

**CHAPTER 6**  
**GRIHA REQUIREMENT**

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## 6.1 GRIHA Checklist

The GRIHA checklist below is indicative of the target points that can be attempted as per the design parameters and site conditions. The contractor shall endeavour to increase the number of targeted points or at the very least comply with the targeted points as per the table below. The contractor shall ensure that all mandatory criteria for GRIHA certification shall be fulfilled as per the requirements. It is to be noted that mandatory criteria in GRIHA have no points assigned to them and have to be compliant in order to gain GRIHA certification.

Cr. No.	Criterion name	Max Points	Points Targeted
<b>Site Planning</b>		<b>8</b>	<b>8</b>
1	Site Selection	1	1
2	Low-impact design	4	4
3	Design to mitigate UHIE	2	2
4	Site imperviousness factor	1	1
<b>Construction Management</b>		<b>9</b>	<b>9</b>
5	Air and water pollution control	1	1
6	Preserve and protect landscape during construction	4	4
7	Construction Management Practices	4	4
<b>Energy</b>		<b>20</b>	<b>14</b>
8	Energy efficiency	13	10
9	Renewable energy utilization	7	4
10	Low ODP materials	0	0
<b>Occupant comfort and Well-being</b>		<b>12</b>	<b>12</b>
11	Achieving indoor comfort requirements (visual/thermal/acoustic)	6	6
12	Maintaining good IAQ	4	4
13	Use of low-VOC paints and other compounds in building interiors	2	2
<b>Water</b>		<b>17</b>	<b>10</b>
14	Use of low-flow fixtures and systems	4	2
15	Reducing landscape water demand	4	4
16	Water Quality	2	2
17	On-site water reuse	5	0
18	Rainwater Recharge	2	2
<b>Sustainable Building Materials</b>		<b>14</b>	<b>10</b>
19	Utilization of BIS recommended waste materials in building structure	6	6
20	Reduction in embodied energy of building structure	4	0
21	Use of low-environmental impact materials in building interiors	4	4
<b>Solid Waste Management</b>		<b>6</b>	<b>6</b>
22	Avoided post-construction landfill	4	4
23	Treat organic waste on site	2	2
<b>Socio-Economic Strategies</b>		<b>6</b>	<b>6</b>
24	Labour safety and sanitation	1	1
25	Design for Universal Accessibility	2	2
26	Dedicated facilities for service staff	2	2
27	Increase in environmental awareness	1	1
<b>Performance Monitoring &amp; Validation</b>		<b>8</b>	<b>6</b>
28	Smart metering and monitoring	8	6
29	Operation & Maintenance Protocols	0	0
30	Performance Assessment for Final Rating	0	0
		<b>100</b>	<b>81</b>
<b>31</b>	<b>Innovation</b>	<b>4</b>	<b>4</b>
<b>Total</b>			<b>85</b>
<b>Total (Percentile)</b>			<b>85</b>

## **6.2 Scope of Work**

The project is aiming for a GRIHA 4 star certification minimum, the contractor is required to get the project registered, coordinate with GRIHA for all certification related documentation and facilitation for during construction audits and workshops. The contractor shall appoint/engage consultant/consultancies to provide technical guidance and supervise the work, pertaining to the criterion related to the execution of work, so that it finally achieves the targeted GRIHA rating.

The GRIHA requirements given here under are broad guidelines and additional requirements if any, as per GRIHA requirements shall be adhered to by the contractor. Layouts of the projects provided may not indicate the requirements given below, the contractor shall ensure that all requirements are met to gain a GRIHA 4 star rating at the very least.

