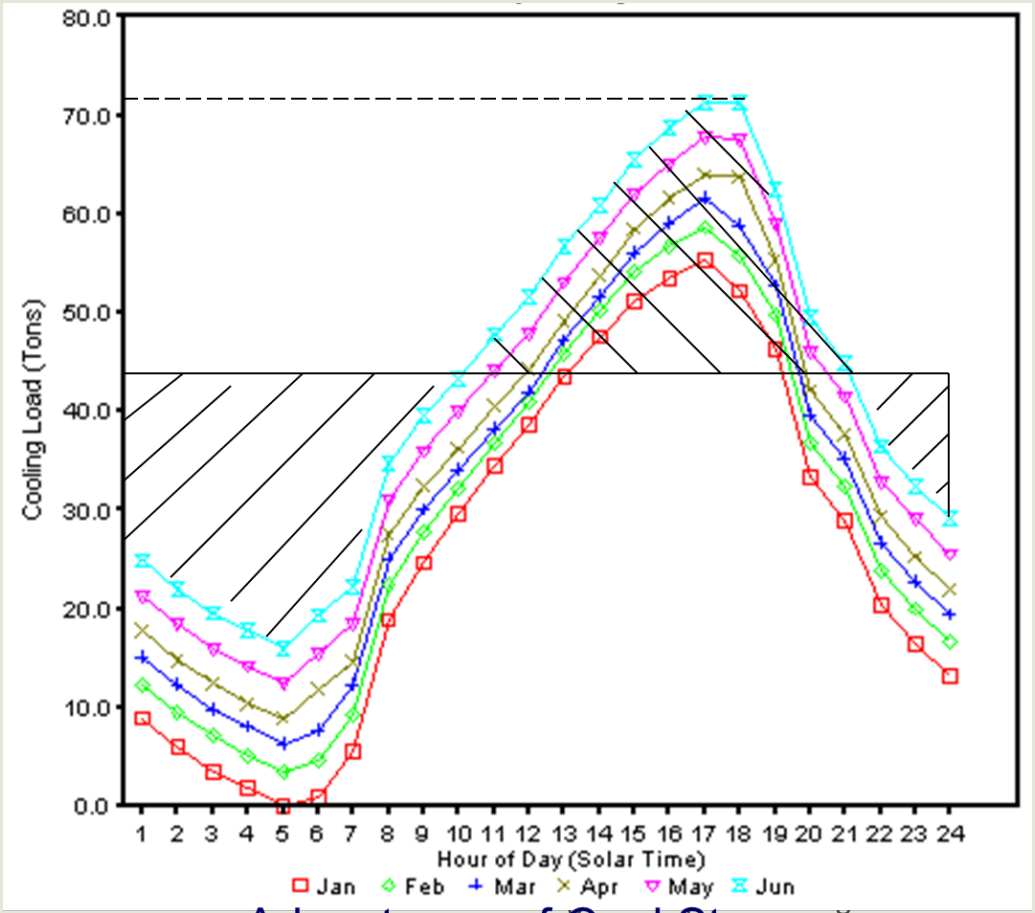


Airside economizer: "A duct-and-damper arrangement and automatic control system that, together, allow a cooling system to supply outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather"
[from ASHRAE Standard 90.1–2004, Section 3]

