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COURSE 4 OF 10
FIRST EDITION 2026

HEAT PUMP TRAINING PROGRAM

Course 4 — Applications and Heat Load Calculation

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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4 Applications and Heat Load Calculation

Level 2 · Application and Design

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LEVEL 2 · APPLICATION AND DESIGN

Course 4 — Applications and Heat Load Calculation

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Powered by Sunniva. This Level 2 (Application and Design) course is for consultants, designers and facility teams who select and size heat pumps for real buildings and plants. After it you will be able to: (1) estimate daily hot water demand for homes, hotels, hostels and hospitals; (2) turn that demand into a load profile, storage volume and heat pump capacity; (3) calculate pool and building heat losses; and (4) judge where heat pumps suit industrial, drying and cold-climate jobs.

4.1 Where heat pumps fit: domestic, commercial, industrial

Key idea: A heat pump fits any job that needs a steady supply of heat below about 80 °C, and it fits best when the temperature lift is small.

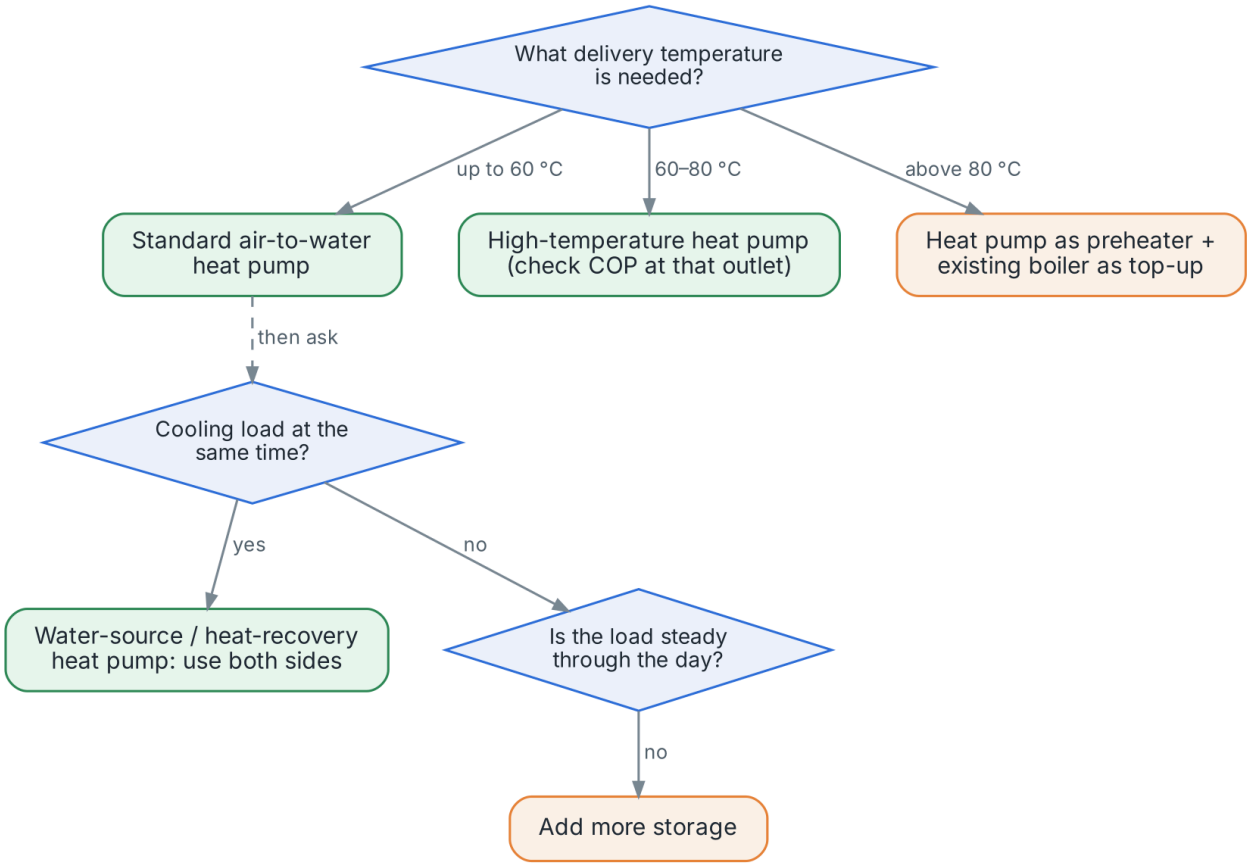
A heat pump moves heat from a low-temperature source (air, water or ground) to a higher-temperature sink (hot water or air). It does not burn fuel. It uses electricity to drive a compressor, like a fridge, but using the heat it rejects instead of the cold it makes.

The key number is the temperature lift. Lift is the difference between the source temperature and the delivery temperature. A small lift means a high COP. COP (coefficient of performance) is heat delivered divided by electricity used.

Think of a pressure cooker. Raising water from 25 °C to 45 °C is easy. Pushing it to 95 °C takes far more effort. Heat pumps behave the same way.

Segment	Typical uses	Typical delivery temperature	Fit
Domestic	Bathing, kitchen, underfloor heating	45–60 °C	Very good
Commercial	Hotels, hostels, hospitals, gyms, laundries, pools	28–65 °C	Very good
Industrial (low temp)	Washing, CIP, boiler feed preheat, dyeing	50–80 °C	Good with high-temperature units
Industrial (high temp)	Steam, frying, sterilising	Above 100 °C	Preheat only, or specialist systems

Is a heat pump a good fit?



Is a heat pump a good fit?

Remember

- Lift drives COP: keep delivery temperature as low as the process allows.
- Domestic and commercial hot water up to 60 °C is the natural home of heat pumps.
- Above about 80 °C, use the heat pump as a preheater.
- A site that needs heating and cooling together is the best case of all.

Field tip: Always ask the client "What temperature do you really need at the tap or process?" The answer is often 10–15 °C lower than the boiler setting.

4.2 Estimating hot water demand: per person, per room, per bed

Key idea: Daily hot water demand equals the number of users multiplied by a typical litres-per-user figure, always stated at a reference temperature.

Demand figures mean nothing without a temperature. "50 litres per person" at 60 °C is about 88 litres at 45 °C (cold water 25 °C), because hot water gets mixed with cold at the tap. Always write the temperature next to the litres.

Use the figures below as starting points. Measure actual use on existing sites whenever you can. Water meters on the hot line are cheap and settle arguments.

Typical daily hot water demand (stored at 60 °C, cold water at about 25 °C). These are typical values, not standards.

Building / user	Unit	Typical L/day at 60 °C
Home, economy	per person	30–40
Home, comfortable	per person	40–60
Hostel / dormitory	per bed	30–50
Hotel, budget	per room	70–100
Hotel, mid-range	per room	100–150
Hotel, luxury / resort	per room	150–250
Hospital, wards only	per bed	70–100
Hospital, incl. kitchen and laundry	per bed	100–160
Restaurant / canteen	per meal	4–8
Gym / sports shower	per shower	15–25
Staff (offices, factories)	per person	5–10

Convert between temperatures with an energy balance. Hot water at temperature T_1 mixed with cold water gives the same energy as a larger volume at a lower temperature.

Worked example — convert demand to another temperature

A spec asks for 80 L per person at 45 °C. Cold water is 25 °C. What is the volume at 60 °C?

$$V_{60} = V_{45} \times \frac{T_{45} - T_c}{T_{60} - T_c}$$

- V_{60} = 80 × (45 − 25) ÷ (60 − 25)
- V_{60} = 80 × 20 ÷ 35 = 45.7 L per person at 60 °C

Worked example — daily energy for an apartment block

A block has 40 flats with 4 people each. Use 45 L/person/day at 60 °C. Winter cold water in Bengaluru is about 20 °C.

$$Q\,(\text{kWh}) = \frac{V\,(\text{L}) \times 4.186 \times \Delta T}{3600} = V \times \Delta T \times 0.001163$$

- Volume = 40 × 4 × 45 = 7,200 L/day
- ΔT = 60 − 20 = 40 K
- Q = 7,200 × 40 × 0.001163 = 335 kWh/day

Remember

- Always state litres together with a temperature.
- 1 litre heated by 1 K needs 0.001163 kWh.
- Use typical tables only as a first estimate; meter real use where possible.
- Design for the coldest inlet water, usually the winter month.