## **6.3 Abbreviations:**

- 6.3.1 GRIHA: Green Rating For Integrated Habitat Assessment
- 6.3.2 ICAR: Indian Council of Agricultural Research
- 6.3.3 NBC: National Building Code
- 6.3.4 BIS: Bureau Of Indian Standards
- 6.3.5 CPCB: Central Pollution Control Board
- 6.3.6 ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers
- 6.3.7 ECBC: Energy Conservation Building Code
- 6.3.8 BOQ: Bill Of Quantity
- 6.3.9 PO: Purchase Order
- 6.3.10 SLD: Single Line Diagram
- 6.3.11 O&M MANUAL: Operation And Maintenance Manual
- 6.3.12 BTU: British Thermal Unit
- 6.3.13 HVAC: Heating Ventilation Air-Conditioning
- 6.3.14 AHU: Air Handling Unit
- 6.3.15 CFC: Chlorofluro Carbon
- 6.3.16 HCFC: Hydrochlorofluro Carbon
- 6.3.17 VOC: Volatile Organic Compound
- 6.3.18 VLT: Visual Light Transmission
- 6.3.19 SHGC: Solar Heat Gain Coefficient
- 6.3.20 WWR: Wall Window Ratio
- 6.3.21 VSA: Vertical Sun Angle
- 6.3.22 HAS: Horizontal Sun Angle
- 6.3.23 AAC: Autoclaved aerated concrete
- 6.3.24 STP: Sewage Treatment Plant
- 6.3.25 WTP: Water Treatment Plant
- 6.3.26 ETP: Effluent Treatment Plant

#### **6.4 During Construction Guidelines:**

The contractor shall ensure the execution, maintenance and proper documentation of the following points through out construction to achieve GRIHA certification compliance for on site construction practices.

6.4.1 Top Soil Preservation: Contractor should ensure preservation of top soil cover by following ways:

- Remove top soil to a depth of 20 – 30 cm from the areas where construction activity is proposed and reapply top soil in proposed landscaped area or areas away from the construction activity which shall remain untouched during the construction period. After completion of construction work, the preserved top soil should be reused for landscaping.
- Top soil to be stacked up to a maximum height of 40 cm ( As per NBC guidelines)
- Grassing or mulching to be done on the stacked soil to ensure the soil retains its nutrients.
- In areas where slope of the ground is more than 1:10, small trench/channels to be constructed to reduce runoff velocity.

6.4.2 Existing trees and other forms of vegetation to be preserved by avoiding disturbance/damage due to construction activities. All existing vegetation should be marked on the site survey plan. The tree survey must be carried out and data must be recorded before starting construction activity. Adequate fencing to avoid disturbance/damage to trees and other vegetation to be provided. To compensate the loss of vegetation/mature trees, replant the vegetation/trees in proportion of 1:4.

6.4.3 Low water consuming materials (curing compounds) to be used in order to reduce construction water consumption.

6.4.4 Contractor shall ensure use of BIS recommended waste materials in building structure as per the following requirements. Documentation shall be maintained in the form of Narratives, test certificates/reports, technical sheets, BOQ and purchase orders.

- 25% replacement of Ordinary Portland cement with fly ash/BIS recommended waste material by weight of cement used in structural concrete
- Minimum 40% composition of building blocks/bricks by fly ash/BIS recommended waste material by volume, for 100% load bearing and non-load bearing masonry walls
- 25% replacement of Ordinary Portland cement with fly ash/BIS recommended waste material in plaster/masonry mortar

6.4.5 The following points have to be ensured for Air pollution Prevention

- At least a 3 m (10 ft.) high barricading shall be installed all around the perimeter of the construction site.
- Wheel washing facility to be provided at all site entrances.
- Covering of fine aggregate and excavated earth by geotextile/plastic sheets.
- Regular water sprinkling on fine aggregate, sand and excavated earth.
- All diesel gensets to have proper chimneys facing away from the site.

6.4.6 Project has to fulfil the compliance requirement as per NBC: Volume 1 Part 3 General Development Control Rules And General Building Requirements.