Energy Recovery Ventilator

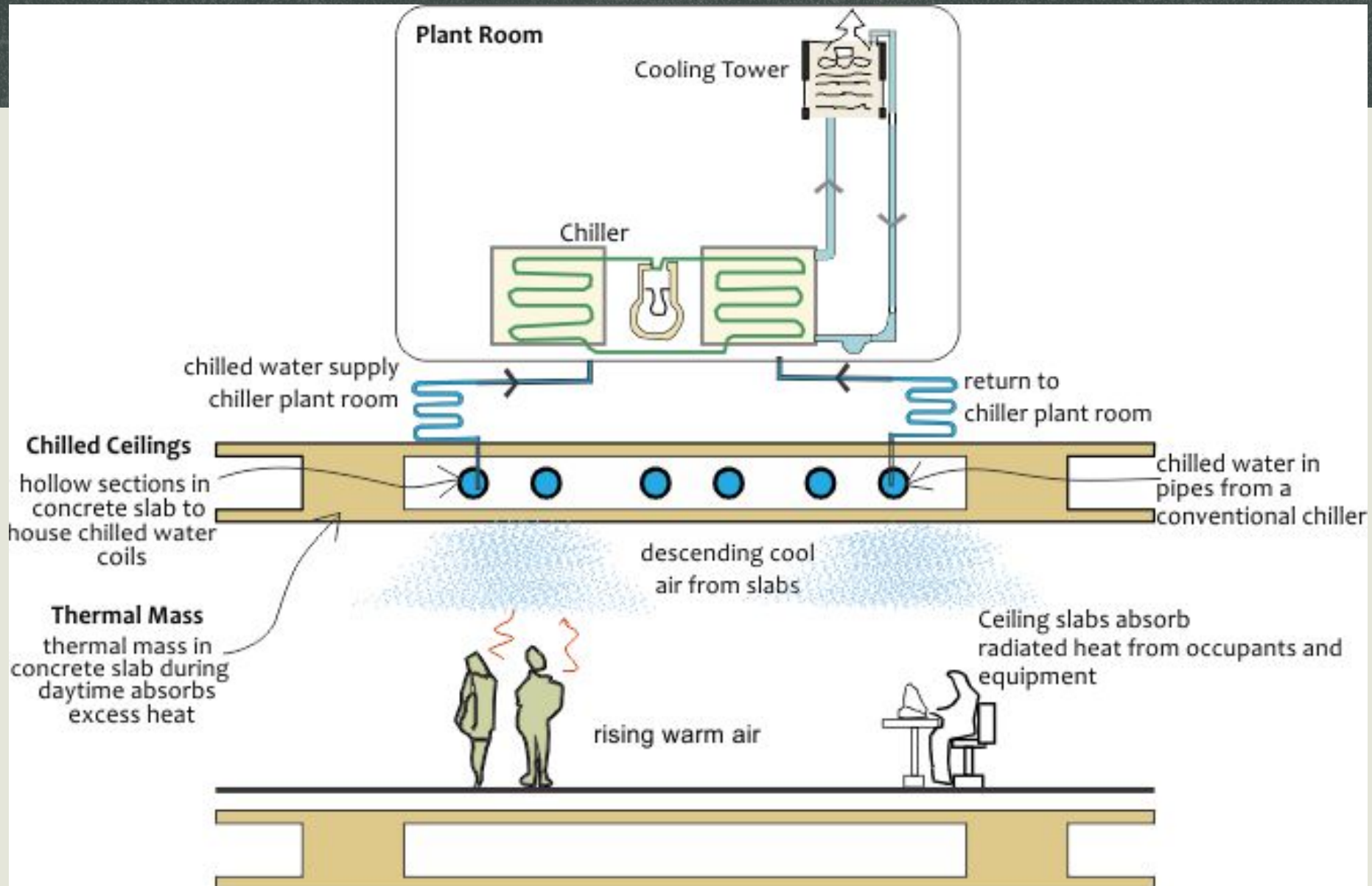


Cold Storage

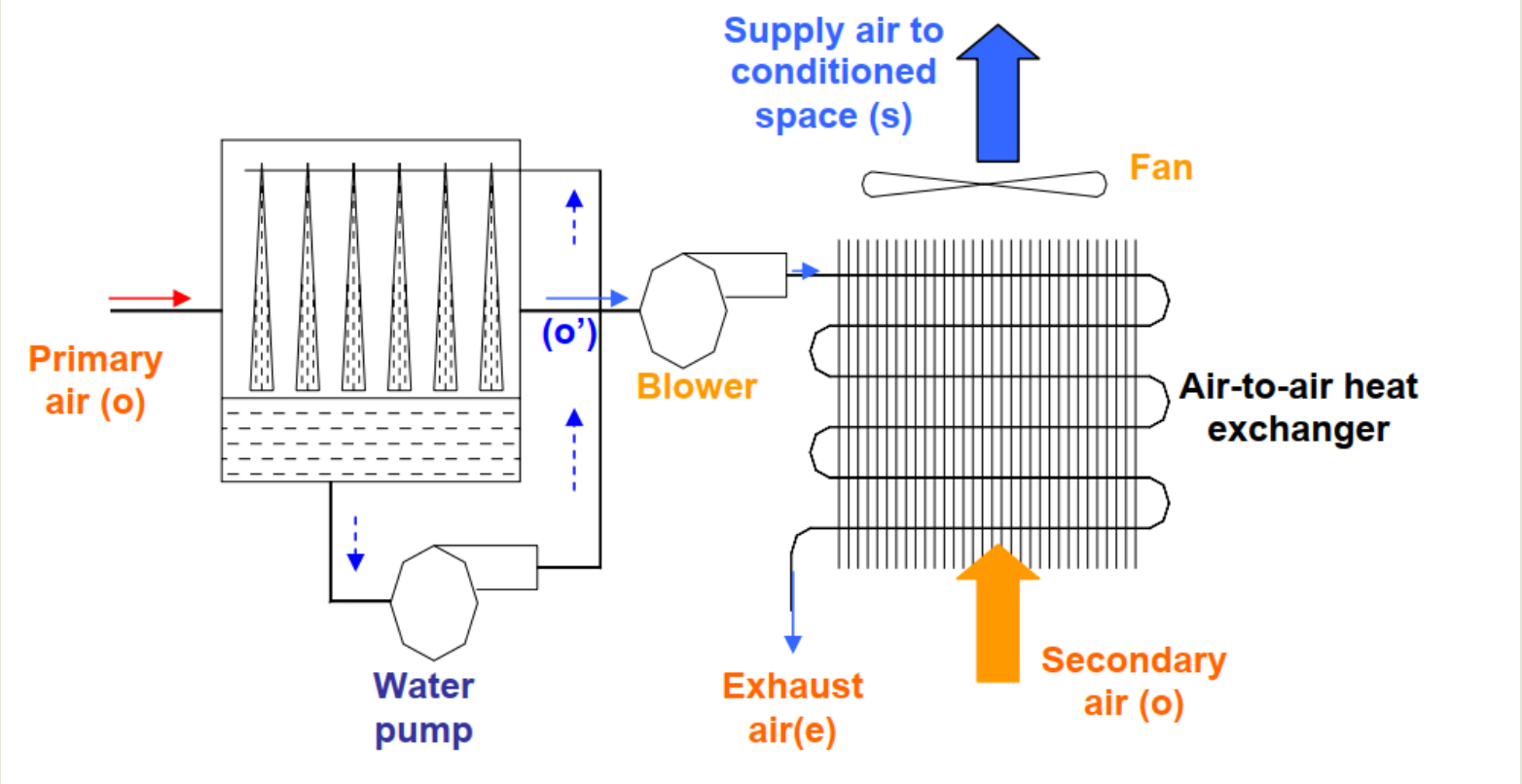


Advantages of Cool Storage

