DESIGN, PLAN & IMPLEMENT NET-ZERO GREEN BUILDING

JK-GreenTech
Greener Smarter Sustainable

KASHMIR / LADAKH/HIMACHAL PRADESH

MEP AND ARCHITECTURAL CONSIDERATIONS

Rev-09

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Document Revision History

Rev	Date	Summary of Change
00–02	2023–2025	Initial issues based on ECBC 2017 (Cold climate) and SVAGRIHA reference.
03	26 May 2025	Consolidated MEP + architectural envelope guidance; ECSBC/PHIUS reference tables.
04	17 Jun 2025	Re-based to the 2024 code generation: ECSBC 2024 (commercial), Eco-Niwas Samhita (ENS) 2024 (residential, mandatory for J&K homes), and SVAGRIHA V.3.
05	27 Jun 2025	Added Chapter 1 — a concise, audience-focused (architects / ENS users) step-by-step planning & implementation
06	02 Jan 2026	Added §4.3 HRV Duct Sleeve
07	10 Jun 2026	Added Chapter 1 — Net-Zero Green Building Essentials & Passive Design
08	02 Jul 2026	Merged §7.1 (Objectives) and §7.2 (Design Principles) from Appendix A into Chapter 1 (§1.1);
09	03 Jul 2026	Re-based to ECSBC 2024/ENS 2024/SVAGRIHA V.3 per audit.

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References (2024 Code Generation)

- **ECSBC 2024** — Energy Conservation and Sustainable Building Code 2024 (for Commercial and Office Buildings), Bureau of Energy Efficiency (BEE), 1st printing December 2024.
- **Eco-Niwas Samhita (ENS) 2024** — Energy Conservation & Sustainable Building Code for Residential Buildings (ECBC-R), Bureau of Energy Efficiency (BEE), 2024.
- **SVAGRIHA V.3** — Simple Versatile Affordable GRIHA, Abridged Manual V1, GRIHA Council, 2024 — https://www.grihaindia.org/
- **PHIUS 2021** — Passive House Institute US performance standard (Climate Zone 5A benchmark), retained as an international high-performance benchmark.
- **Ministry of New and Renewable Energy (MNRE)** — https://mnre.gov.in/solar/schemes/
- **Indian Insulation Forum** — http://www.indiainsulationforum.in/
- **Applicable BIS standards:** IS 2185 (Part 3) AAC blocks; IS 13129 (Parts 1 & 2) solar water heating; IS 16542:2016 / IS 16543:2016 / IS 16544:2016 (evacuated-tube collectors & systems); NBC 2016.

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1 Net-Zero Green Building — Passive Design for Kashmir/Ladakh/Himachal

This chapter sets out **JKGT's Net-zero green building approach** and the passive-design fundamentals — orientation, fenestration, overheating control and wall construction **— that shape every project across Kashmir, Ladakh and Himachal Pradesh's cold climate**. Occupant comfort, achieved sustainably, is the goal that runs through this entire document; Chapters 2–9 develop the detailed planning, MEP and standards guidance that deliver it. This document is the result of our experience implementing green building solutions across numerous projects. Drawing on practical insights gained from real-world applications, it serves as a continuously evolving guide that **incorporates emerging standards, industry best practices, and lessons learned.** We regularly update and refine its contents to support continuous improvement in sustainable building design and execution.

1.1 Our Net-Zero Green Building Approach

JKGT designs, plans and implements net-zero, code-compliant green buildings — architectural and structural design, MEP integration, and green-building certification (ECSBC 2024 / ENS 2024 / SVAGRIHA V.3) — under one integrated scope.

Every JKGT project targets: year-round comfortable and healthy indoor conditions; an extremely high level of energy efficiency (a prerequisite for cost-effective operation and climate protection); a high level of user satisfaction; and a healthy environment — continuously ventilated, filtered air, with reduced contaminants and mould prevention. Five design essentials, carried through every chapter of this document, deliver those targets:

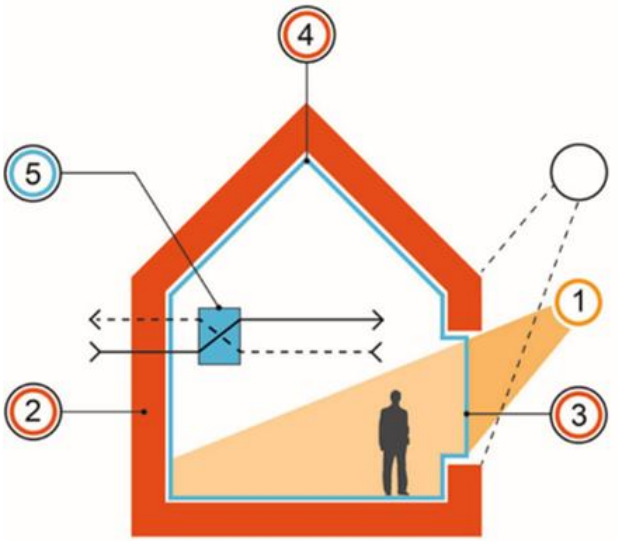

Figure 1 The five essentials of a JKGT green building.

1. **Solar orientation & passive heating —** optimal solar orientation with dense thermal-mass materials that absorb, store and radiate heat over time (§1.3).
2. **Insulation (ECSBC) —** continuous insulation across the entire enclosure to the 2024 code targets, eliminating thermal bridges (Chapter 4).
3. **Performance windows —** high-performance, correctly-placed double glazing with attention to solar heat gain and orientation (§1.4).
4. **Air-tight enclosure —** a sealed, thermal-bridge-free envelope that removes cold corners and reduces interior mould risk (Chapter 4).
5. **Mechanical ventilation —** balanced heat-recovery ventilation for fresh, filtered indoor air (Chapter 5).

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1.2 Why This Matters — For Architects and For End Users

This document is written for two readers, and both matter to the outcome. Architects and MEP/structural consultants need the numbers — U-factors, WFR limits, duct and shaft sizes, thermostat and cable specifications — to turn passive-design intent into a buildable, code-compliant drawing set. Home owners and end users rarely need the numbers, but they do need to understand what those numbers buy them: a warmer floor in January, a lower electricity bill, cleaner indoor air, and a home whose promised performance can be independently verified at handover. This section is written so both readers can find what they need before moving into the detailed chapters.

For Architects & MEP Consultants

Kashmir/Ladakh/Himachal is a heating-dominated climate with a short, and increasingly warm, cooling season (§5.4). Every passive-design recommendation in §1.3–1.7 is tied to a specific ECSBC 2024 / ENS 2024 / SVAGRIHA V.3 clause and a JKGT target that meets or exceeds it — cross-check the Standards Compliance Matrix (Chapter 9) before issuing for construction. Treat this chapter as a design-stage checklist, not background reading: orientation and window-to-floor ratio are effectively fixed once the plot layout and Phase 2 concept (§2.2) are frozen, and are expensive or impossible to correct once foundations are cast. Insulation continuity (Chapter 4), airtightness detailing, and HRV/UFH shaft coordination (§3.6, §5.3) are the next irreversible decisions — they must be resolved on the drawing board, not on site.

For Home Owners & End Users

You do not need to understand a U-factor to benefit from one. What good passive design buys you, room by room and season by season, is:

- **Warmer winters, cheaper heating —** lower fuel/electricity bills, because heat generated indoors is not lost through the walls, roof and windows as fast as in a conventionally-built home (Chapter 4);
- **No cold corners or draughts —** there are no gaps in the insulation or air-barrier line for cold air to find (§1.6, Chapter 4);
- **Fresh air without the heat loss —** continuous fresh, filtered air even with every window shut in the depth of winter, delivered by the HRV system without the heat loss of opening a window (Chapter 5);
- **A home that copes with hot summers, too —** a well-shaded, thermally-massive design that stays comfortable on hot July afternoons without needing to run air-conditioning every day (§5.4);
- **Warm floors where you need them —** electrical underfloor heating in bathrooms and living areas warms only the rooms you use, without the cost of heating the whole house (Chapter 6);
- **A rating you can point to —** a recognised, third-party-verified rating (SVAGRIHA / ENS compliance) if you choose to pursue one — useful at resale, and a check that what was promised at design stage was actually built (Chapter 2, Chapter 9).