Common mistake: Mixing 45 °C demand figures with a 60 °C storage design. This undersizes the system by 40% or more.

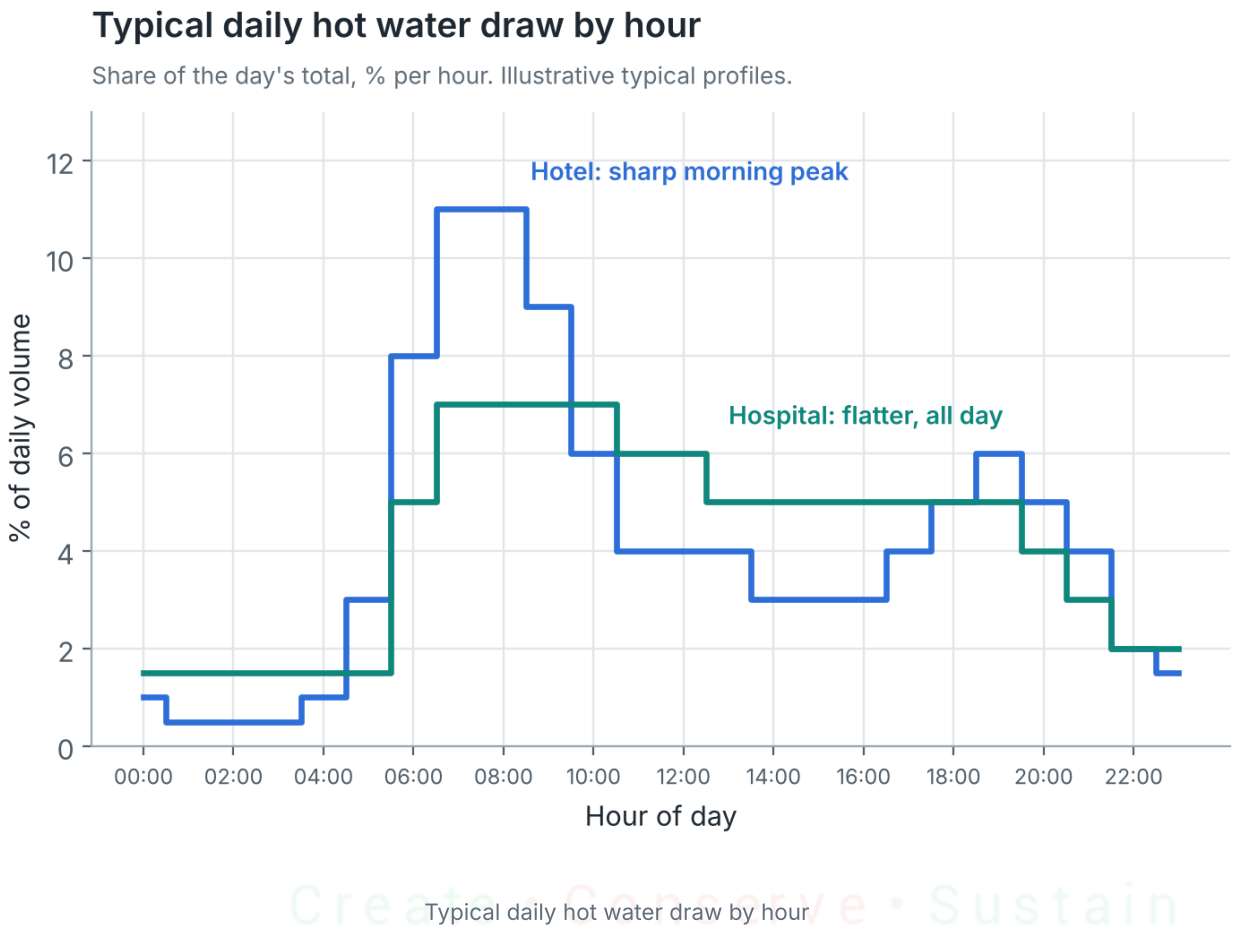
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4.3 Daily load profiles and peak demand

Key idea: The daily total sets the heat pump size; the peak hours set the storage size.

A load profile shows how much hot water is drawn in each hour of the day. Hotels and hostels have sharp morning peaks. Hospitals draw more evenly through the day.

A heat pump heats slowly but steadily. A storage tank is like an overhead water tank: it fills slowly and can be emptied quickly. The tank covers the peak while the heat pump catches up.



Typical daily hot water draw by hour

There is a trade-off. A bigger tank lets you use a smaller heat pump that runs longer. A smaller tank needs a bigger heat pump that can follow the peak.

Design choice	Heat pump	Storage	Suits
Large storage	Smaller, runs 16–20 h	30–50% of daily volume	Hotels, hostels with sharp peaks
Medium storage	Medium, runs 12–16 h	20–30% of daily volume	Most commercial jobs
Small storage	Large, follows load	10–15% of daily volume	Hospitals, process with even draw

Worked example — storage for a peak period

A hostel uses 6,000 L/day at 60 °C. Cold water is 25 °C. The morning peak (6–9 am) takes 35% of the day. The heat pump delivers 20 kW. Usable storage fraction is 0.75 (the bottom of the tank mixes with incoming cold water).

$$V_{store} = \frac{V_{peak} - V_{recovery}}{f_{usable}}, \qquad V_{recovery} = \frac{P_{HP} \times t}{\Delta T \times 0.001163}$$

- Peak draw = 0.35 × 6,000 = 2,100 L
- Recovery in 3 h = 20 × 3 ÷ (35 × 0.001163) = 60 ÷ 0.0407 = 1,474 L
- Net from tank = 2,100 − 1,474 = 626 L
- Storage = 626 ÷ 0.75 = 835 L → select 1,000 L

Remember

- Daily kWh ÷ running hours = heat pump capacity.
- Peak period draw minus recovery = storage need.
- Only about 70–80% of a tank is usable hot water.
- Hostels have the sharpest peaks; hospitals the flattest.

Field tip: Ask the client for check-in/check-out times, shift changes and laundry hours. These create the real peaks.

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4.4 Hotels, hostels and hospitals

Key idea: These three building types differ mainly in their peak pattern, their required temperatures and their hygiene rules.