Radiant cooling system



Evaporative cooling



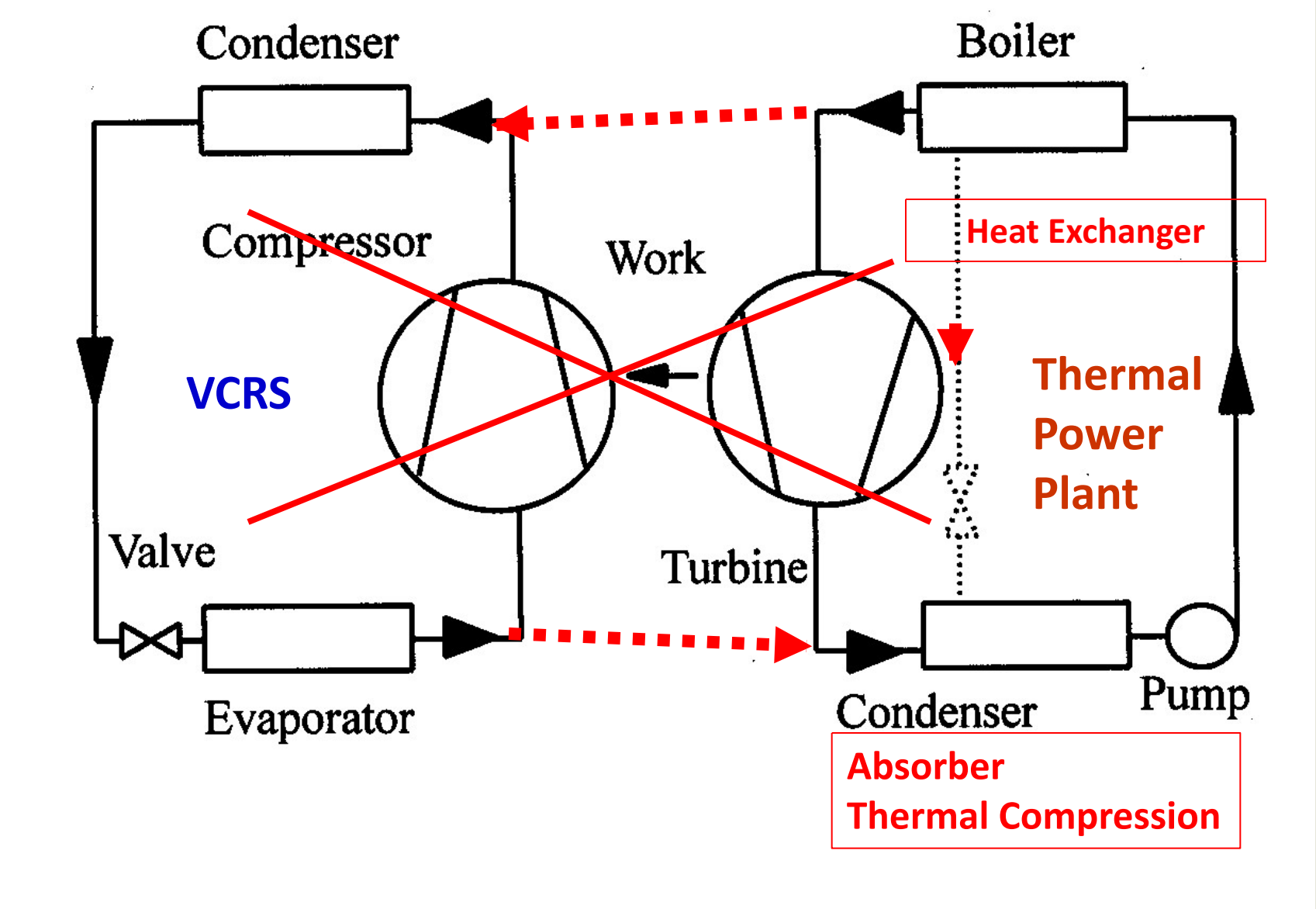
Vapor absorption system

Working Pairs:

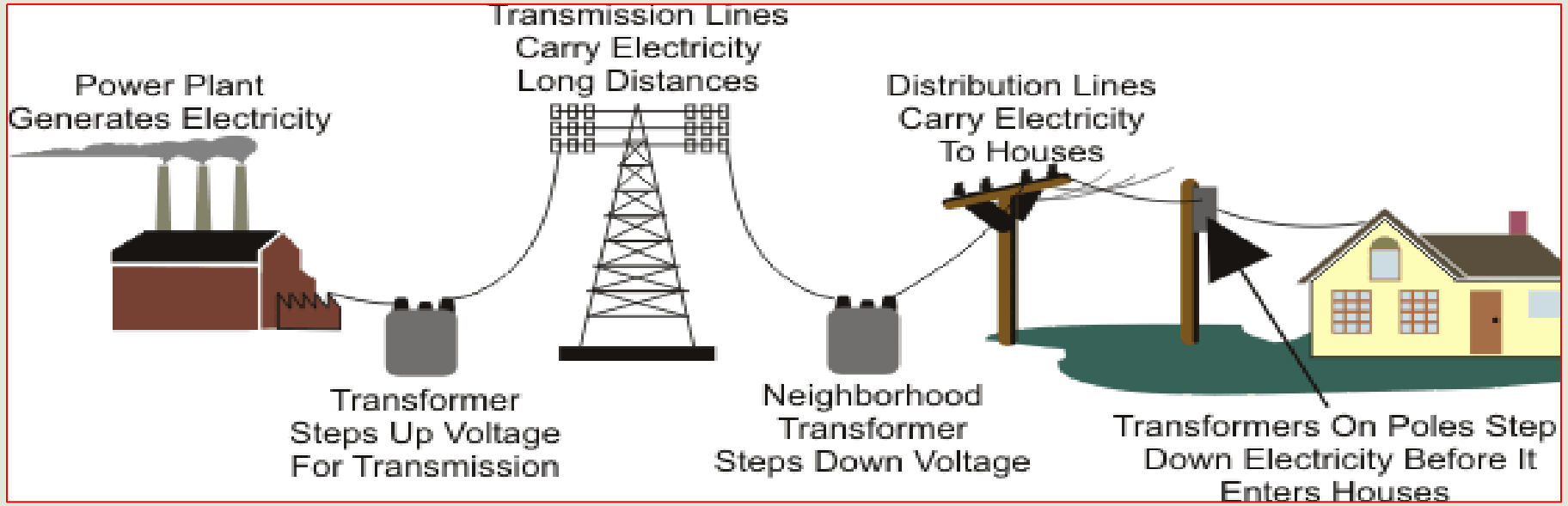
$LiBr - H_2O$,

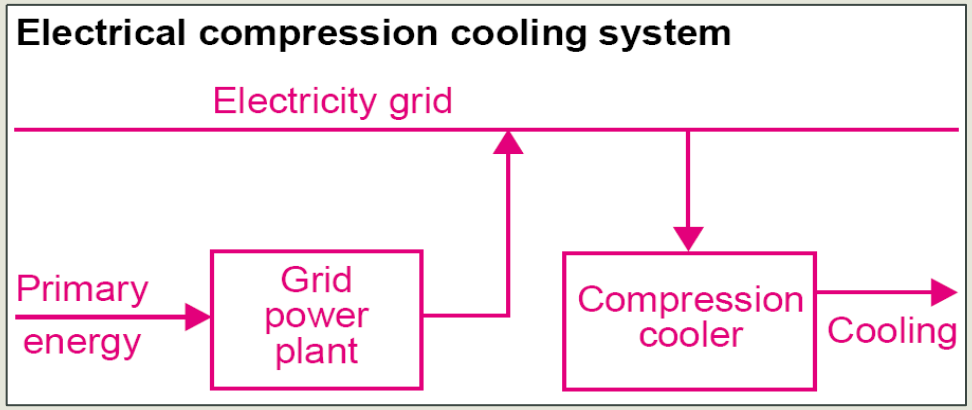
$NH_3 - H_2O$,

R134a - DMAC



Power generation – Transmission – Compression Cooling





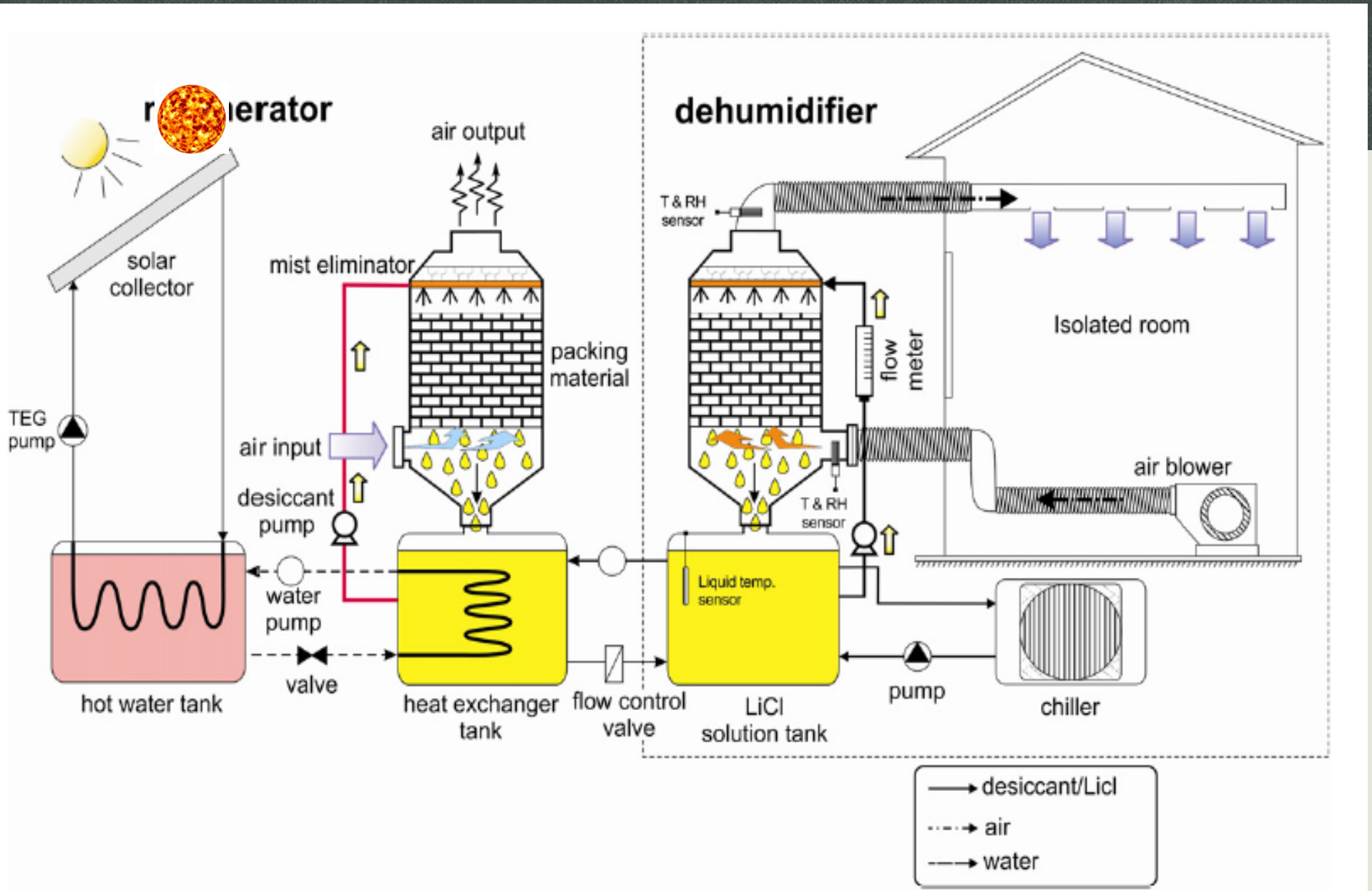
Expected losses in power lines

Power plant loss : 70%
(Efficiency = 30%)
Generator Loss : 5%
T &D Loss : 30%
End Equipment loss : 10%

