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COURSE 3 OF 10
FIRST EDITION 2026

HEAT PUMP TRAINING PROGRAM

Course 3 — Types of Heat Pumps

One of ten vendor-neutral courses, with worked examples, P&IDs, a quiz and a glossary, written for Indian conditions.

Values marked "typical", "approximate" or "illustrative" are not test data; check them against manufacturers' manuals and current standards before use.

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LEVEL 1 · FOUNDATIONS

Course 3 — Types of Heat Pumps

Powered by Sunniva. This Level 1 Foundations course is for everyone: technicians, engineers, sales and service staff, consultants and students. No prior knowledge beyond Course 1 and 2 is needed. After this course you will be able to:

- Name any heat pump by its heat source and heat sink, and say where it fits.
- Sketch a simple system schematic for air-to-water, water-to-water, ground-source and air-to-air machines.
- Explain the difference between monoblock and split construction, and between standard and high-temperature machines.
- Compare a heat pump with a solar water heater, a boiler and an electric geyser on running cost for an Indian site.

3.1 Classifying by heat source and heat sink

Key idea: Every heat pump is named "source-to-sink" — where it takes heat from, and where it delivers heat to.

A heat pump moves heat from a cooler place to a warmer place. The place it takes heat from is the **heat source**. The place it delivers heat to is the **heat sink**.

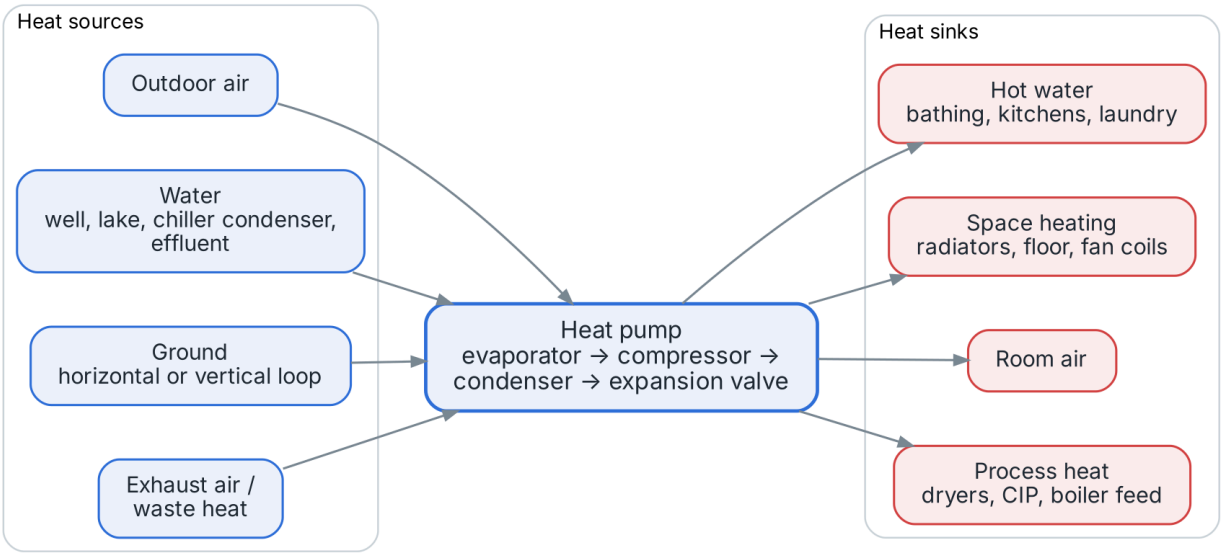
Think of a fridge. It takes heat from the food (source) and throws it out at the back grille into kitchen air (sink). A heat pump works the same way, but we use the hot side on purpose.

The name follows a simple rule: source first, sink second. An "air-to-water" heat pump takes heat from outdoor air and heats water. A "water-to-water" heat pump takes heat from one water stream and heats another.

The three common sources are air, water and ground. The three common sinks are water, air and process (a product, a dryer, or steam).

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Heat pumps are named by where heat comes from and where it goes



Heat pumps named by source and sink

Type	Heat source	Heat sink	Typical Indian use
Air-to-water	Outdoor air	Water	Hotel, hostel, hospital hot water
Water-to-water	Water stream (well, chiller condenser, effluent)	Water	Waste-heat recovery in factories
Ground-source (brine-to-water)	Ground via a buried loop	Water	Cold regions, very large buildings
Air-to-air	Outdoor air	Indoor air	Room AC with heating mode, VRF
Exhaust air-to-water	Warm exhaust air	Water	Kitchens, laundries, dryers

Remember

- Name = source first, sink second.
- Sources: air, water, ground, waste heat.
- Sinks: water, air, process.
- A warmer source means less work for the compressor and a higher COP.

Field tip: On a site visit, first ask "what warm stream is already being thrown away?" It may be a better source than outdoor air.

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3.2 Air-to-water heat pumps

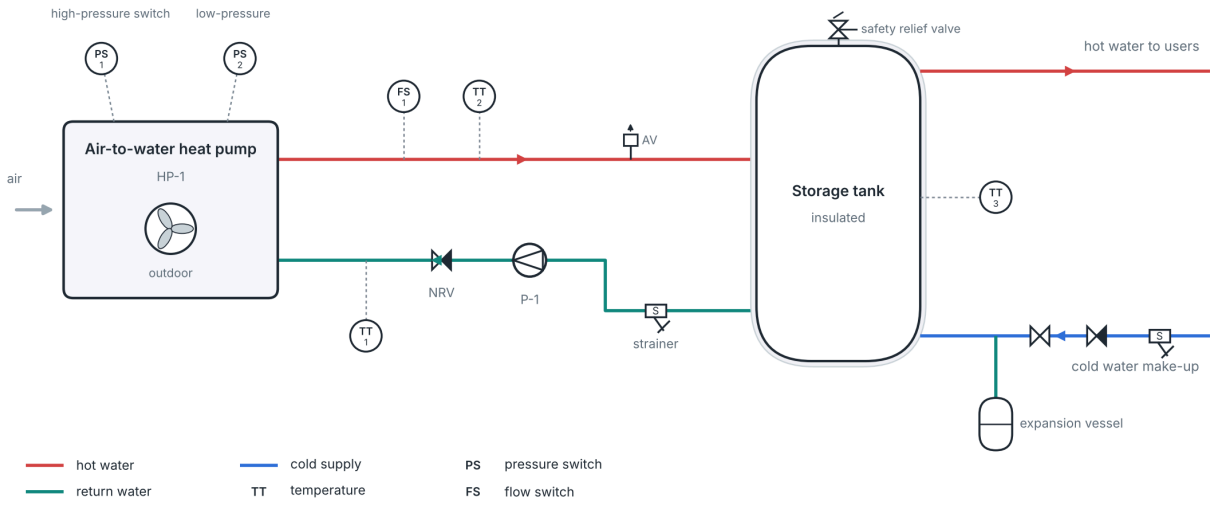
Key idea: An air-to-water heat pump pulls heat from outdoor air with a fan and coil, and puts it into water through a plate or tube heat exchanger.

This is the most common heat pump for hot water in India. It needs no well, no borehole and no waste stream. It needs only outdoor air and a place with good airflow.