Questions Worth Asking Before You Sign Off on Drawings

Whichever role you are reading this in, these are the questions that separate a green building on paper from one that performs as designed:

- **Which way does the house face, and why? —** Confirm which face the main living rooms and bedrooms open onto, and why (§1.3).
- **What U-factor is the envelope actually achieving? —** Ask for the calculated roof, wall and floor U-factors against the ENS/ECSBC limits in Chapter 4 — not just a materials list.
- **Is the insulation continuous, or does it stop at every junction? —** A continuous insulation and air-barrier line, with every junction detailed, is what prevents cold corners and mould (§1.6, Chapter 4).

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- **How will the house be ventilated and kept cool in summer? —** Confirm HRV heat-recovery effectiveness (≥70–85% target, §5.1) and the summer-cooling strategy for July/August (§5.4).
- **Can I see photographic proof of what is inside my walls? —** Ask for dated photographs of insulation, air-barrier and waterproofing work before it is covered up (§2.2, Phase 4) — this is your only record once the walls are finished.

The remainder of this chapter (§1.3–1.7) sets out the passive-design fundamentals that answer these questions in detail; Chapters 2–9 carry them through planning, MEP, envelope construction and code compliance.

1.3 Best Building Orientation for Kashmir/Ladakh/Himachal

In a heating-dominated Himalayan climate, orientation is the cheapest design decision with the biggest impact on comfort and energy use. JKGT's default is to place the building's long axis east–west, with the main façade and habitable rooms facing true south (within ~15–20° either side) to maximise low-angle winter sun. Excessive east/west exposure brings little useful winter heat but adds shoulder-season glare and overheating risk, so it is minimised.

Check the site for overshadowing from neighbouring structures, trees and — in valley locations — surrounding mountains, since solar access can be reduced for several winter months. Where plot orientation is fixed by the site, adjust the room layout instead: living rooms and bedrooms to the south, and stores, stairs, garages and toilets to the north as a thermal buffer.

1.4 Passive Heating & Fenestration Strategy

Orientation only pays off if glazing is placed and sized to match it:

- **South façade — large openings:** WFR ~15–20 % with high-SHGC glazing to capture winter sun and daylight.
- **North façade — small openings:** minimal, high-insulation, low-U windows only, since this face gains no useful winter sun and loses the most heat.
- **East/West façades — moderate, shaded:** enough glazing for daylight, controlled with shading to limit shoulder-season heat gain and glare.

In Cold climate the fenestration strategy maximizes beneficial solar gain while controlling night-time loss. Use south-facing windows (Northern Hemisphere) and high-SHGC glazing. The applicable 2024-code limits are: ECSBC 2024 vertical fenestration **U ≤ 1.80 W/m²·K with SHGC up to 0.62**; ENS 2024 minimum openable WFR_{op} ≥ 8.33 % (ventilation) and a minimum VLT that varies with Window-to-Wall Ratio (WWR).

> **Two different window ratios apply — do not confuse them:** (a) ENS WFR_{op} ≥ 8.33 % is the minimum **openable** area for natural ventilation; (b) JKGT recommends a glazing Window-to-Floor Ratio (WFR) of ~15–20 % on the south face for passive solar daylight and heat gain. Both must be satisfied.

*Table 1 **ENS 2024 minimum Visible Light Transmittance (VLT) by Window-to-Wall Ratio***

Window-to-Wall Ratio (WWR)	Minimum VLT
0.00 – 0.30	0.27
0.31 – 0.40	0.20
0.41 – 0.50	0.16
0.51 – 0.60	0.13
0.61 – 0.70	0.11

Table 7 ENS 2024 Table 9 — minimum VLT requirement (glazing daylight transmission).

Glazing selection for Kashmir: double-glazed units with insulated/UPVC frames to achieve U ≤ 1.80 W/m²·K, high SHGC (~0.60) on south façades for solar gain, and VLT compliant with Table 7. Solar radiation transmitted through glazing is absorbed by internal thermal mass and gradually re-radiated, improving thermal performance.

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1.5 Preventing Summer Overheating — Kashmir & Leh

Cold-climate design must still guard against summer and daytime overheating, and the risk differs sharply between Kashmir and Ladakh, which shapes the architecture in each region:

- **Kashmir (Srinagar valley):** moderate, moister summers — size roof overhangs to cut off high summer sun on south glazing while still admitting low winter sun, and provide openable windows/vents for cross-ventilation on warm afternoons.
- **Leh/Ladakh (high-altitude cold desert):** intense solar radiation, very low humidity and a large day–night swing — use deeper roof overhangs, higher exposed thermal mass (RCC/masonry) to buffer daytime heat, and night-purge ventilation to flush heat out after sunset.
- **Avoid large, unshaded west-facing glazing** in both regions — it drives the sharpest afternoon overheating.
- **Keep the building form compact** (low area-to-volume ratio); complex, articulated shapes cost more to insulate and are harder to keep airtight.

1.6 Wall Construction: AAC Blocks

JKGT's default envelope wall is Autoclaved Aerated Concrete (AAC) block, ~200 mm thick (full specification at §8.2). AAC's cellular structure gives it materially better inherent thermal resistance than solid brick or dense concrete block, reduces thermal bridging at the wall itself, is lighter — lowering dead load and foundation cost — and is faster to lay, while remaining fully compatible with JKGT's continuous-insulation and internal gypsum-plaster finish system.

1.7 Occupant Comfort — Our Design Goal

Every strategy in this chapter — orientation, fenestration, overheating control and envelope material — serves one outcome: a home that stays comfortable, healthy and affordable to run in every season, delivered sustainably and in line with ECSBC 2024, ENS 2024 and SVAGRIHA V.3. Occupant comfort is not a by-product of compliance; it is the goal compliance is built to serve.

2 Planning & Implementing a Green Building

This chapter gives architects and home users a concise, code-aligned roadmap for taking a green building from concept to occupancy. It follows the Integrated Design Process (IDP) embraced by Eco-Niwas Samhita (ENS) 2024, ECSBC 2024, SVAGRIHA V.3 and PHIUS, in which **energy, comfort and sustainability decisions** are made early and collaboratively rather than bolted on later. The detailed MEP, envelope and standards guidance for each step is developed in Chapters 3–9 customized for cold climate such as Kashmir, Leh and parts of Himachal Pradesh. We may need to fine-tune for specific locations to accommodate local weather/climate.

What you, the home owner, should do and expect:

- Be clear about what you want: lower energy bills, a home that stays warm in winter and comfortable in summer, clean indoor air, and — if you wish — a recognized green rating.
- Bring in an experienced green-building consultant or architect early, before any drawings are made. The right choices made now cost little but save a lot later.
- Share how you live: family size, number of rooms, daily routine, and how long you plan to stay in the home.
- Expect a few extra planning meetings and a little more design time up front — this avoids costly changes once construction has started.
- Approve the comfort and energy goals before building begins, and be ready to invest a little more in good insulation, windows and certified materials; they pay you back in comfort and lower bills.

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- Allow the team to inspect the work and take dated photographs during construction — these are needed for your green rating.
- At the end, ask for a walkthrough: have the heating, ventilation, solar and hot-water systems tested and demonstrated, and collect all manuals and warranties.
- Look after the finished home with simple upkeep (such as changing air filters on time) to keep it efficient, healthy and low-cost for years.

2.1 Integrated Design Process (IDP)

The IDP brings the architect, MEP/services engineer, civil engineer and the ENS user (owner) together from day one. Because orientation, envelope and systems are interdependent, decisions are taken jointly and revisited iteratively. The cheapest and most effective green measures are those fixed at concept stage — before drawings are frozen and before money is committed to construction.