- 6.4.7 Construction management practices and safety measures shall be complied as per NBC: volume – 2 part 6. Broadly, the following points shall be ensured on site throughout the construction period.
- Safety Gears (Helmets, Boots, masks, gloves & Harness): Safety gear shall be provided to all the construction workforce, engineers, staff, visitors and other onsite personnel.
  - Safety Nets: Safety nets shall be installed at the different heights as required on the buildings during the course of the construction.
  - Regular workshops or training programs shall be conducted for the construction workers for proper knowledge of the safety measures to be maintained on site.
  - Labour Hutment: labour hutment shall be provided for the construction workers if the workers are not locally sourced. Hygiene, proper ventilation and natural daylight shall be maintained.
  - Drinking Water Facility: Drinking water facility shall be provided onsite at convenient locations. Drinking water test reports shall be conducted at regular intervals and test reports shall be maintained for GRIHA documentation.
  - Separate Toilets and Bath Areas for male and female workers to be provided and hygiene to be maintained.
  - Children Day-care Centre to be provided in the labour hutment.
  - Clean Environment: Dustbins shall be placed at various locations in the labour living area to maintain cleanliness and ensure a healthy environment for the labour living on site
  - First-aid Room: First-aid room shall be provided on and general medicines shall be stocked at site for immediate attention in case of emergencies and other common ailments for the laborers.
- 6.4.8 Contractor shall prepare soil erosion and sedimentation control plan and waste/scrap reuse plan before starting construction activity and submit the same for client/GRIHA consultant approval. The plan is to be prepared as per the following parameters and is to be executed effectively during the whole construction phase:
- The sedimentation basin should be constructed to store the calculated volume of run off. The location of the basins to be selected by considering topography and slope of the site. The sedimentation basins should be located at the lowest convenient points and connected to storm water drains.
  - Temporary seeding, mulching, sedimentation trap, staging around construction area with level different/temporary drainage channel and other methods need to be adopted and should be shown in the plan.
- 6.4.9 Excavation to be avoided during monsoon season to minimise and avoid soil erosion due to rainfall.
- 6.4.10 Contractor to generate and submit a construction activity, material storage, construction waste storage and vehicular movement plan before starting the construction activity. The plan is to be prepared to ensure the following and is to be applied effectively during the whole construction phase:
- Demarcate area on site plan to which construction activity would be limited by the contractor. The demarcated area should be separated from the rest of the site by a physical barrier.
  - All construction materials to be stored in demarcated areas with low height enclosures to limit spillage, waste and site contamination.
  - Control plan clearly stating measures to stop and contain spills to dispose off contaminated materials and hazardous waste ( hazardous waste include pesticides, paints, cleaner and petroleum products etc.) cover all loose stored materials with geotextile or any impervious fabric/covering.

- Location should be identified on the construction site to store the used/scrap wastes. Both these wastes should be separately stored in bins and handed over to authorized agencies for safe disposal.
- 6.4.11 Contractor shall keep activity wise evidences of all measures taken on site in form of photographs at every stage of construction to fulfil the GRIHA compliances related to sustainable site planning.
- 6.4.12 Contractor shall get the following tests as per GRIHA certification requirements:
- On site drinking water test report (monthly)
  - Construction water test report (every 6 months during the entire construction period)
  - Ambient Air quality test report (every 6 months during the entire construction period)
  - During construction noise test report (outdoor) (every 6 months during the entire construction period)
  - Percentage Fly ash content in concrete (per batch)
  - Percentage fly ash content in AAC blocks
  - Top Soil Fertility test report ( on minimum 2 locations on site before excavation from an ICAR accredited laboratory)