The fan blows outdoor air across the **evaporator** (a finned coil where the refrigerant boils and absorbs heat). The **compressor** raises refrigerant pressure and temperature. The **condenser** (a plate or shell-and-tube heat exchanger) gives this heat to the water. The **expansion valve** drops the pressure so the cycle can repeat.

Most of India is warm, so air is a good source for most of the year. In Chennai or Mumbai, outdoor air is 25–35 °C almost all year. In Delhi winter nights it can drop to 5 °C, and in Leh to well below 0 °C. COP falls as air gets colder.

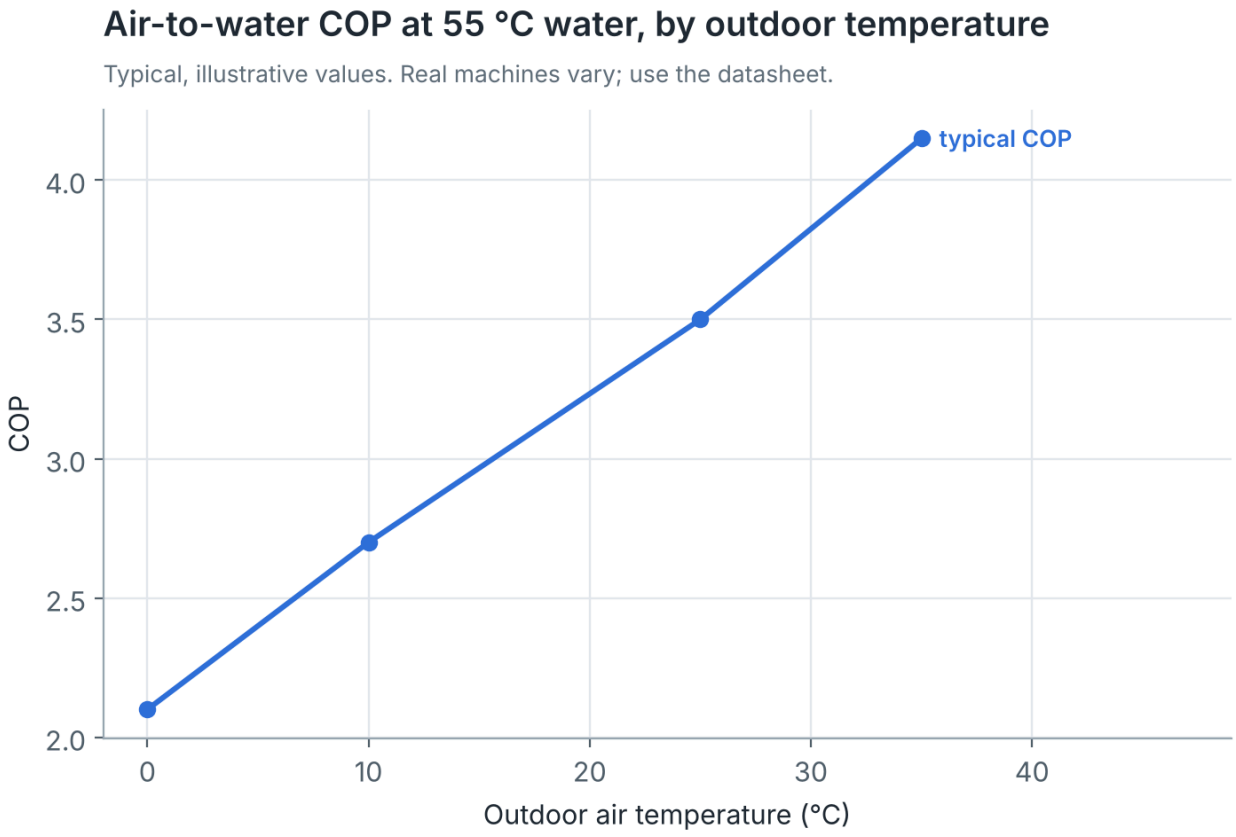
Air-to-water heat pump with storage tank (P&ID)
Packaged unit outdoors; water loop to an insulated tank; hot water drawn from the top



P&ID: air-to-water heat pump with storage tank

Outdoor air (°C)	Typical COP, water to 55 °C	Notes
35	3.8–4.5	Summer, coastal cities
25	3.2–3.8	Most Indian plains, average
10	2.4–3.0	North India winter
0	1.8–2.4	Hill stations; defrost needed

(All values typical; check the machine's datasheet.)



Air-to-water COP by outdoor temperature

Worked example — Hotel hot water in Pune

A hotel needs 1,000 L of water heated from 25 °C to 55 °C each day. Compare an electric geyser and an air-to-water heat pump (typical COP 3.5). Example electricity rate ₹9/kWh.

$$Q = \frac{m \cdot c_p \cdot \Delta T}{3600}$$

- m = 1,000 kg, cp = 4.186 kJ/kg·K, ΔT = 30 K
- Q = 1,000 × 4.186 × 30 ÷ 3,600 = 34.9 kWh of heat per day
- Electric geyser (about 98 % efficient): 34.9 ÷ 0.98 = 35.6 kWh → 35.6 × ₹9 = ₹320 per day
- Heat pump: 34.9 ÷ 3.5 = 10.0 kWh → 10.0 × ₹9 = ₹90 per day
- Saving: about ₹230 per day, or roughly ₹84,000 per year.

Remember

- Source = outdoor air; sink = water.
- Needs free airflow; do not box the unit in.
- COP falls in cold weather; below about 5 °C, the coil may frost and need defrost.
- Best fit for most Indian hot-water jobs.

Common mistake: Installing the unit in a closed basement or shaft. It recirculates its own cold exhaust air and COP collapses.

3.3 Water-to-water and waste-heat recovery heat pumps

Key idea: A water-to-water heat pump takes heat from a warm water stream that is already available and lifts it to a useful temperature.

Many factories and buildings throw heat away. A chiller rejects heat at its cooling tower at about 32–37 °C. Laundries drain warm water. Dairies and pharma plants have warm effluent and condenser water.