2.2 Phased Workflow (Concept to Occupancy)

Table 2 ***Phased Green-Building Workflow***

Phase	Objective	Key Steps (architect / ENS-user actions)	Standards & Tools
Phase 1 — Conceive	Fix targets & assemble the team	Define performance goals and select the compliance / rating path (ENS 2024 mandatory; SVAGRIHA & PHIUS optional). Form an integrated team and hold a design-goals workshop. Analyse site, Cold-zone climate and sun path; register the project on the SVAGRIHA portal.	ENS 2024; SVAGRIHA registration
Phase 2 — Design	Lock in form & passive strategy	Optimise orientation, building form and Window-to-Wall / Floor ratios for daylight and winter solar gain. Set the envelope concept — continuous insulation, thermal breaks, one airtight line. Plan passive solar, shading and natural ventilation ($WFR_{op} \geq 8.33$ %).	ENS WFR_{op}; SVAGRIHA Crit. 2–3; PHIUS
Phase 3 — Document	Prove compliance on paper	Calculate envelope U-factors, $U_{envelope}$,cold and U_{roo}f; run the ENS and SVAGRIHA online calculators. Size MEP — HRV, centralised hot water, solar PV / thermal and low-flow water. Issue coordinated drawings, specifications and a low-impact / BEE-star material schedule.	ENS & SVAGRIHA calculators; ECSBC EPF
Phase 4 — Build	Build it as designed	Procure code-compliant materials (GRIHA catalogue, BEE-star). Enforce site QA — continuous insulation, sealed air-barrier and thermal-bridge-free junctions. Hold intermittent inspections and record progress with date-stamped photographs.	GRIHA catalogue; JKGT QA checklists
Phase 5 — Verify	Test, commission, certify	Test and commission HVAC / HRV, solar and controls; carry out an airtightness (blower-door) check. Submit final documentation, attend the SVAGRIHA mandatory site visit and obtain the rating / ENS compliance.	SVAGRIHA site visit; commissioning reports
Phase 6 — Occupy	Sustain performance	Hand over with O&M manuals and occupant orientation. Monitor energy and water use, maintain filters and systems, and conduct a post-occupancy review to confirm performance in use.	O&M manual; sub-metering

The workflow is iterative — teams loop back to earlier phases whenever calculations or site conditions require.

2.3 Golden Rules for Architects & End Users

- **Set targets first:** agree the ENS-mandatory limits (U_{roo}f ≤ 1.20, $U_{envelope}$,cold ≤ 1.80, $WFR_{op} \geq 8.33$ %) and any SVAGRIHA / PHIUS goals before schematic design.
- **Passive before active:** orientation, form, insulation and airtightness come before mechanical systems — every watt avoided is a watt you never have to generate.
- **Insulate continuously:** keep one unbroken insulation and air-barrier line around the whole envelope, and detail every junction.

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- **Model, don't guess:** confirm every U-factor and the ENS / SVAGRIHA calculator outputs at design stage, not on site.
- **Document as you build:** date-stamped photographs and material records are required for SVAGRIHA rating and ENS compliance.
- **Commission and verify:** an untested system is an unproven one — commission HVAC / HRV, solar and controls before handover.

3 JKGT Green Building MEP Requirements

These represent the key MEP requirements for a Green Building, which must be carefully integrated into the architectural design and subsequently coordinated and executed on site by the Project Civil Engineer to ensure performance, efficiency, and compliance with the sustainability objectives of ECSBC 2024, Eco-Niwas Samhita 2024 and SVAGRIHA V.3.

3.1 Power / HRV Room

- **Location:** Central service zone in basement, vertically aligned with GF/FF for shaft routing; separated from habitable areas.
- **Size:** 10′×10′ (preferred), 10′×8′ (minimum).
- **Equipment:** HRV/ERV unit, main power panel, solar hybrid inverter, 10 kWh lithium battery, 10 kW dry transformer.
- **Clearances:** Minimum 3′ working clearance in front of electrical panels.
- **Shaft:** Dedicated vertical shaft to GF/FF for electrical risers and 250 mm HRV ducts (supply/return).
- **Low voltage:** Provisioned Cat6 pathways for CCTV, automation hub, and network switches (supports ENS/SVAGRIHA smart-metering and controls).
- **Requirements:** Adequate ventilation for heat dissipation; maintain moderate temperature for batteries; fire-safe finishes recommended.

3.2 Pump Room

- **Location:** Adjacent to basement WC or GF and service shaft; away from main hall to reduce noise, or in GF.
- **Size:** 8′×8′ (preferred), 8′×6′ (minimum).
- **Equipment:** Domestic water pumps, hot-water circulation pumps, sewage/sump pump, and the centralized hot-water heat-pump/solar-thermal interface (see Section 6).
- **Water supply:** Main inlet from OHT using 32 mm PPR pipe.
- **Risers:** 32 mm PPR vertical risers via shaft for hot-water supply and return circulation.
- **Construction:** Sloped floor with drain, full waterproofing, anti-vibration mounts, adequate ventilation.

3.3 WC Plumbing Design

- **System:** Three independent lines per WC with individual stop cocks — cold water, hot water, hot-water return.
- **Pipe sizing:** 32 mm PPR for mains; 25 mm PPR for internal WC piping.
- **Hot-water loop:** Supply and return originate from the Pump Room and run via shaft (32 mm risers).
- **Drainage:** Basement WC to use sewage lifting system; discharge to septic tank.
- **Water efficiency:** Specify low-flow / dual-flush sanitary fixtures to meet ENS 2024 building water-use reduction and SVAGRIHA Criterion 10 (reduction from base case).

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- **Protection:** Provide vent pipes for odour control; insulate pipes where required for freeze protection.
- **Maintenance:** Ensure an accessible layout for inspection and servicing.

3.4 Basement WC

- **Location:** Close to Pump Room and service shaft for efficient layout and maintenance.
- **Fixtures:** Water closet (WC), washbasin, optional shower — all low-flow rated.
- **Construction:** Full waterproofing to floors/walls; anti-skid flooring; proper floor slope to drain.
- **Ventilation:** Natural or mechanical to control dampness, odours, and mould.
- **Plumbing:** Mandatory connection to sewage lifting system; include vent line and accessible routing.
- **Advanced option:** Compact lifting unit (e.g., Grundfos Sololift2) for flexible placement.
- **Grey-water advantage:** Pump discharge enables ~1″ line, simplifying routing and avoiding large gravity pipes.
- **Operational goals:** Hygienic, easy maintenance, suited for intermittent use.

3.5 Solar Power System

- **Roof design:** Clear southern exposure; avoid shading; ensure structural capacity. Establish a shadow-free Renewable Energy Generation Zone (REGZ) per ENS 2024 §5.2.4.2.
- **Components:** PV panels, hybrid inverter, 5-100 kWh lithium battery (in Power/HRV room).
- **Capacity:** Design for 5–30 kW initial, with provisions for expansion. Size the renewable installation to satisfy ENS 2024 mandatory renewable-energy provision and SVAGRIHA Criterion 8.
- **Routing:** All solar cabling through the vertical shaft with organized trays.
- **Safety:** Ensure electrical-room ventilation and temperature control for battery performance.

3.6 MEP Coordination

- Centralized planning with a dedicated vertical service shaft from basement to roof.
- Shaft accommodates electrical risers, 250 mm HRV ducts, and 32 mm PPR hot-water risers.
- Provide minimum shaft size (~2′×2′) with fire-sealed penetrations and access panels.
- **Electrical routing:** Separate power and data (Cat6, CCTV, automation) in dedicated conduits.
- **Plumbing coordination:** Align WC, pump room, and shaft to minimize pipe runs; ensure valve accessibility.
- **HVAC/HRV:** Direct routing of ducts with minimal bends; provide insulation and access for maintenance.
- **Clash avoidance:** Prioritize routing (ducts → pipes → electrical).
- **Execution:** Prepare coordinated MEP drawings before construction to avoid conflicts and rework.