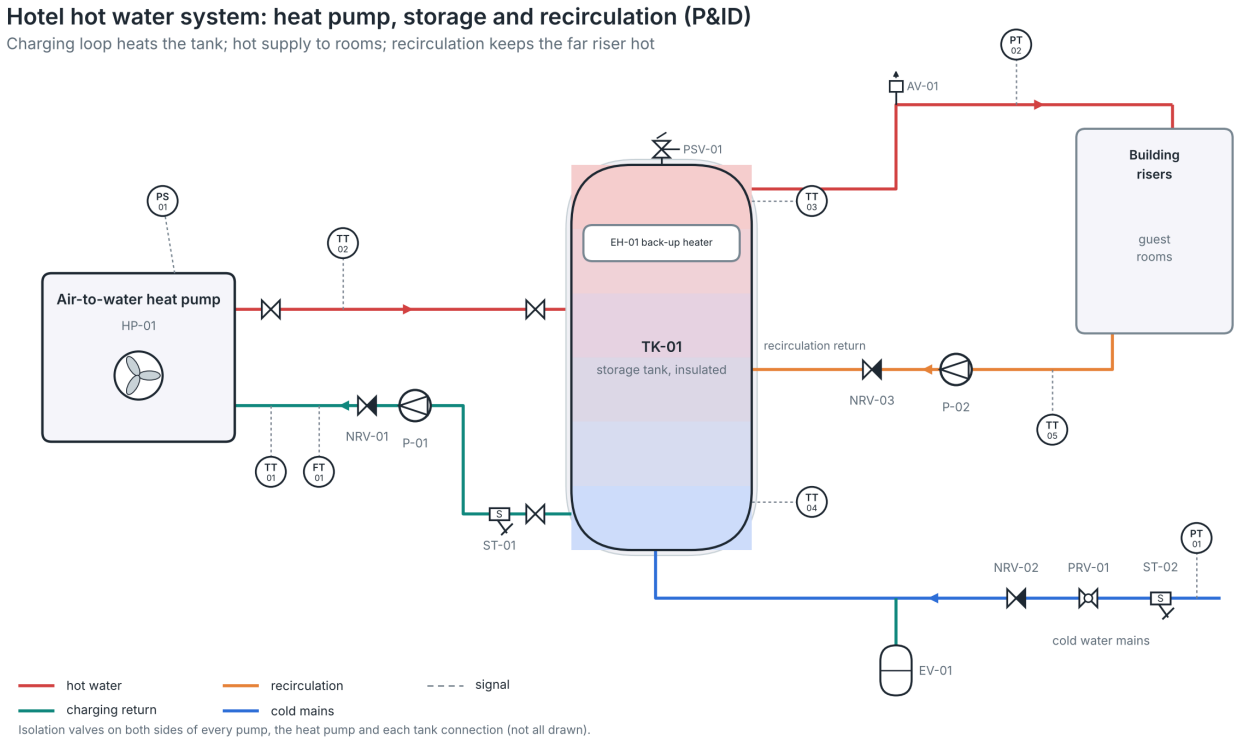
Hotels have morning and evening peaks. Their kitchens and laundries add large daytime loads. Guests expect hot water in seconds, so a recirculation loop is needed.

Hostels have short, very sharp peaks. Two hundred students may shower in 90 minutes. Storage must be generous.

Hospitals need water hot enough to control Legionella. Legionella is a bacterium that grows in warm stagnant water between about 25 °C and 45 °C. Common practice is to store at 60 °C or above and keep the return loop at 50 °C or above. Follow your local code and the hospital's infection-control team.

Item	Hotel	Hostel	Hospital
Peak shape	Morning + evening	Very sharp morning	Spread over the day
Storage temperature	55–60 °C	55–60 °C	60 °C or more
Recirculation loop	Yes	Usually	Yes, mandatory in practice
Special loads	Kitchen, laundry, spa	Mess kitchen	Laundry, CSSD, kitchen
Back-up heating	Electric or existing boiler	Electric	Always provide redundancy

High-temperature points need boosters. A dishwasher final rinse needs about 82 °C. Do not raise the whole system to that temperature. Use a local booster heater instead.



P&ID: hotel hot water system with storage and recirculation

Remember

- Hotels: two peaks plus kitchen and laundry.
- Hostels: one very sharp peak, so big storage.
- Hospitals: hygiene first — 60 °C storage, 50 °C or more on return, redundancy.
- Use local boosters for 80 °C+ points, not the whole system.

Common mistake: Forgetting the recirculation loop heat loss. On large hotels it can add 10–20% to the daily load.

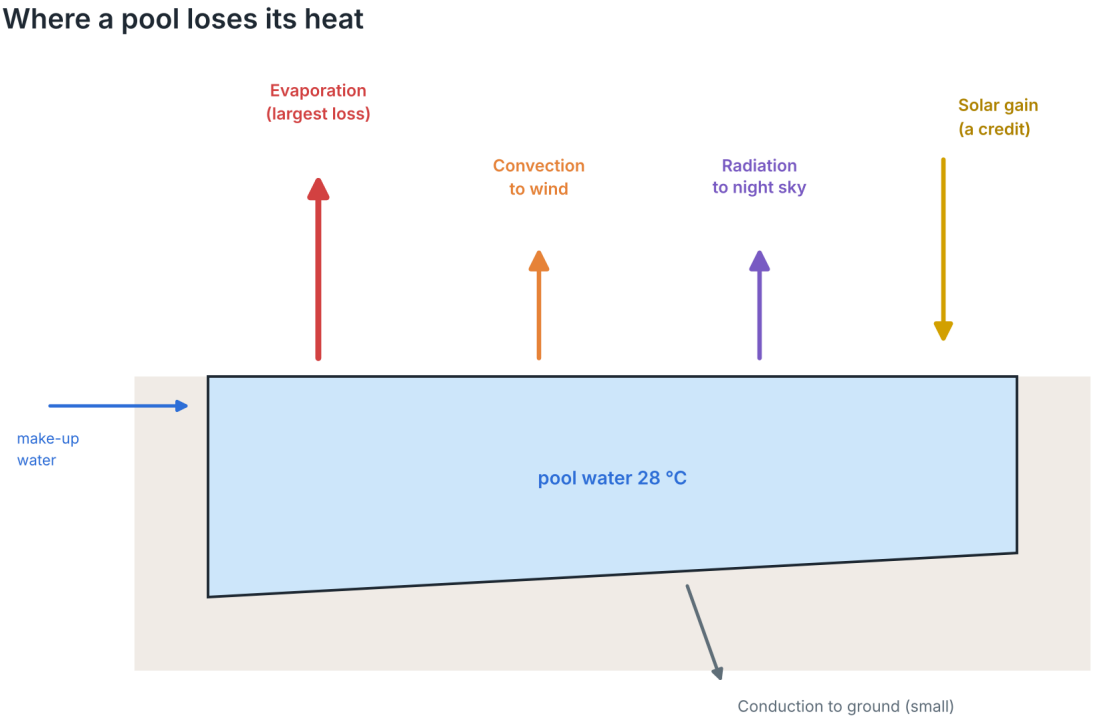
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4.5 Swimming pools: heat-loss calculation

Key idea: A pool loses heat mainly by evaporation, so a cover saves more energy than any other measure.

A pool loses heat four ways. Evaporation is water turning to vapour at the surface. Convection is warm water heating the air that blows across it. Radiation is heat lost to the cold sky. Conduction is heat lost through walls and floor to the ground.

Evaporation is usually half or more of the total. It depends on the vapour-pressure difference between water and air, and on wind speed. A matka cools water the same way, by evaporation.



Where a pool loses its heat

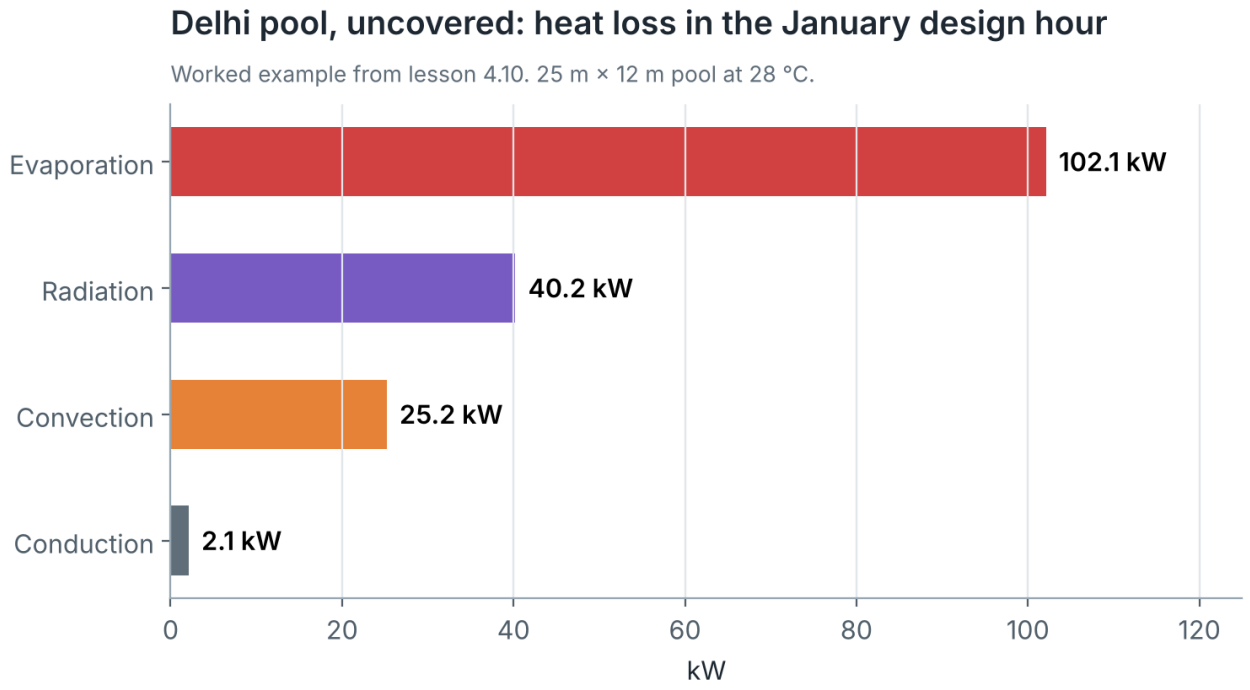
Widely used empirical formulas:

$$Q_{evap} = A\,(p_w - p_a)\,(0.089 + 0.0782\,V) \quad [\text{kW};\ A\ \text{m}^2,\ p\ \text{kPa},\ V\ \text{m/s}]$$

$$Q_{conv} = h\,A\,(T_w - T_a), \qquad Q_{rad} = \varepsilon\,\sigma\,A\,(T_w^4 - T_{sky}^4), \qquad Q_{cond} = U\,A_{shell}\,(T_w - T_{ground})$$

- p_w = saturation vapour pressure at water temperature; p_a = actual vapour pressure of air.
- h = surface heat transfer coefficient, typical 5–10 W/m²K in light wind.
- ε = emissivity of water, about 0.95; σ = 5.67 × 10⁻⁸ W/m²K⁴.
- T_{sky} is often 10–15 K below air temperature on clear nights (typical).

Saturation vapour pressure	kPa
10 °C	1.23
14 °C	1.60
20 °C	2.34
26 °C	3.36
28 °C	3.78
30 °C	4.25



Delhi pool heat loss in the design hour

The full worked example is in Lesson 4.10.

Remember

- Evaporation is usually the biggest loss.
- A night cover typically cuts evaporation by 80–90%.
- Wind shelter (walls, hedges) reduces evaporation and convection.
- Indoor pools lose far less heat but need dehumidification.

Field tip: Measure wind at the water surface, not on the roof. Boundary walls often cut it to under 1 m/s.

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4.6 Space heating: building heat loss

Key idea: Building heat loss equals fabric loss through walls, roof, floor and windows plus ventilation loss, both proportional to the indoor–outdoor temperature difference.

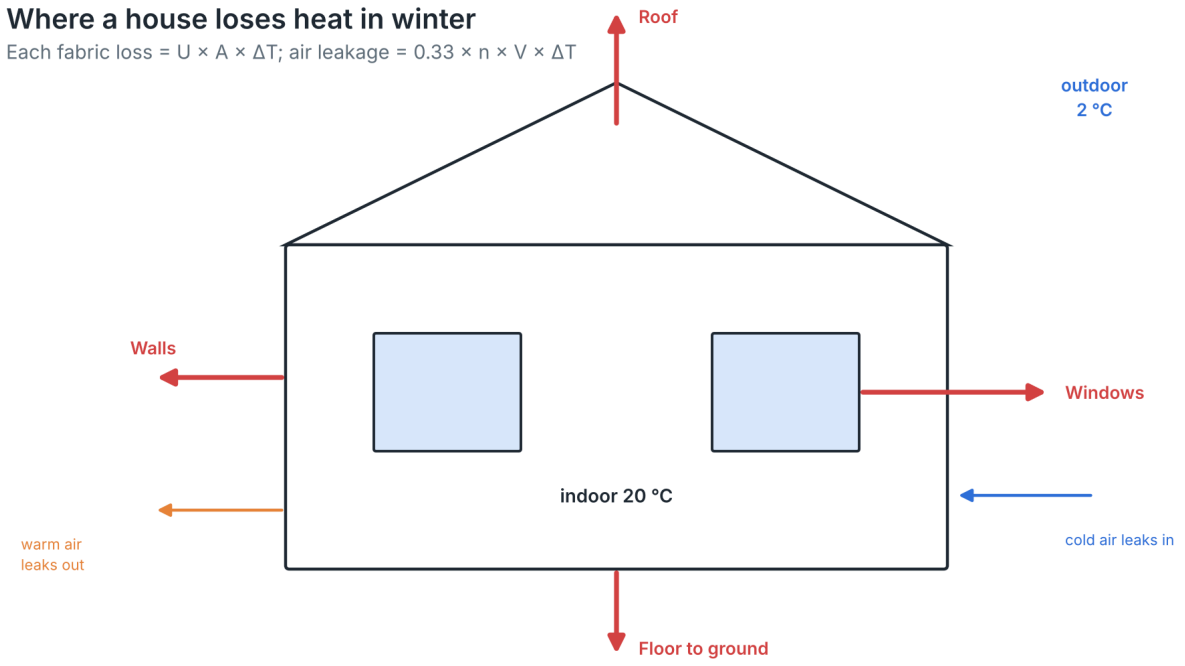
Heat leaks through every surface. The U-value tells how fast. U-value is the heat flow in watts through 1 m² for each 1 K of temperature difference (W/m²K). Lower U means better insulation.

Air leaking in and out also carries heat. We count it as air changes per hour (ACH). One ACH means the full room volume is replaced every hour.

$$Q_{fabric} = \sum U\,A\,\Delta T, \qquad Q_{vent} = 0.33\,n\,V\,\Delta T \quad [\mathrm{W}]$$

- 0.33 = density × specific heat of air ÷ 3600, in Wh/m³K.
- n = air changes per hour; V = room volume in m³.

Element (typical Indian construction)	Typical U (W/m²K)
230 mm brick wall, plastered	1.9–2.2
230 mm brick wall + 50 mm insulation	0.5–0.6
150 mm RCC roof, no insulation	2.8–3.3
RCC roof + 50 mm insulation	0.5–0.7
Single glazing, aluminium frame	5.5–6.0
Double glazing, uPVC frame	2.5–3.0