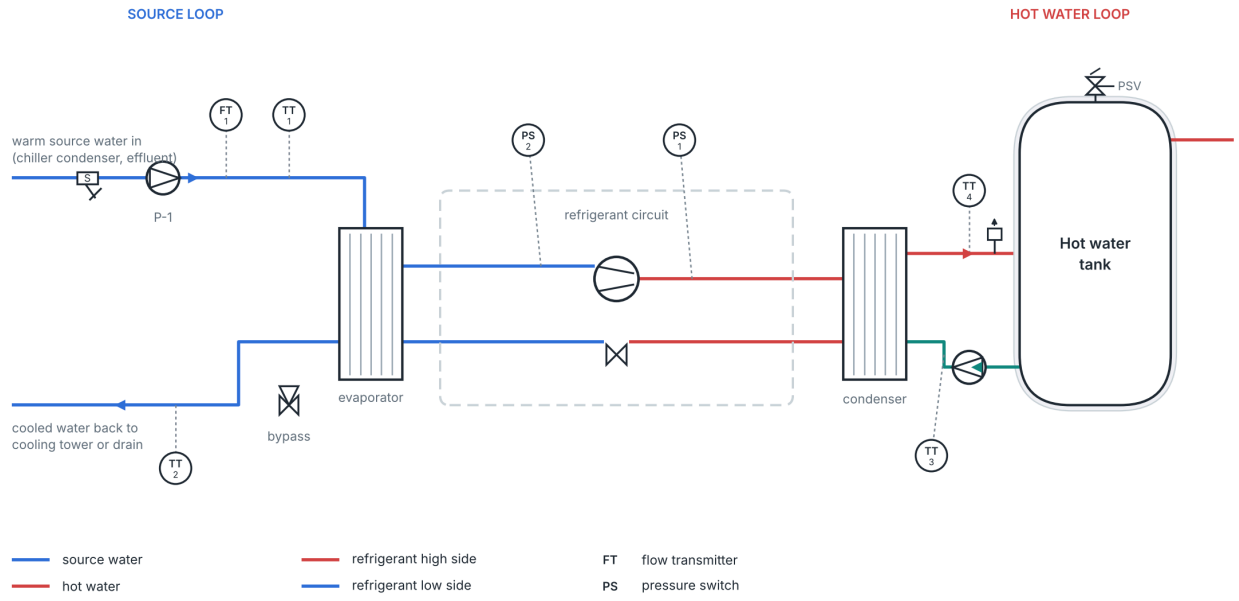
These streams are too cool to use directly. A water-to-water heat pump lifts them to 55–80 °C. Because the source is warm and steady, COP is high, typically 4–6.

Both sides are water, so the machine is compact. The evaporator and condenser are both plate or shell-and-tube heat exchangers. There is no fan and no defrost.

Every cooling tower and drain carries heat away to be wasted. A waste-heat heat pump catches that heat and puts it back to work.

Water-to-water heat pump recovering waste heat (P&ID)

Warm source water is cooled in the evaporator; the condenser heats a hot water tank



P&ID: water-to-water heat pump recovering waste heat

Waste-heat source	Typical temperature (°C)	Typical hot-water output (°C)
Chiller condenser water	30–37	55–65
Air compressor cooling water	35–50	60–75
Laundry / dyeing drain	30–45	55–70
Process effluent	25–40	55–65
Borewell water	25–30	50–60

(All values typical.)

Worked example — Chiller heat recovery in a Chennai hospital

Condenser water flows at 20 m³/h, cooled from 37 °C to 32 °C. A water-to-water heat pump (typical COP 5) uses this heat.

$$Q_{source} = \dot{V} \times 1.163 \times \Delta T \qquad Q_{hot} = Q_{source} \times \frac{COP}{COP - 1}$$

- 1.163 kWh/m³·K is the heat capacity of water.
- Q source = 20 × 1.163 × 5 = 116 kW
- Q hot = 116 × 5 ÷ 4 = 145 kW of hot water heat
- Electrical input W = 145 − 116 = 29 kW
- Bonus: the cooling tower now rejects 116 kW less heat, saving fan power and make-up water.

Remember

- Warm, steady source → high COP.
- No fan, no defrost, compact.
- Check source flow and temperature over a full day, not one reading.
- Use a strainer and a plate HX that suits the water quality.

Field tip: Indian borewell and effluent water is often hard or dirty. Fit a strainer and consider an intermediate plate heat exchanger to protect the evaporator.

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3.4 Ground-source heat pumps

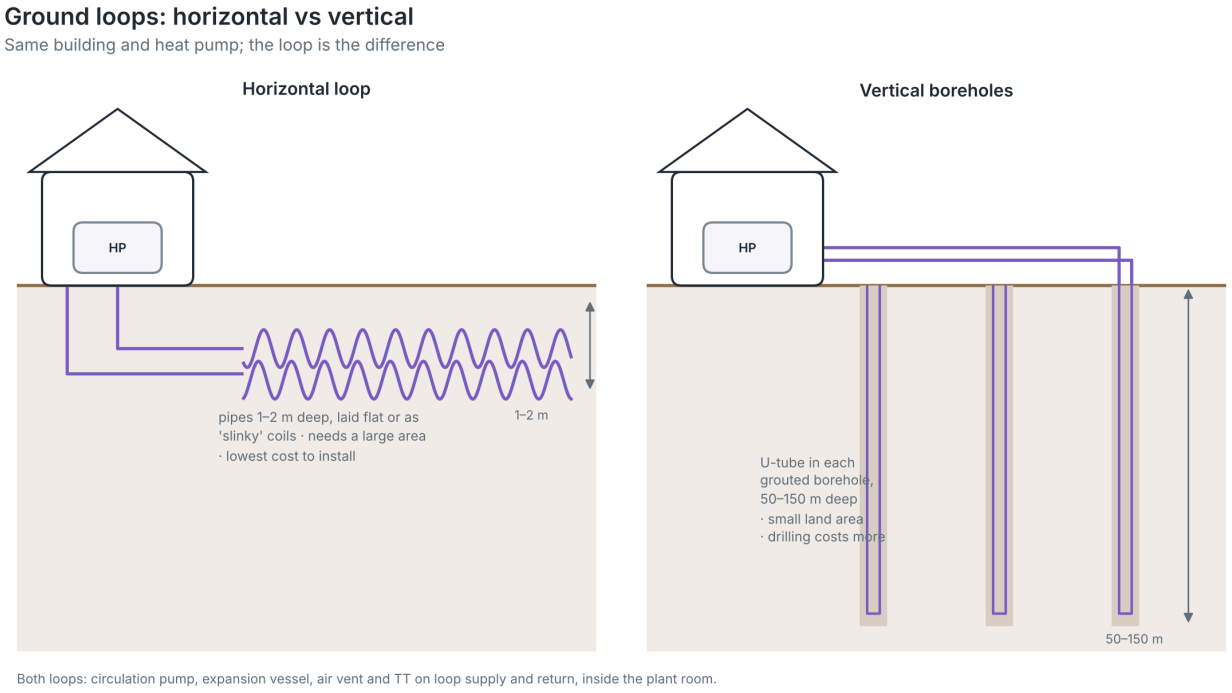
Key idea: A ground-source heat pump uses the steady temperature of the earth, reached through a buried pipe loop filled with water or brine.

A few metres below the surface, ground temperature stays almost the same all year. It is close to the area's average annual air temperature. In most of the Indian plains this is about 24–30 °C. In Leh or Shimla it is much colder, typically 5–15 °C.

A plastic (HDPE) pipe loop is buried in the ground. Water or **brine** (water with antifreeze, such as glycol) circulates through it. It picks up heat from the soil and carries it to the heat pump's evaporator.

There are two main loop types. A **horizontal loop** is laid in trenches about 1–2 m deep and needs a large open area. A **vertical loop** uses boreholes, typically 50–150 m deep, and needs little land.

In hot Indian climates, ground-source is mostly used for cooling, where the ground absorbs condenser heat. For heating, it pays off most in cold regions where air is very cold in winter.



Ground loops: horizontal vs vertical

Feature	Horizontal loop	Vertical loop
Depth	1–2 m	50–150 m (typical)
Land needed	Large	Small
Installation cost	Lower (trenching)	Higher (drilling)
Ground temperature stability	Varies a little with season	Very stable
Typical heat extraction	10–25 W per m² of land	30–60 W per m of borehole

(Heat extraction depends strongly on soil and moisture; values typical.)