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4 JKGT Green Building Insulation / Architectural Considerations

4.1 Building Envelope

The building envelope is the continuous outer layer of a building that separates indoor spaces from the external environment and controls heat, air, and energy flow to maintain comfort and efficiency.

ECSBC 2024 (Chapter 5, Building Envelope) defines the envelope as the exterior façade — walls, roofs, floors, windows, and doors — and regulates it through maximum Assembly U-factors and SHGC, or by an Envelope Performance Factor (EPF) trade-off path.

Eco-Niwas Samhita (ENS) 2024 — the residential code applicable to J&K homes — controls the envelope through the Thermal Transmittance of Roof (U_{roof}), and, for Cold climate, the Thermal Transmittance of the building envelope except roof ($U_{envelope,cold}$), together with a minimum openable Window-to-Floor Ratio (WFR_{op}) and a minimum Visible Light Transmittance (VLT).

SVAGRIHA V.3 (Criterion 3, Efficient Envelope Design) treats the envelope as a climate-responsive skin: in Cold climates the objective inverts — the design must **increase** beneficial solar insolation through fenestration and **minimize peak heat loss** through the envelope, the opposite of the heat-gain logic used in hot climates.

PHIUS further refines the definition by emphasizing a continuous, highly insulated and airtight boundary with strict control of thermal bridges — retained here as the high-performance benchmark.

4.2 Cold-Climate Envelope Targets (2024 Codes)

The following consolidated targets govern this design. Residential projects must meet the mandatory ENS 2024 values; ECSBC 2024 values are the higher-performance commercial benchmark; PHIUS is the aspirational benchmark.

*Table 3 **ECSBC 2024 — Cold-climate maximum Assembly U-factor & SHGC (Chapter 5)***

Envelope Element	ECSBC	ECSBC+	Super ECSBC
Roof Assembly — U (W/m²·K)	0.20	0.20	0.18
Opaque External Wall — U (W/m²·K)	0.34	0.22	0.22
Vertical Fenestration — U (W/m²·K)	1.80	1.80	1.80
Vertical Fenestration — SHGC (N & non-N)	0.62	0.62	0.62

Table 1 ECSBC 2024 prescriptive envelope requirements (Cold climate column, Tables 5.3–5.11).

> **Cold-climate SHGC = 0.62 is deliberately high** — ECSBC 2024 permits (indeed encourages) solar heat gain through glazing in Cold climate, directly supporting the passive-solar strategy in §1.4. This is the reverse of the low-SHGC (≤0.25) requirement in hot climates.

*Table 4 **Eco-Niwas Samhita (ENS) 2024 — Mandatory residential provisions, Cold climate***

Parameter (ENS clause)	Mandatory Requirement	Code Ref.
Thermal Transmittance of Roof, U_{roof}	≤ 1.20 W/m²·K	5.2.1.3 / 9.4
Envelope (except roof), $U_{envelope}$,cold	≤ 1.80 W/m²·K	5.2.1.5 / 9.7
Min. openable Window-to-Floor ratio, WFR_{op}	≥ 8.33 %	5.2.1.1 / Table 8
Solar Water Heating (BEE ≥3-star, IS 13129)	≥ 10 % of plot area	5.2.4.1

ENS 2024 mandatory envelope & renewable provisions for Cold climate (note: the RETV ≤ 15 W/m² route applies only to Composite/Hot-Dry/Warm-Humid/Temperate zones, not Cold).

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Table 5 ***PHIUS 2021 — Prescriptive R-value benchmark (Zone 5A core, USA)***

Area	R-Value (m^2K/W)	R-Value ($ft^2 \cdot °F \cdot h/BTU$)
Walls & overhanging floors	5.64	32
Walls & floors (below grade)	2.82	16
Roofs	10.57	60
Ceilings	3.87	22

PHIUS 2021 minimum R-value benchmark retained for high-performance reference.

4.3 JKGT Thermal Break Implementation

The JKGT thermal-break strategy ensures the building envelope performs as a continuous, well-insulated barrier by keeping all structural elements — columns, beams, and slab edges — within the insulated envelope. This aligns with ECSBC 2024 envelope continuity, ENS 2024 U-envelope limits, SVAGRIHA's climate-responsive skin, and PHIUS thermal-bridge minimization. In Cold climates like Kashmir, uninterrupted insulation around structural members is critical to prevent heat loss, improve indoor comfort, and reduce heating demand.

Important Design and Implementation Points

- Provide AAC block wall thickness of approximately **200 mm** to fully enclose structural elements within the thermal envelope.
- Ensure all **RCC columns and beams are placed inside the wall line**, avoiding exposure to external conditions.
- Provide **continuous external insulation (50–100 mm for Kashmir)** across the entire façade to meet the ENS U-envelope ≤ 1.80 and approach the ECSBC+ wall U ≤ 0.22.
- Maintain total wall projection of approximately **250–300 mm (structure + wall + insulation)** from the structural face.
- Ensure **continuous insulation across all junctions** — slab edges, beam-column joints, parapets, and plinth.
- Align **window and door frames within the insulation layer** to prevent thermal bridging at openings.
- Detail the **plinth and foundation interface carefully** to maintain an uninterrupted thermal envelope.
- Avoid exposed concrete on the exterior; **wrap or isolate with insulation wherever unavoidable**.
- Ensure early coordination between architectural and structural design to accommodate insulation without reducing usable space.

4.4 Envelope Wall Insulation

External walls shall include continuous external insulation, with structural elements designed to accommodate it without affecting alignment or façade. External insulation is preferred over internal insulation as it insulates columns and beams, reduces thermal bridging, and preserves internal thermal mass, which regulates indoor temperatures by absorbing and releasing heat gradually.

Opaque walls must satisfy ENS 2024 (contribution to $U_{envelope,cold} \le 1.80$ W/m²·K) and ECSBC 2024 ($U \le 0.34$ W/m²·K compliant; $U \le 0.22$ W/m²·K for ECSBC+/Super). Two assemblies are given below: Option A is the ECSBC-compliant baseline (50 mm insulation); Option B is the recommended Kashmir high-performance assembly (100 mm insulation) that meets the ECSBC+ / Super-ECSBC wall target.

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Table 6 ***Opaque external wall — Option A (ECSBC-compliant, 50 mm insulation)***

Layer	Thk (m)	λ (W/mK)	R (m²K/W)	U (W/m²K)
Internal surface (Rsi)	—	—	0.13	
Gypsum plaster	0.020	0.20	0.10	
AAC block (200 mm)	0.200	0.160	1.25	
External insulation (50 mm)	0.050	0.030	1.67	
External surface (Rse)	—	—	0.04	
TOTAL			3.19	0.31

Option A meets ECSBC-compliant wall (U ≤ 0.34) and ENS U-envelope ≤ 1.80.

Table 7 ***Opaque external wall — Option B (recommended for Kashmir, 100 mm insulation)***

Layer	Thk (m)	λ (W/mK)	R (m²K/W)	U (W/m²K)
Internal surface (Rsi)	—	—	0.13	
Gypsum plaster	0.020	0.20	0.10	
AAC block (200 mm)	0.200	0.160	1.25	
External insulation (100 mm)	0.100	0.030	3.33	
External surface (Rse)	—	—	0.04	
TOTAL			4.85	0.21

Option B achieves U ≈ 0.21 W/m²·K — satisfies ECSBC+ / Super-ECSBC wall (U ≤ 0.22) and exceeds ENS Cold requirements.

4.5 Roof Assembly Insulation

ENS 2024 makes the roof a mandatory residential element: U_{roof} ≤ 1.20 W/m²·K. ECSBC 2024 is far more stringent for Cold climate (U ≤ 0.20 compliant; ≤ 0.18 Super-ECSBC). Roofs are the dominant heat-loss path in Kashmir attic/sloped construction, so JKGT targets the ECSBC level. The assembly below uses 150 mm XPS to reach U ≈ 0.19 W/m²·K.