25 kW – 7.5 kW – 6.75 kW – 4.75 kW – 4.25 kW

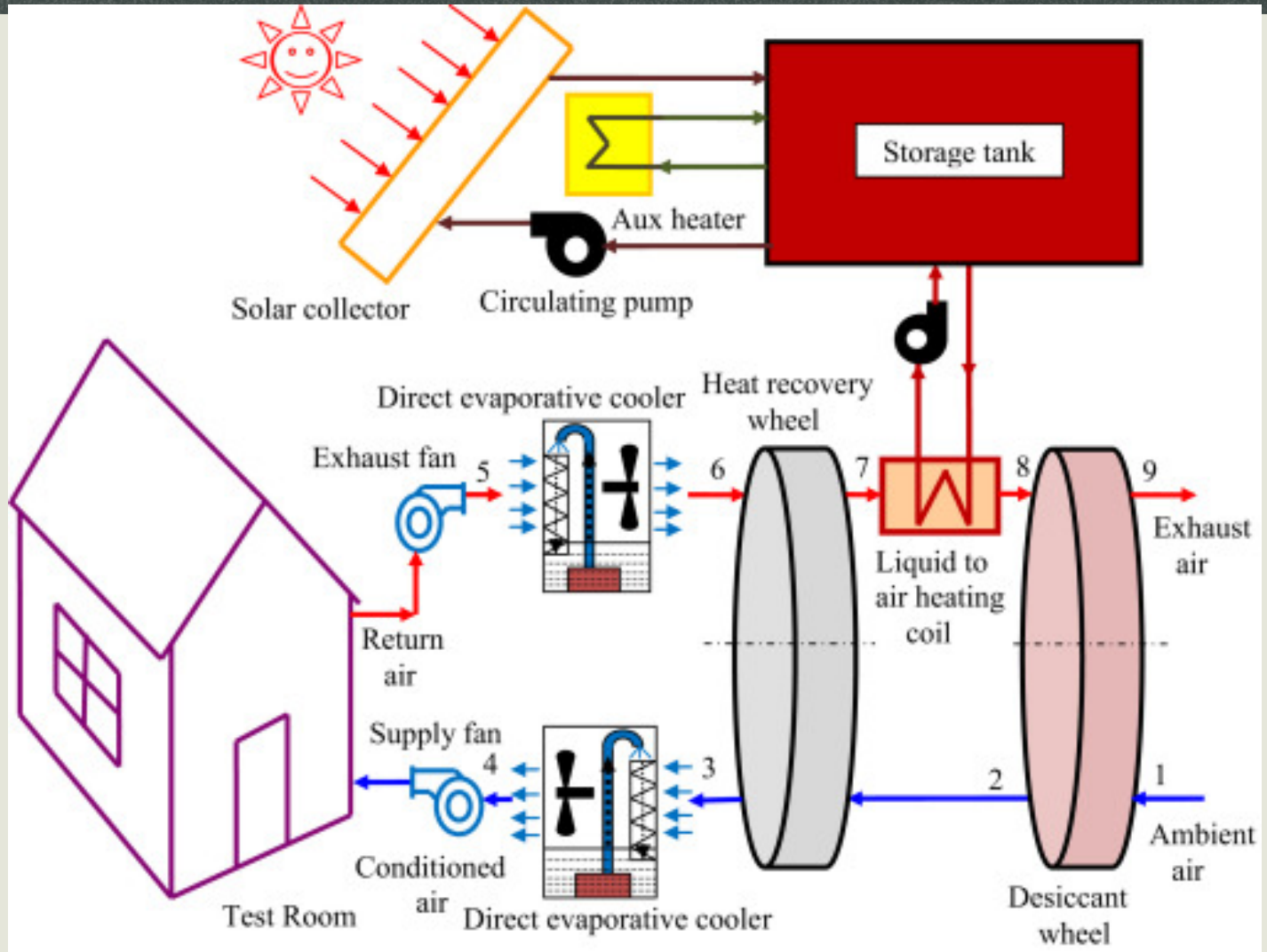
Heat Source to Site Power Factor: 4.25/25 = 0.17