Worked example — Borehole length for a Shimla guest house

Heating need is 10 kW. Heat pump COP is 4. Soil allows a typical 40 W per metre of borehole.

$$Q_{ground} = Q_{heat} \times \frac{COP - 1}{COP} \qquad L = \frac{Q_{ground}}{q}$$

- Q ground = 10 × 3 ÷ 4 = 7.5 kW = 7,500 W
- L = 7,500 ÷ 40 = 188 m of borehole
- Practical layout: two boreholes of about 95 m each.

Remember

- Ground stays near the annual average air temperature.
- Horizontal = shallow, large area; vertical = deep, small area.
- Highest first cost of all types; lowest variation in COP.
- Best fit in cold regions, or for large combined heating and cooling.

Common mistake: Undersizing the loop. The ground slowly cools (or heats) over years and COP drops season after season.

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3.5 Air-to-air and heat-recovery air conditioning

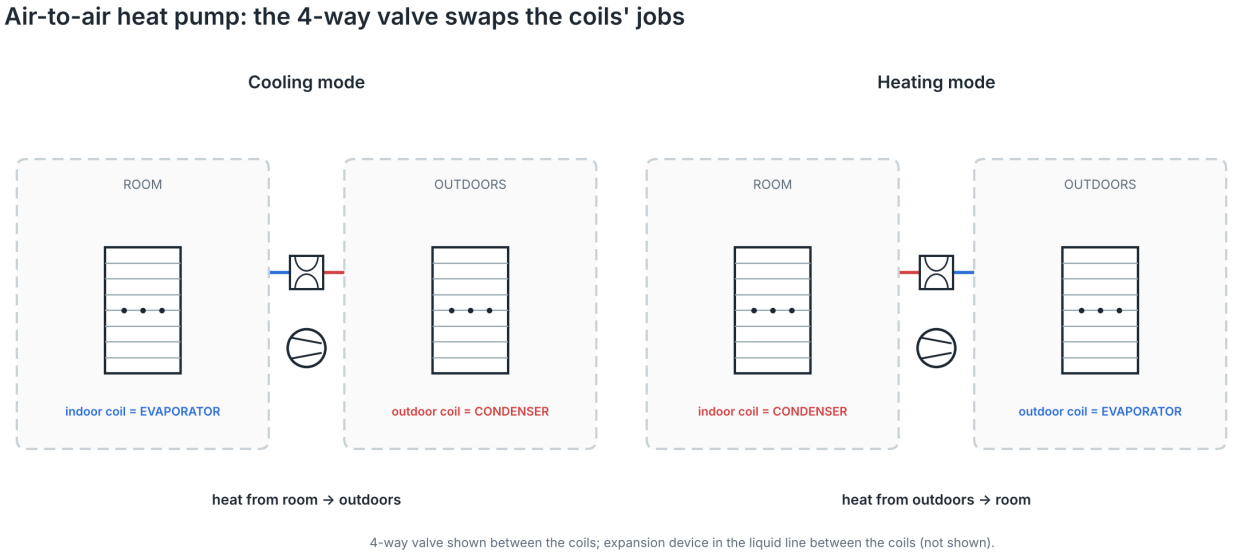
Key idea: Every room air conditioner is an air-to-air heat pump; a reversing valve lets many of them heat as well as cool.

In cooling mode, an AC takes heat from room air and throws it outdoors. In heating mode, a **four-way reversing valve** swaps the flow. The outdoor coil becomes the evaporator and the indoor coil becomes the condenser.

Heating-mode ACs are useful in north Indian winters. They give 2.5–4 kW of heat per kW of power, typically, versus 1 kW from an oil-filled or fan heater.

Larger buildings use **VRF** (variable refrigerant flow) systems. One outdoor unit serves many indoor units. A **heat-recovery VRF** can cool some rooms and heat others at the same time. It moves heat from the server room to the reception, for example.

A simpler form of heat recovery is a **desuperheater**. This small heat exchanger on the hot discharge gas of an AC or chiller makes free hot water while the unit cools.



Air-to-air heat pump in cooling and heating mode

Feature	Room AC (heat pump mode)	Heat-recovery VRF	Desuperheater
Heats	Room air	Some rooms, while cooling others	Water
Typical size	1–2.5 TR	8–60 TR outdoor units	Fraction of chiller rating
Main benefit	Low-cost winter heating	Moves heat between zones	Free hot water while cooling

(1 TR = 3.517 kW of cooling.)

Remember

- An AC is a heat pump; the reversing valve gives heating.
- Heat-recovery VRF heats and cools different rooms at once.
- A desuperheater recovers some condenser heat as hot water.
- Air-to-air heats air, not water.

Field tip: In heating mode the outdoor coil can frost in cold, humid weather. Short pauses for defrost are normal, not a fault.

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3.6 Monoblock vs split construction

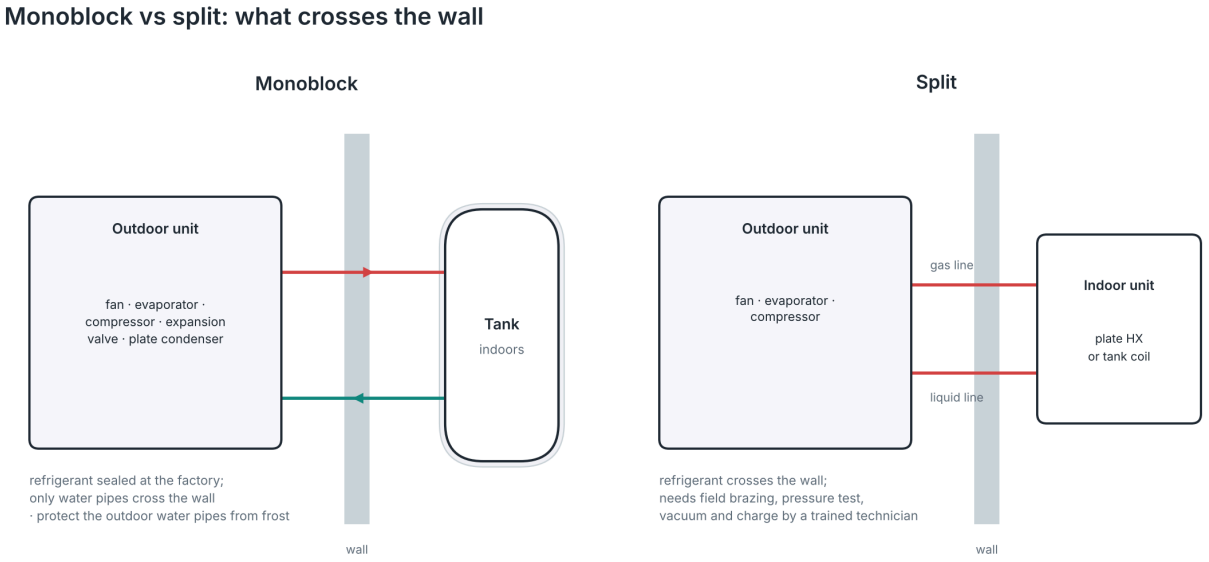
Key idea: In a monoblock, the whole refrigerant circuit is sealed in one outdoor box; in a split, refrigerant pipes run between an outdoor and an indoor unit.