Table 8 ***Roof assembly (insulated RCC / attic deck)***

Layer	Thk (m)	λ (W/mK)	R (m²K/W)	U (W/m²K)
Internal surface (Rsi, roof)	—	—	0.10	
False ceiling / gypsum board	0.0125	0.250	0.05	
RCC slab	0.150	1.580	0.095	
XPS insulation (150 mm)	0.150	0.030	5.00	
Screed / weathering course	0.050	1.400	0.036	
External surface (Rse)	—	—	0.04	
TOTAL			5.32	0.19

Roof U ≈ 0.19 W/m²·K — meets ECSBC compliant (0.20), approaches Super-ECSBC (0.18), and far exceeds ENS U_{roof} ≤ 1.20.

4.6 Internal Gypsum Plaster

Cement plaster shall not be used for internal wall finishes. Instead, gypsum plaster 5–20 mm thick shall be applied on all internal wall surfaces including AAC block walls and partitions. Gypsum plaster aligns with SVAGRIHA Criterion 5 (low-environmental-impact walling/plaster) and provides:

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- Smooth, uniform, paint-ready finish without additional putty.
- Faster application and setting than cement plaster; no water curing (reduced water use and labour).
- Reduced shrinkage and cracking; lightweight, reducing structural load.
- Improved thermal-insulation performance, indoor comfort, and good fire resistance.

Site execution — gypsum plaster application to internal wall surface, smooth trowel finish

4.7 Floor Design (with Electrical UFH)

Thermal mass stores and releases heat gradually (thermal lag), stabilising indoor temperatures and reducing energy demand. Electric Underfloor Heating (UFH) in guest rooms and bathrooms provides uniform floor-to-ceiling radiant heat with minimal stratification.

The UFH is installed within a 25–50 mm screed, supported by 50–100 mm XPS below to reduce downward loss. **Total build-up (excl. finish): 75–150 mm**, to be accounted for in structural/architectural floor levels. The ground floor contributes to the ENS $U_{envelope,cold} \leq 1.80$ W/m²·K limit — the assembly below uses 75 mm XPS.

Table 9 ***Floor insulation (GF / FF slab with UFH)***

Layer	Thk (m)	λ (W/mK)	R (m²K/W)	U (W/m²K)
Internal surface (Rsi)	—	—	0.13	
Screed (50 mm, with elec. heating)	0.050	0.140	0.357	
Floor insulation XPS (75 mm)	0.075	0.030	2.50	
External surface (Rse)	—	—	0.04	
TOTAL			3.03	0.33

Enhanced floor assembly U ≈ 0.33 W/m²·K (75 mm XPS) — comfortably within ENS U-envelope ≤ 1.80.

4.8 Basement Wall — Waterproofing & Insulation

The basement retaining wall must have a robust external waterproofing and insulation system. External treatment protects the structure, keeps the wall warm, and reduces condensation. Moisture intrusion from groundwater pressure is controlled by external membranes and protective layers applied after excavation.

4.8.1 Waterproofing System

- Bitumen-based waterproofing coating (min. 2 coats) on the external face of the retaining wall.

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- Continuous, uniform application without gaps; extend from foundation level to plinth/top.

4.8.2 External Insulation

- Provide 50–75 mm high-density EPS/XPS boards over the waterproofed surface.
- Maintain a continuous insulation layer to minimise thermal bridging and keep wall mass warm.

4.8.3 Protection & Drainage

- Drain board (dimple board) over insulation to protect it and create drainage cavities.
- Perimeter French drain at base; free-draining gravel backfill; slope discharge away from building.

4.8.4 Execution

- Excavate full perimeter; clean surface before application; protect membrane during backfill; inspect all layers before covering.

Table 10 ***R-value calculation for basement wall (below grade)***

Layer	Thk (m)	λ (W/mK)	R (m²K/W)	U (W/m²K)
Internal surface (Rsi)	—	—	0.13	
Gypsum plaster	0.020	0.200	0.10	
RCC wall	0.200	1.400	0.14	
EPS/XPS insulation (75 mm)	0.075	0.030	2.50	
External surface (Rse)	—	—	0.04	
TOTAL			2.91	0.34

Basement wall U ≈ 0.34 W/m²·K with 75 mm insulation (PHIUS below-grade benchmark R ≥ 2.82 m²K/W met).

Execution Reference & Warranty Linkage (New in Rev-06)

Detailed step-by-step application procedure, materials/tools schedule, and stage-wise QA sign-off checkpoints for this waterproofing, insulation and French-drain build-up are maintained separately in **JKGT-INS-100 — Basement Waterproofing, Insulation & French Drain: Application & QA Procedure**. Where a project warranty is issued under the JKGT-PATTAN-RPT-001 structure (or an equivalent JKGT warranty letter), the 10-year workmanship/materials warranty (Part A) and 5-year system watertightness warranty (Part B) are conditional on this build-up being executed exclusively by JKGT, following JKGT-INS-100, with every QA checkpoint signed off before backfilling.

Site execution — external bitumen waterproofing coating and HDPE drain board transition at basement retaining wall

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Site execution — perforated French drain pipe bedded in round rock, wrapped in geotextile, at wall footing

5 Mechanical Ventilation (HRV) & Passive Cooling

5.1 HRV Overview

Mechanical Ventilation with Heat Recovery (HRV) is critical for high-performance buildings in Cold climates like Kashmir, where airtight construction and low infiltration are essential. An HRV/ERV supplies continuous fresh air while recovering heat from outgoing stale air, maintaining indoor air quality without significant energy loss. The system forms part of a continuous, airtight boundary with controlled ventilation.

ECSBC 2024 §6.3.11 requires energy/heat-recovery equipment with a minimum 60 % recovery effectiveness where energy-recovery systems are installed; PHIUS practice and JKGT both target 70–85 %. ENS 2024 and SVAGRIHA Criterion 9 require adequate ventilation and indoor air quality for all regularly-occupied spaces.

5.2 Key HRV Design & Architectural Plan

- Ensure heat-recovery effectiveness **≥ 70–85 %** (ECSBC mandatory floor: 60 %).
- Maintain a tight building envelope (low infiltration) for optimal HRV performance.
- Design ventilation rates of **0.3–0.5 air changes per hour (ACH)** depending on occupancy.
- Provide dedicated vertical service shafts (**200–300 mm**) for main HRV supply and exhaust ducting.
- Provide secondary distribution ducts (**75–100 mm**) to individual rooms.
- Supply fresh air to habitable spaces (living rooms, bedrooms); extract stale air from wet areas (toilets, kitchens, utility).
- Insulate ducts passing through unconditioned spaces to prevent heat loss and condensation.
- Provide accessible HRV locations for filter replacement; low-noise, vibration-controlled design for residential comfort.
- Coordinate shaft placement and duct routing during the architectural planning stage; consider ERV where humidity control is required.

5.3 HRV Duct Sleeve Coordination (Structural Interface)

Every JKGT project using the standard HRV/ERV system (§5.1-5.2) requires cast-in sleeves through the floor/slab beams so branch ducting and control wiring can run concealed through the false ceiling. This is a mandatory

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MEP-structural coordination step, issued to the Project Structural Engineer as a formal coordination note before every suspended-slab and beam casting.

Which beams this applies to: horizontal HRV ducts run at ceiling level on each floor, so sleeves are required in the FLOOR/SLAB beams at each floor. They do NOT pass through PLINTH/base beams. The only base-level provision is the vertical-riser path within the dedicated HRV shaft.