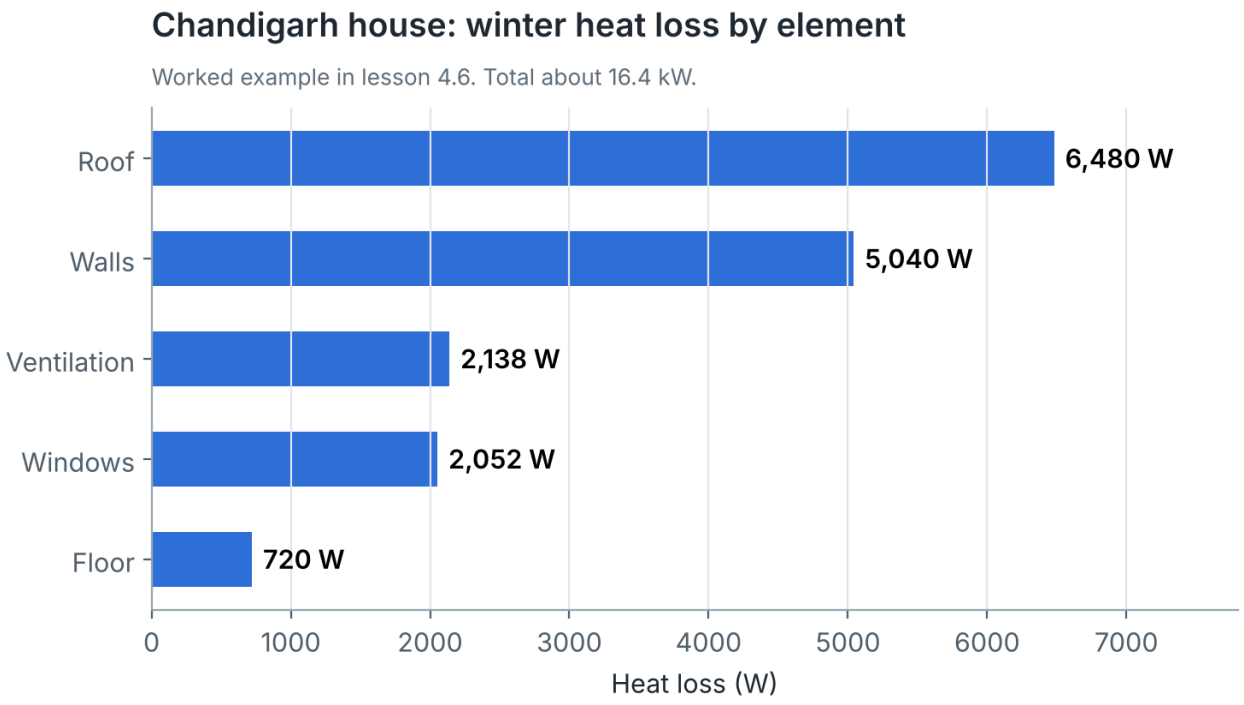


Where a house loses heat in winter

Worked example — 120 m² house in Chandigarh

Design outdoor 3 °C, indoor 21 °C, ΔT = 18 K. Ground below floor about 15 °C. Height 3 m, n = 1.0 ACH.

- Walls: 2.0 × 140 m² × 18 = 5,040 W
- Windows: 5.7 × 20 m² × 18 = 2,052 W
- Roof: 3.0 × 120 m² × 18 = 6,480 W
- Floor: 1.0 × 120 m² × 6 = 720 W
- Ventilation: 0.33 × 1.0 × 360 m³ × 18 = 2,138 W
- Total = 16,430 W ≈ 16.4 kW → with 10% margin, about 18 kW
- With 50 mm roof insulation (U = 0.6), roof loss drops to 1,296 W and total to about 11.2 kW.



Chandigarh house heat loss by element

Low flow temperatures raise COP. Underfloor heating works at 30–40 °C. Fan coils work at 40–50 °C. Old radiators may need 55–65 °C. Weather compensation lowers the flow temperature on milder days and saves energy.

Remember

- Roof losses dominate in Indian flat-roof houses.
- Insulate first, then size the heat pump.
- Use low flow temperatures: underfloor 30–40 °C is ideal.
- Design at the local winter design temperature, not the average.

Common mistake: Sizing from "watts per m²" rules of thumb without checking the roof. An uninsulated RCC roof can double the load.

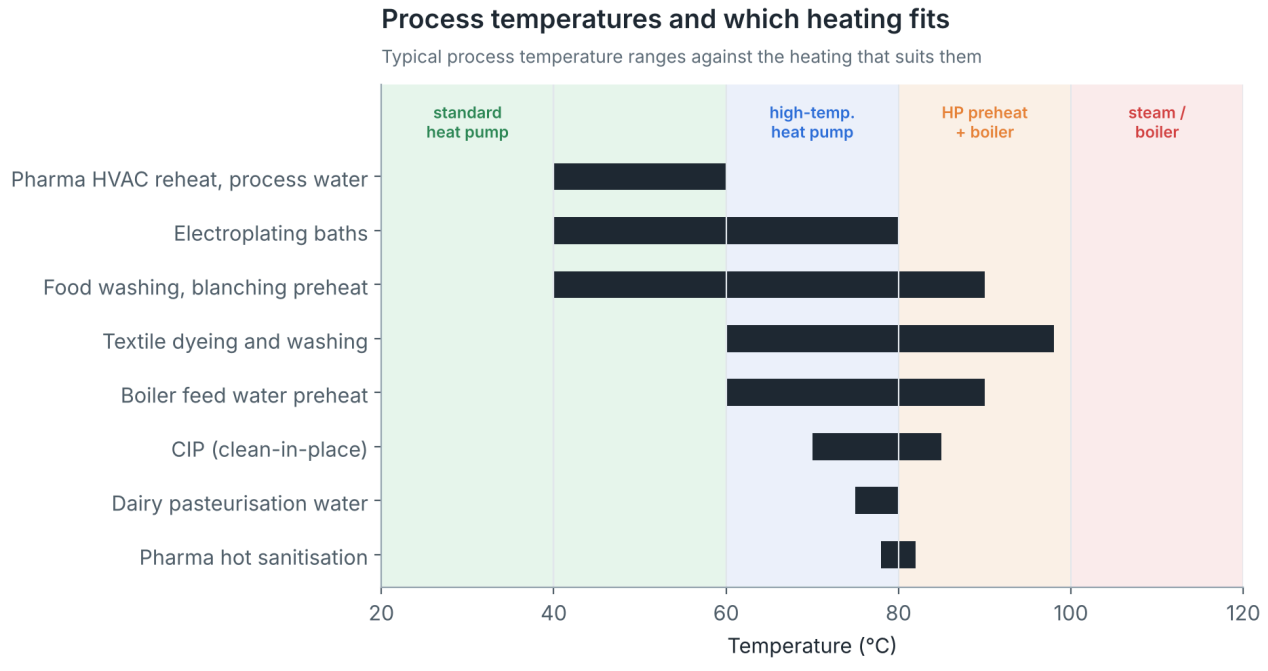
4.7 Industrial process heat: dairy, food, pharma, textiles

Key idea: Many factory processes need hot water at 50–80 °C, which a heat pump can supply far more cheaply than a boiler.

Most factories run boilers at steam pressure for jobs that need only hot water. Each conversion from steam to hot water wastes energy. A heat pump can supply that hot water directly.

The best sites need heating and cooling together. A dairy chills milk to about 4 °C and also washes equipment at 70–80 °C. One heat pump can do both: the cold side chills, the hot side heats.

Industry	Process	Typical temperature
Dairy	Pasteurisation (HTST)	72 °C hold, water at 75–80 °C
Dairy / food	CIP (clean-in-place)	70–85 °C
Food	Washing, blanching preheat	40–90 °C
Pharma	Purified water hot sanitisation	About 80 °C
Pharma	HVAC reheat, process water	40–60 °C
Textiles	Dyeing, washing	60–98 °C
All	Boiler feed water preheat	60–90 °C
Electroplating	Bath heating	40–80 °C



Process temperatures and which heating fits

Worked example — dairy CIP hot water

A dairy uses 10,000 L/day of CIP water at 75 °C, heated from 30 °C. Today a diesel boiler (80% efficient) does this. Use example rates: diesel ₹100/L at about 10 kWh/L; electricity ₹9/kWh. Heat pump COP at 75 °C outlet, typical 2.8.

$$Q = V \times \Delta T \times 0.001163, \qquad \text{Fuel} = \frac{Q}{CV \times \eta}, \qquad E_{HP} = \frac{Q}{COP}$$

- Q = 10,000 × 45 × 0.001163 = 523 kWh/day
- Diesel = 523 ÷ (10 × 0.80) = 65.4 L → ₹6,540/day
- Heat pump electricity = 523 ÷ 2.8 = 187 kWh → ₹1,683/day
- Saving ≈ ₹4,857/day, before any value from cooling

Remember

- Hot water up to 80 °C is heat pump territory.
- Combined heating and cooling gives the highest overall value.
- Use the heat pump as a preheater for steam boilers above 80 °C.
- Waste heat (chiller condensers, compressor cooling) is an ideal source.