A **monoblock** (also called packaged) heat pump has compressor, evaporator, condenser and valves in one unit. The factory charges and tests it. On site, the installer only connects water pipes and power.

A **split** heat pump has two parts. The outdoor unit holds the fan, coil and usually the compressor. The indoor unit holds the water heat exchanger (and sometimes the tank). Copper refrigerant lines join them.

The split needs field brazing, nitrogen pressure test, vacuum and refrigerant charging. This needs a trained refrigeration technician. The monoblock avoids this, so leak risk on site is lower.

The monoblock's weakness is that water pipes run outdoors. In cold regions they can freeze, so glycol or trace heating is needed. In most of India this is not a problem, but in cold, high-altitude regions such as Leh and Shimla it is a real risk; see lesson 4.9.



Monoblock vs split

Feature	Monoblock	Split
Refrigerant work on site	None	Brazing, pressure test, vacuum, charge
Leak risk on site	Low	Higher
What crosses the wall	Water pipes	Refrigerant pipes
Freeze risk	Water pipes outdoors (cold regions)	Low; water stays indoors
Indoor space	Only tank	Indoor unit + tank
Service	Mostly at the outdoor unit	Two locations
Typical sizes	Small to very large	Mostly small domestic

Remember

- Monoblock: factory-sealed, water connections only.
- Split: refrigerant lines, needs a trained technician.
- Monoblock is the usual choice for commercial and industrial jobs.
- Split suits homes where only small pipes can enter the building.

Common mistake: On a split, skipping the deep vacuum. Moisture left in the lines causes acid, ice at the expansion valve and compressor failure.

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3.7 High-temperature heat pumps (80–120 °C) and refrigerant choice

Key idea: To deliver 80–120 °C, a heat pump needs a refrigerant that can condense at high temperature, and a warm source to keep the lift small.

Standard heat pumps deliver water up to about 55–65 °C. Many industries need more: pasteurisation, dyeing, CIP (clean-in-place) washing, drying and boiler feed water. A **high-temperature heat pump** (HTHP) delivers 80–120 °C.

Every refrigerant has a **critical temperature**. Above it, the gas cannot be condensed into liquid. To condense at 100 °C, the refrigerant's critical temperature must be well above 100 °C.

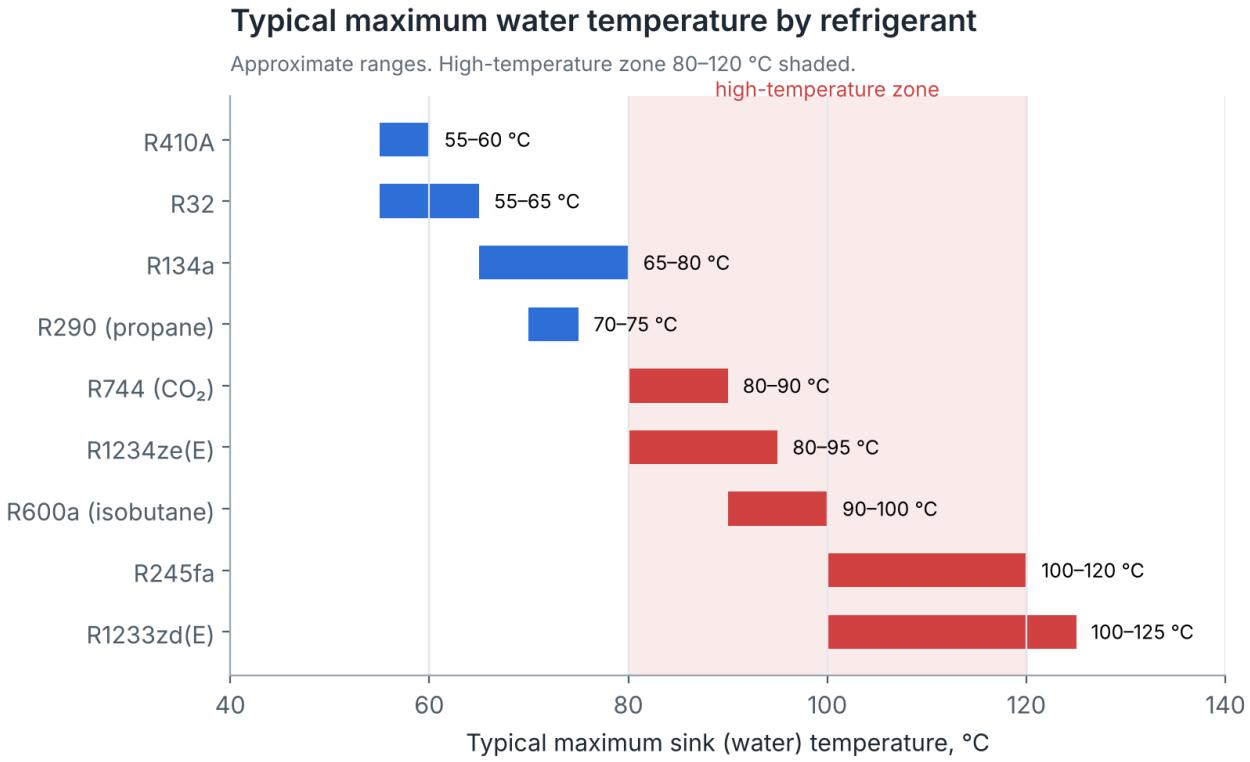
The **temperature lift** is the gap between source and sink temperature. A bigger lift means a lower COP. So HTHPs work best with a warm source, such as 40–60 °C waste water.

Think of a pressure cooker. Raising the pressure lets water stay liquid above 100 °C. A heat pump refrigerant also needs high pressure to condense at high temperature, and every refrigerant has its own limit.

Refrigerant	Type	Critical temp. (°C, approx.)	GWP (approx.)	Typical max. sink temp.	Notes
R410A	HFC blend	71	~2,090	55–60 °C	Common in older units
R32	HFC	78	~675	55–65 °C	Mildly flammable (A2L)
R134a	HFC	101	~1,430	65–80 °C	Widely used, being phased down
R290 (propane)	Natural (HC)	97	~3	70–75 °C	Flammable (A3); small charge
R744 (CO_2)	Natural	31	1	80–90 °C (transcritical)	Very high pressure; best with cold inlet water
R1234ze(E)	HFO	109	<1	80–95 °C	Mildly flammable (A2L)
R600a (isobutane)	Natural (HC)	135	~3	90–100 °C	Flammable (A3)
R245fa	HFC	154	~1,030	100–120 °C	Low pressure
R1233zd(E)	HFO	166	~1	100–120+ °C	Low pressure, non-flammable

(Values approximate; GWP figures vary by IPCC report. Check the refrigerant datasheet.)

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Typical maximum water temperature by refrigerant

Worked example — Why lift matters (ideal COP)

Compare lifting heat to 90 °C from 40 °C waste water versus from 25 °C outdoor air. Real machines achieve typically 35–45 % of the Carnot COP calculated from source and sink temperatures.

$$COP_{Carnot} = \frac{T_{sink}}{T_{sink} - T_{source}} \quad (T \text{ in kelvin})$$

- From 40 °C water: 363 ÷ (363 − 313) = 363 ÷ 50 = 7.3 → real about 40 % → COP ≈ 2.9
- From 25 °C air: 363 ÷ (363 − 298) = 363 ÷ 65 = 5.6 → real about 40 % → COP ≈ 2.2
- The warm source gives about 30 % more heat per kWh.