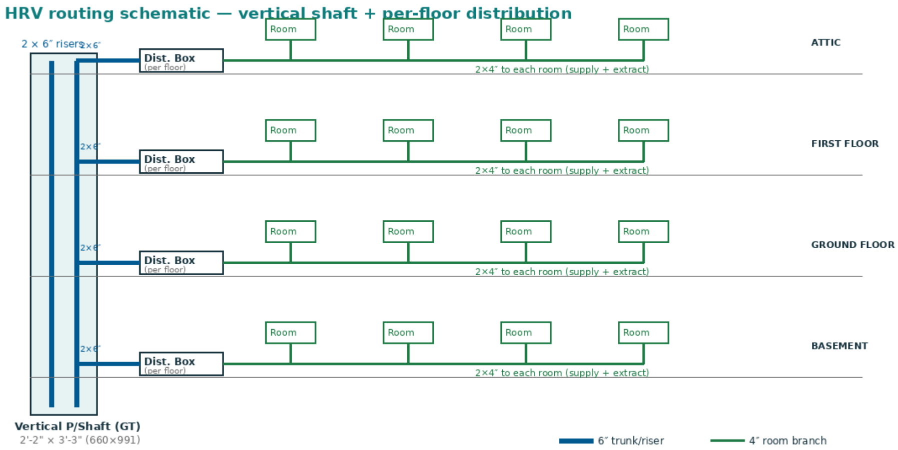
Ducting to be Provisioned

Duct	Nominal Size	Sleeve to Cast In	Service
Main HRV trunk	2 × 160 mm (≈6″)	2 × 200 mm slab openings in shaft	Supply + return / fresh + stale trunk lines
Room branches	2 × 75 mm pipe per room/area	2 × 100 mm dia. sleeve in every beam crossed	One fresh-air supply + one stale-air extract per room
Electrical / control wiring	Cabling in false ceiling	1 × 50 mm dia. sleeve per beam	Control / power wiring in false-ceiling void

Mandatory Zones for Sleeve Placement

- Vertical position: middle third of the beam depth is structurally preferred; where the fixed false-ceiling running level (≈150 mm below slab) falls outside this zone, provide opening reinforcement to suit — do not lower the sleeves below the ceiling line.
- Horizontal position: middle half of the clear span (low-shear zone); avoid the end quarters near supports/columns.
- Spacing: clear gap between adjacent sleeves ≥ 2 × sleeve diameter; sleeve edge to beam end ≥ beam depth.
- Diameter cap: no single sleeve to exceed 0.33 × beam depth without the engineer's specific design check.
- Reinforcement: additional trimming bars/links around every opening per the engineer's standard opening detail, IS 456 and ductile-detailing requirements.

Indicative Sleeve Section & Routing Model



HRV routing model — vertical risers in the dedicated shaft feed a per-floor distribution box, from which branch pipes cross floor beams to each room

5.4 Passive Cooling Strategy — Srinagar Climate

Srinagar is a heating-dominated (Cold-climate) location, but its cooling season — roughly June to August — is no longer uniformly mild. Long-term normals (1991–2020) give a July mean daily maximum of ≈30.5°C and mean daily minimum of ≈18.3°C, a diurnal swing of 12–15 K that is close to ideal for night-purge passive cooling. However, recent summers have repeatedly broken records: 37.4°C on 5 July 2025 (hottest July day since 1953)

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and 36.2°C on 28 July 2024, with night minima climbing to 24.6–25.2°C — the highest July night-time minimums in over 130 years. The design basis below therefore uses both climate normals and recent actual extremes, condensed from JKGT/EcoGreen's internal engineering analysis of passive cooling and HRV pre-conditioning for the Kashmir valley.

Design Day	Day Max (°C)	Night Min (°C)	Diurnal Swing
Typical July day	31	17	14 K — favourable for night purge
Heatwave day (2024–25 basis)	36	24	12 K — compressed, reduced flush potential

Design days adopted for Srinagar passive-cooling analysis, derived from IMD climate normals and 2024–25 actual extremes.

Humidity is not the constraining factor for Srinagar cooling — the wet-bulb depression is large enough (≈11 K on a typical afternoon) that sensible (dry) cooling dominates and latent load stays a small fraction of the total. The limiting factor is the night-time minimum temperature: it sets how much heat the building's thermal mass can shed overnight, ready to absorb the next day's gain.

Passive-Cooling Design Targets vs. ENS 2024 Cold-Zone Minimum

JKGT's passive-cooling envelope target goes well beyond the ENS 2024 mandatory floor, because the same continuous-insulation, low-SHGC, airtight assembly that keeps winter heating load down (Chapter 4) is also what keeps summer solar gain out — the two are not in conflict.

Parameter	ENS 2024 Cold-Zone Minimum	JKGT Passive-Cooling Target	Basis / Benefit
Envelope U-value (excl. roof)	≤ 1.80 W/m²K	≈ 0.30 W/m²K	Continuous insulation, AAC + CI (§4.4)
Roof U-value	≤ 1.20 W/m²K	≈ 0.20 W/m²K	Limits solar roof gain (§4.5)
Window SHGC	— (up to 0.62 permitted, §1.4)	≈ 0.25–0.30 on E/W & unshaded faces	Solar control is the dominant lever — see below
Air-tightness	—	≤ 0.6 ACH_{50} (Passive-House-grade)	Reduces uncontrolled summer heat ingress

Passive-cooling envelope targets are additive to, not a substitute for, the mandatory ENS 2024 winter envelope limits already set out in Chapter 4.

Parametric sensitivity analysis of the Srinagar model ranks the design levers by their effect on the indoor peak temperature on a typical day: window SHGC is the dominant parameter (≈1.0°C change in indoor peak per 0.1 change in SHGC) — roughly an order of magnitude stronger than further wall or roof insulation, which is already deep into diminishing returns at JKGT's target U-values. The design priority for cooling is therefore, in order: (1) low-SHGC glazing with external shading on east/west and unshaded south façades, (2) accessible internal thermal mass (exposed RCC/masonry), and (3) adequate night-purge airflow.

Night-Purge Strategy via HRV Summer Bypass

A standard HRV/ERV sized for continuous winter fresh-air supply (§5.1–5.2, ≈0.5 ACH) cannot move enough air for an effective night flush — night-purge cooling needs roughly 4–6 ACH. JKGT's passive-cooling design therefore couples the winter HRV/ERV with a true summer-bypass damper (routing outdoor air around the heat-exchange core once it is cooler outside than in) and, where the project scope and budget allow, a dedicated higher-flow fresh-air path for the night-purge duty. On a typical July design day, dynamic simulation shows night-purge free cooling lowers the indoor peak by ≈5°C compared with a sealed house, holding the home within or just above the 24–26°C comfort band with no mechanical cooling at all.

- **Trigger —** Enable bypass when outdoor dry-bulb is at least 2 K below indoor temperature.

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- **Time window —** nominally 22:00–07:00, extendable while indoor temperature remains above 26°C and outdoor air is cooler.
- **Minimum outdoor cut-off —** do not purge below ≈12°C outdoor, to avoid overcooling the exposed thermal mass ahead of the next heating season.
- **Humidity guard —** suspend purge above ≈80% outdoor RH to avoid condensation risk on cooled internal surfaces.

Heatwave Days — When Passive Alone Is Not Enough

On record heatwave nights (≈24–25°C minimum, as seen in 2024–25) the diurnal swing compresses to ≈12 K and the night-flush reservoir shrinks sharply: passive measures still cut the peak by ≈5°C, but the home can be left above the comfort band. JKGT's recommendation for projects where the client wants full heatwave resilience — not just typical-day passive comfort — is to size a right-sized heat-pump backstop (indicatively ≈5 kW for a ≈150 m² home) integrated with the ventilation supply via a dual-mode (chilled/hot water) coil downstream of the HRV core, bypassed during free-cooling night purge to preserve its low static pressure. On this basis the heat pump is expected to run on only ≈5–10 days per cooling season — near-passive operation for roughly 90% of the season — while also serving as a useful winter heating supplement. This is an optional, client-driven upgrade beyond the mandatory HRV/ERV scope of §5.1–5.3, to be scoped project-by-project.