Field tip: Walk the plant with an IR thermometer. Find where steam is used to make hot water — that is your first project.

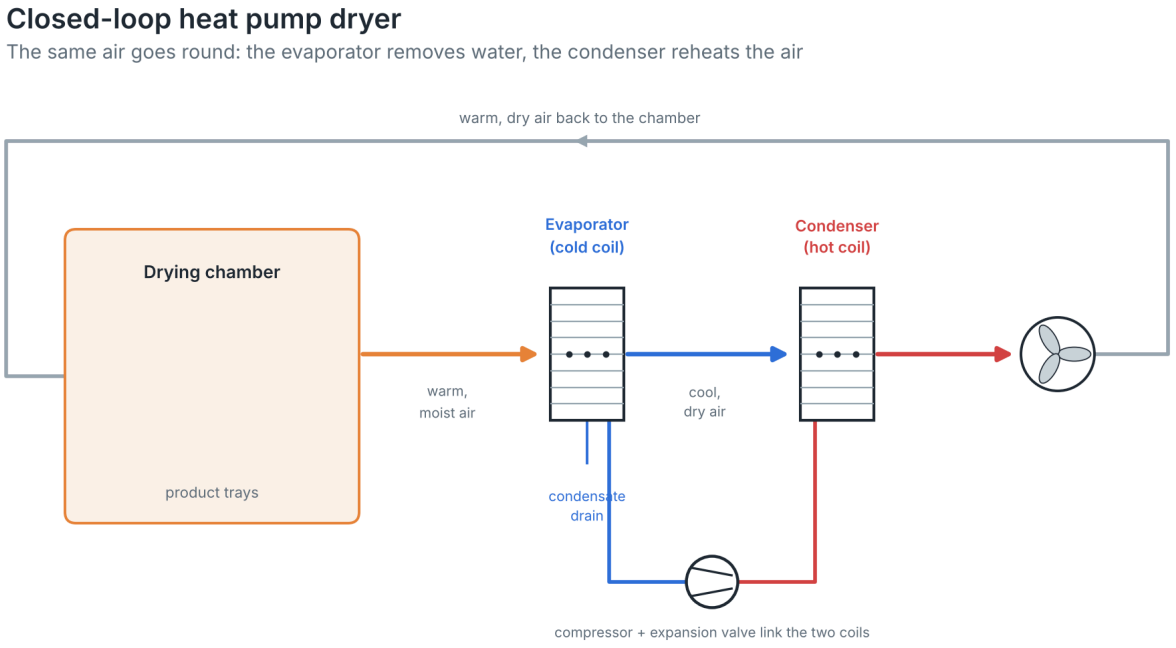
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4.8 Drying and dehumidification

Key idea: A heat pump dryer removes water by cooling air below its dew point and reuses the heat, so it uses far less energy than a heater-and-vent dryer.

Drying needs two things: heat to evaporate water, and a way to remove the vapour. A conventional dryer heats air, passes it over the product and vents it outside. The heat leaves with the air.

A heat pump dryer runs in a closed loop. Moist air passes over the cold evaporator. Its moisture condenses and drains away. The same air is reheated on the condenser and sent back over the product. The dew point is the temperature at which air becomes saturated and water starts to condense.



Closed-loop heat pump dryer

The key performance figure is SMER (specific moisture extraction rate). It is kilograms of water removed per kWh of electricity.

Dryer type	Typical SMER (kg/kWh)	Typical air temperature
Electric heater, open vent	0.3–0.9	50–80 °C
Heat pump, closed loop	1.0–4.0	35–65 °C

Low drying temperatures protect colour, aroma and nutrients. This suits spices, fruits, herbs, fish and some pharma products.

Worked example — fruit slices

A batch of 500 kg fresh fruit slices at 80% moisture (wet basis) is dried to 10%. Latent heat of water is about 0.68 kWh/kg. Heat pump SMER is 2.5 kg/kWh; a heater dryer is 0.6 kg/kWh.

$$m_{dry} = m_{wet}(1 - x_{wet}), \quad m_{final} = \frac{m_{dry}}{1 - x_{final}}, \quad m_{water} = m_{wet} - m_{final}$$

- Dry solids = 500 × 0.20 = 100 kg
- Final mass = 100 ÷ 0.90 = 111.1 kg
- Water removed = 500 − 111.1 = 388.9 kg
- Heat pump: 388.9 ÷ 2.5 = 156 kWh → ₹1,404
- Heater dryer: 388.9 ÷ 0.6 = 648 kWh → ₹5,832
- Over a 20 h batch, the dryer must remove 19.4 kg/h on average.

Remember

- Size a dryer by water removed per hour, not by product weight.
- SMER compares dryers fairly.
- Closed-loop heat pump dryers work at gentle temperatures.
- Moisture removal is fastest at the start of a batch.

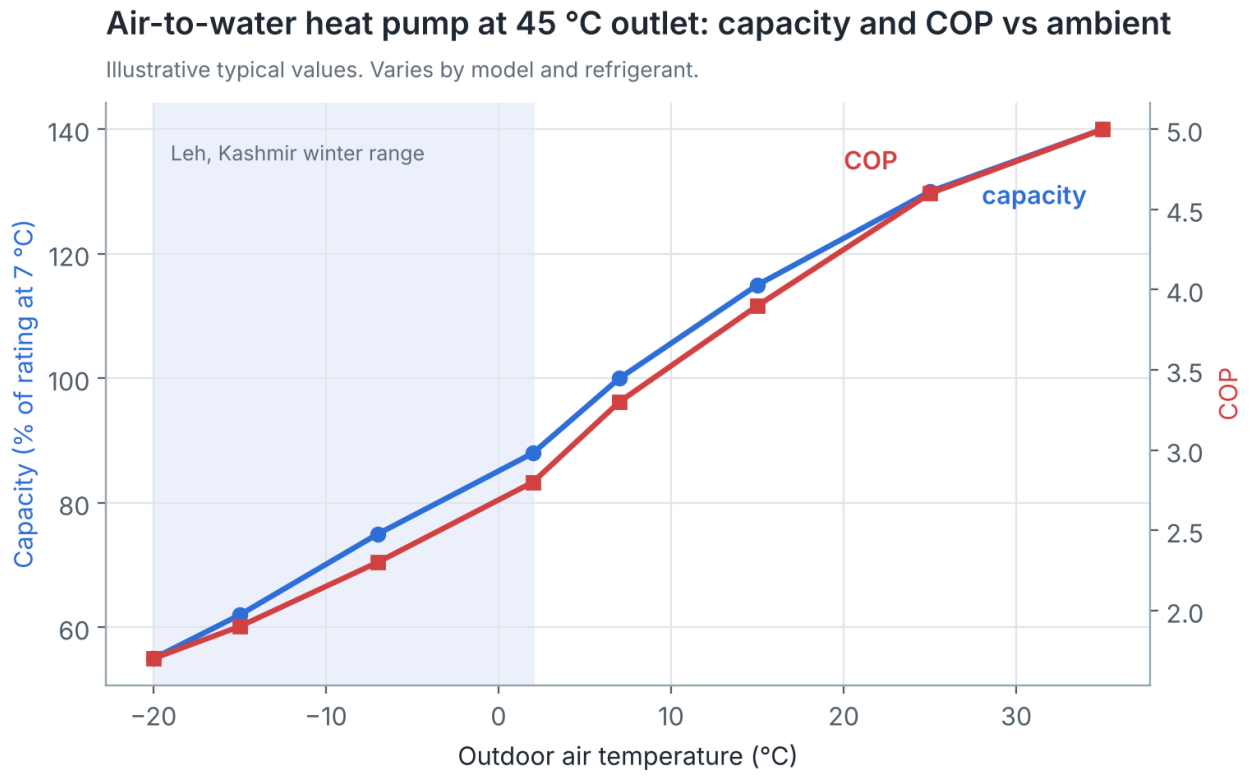
Common mistake: Sizing on average moisture removal. The first hours remove water two to three times faster than the average.