Remember

- HTHP = 80–120 °C output for industry.
- Refrigerant critical temperature sets the upper limit.
- Smaller lift → higher COP; pair HTHPs with warm waste heat.
- Low-GWP options: R290, R744, R600a, HFOs; note flammability class.

Common mistake: Promising 90 °C from a standard R410A or R32 machine. Its refrigerant cannot condense that hot.

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3.8 Simultaneous heating and cooling

Key idea: A heat pump always produces cooling at the evaporator and heating at the condenser; using both at once nearly doubles the useful output for the same power.

A normal hot-water heat pump throws its cold side away to outdoor air. A normal chiller throws its hot side away at the cooling tower. A **simultaneous heating and cooling** heat pump uses both sides.

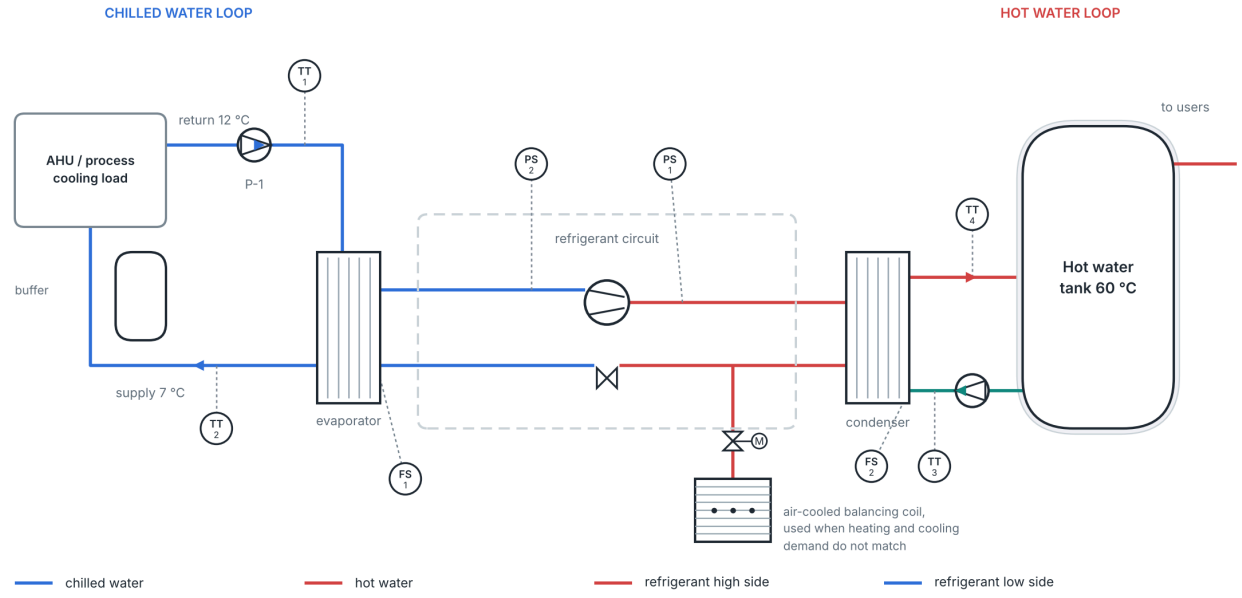
The evaporator chills water, typically to 7 °C supply and 12 °C return. The condenser heats water, typically to 55–65 °C. Both are put to work.

Good matches in India: hotels (AC plus bathing water), dairies (milk chilling plus CIP hot water), hospitals, food plants and pharma units.

When demand on one side drops, a **balancing coil** (an air-cooled coil) or the cooling tower rejects or picks up the extra heat. This keeps the machine running safely.

One heat pump, two useful outputs: chilled water and hot water (P&ID)

Evaporator cools the chilled water loop; condenser heats the hot water tank



P&ID: simultaneous heating and cooling

Worked example — Dairy in Anand, Gujarat

Power input W = 10 kW. Cooling output Qc = 20 kW (milk chilling). Heating output Qh = 30 kW (hot water at about 60 °C; 75–85 °C CIP water needs a booster or a high-temperature unit).

$$Q_h = Q_c + W \qquad COP_{total} = \frac{Q_h + Q_c}{W}$$

- Check: 20 + 10 = 30 kW ✓
- Heating-only COP = 30 ÷ 10 = 3.0
- Total COP = (30 + 20) ÷ 10 = 5.0
- Daily for 10 h: 100 kWh power × ₹9 = ₹900 gives 300 kWh heat plus 200 kWh cooling.

Remember

- Evaporator = cooling, condenser = heating; use both.
- Total COP = (heating + cooling) ÷ power, often 4.5–6 (typical, 7 °C chilled / 55–65 °C hot water).
- Best where heating and cooling are needed at the same hours.
- Plan a balancing coil or tower for mismatched loads.

Field tip: Log the hourly heating and cooling loads first. If they never overlap, a storage tank or two separate machines may be better.

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3.9 Heat pumps vs solar water heaters, boilers and geysers: where each fits

Key idea: Each hot-water technology has a place; choose by running cost, reliability of supply, space and temperature needed.

An **electric geyser** turns 1 kWh of electricity into about 1 kWh of heat. It is cheap to buy and suits small, occasional use. Running cost is high for large volumes.

A **solar water heater** uses sunlight on flat-plate or evacuated-tube collectors. Fuel is free, but output depends on sunshine. It needs roof space and a backup for cloudy days and monsoon.

A **boiler** burns LPG, PNG, diesel or biomass. It can reach high temperatures and steam quickly. Fuel cost, emissions, safety and fuel handling are the drawbacks.

A **heat pump** gives 3–4 kWh of heat per kWh of power, typically. It works day and night, in any weather. First cost is higher than a geyser, but running cost is the lowest of the electric options.