The figures in this section are engineering design estimates from a single-zone lumped-capacitance thermal model, calibrated to IMD climate data for Srinagar; they are indicative and should be confirmed by project-specific dynamic simulation, envelope schedule and site orientation before being relied on for equipment selection. Full methodology, duct sizing, coil selection and economic analysis are maintained separately in JKGT/EcoGreen's internal engineering report, EcoGreen Passive Cooling and Pre-Conditioning HRV — referenced here as this document's passive-cooling design basis for Srinagar.

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6 Underfloor Heating (UFH) & Centralized Hot Water (CHW) Systems

This chapter covers the two building-wide thermal-comfort services that share JKGT's central Pump Room and vertical service shaft (§3.2, §3.6): electrical underfloor heating (UFH) for targeted comfort/direct floor heating in bathrooms and living areas (§6.1–§6.2), and the centralized solar + heat-pump hot-water system serving all WCs (§6.3–§6.4). Both are dimensioned and coordinated at the same MEP-drawing stage as the HRV and electrical risers.

6.1 Electrical Underfloor Heating (UFH) — System Overview

JKGT specifies screened, IEC-compliant electrical UFH (cable or thin heating mat) as the default heating source for guest-room and bathroom floors, installed within the floor build-up already set out in §4.7. Three system types are recognised, and JKGT's default residential scope uses the first:

- **Comfort (warm-floor) heating —** the standard JKGT application — a thermostat with a floor sensor holds the floor surface at a set comfort temperature, independent of the room's primary heating; used in bathrooms, kitchens and living-area floors for warm-underfoot comfort.
- **Total / Direct floor heating —** the floor is the sole heating source for the room, sized against the room's calculated heat loss with a 1.2–1.3 safety factor and controlled by a thermostat with air + floor sensors; used only where a room has no other heat source.
- **Accumulating heating —** cables embedded in a thick (7–15 cm) concrete layer are charged during low-tariff night hours and release stored heat over the following day; not JKGT's default for J&K residential projects but available where net-metering/tariff structures justify it.

Cable/mat selection follows the floor construction thickness: heating cable (screened twin-conductor, typically 10–18 W/m) for concrete floor build-ups of 3 cm or more above the element; thin heating mat (3–4.5 mm thick, self-adhesive) for tile-glue/thin build-ups under 3 cm, most relevant to renovation and bathroom retrofits where floor-level rise must stay minimal. Installation is governed by the cable-to-cable (C-C) spacing — the closer the spacing, the higher the areal output and the more even the surface temperature; JKGT's comfort-heating default is C-C = 7.5–10 cm.

6.2 Key UFH Design & Selection Summary

- **Installed output (comfort heating) —** Bathrooms/wet rooms 150–180 W/m²; dry rooms with insulated floor 100–120 W/m² minimum; floors without insulation 130–160 W/m²; overall ceiling 200 W/m² in any concrete floor construction — select per §4.7 floor build-up and room type.
- **Wooden-floor surfaces —** where UFH is installed under timber/laminate flooring (guest-room build-ups), cap installed output at 100 W/m² (thin floor) or 55–80 W/m² (on wooden sub-floor/joists), and limit floor surface temperature to 27°C — always via a thermostat with a floor sensor and a hard maximum-temperature cut-out.
- **Thermostat & sensor —** every UFH circuit must use a thermostat with a dedicated floor sensor (plus air sensor for total/direct heating), factory-preset to a 35°C floor-temperature ceiling; a spare sensor conduit should always be provisioned even where not immediately wired.
- **Safety factor & zoning —** apply a 1.2–1.3 safety factor to the calculated cable/mat output; a single thermostat relay is typically limited to ≈3450–3680 W (15–16 A) — split larger areas into independent zones with separate thermostats rather than one oversized circuit.
- **Insulation coordination —** UFH cable/mat must sit on a continuous insulation layer (the 75–100 mm XPS already specified in §4.7) to prevent downward heat loss; the element must never be pressed into or embedded within the insulation itself — a separating layer (thin screed, mesh or foil) keeps the two apart.

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- **Electrical coordination —** provision dedicated UFH circuits from the Power/HRV Room distribution board (§3.1) sized to the connected floor-heating load, in addition to — not shared with — general lighting/socket circuits; route sensor cabling through the same conduit pathways as the pump-room hot-water controls where practical.

Illustrative product basis: screened twin-conductor cable systems (e.g. Danfoss ECflex range or equivalent, manufactured to IEC 60800) and self-adhesive thin heating mats (e.g. Danfoss ECmat/ECcomfort range or equivalent, to IEC 60335-1/-2-96) are acceptable references for specification; JKGT does not mandate a single vendor, but any substituted system must meet the same IEC compliance, C-C spacing flexibility and floor-sensor thermostat requirements set out above.

6.3 Centralized Hot Water (CHW) — System Overview

A centralized hot-water system is recommended for energy efficiency, reliability, and uniform distribution. It comprises a centralized insulated storage tank (250–1000 L per building size/occupancy) in the pump house, served by a solar water-heating array and an external heat-pump unit. This satisfies the ENS 2024 mandatory renewable-energy provision (solar water heater of minimum BEE 3-star per IS 13129, installed over ≥ 10 % of plot area) and contributes to SVAGRIHA Criterion 8. The distribution network is a recirculating system to minimise heat loss and waiting time, integrated with pumps, non-return valves (NRVs), and controls.

> **ECSBC 2024 service-water-heating path:** solar water heating should provide at least 40 % of the hot-water design requirement, with the balance met by a high-efficiency system (e.g., heat pump) — the solar + heat-pump configuration here is designed to that intent.

6.4 Key CHW Design & Architectural Plan

- Centralized insulated storage tank (**250–1000 L**) in the pump house.
- Solar collectors (evacuated-tube/flat-plate, IS 16542/16543/16544 compliant) plus external heat-pump back-up, with space, ventilation, and service access.
- Main circulation piping **32 mm dia.**; branch connections **25 mm dia.** to WCs/usage points.
- Recirculation loop with circulation pumps for continuous/demand-based flow; NRVs to prevent backflow.
- Isolation and balancing valves for maintenance and hydraulic control; thermal insulation on all hot-water pipes.
- Pump-house layout to accommodate tank, pumps, valves, controls with maintenance access.
- Pressure-relief and overflow safety provisions; future scalability for capacity expansion.

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7 Appendix A — Green Building Codes and Standards (India/International)

7.1 ECSBC 2024 — Commercial / Office Benchmark

The Energy Conservation and Sustainable Building Code (ECSBC 2024), published by BEE in December 2024, supersedes ECBC 2017 for commercial and office buildings. It is organised as Sustainable Sites & Planning (Ch.4), Building Envelope (Ch.5), Comfort Systems & Controls (Ch.6), Lighting (Ch.7), and Electrical & Renewables, with three performance tiers — ECSBC, ECSBC+ and Super-ECSBC — and an Envelope Performance Factor (EPF) trade-off path. Cold-climate prescriptive envelope targets are summarised in Table 1 (§4.2). Key non-envelope provisions used in this design: heat/energy recovery ≥ 60 % effectiveness (§6.3.11) and solar water heating ≥ 40 % of hot-water demand.

7.2 Eco-Niwas Samhita (ENS) 2024 — Residential Code (Mandatory)

Eco-Niwas Samhita 2024 (the residential ECBC-R) is the mandatory code for J&K homes. Its structure mirrors ECSBC — Sustainable Site Management (Ch.4), Energy Conservation & Management (Ch.5), Water (Ch.6), Waste (Ch.7) — with mandatory and incremental provisions. For Cold climate the mandatory envelope provisions are:

- U_{roof} ≤ 1.20 W/m²·K (§5.2.1.3).
- $U_{envelope,cold}$ ≤ 1.80 W/m²·K for the envelope except roof (§5.2.1.5 / 9.7).
- Minimum openable WFR_{op} ≥ 8.33 % for natural ventilation (§5.2.1.1).
- Minimum VLT by WWR (Table 7 of this document).
- Renewable energy: solar water heating (BEE ≥ 3-star, IS 13129) over ≥ 10 % of plot area, and/or solar PV in a shadow-free REGZ.
- Building water-use reduction (low-flow fixtures), rainwater harvesting, and low-VOC interior paints.