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4.9 Cold climates and high altitude

Key idea: In cold air, an air-source heat pump loses capacity and COP and must defrost; at altitude, thinner air reduces airflow mass and boils water at lower temperatures.

As outdoor air gets colder, the evaporator has less heat to pick up. Capacity falls and COP falls. Below about 5 °C with humid air, ice forms on the coil. The unit must defrost, usually by briefly reversing the cycle.



Capacity and COP vs ambient at 45 °C outlet

Place (typical)	Altitude	Typical winter low	Notes
Delhi	~220 m	3–7 °C	Light frost risk, fog
Shimla	~2,200 m	−2 to 2 °C	Defrost frequent
Srinagar	~1,600 m	−5 to −2 °C	Glycol advisable
Leh	~3,500 m	−15 to −25 °C	Low-ambient design, glycol, back-up

Design rules for cold sites:

- Size at the local design low, not at the rated 7 °C point.
- Choose units built for low ambient (for example, vapour injection or CO_2 cycles).
- Protect water circuits with glycol (antifreeze) or drain-down. About 30% ethylene glycol protects to roughly −15 °C; about 40% to roughly −24 °C (typical).
- Glycol lowers heat transfer and raises pumping power; allow 5–10% derating (typical).
- Keep snow and ice away from the coil and condensate drains.

At altitude the air is thinner. At about 3,500 m air density is roughly 70% of sea level. A fan moves the same volume but less mass, so coil capacity falls. Water boils at about 88–89 °C at that height, so keep vent and relief settings in mind.

Worked example — derating at Leh

A heat pump gives 20 kW at 7 °C ambient at sea level. At Leh, design ambient is −15 °C. Use capacity factor 0.62 (from the chart), altitude factor 0.90 and glycol factor 0.95 (typical assumptions; check maker data).

$$P_{site} = P_{rated} \times f_{ambient} \times f_{altitude} \times f_{glycol}$$

- P = 20 × 0.62 × 0.90 × 0.95 = 10.6 kW
- A 20 kW-rated unit gives only about 10.6 kW at Leh. Size accordingly.

Remember

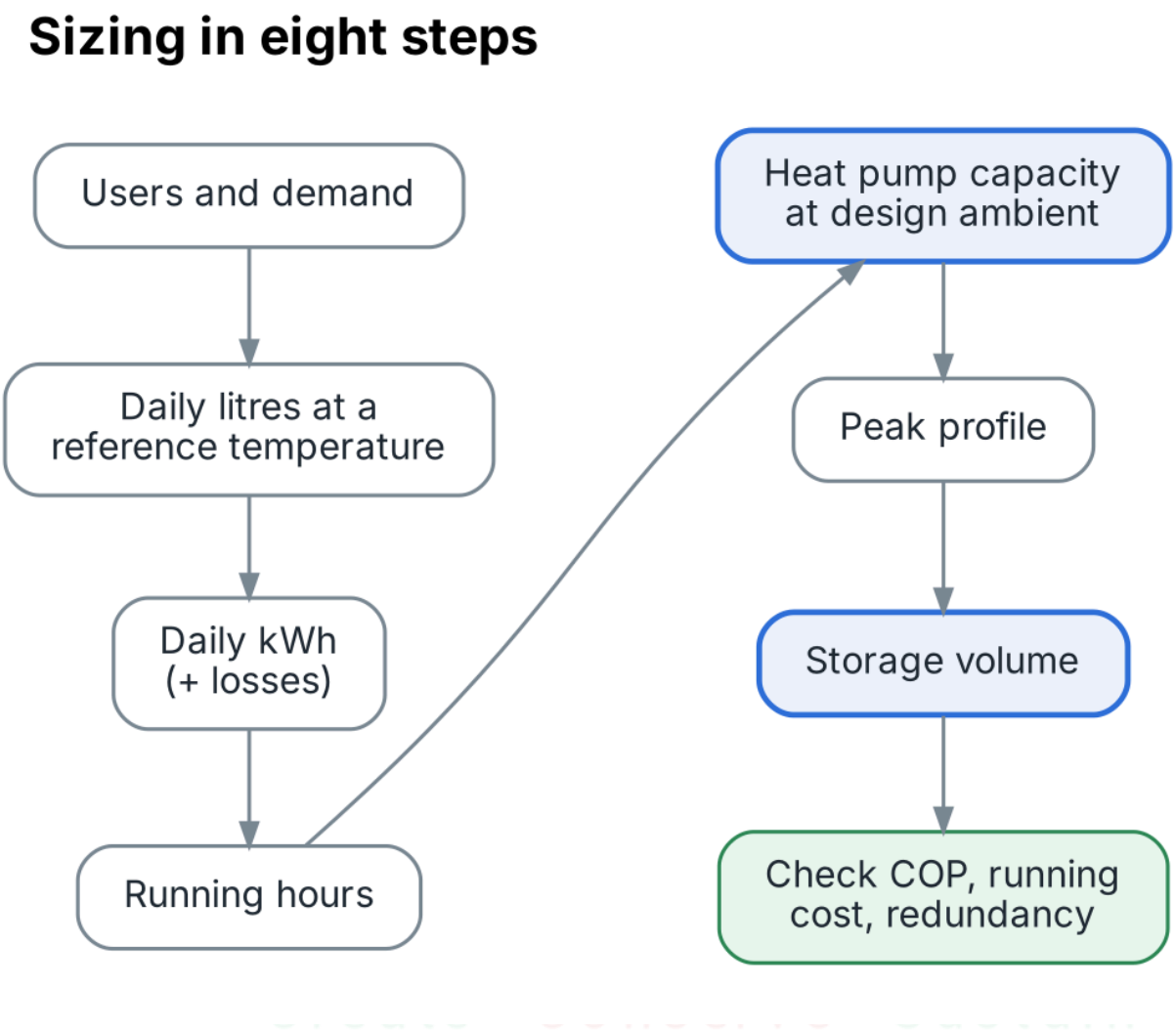
- Capacity and COP both fall as ambient falls.
- Defrost cycles take a share of every cold hour.
- Altitude reduces air mass flow and boiling point.
- Always protect water circuits from freezing.

Field tip: Raise outdoor units at least 300–500 mm above expected snow level and keep the condensate drain heated.

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4.10 Worked examples, start to finish

Key idea: Every sizing job follows the same path — demand, energy, losses, running hours, capacity, storage — and checks the result against design conditions.



Sizing in eight steps

Case A — 60-room mid-range hotel in Pune

Step 1. Demand. Design at 100% occupancy (typical 2 guests per room). Storage at 60 °C.

Load	Basis (typical)	L/day at 60 °C
Guest rooms	60 rooms × 140 L	8,400
Restaurant	150 meals × 6 L	900
Staff	20 × 10 L	200
Total		**9,500**

Laundry is assumed outsourced. Add it if done in-house.

Step 2. Daily energy. Pune winter cold water is about 20 °C, so ΔT = 40 K.

$$Q = V \times \Delta T \times 0.001163$$

- Q = 9,500 × 40 × 0.001163 = 442 kWh/day
- Add 15% for tank and recirculation losses: 442 × 1.15 = 508 kWh → use 510 kWh/day

Step 3. Heat pump capacity. Allow 16 running hours a day. This leaves margin for peaks and service.

$$P_{HP} = \frac{Q_{day}}{t_{run}}$$

- P = 510 ÷ 16 = 31.9 kW → select about 32 kW at the winter design ambient (about 10–12 °C early morning in Pune)

Step 4. Storage. From the profile in 4.3, 6–9 am takes 30% of the day.