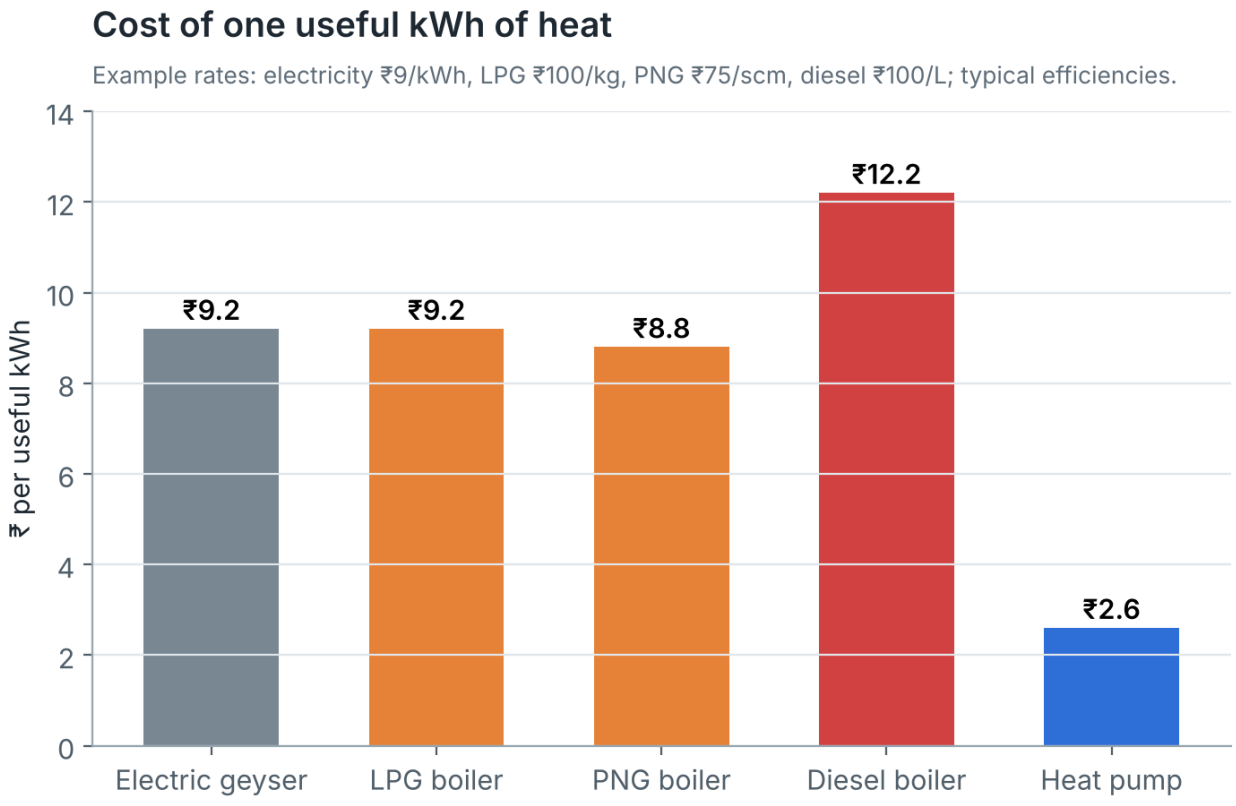
Worked example — Cost of 1 kWh of useful heat (example fuel rates)

Example rates: electricity ₹9/kWh, LPG ₹100/kg, PNG ₹75/scm, diesel ₹100/L. Typical heating values: LPG ≈ 12.8 kWh/kg, PNG ≈ 10 kWh/scm, diesel ≈ 10 kWh/L.

$$\text{Cost per useful kWh} = \frac{\text{Fuel price}}{\text{Heating value} \times \text{Efficiency}}$$

- Electric geyser: ₹9 ÷ (1 × 0.98) = ₹9.2
- LPG boiler: ₹100 ÷ (12.8 × 0.85) = ₹9.2
- PNG boiler: ₹75 ÷ (10 × 0.85) = ₹8.8
- Diesel boiler: ₹100 ÷ (10 × 0.82) = ₹12.2
- Heat pump (COP 3.5): ₹9 ÷ 3.5 = ₹2.6

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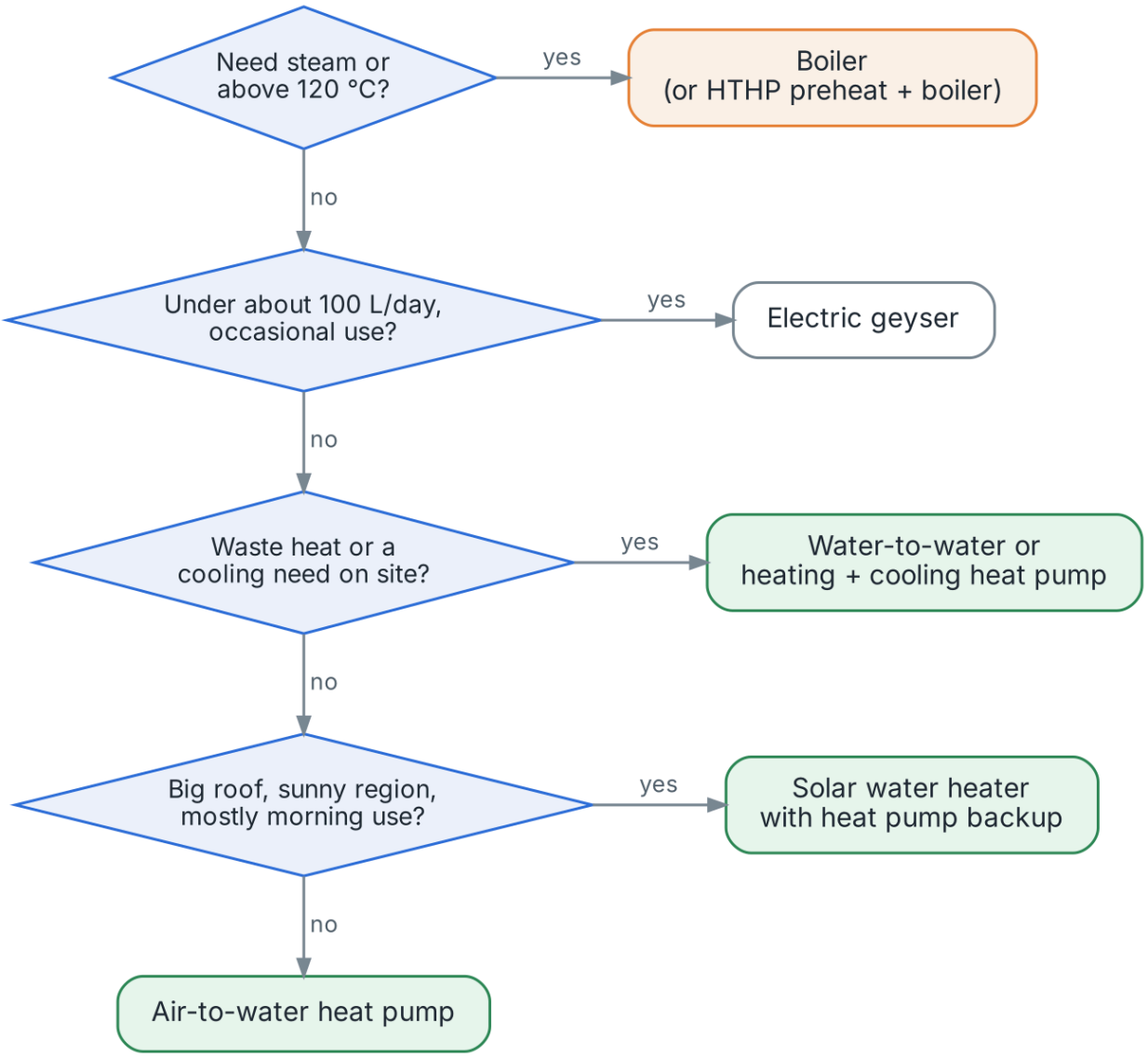


Cost of one useful kWh of heat

Technology	Typical efficiency / COP	Max. temp. (typical)	Works at night / monsoon	Best fit
Electric geyser	0.95–0.99	60–75 °C	Yes	Homes, small daily use
Solar water heater	Depends on sun	50–70 °C	No, needs backup	Sunny sites with roof space, morning use
LPG / PNG / diesel boiler	0.80–0.90	Steam / >100 °C	Yes	Steam, very high temperature
Heat pump	COP 3–4.5	55–65 °C standard; 80–120 °C high-temp	Yes	Large daily hot water, process heat to 90 °C
Solar + heat pump	Combined	55–65 °C	Yes	Lowest running cost, good space

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Which hot water system fits?