Liquid desiccant cooling system



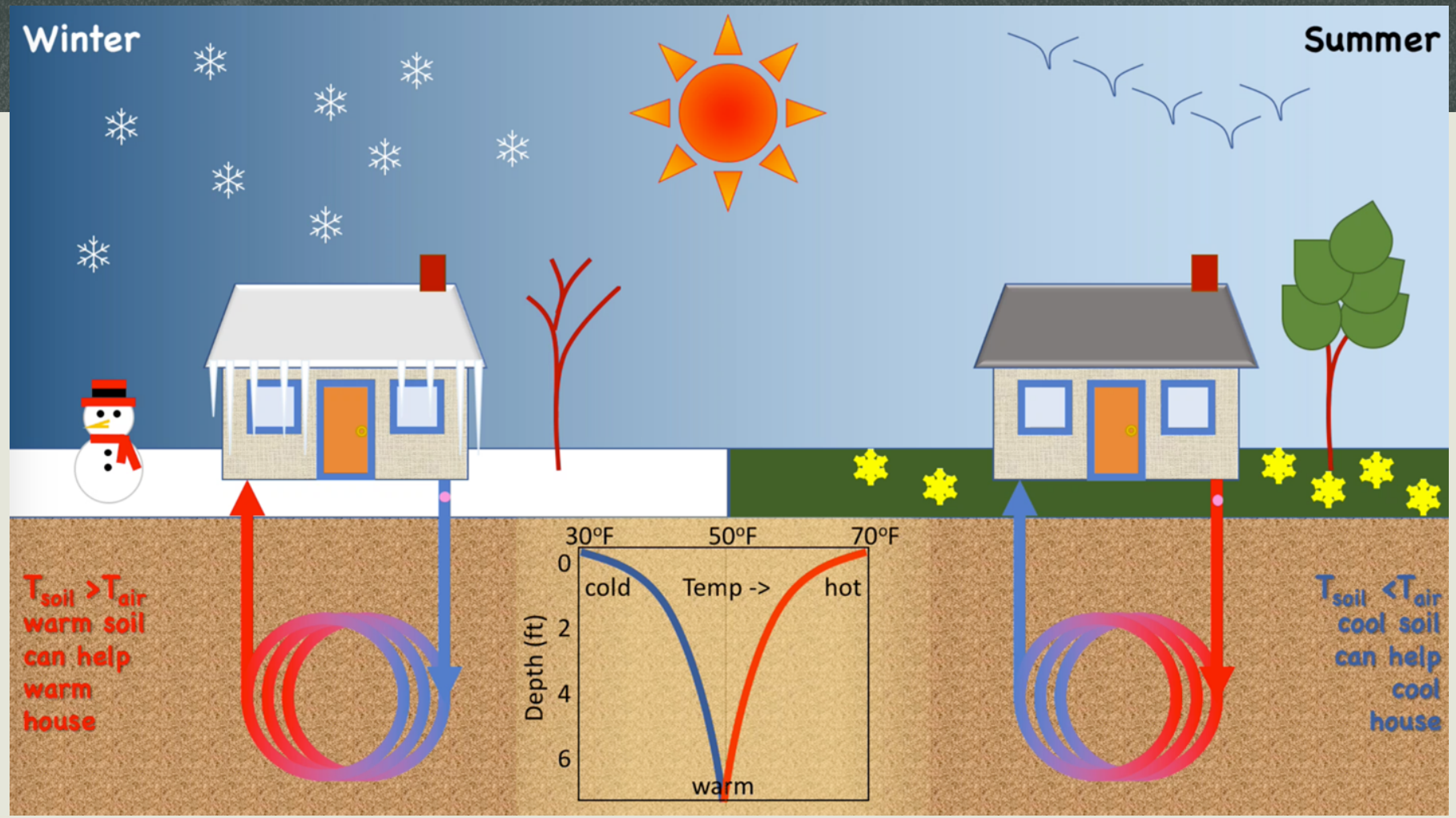
Solid desiccant cooling system

Passive cooling

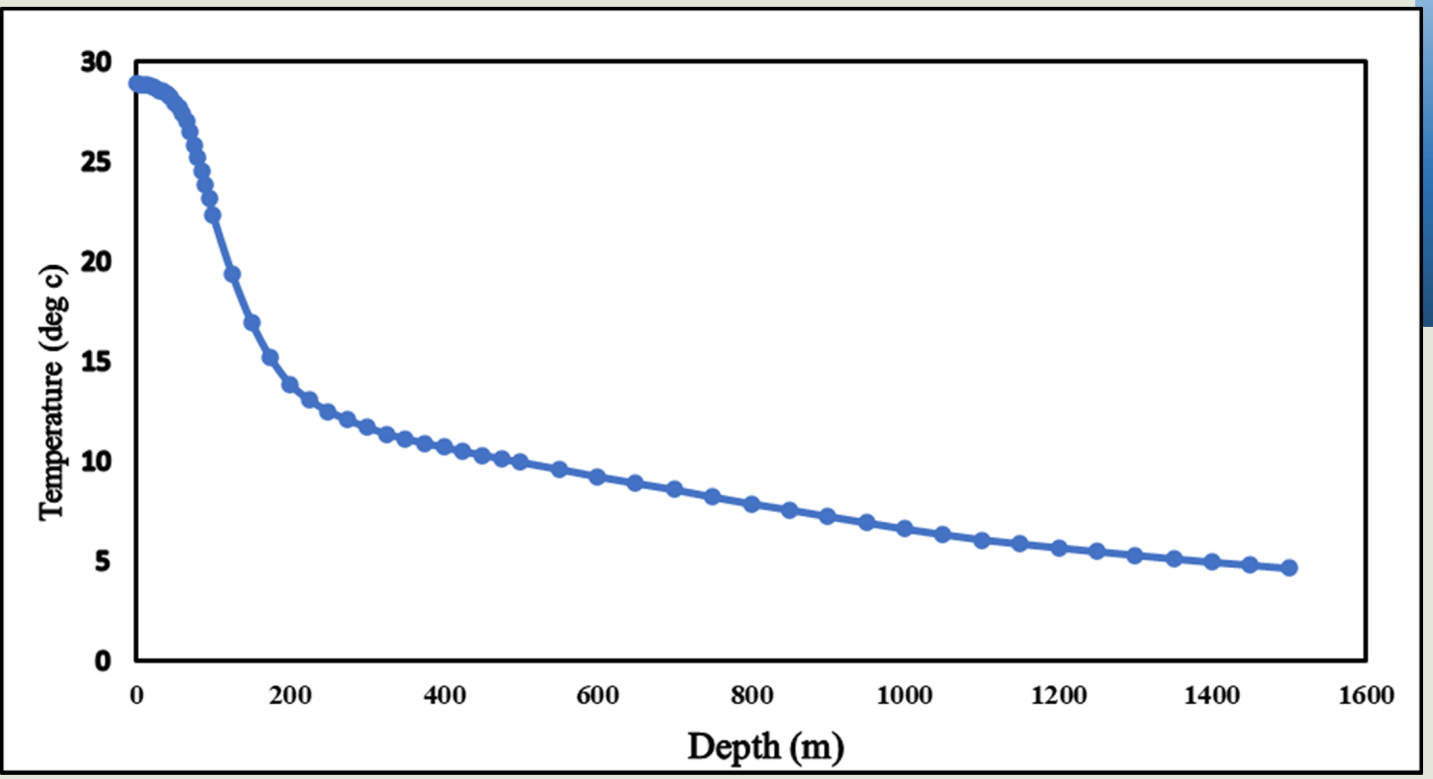


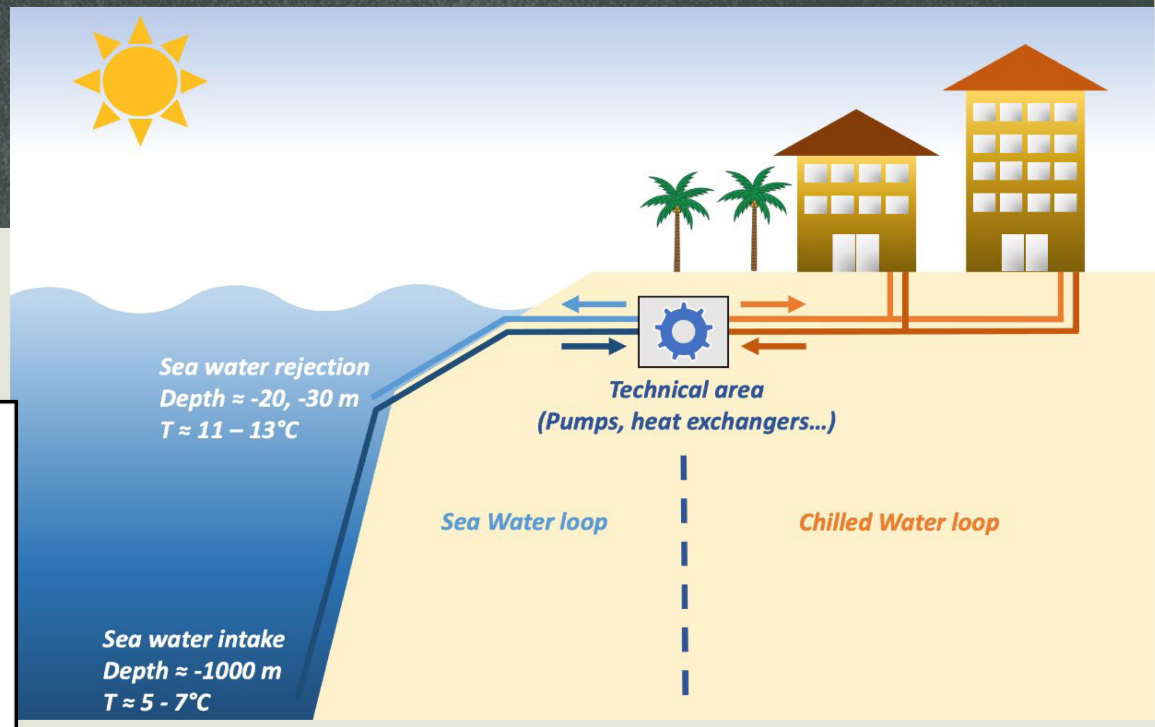
Geothermal cooling

Passive cooling

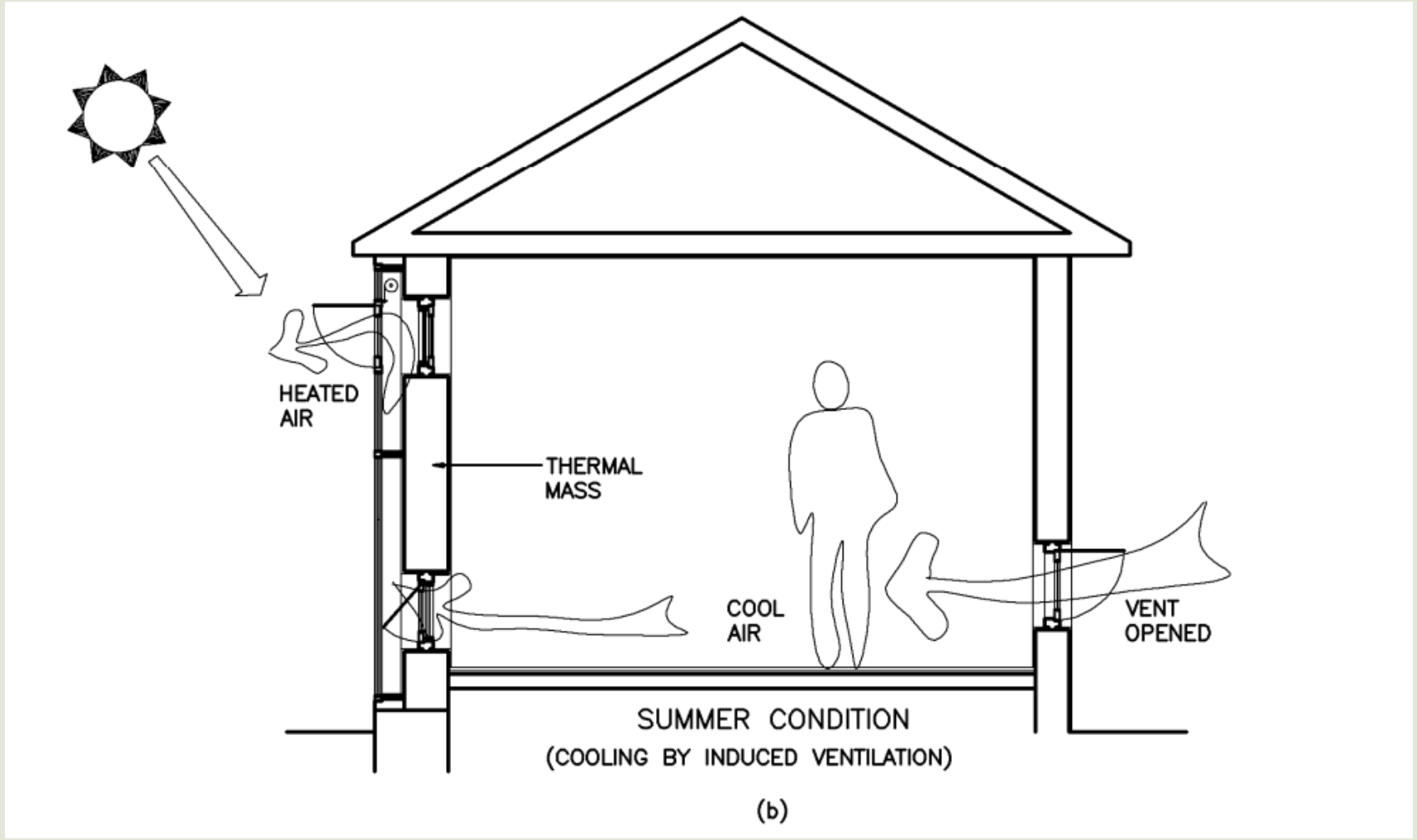


Deep Sea Water Cooling System

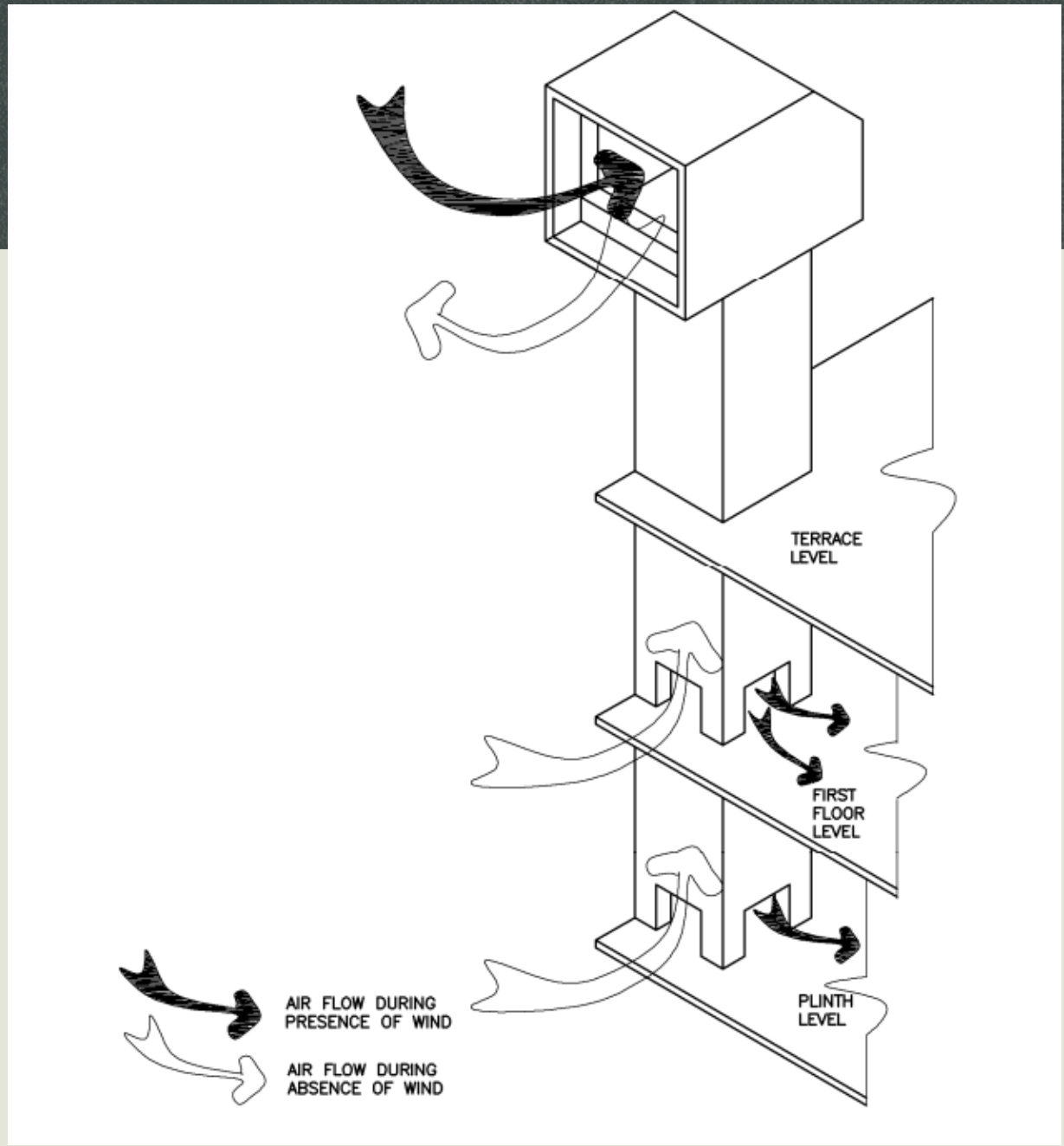




Trombe wall / Solar chimney



Wind tower


TERRACE
LEVEL
FIRST
FLOOR
LEVEL
PLINTH
LEVEL
AIR FLOW DURING
PRESENCE OF WIND
AIR FLOW DURING
ABSENCE OF WIND

References

- https://www.trane.com/content/dam/Trane/Commercial/global/products-systems/education-training/engineers-newsletters/airside-design/admapn020en-0406.pdf
- https://nzeb.in/knowledge-centre/hvac-2/radiant-cooling-systems/
- NPTEL, Mechanical Engineering - Refrigeration and Air Conditioning
- https://archive.nptel.ac.in/courses/112/105/112105129/
- Karthik Panchabikesan, Kumaresan Vellaisamy, Velraj Ramalingam, Passive cooling potential in buildings under various climatic conditions in India, Renewable and Sustainable Energy Reviews, Volume 78, 2017, Pages 1236-1252,
- https://climate.earthathome.org/sunlight-stored-in-soil/
- https://fairconditioning.org/knowledge/passive-design/shading/
- https://www.sciencedirect.com/science/article/pii/S1364032116002665#f0010