- Peak draw = 0.30 × 9,500 = 2,850 L
- Recovery in 3 h = 32 × 3 ÷ (40 × 0.001163) = 96 ÷ 0.0465 = 2,064 L
- Net from tank = 2,850 − 2,064 = 786 L → ÷ 0.75 usable = 1,048 L
- Check against the rule of 20–30% of daily volume (1,900–2,850 L). Select 2,000 L to cover group check-outs and full-house days.

Step 5. Running cost (example rates). COP at 60 °C outlet, typical 3.0. LPG net calorific value about 12.8 kWh/kg, boiler efficiency 85%.

- Heat pump: 510 ÷ 3.0 = 170 kWh × ₹9 = ₹1,530/day
- LPG: 510 ÷ (12.8 × 0.85) = 46.9 kg × ₹100 = ₹4,690/day

Result: about 32 kW heat pump capacity at design ambient, 2,000 L storage at 60 °C, with recirculation loop and electric back-up.

Case B — 25 m × 12 m outdoor pool in Delhi, January

Step 1. Data.

- Area A = 300 m²; average depth 1.5 m; volume 450 m³
- Water 28 °C; daily mean air 14 °C; RH 70%; wind at surface 0.5 m/s (walled)
- Ground about 18 °C; shell area = 300 + 2 × (25 + 12) × 1.5 = 411 m²
- Pool used 12 h uncovered; covered 12 h at night
- Solar gain ignored for design (Delhi winter fog days)

Step 2. Evaporation (uncovered).

- p_w at 28 °C = 3.78 kPa; p_a = 0.70 × 1.60 = 1.12 kPa; Δp = 2.66 kPa
- Q_{evap} = 300 × 2.66 × (0.089 + 0.0782 × 0.5) = 300 × 2.66 × 0.128 = 102.1 kW

Step 3. Convection. h = 6 W/m²K (typical, light wind).

- Q_{conv} = 6 × 300 × (28 − 14) = 25,200 W = 25.2 kW

Step 4. Radiation. T_w = 301 K; T_{sky} ≈ 14 − 12 = 2 °C = 275 K.

- Q_{rad} = 0.95 × 5.67 × 10^{-8} × 300 × (301^4 − 275^4)
- = 0.95 × 5.67 × 10^{-8} × 300 × (8.209 − 5.719) × 10^9 = 40.2 kW

Step 5. Conduction. U ≈ 0.5 W/m²K to ground (typical, uninsulated).

- Q_{cond} = 0.5 × 411 × (28 − 18) = 2,055 W = 2.1 kW

Step 6. Totals.

Loss	Uncovered (kW)	Covered (kW, typical cover effect)
Evaporation	102.1	10.2 (−90%)
Convection	25.2	12.6 (−50%)
Radiation	40.2	20.1 (−50%)
Conduction	2.1	2.1
Total	**169.6**	**45.0**

- Daily loss = 12 × 169.6 + 12 × 45.0 = 2,035 + 540 = 2,575 kWh
- Make-up water: about 2 m³/day evaporated, heated from 15 °C: 2,000 × 13 × 0.001163 = 30 kWh
- Add 5% for pipe and filter losses: (2,575 + 30) × 1.05 = 2,735 kWh/day

Step 7. Capacity. Allow 20 running hours (defrost and filtration margin).

- P = 2,735 ÷ 20 = 137 kW at design ambient (night lows 6–8 °C)
- Pool heat pumps are often rated at higher ambient. The nameplate at that rating will be larger; check output at 7–10 °C air.
- Without a cover: 24 × 169.6 × 1.05 ≈ 4,270 kWh/day → about 215 kW. The cover saves over a third of the plant.

Step 8. Initial heat-up.

- Q = 450,000 L × (28 − 15) × 0.001163 = 6,804 kWh
- With the cover on 24 h, about 90 kW is spare after losses → about 75 h, or 3–4 days.

Step 9. Running cost (example). Typical pool COP 4.0 at these conditions.

- 2,735 ÷ 4.0 = 684 kWh × ₹9 = ₹6,156/day

Result: about 137 kW heat pump capacity at Delhi January design conditions, with a mandatory night cover.

Remember

- Follow the same path every time: demand → kWh → hours → kW → storage.
- State every assumption (occupancy, temperatures, wind, cover).
- Check capacity at the design ambient, not the catalogue rating.
- Covers and insulation cut plant size more cheaply than bigger machines.

Common mistake: Sizing a pool heat pump from the heat-up energy alone. The daily loss sets the size; heat-up just sets how long you wait.

Quiz 4

1. Which figure mainly decides the heat pump capacity for a hot water system?
   - A. Peak hourly draw B. Daily energy ÷ running hours C. Tank volume D. Pipe size
2. 80 L at 45 °C with cold water at 25 °C equals how much at 60 °C?
   - A. 46 L B. 60 L C. 80 L D. 107 L
3. Energy to heat 1,000 L by 40 K is about:
   - A. 4.6 kWh B. 23 kWh C. 46.5 kWh D. 167 kWh
4. Which building usually has the flattest daily hot water profile?
   - A. Hostel B. Hotel C. Hospital D. Gym
5. Typical minimum return-loop temperature for Legionella control is:
   - A. 35 °C B. 40 °C C. 50 °C D. 70 °C
6. The largest heat loss from an outdoor pool is usually:
   - A. Conduction B. Radiation C. Convection D. Evaporation
7. A pool cover mainly saves energy by cutting:
   - A. Conduction B. Evaporation C. Solar gain D. Pump power
8. Ventilation heat loss in watts is:
   - A. $0.33\ n\ V\ \Delta T$ B. $U\ A\ \Delta T$ C. $4.186\ V\ \Delta T$ D. $\varepsilon\ \sigma\ A\ T^4$
9. SMER in a dryer means:
   - A. kWh per kg product B. kg water removed per kWh C. Air flow per kW D. Drying time per batch
10. At high altitude an air-source heat pump loses capacity mainly because:
    - A. Water boils hotter B. Air density is lower C. Electricity is weaker D. Refrigerant leaks

Answer key

1. B — Daily kWh spread over running hours sets the kW; peaks set storage.
2. A — $80 \times (45 - 25) \div (60 - 25) = 45.7$ L.
3. C — $1{,}000 \times 40 \times 0.001163 = 46.5$ kWh.
4. C — Hospitals run round the clock, so draw is spread out.
5. C — Common practice keeps the return at 50 °C or above.
6. D — Evaporation is usually half or more of the total.
7. B — Covers stop vapour leaving the surface.
8. A — 0.33 Wh/m³K × air changes × volume × ΔT.
9. B — Specific moisture extraction rate, kg/kWh.
10. B — Less air mass passes over the coil for the same fan volume.

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Glossary

Term	Meaning
ACH (air changes per hour)	Number of times a room's air volume is replaced in one hour
CIP (clean-in-place)	Cleaning process equipment with hot solutions without dismantling it
COP	Heat delivered ÷ electricity used
Defrost	Removing ice from the outdoor coil, usually by reversing the cycle briefly
Dew point	Temperature at which air becomes saturated and water condenses
Design ambient	Outdoor temperature used for sizing, usually a cold winter value
Emissivity (ε)	How well a surface radiates heat compared with a perfect radiator
Glycol	Antifreeze added to water circuits to prevent freezing
Legionella	Bacteria that grow in warm stagnant water and cause lung infection
Load profile	How demand varies hour by hour over a day
Make-up water	Fresh water added to replace evaporation and backwash losses
Recirculation loop	Pipe loop that keeps hot water moving so it reaches taps quickly
Recovery	Hot water the heat pump produces during a draw period
SMER	Specific moisture extraction rate: kg water removed per kWh
Temperature lift	Difference between source and delivery temperature
U-value	Heat flow through 1 m^2 per 1 K difference, W/m^2K
Usable fraction	Share of tank volume available at useful temperature, typically 0.7–0.8
Vapour pressure	Pressure exerted by water vapour; drives evaporation
Weather compensation	Control that lowers heating flow temperature on milder days

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> *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

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THANK YOU.

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

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