Which hot water system fits?

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Remember

- Geyser: cheap to buy, costly to run.
- Solar: free fuel, but weather-dependent; always needs backup.
- Boiler: for steam and very high temperatures.
- Heat pump: lowest running cost for most hot-water jobs up to 90 °C.
- Solar plus heat pump is a strong combination.

Common mistake: Comparing only purchase price. Over 5–10 years, running cost is usually far bigger than first cost.

Quiz 3

1. A heat pump that takes heat from a chiller's condenser water and makes hot water is called:
    - A. Air-to-water
    - B. Water-to-water
    - C. Air-to-air
    - D. Ground-source
2. In heat pump names, the first word describes the:
    - A. Refrigerant
    - B. Heat sink
    - C. Heat source
    - D. Compressor type
3. Why does an air-to-water heat pump's COP drop in winter?
    - A. Water gets hotter
    - B. The temperature lift increases
    - C. The fan stops
    - D. The refrigerant changes
4. A vertical ground loop typically uses boreholes of:
    - A. 1–2 m
    - B. 5–10 m
    - C. 50–150 m
    - D. 500–1,000 m
5. In an air-to-air heat pump, which part switches between cooling and heating?
    - A. Expansion valve
    - B. Four-way reversing valve
    - C. Filter drier
    - D. Flow switch
6. Which statement about a monoblock heat pump is true?
    - A. Refrigerant lines are brazed on site
    - B. Only water pipes and power are connected on site
    - C. It cannot be used for commercial jobs
    - D. It has no compressor
7. What mainly limits the maximum sink temperature of a refrigerant?
    - A. Its colour
    - B. Its critical temperature
    - C. Its oil type
    - D. Its cylinder size
8. A machine uses 10 kW to give 30 kW cooling and 40 kW heating at the same time. Total COP is:
    - A. 3

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- B. 4
- C. 7
- D. 10

9. With example rates (electricity ₹9/kWh), useful heat from a heat pump at COP 3.5 costs about:
   - A. ₹0.9/kWh
   - B. ₹2.6/kWh
   - C. ₹9.2/kWh
   - D. ₹12.2/kWh
10. A solar water heater on its own is not enough because:
   - A. It cannot heat above 30 °C
   - B. It needs diesel
   - C. Output depends on sunshine, so it needs backup
   - D. It uses refrigerant

Answer key

1. B — Both source (condenser water) and sink (hot water) are water.
2. C — The name is always source first, sink second.
3. B — Colder air means a larger gap to the water temperature, so the compressor works harder.
4. C — Vertical boreholes are typically 50–150 m deep.
5. B — The reversing valve swaps the roles of the indoor and outdoor coils.
6. B — The refrigerant circuit is sealed and charged at the factory.
7. B — Above the critical temperature, the refrigerant cannot condense.
8. C — (40 + 30) ÷ 10 = 7.
9. B — ₹9 ÷ 3.5 ≈ ₹2.6.
10. C — Cloudy days, monsoon and night use need a backup heater.

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Glossary

Term	Meaning
Heat source	The place or medium a heat pump takes heat from (air, water, ground, waste heat).
Heat sink	The place or medium a heat pump delivers heat to (water, air, process).
Air-to-water	Heat pump that takes heat from outdoor air and heats water.
Water-to-water	Heat pump that takes heat from one water stream and heats another.
Ground-source heat pump	Heat pump that uses the ground as its source through a buried loop.
Brine	Water mixed with antifreeze (for example glycol) used in ground or cold loops.
Horizontal loop	Ground loop laid in trenches about 1–2 m deep.
Vertical loop	Ground loop placed in boreholes, typically 50–150 m deep.
Air-to-air	Heat pump that heats or cools air directly, such as a room AC.
Four-way reversing valve	Valve that swaps an air-to-air heat pump between cooling and heating.
VRF	Variable refrigerant flow: one outdoor unit serving many indoor units.
Heat-recovery VRF	VRF that heats some rooms and cools others at the same time.
Desuperheater	Small heat exchanger that recovers heat from hot discharge gas to make hot water.
Monoblock	Heat pump with the full refrigerant circuit sealed in one unit; water connected on site.
Split	Heat pump with outdoor and indoor units joined by refrigerant pipes.
High-temperature heat pump (HTHP)	Heat pump delivering about 80–120 °C.
Critical temperature	Temperature above which a refrigerant cannot be condensed to liquid.
Temperature lift	Difference between sink and source temperatures; bigger lift lowers COP.
GWP	Global warming potential: warming effect of a gas compared with CO_2.
Carnot COP	The ideal, highest possible COP between two temperatures.
Simultaneous heating and cooling	Using a heat pump's cold and hot sides at the same time.
Balancing coil	Air coil that rejects or absorbs extra heat when heating and cooling loads do not match.
Waste heat	Heat currently thrown away, such as chiller condenser water or warm drain.
Solar water heater	System that heats water with sunlight using flat-plate or evacuated-tube collectors.
Electric geyser	Resistance water heater; about 1 kWh heat per kWh of electricity.

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ABOUT THE AUTHOR

Kashyap Anandpara

Founder Director, Sunniva Encon LLP
M-Tech (Mechanical) · MBA (Marketing)



> *It started as an instinct. In 2012 I wanted to do something in energy conservation. That was the whole of it. There was no plan to build machines, and no plan to build them in India. Both came later.*

Kashyap founded Sunniva Encon in 2012 to work on energy conservation. The company now designs and builds heat pumps at its own factory in Asangaon, Maharashtra, with its office in Mumbai, and supplies hot water, space heating and process heat systems across India, including remote, high-altitude sites.

Over these years he has seen heat pumps chosen, sized, installed and serviced in every kind of Indian condition, and seen how often good machines are let down by poor selection, rushed installation or missing maintenance. Most of those problems come from knowledge that is not widely taught.

This program is his answer: an open, vendor-neutral course that shares that knowledge with students, technicians, installers, consultants and facility teams. It teaches the technology, not a brand. The lessons carry no product names or sales claims; Sunniva's part is only to make the material available.

- Founder Director, Sunniva Encon LLP, since 2012
- More than 5,000 heat pump installations across India
- Own heat pump factory in Asangaon, Maharashtra, built for 2,000 machines a year
- Nationwide service network reaching sites as remote as Leh
- Published research paper on ScienceDirect (Elsevier, 2015): sciencedirect.com/science/article/pii/S1877050915007735

LinkedIn
linkedin.com/in/kashyapya

Website
sunnivaencon.com

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THANK YOU.

Thank you for learning with us. Questions, corrections and suggestions for the next edition are welcome.

OFFICE

C-443, Oshiwara Industrial Centre Premises CHS,
New Link Road, Goregaon West,
Mumbai, Maharashtra

FACTORY

Tirupati Industrial Complex, Plot No. 41,
Sambhaji Nagar, Asangaon,
Maharashtra 421601

+91 93213 65103 **sales@sunnivaencon.com** **www.sunnivaencon.com**

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