> **RETV vs U-envelope:** ENS 2024 controls the envelope of Composite/Hot-Dry/Warm-Humid/Temperate zones via the Residential Envelope Transmittance Value (RETV ≤ 15 W/m²). For **Cold** climate (Srinagar/Leh) RETV does not apply — the $U_{envelope,cold}$ ≤ 1.80 W/m²·K route governs instead.

7.3 SVAGRIHA V.3 — Rating & Impact Tool

SVAGRIHA V.3 (Simple Versatile Affordable GRIHA, GRIHA Council 2024) is a guidance-cum-rating-cum-impact-analysis tool for projects with built-up area 100–2500 m² — well suited to J&K residences. It is a 50-point system across seven scoring sections plus a 2-point Innovation bonus, with 14 criteria, each requiring minimum section points.

*Table 11 **SVAGRIHA V.3 sections, criteria and points***

Section	Criteria	Max	Min
Sustainable Site Planning	1 Site Planning, 2 Passive Design, 3 Efficient Envelope	12	6
Low-Impact Materials	4 Structure, 5 Walling, 6 Fenestrations & Interiors	7	4
Energy Optimization	7 Optimizing Energy Use, 8 Renewable Energy	8	4
Occupant Comfort & Well-being	9 Indoor Air Quality & Comfort	7	4
Water Management	10 Building/Landscape Demand, 11 Rainwater	8	4
Solid Waste Management	12 Waste Management	3	1
Sustainable Lifestyle	13 Sustainable Lifestyle	5	2
Innovation (bonus)	14 Innovation	2	—

Table 10 SVAGRIHA V.3 scoring structure (50 points + 2 bonus).

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Criterion 3 (Efficient Envelope Design) is climate-inverted for Kashmir: in Cold climates the project must **increase** overall solar insolation through fenestration above the base case (Table 3.2) and **minimize peak heat loss** through the envelope (Table 3.4) — reinforcing the high-SHGC, high-insulation strategy adopted here. Other relevant credits: Site Planning (25 % softscape, 1 tree/200 m² for residential), low-impact materials (100 % OPC→PPC, AAC, low-VOC, urea-formaldehyde-free), renewable energy (100 LPD solar hot water ≡ 1.5 kWp), and IAQ (daylight, acoustic comfort, low-VOC paints).

7.4 PHIUS Standard

PHIUS sets the industry baseline for net-zero building design, emphasising quality, durability, health, safety, and cost-optimised conservation. Passive-building principles — built correctly from the start — reduce the renewables load and offer the best path to net-zero/net-positive buildings. PHIUS 2021 Zone 5A R-values (Table 3) are retained as the high-performance benchmark.

7.5 Air Barrier Layer

Air leakage is the uncontrolled movement of air through cracks, joints, and gaps in the envelope. A continuous air-barrier system must be incorporated at design stage — ENS 2024 and ECSBC 2024 both address building air leakage. Special attention is required at attic/sloping roofs in the Kashmir climate, where extreme cold and wind increase heat loss and moisture ingress if not sealed. Most common air-leakage paths:

- Air pathways through floor/ceiling voids into cavity walls and to exterior; gaps around window frames.
- Ceiling-to-wall junctions (especially at eaves); open/unused chimneys; loft/attic hatches.
- Service penetrations (pipes, ducts, cables); roof/ceiling vent penetrations.
- Bathroom/kitchen wall vents or extract fans and waste-pipe gaps; electrical fittings in hollow walls.

All leakage points must be **sealed and integrated into a continuous air-barrier system** to ensure airtightness, energy efficiency, and thermal comfort — critical in Cold climates like Kashmir.

8 Appendix B — Green Building Materials (Recommended)

8.1 General

Products listed on the GRIHA Product Catalogue are evaluated against GRIHA / SVAGRIHA technical criteria using third-party test reports and manufacturer declarations. Deploy products from the catalogue and prefer SVAGRIHA low-environmental-impact materials (Criteria 4–6). Catalogue: https://www.grihaindia.org/products-catalogue

8.2 AAC Blocks

AAC (Autoclaved Aerated Concrete) blocks per IS 2185 (Part 3), size 625 × 240 × 200 mm, are proposed. AAC contains 70–80 % air via autoclaving, giving low thermal conductivity ($\lambda \approx 0.16$ W/mK), light weight, and good fire resistance — supporting both the envelope U-targets and SVAGRIHA low-impact walling credit.

8.3 Gyproc Dampline

Gypsum is non-toxic and not hazardous to health. Gyproc Dampline™ is a gypsum board with special additives for moisture-resistance, inhibiting interior dampness — suitable for the internal gypsum-plaster/board finish specified in §4.6.

8.4 Low-Impact & Low-Emission Materials (SVAGRIHA / ENS)

- **Cement:** replace 100 % OPC with PPC in structure, masonry mortar, and plaster (SVAGRIHA 4.1.1).
- **Insulation:** XPS/EPS and mineral wool with declared λ; prefer products with EPD / GRIHA certification.

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- **Paints & finishes:** low-VOC, lead-free interior paints (ENS 2024 / SVAGRIHA 9.1.5).
- **Wood products:** composite wood free from urea-formaldehyde; FSC/recycled where possible.
- **Fenestration & interiors:** UPVC/low-impact window and door frames; high-SRI roof finishes (SR ≥ 0.60, emittance ≥ 0.90, or SRI ≥ 0.70).

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9 Appendix C — Standards Compliance Matrix

The matrix summarizes how this design satisfies the 2024 code generation for a Cold-climate (Srinagar/Leh) project. ✓ = met by the specified assembly; values reference the tables in Section 4.

Table 12 JKGT Standards Compliance

Parameter	Code Requirement	JKGT Design	Result	Ref.
Roof U-factor	ENS ≤ 1.20 / ECSBC ≤ 0.20	≈ 0.19 (150 mm XPS)	✓ Meets Super-ECSBC	Table 6
Opaque wall U	ENS env ≤ 1.80 / ECSBC ≤ 0.34 (+ ≤ 0.22)	0.31 (Opt A) / 0.21 (Opt B)	✓ Opt B meets ECSBC+	Tables 4–5
Floor U (GF/FF)	ENS env ≤ 1.80	≈ 0.33 (75 mm XPS)	✓ Met	Table 8
Basement wall	PHIUS R ≥ 2.82 m²K/W	R ≈ 2.91 (U 0.34)	✓ Met	Table 9
Fenestration U	ECSBC ≤ 1.80 W/m²·K	DGU + UPVC ≤ 1.80	✓ Met	§1.4
Fenestration SHGC	ECSBC Cold ≤ 0.62 (high gain)	~0.60 south façade	✓ Passive solar	Table 1
Openable WFR_{op}	ENS ≥ 8.33 %	Per room ventilation design	✓ To verify	§1.4
VLT by WWR	ENS Table 9	Glazing selected to suit WWR	✓ To verify	Table 7
Heat recovery	ECSBC ≥ 60 % effectiveness	HRV/ERV 70–85 %	✓ Exceeds	§5.2
Solar water heating	ENS BEE ≥3-star, ≥10 % plot / ECSBC ≥40 %	Solar + heat-pump CHW	✓ Met	§6
Renewable energy	ENS RES / SVAGRIHA Crit. 8	15–20 kW PV + solar HW	✓ Met	§3.5
Low-impact materials	SVAGRIHA Crit. 4–6	PPC, AAC, low-VOC, UF-free	✓ Met	§8

Table 11 Standards Compliance Matrix (Cold climate). "To verify" items depend on final room-by-room glazing schedule.

> **Disclaimer:** U-/R-values are design calculations based on declared material properties and standard surface resistances; final compliance must be confirmed against the as-built assembly, the project's climatic data, and the SVAGRIHA / ENS online calculators and authority-having-jurisdiction review.

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