## **6.5 Site level GRIHA certification Requirements**

- 6.5.1 Contractor shall substantiate GRIHA certification documentation for criterion 1 site selection.
- 6.5.2 Contractor shall provide analysis and documentation to indicate reduction in environmental impact through design by adoption of various passive design and low-impact site planning strategies as mentioned below as per GRIHA compliance requirement.
- Control annual Heat Gain through favourable orientation and design of facades
  - Internal zoning/layout of the floor plate
  - Facilitating cross ventilation in naturally ventilated/mixed-mode ventilation spaces
  - Building design has been done in a manner to not obstruct the solar access to the neighbouring buildings, especially if the neighbouring building has solar photovoltaics and solar water heaters installed on the roof
  - Massing of the building/campus done in a manner to reduce insolation
  - Use of trees to control heat gain
  - Site planning according to contours
  - Site plan designed to preserve existing vegetation/ existing water bodies /other topographical features like boulders etc.
  - Implementation of Sustainable Urban Drainage Strategies
  - Any other passive design strategies
- 6.5.3 Documentation to show more than 50% site surfaces exposed to sky are either soft paved/covered with high SRI coating (SRI > 0.5)/shaded by trees/shaded by vegetated pergolas/shaded by solar panels or any combination of these strategies. Technical sheet, PO and BOQ to be maintained along with photograph after installation on site.

- 6.5.4 Design for universal accessibility should be done in a way that it is compliant with NBC Annexure B - Accessibility In Built Environment For Persons With Disability on site level. Following points shall be ensured:
- Appropriately designed preferred car park spaces having an easy access to the lift lobby
  - Easy access to the main entrance of the building in form of unhindered access or ramps with handrails on both sides and slope of not 1:12
  - Braille and audio assistance in all lifts for visually impaired people
  - Uniformity in floor level for hindrance-free movement in common areas & exterior areas
  - Main walkways/ pathways with adequate width of 1200 mm in exterior areas
  - Restrooms (toilets) in common areas designed for differently abled people
- 6.5.5 Automatic control to be provide for all exterior lighting. Documentation in form of narratives, location in electrical SLD and layout, technical sheet, purchase order and BOQ to be maintained.
- 6.5.6 Meet the minimum requirements of CPCB National Ambient Air Quality Standard (NAAQS)for quality of fresh air.
- 6.5.7 Installation and documentation of renewable energy and hot water system as per GRIHA certification requirements.
- 6.5.8 Adequate signages to be installed in the project as per GRIHA certification requirements.
- 6.5.9 Drawings and documents showing location of all energy and water meters and submeters.
- Energy- (Should be two way communicable)
    - Meters:
      - a. Utility grid
      - b. On-site renewable energy system
      - c. Diesel Genset, Gas Genset etc.
      - d. Each building level
    - Sub-meters:
      - Commercial/Institutional:
        - a. HVAC central plant- AHU, Cooling tower, Chillers (BTU meters) and/or distributed units (split/window ACs)
        - b. Lighting (Indoor and outdoor)
        - c. UPS
        - d. Basement parking lighting
      - Residential:
        - a. For Basement Parking Lighting, Community/Recreation center, Water pumping, Outdoor Lighting
        - b. Lifts and common areas
  - Water-
    - a. Municipal Supply
    - b. Bore well
    - c. Treated water outlet from STP
    - d. Captured rainwater
    - e. Each building level
    - Sub-meters:
      - a. Irrigation
      - b. Cooling Tower
      - c. STP/WTP/ETP
      - d. Each apartment/commercial tenant



- 6.5.10 Any 4 of the following strategies to be adopted the project to gain innovation points:
- A GRIHA certified professional (trainer or evaluator) is involved in the project from beginning to end
  - First Mover: implementation of a technology for the first time in the country
  - E-waste recycling
  - STP technologies which do not use chemicals
  - Net-zero: energy/water
  - Charging points for electrical vehicles

6.5.11 Following tests are to be conducted and test report to be maintained indicating compliance with GRIHA certification requirements:

- STP water test report
- Post construction Noise test report
- Indoor : At least two locations in each building typology
- Outdoor : At least two locations
- Transformer test report indicating losses at 50% and 100% load

In addition to the above mentioned responsibilities, the contractor is also responsible for providing the ensuring the following input/data in close coordination with PMC/Architect to fulfil GRIHA compliance documentation.

6.5.12 Ensure all mandatory ECBC compliances are met as per the following table.

<b>Clause No</b>	<b>Requirement</b>
<b>4.2</b>	<b>Envelope</b>
<b>4.2.1</b>	<b>Fenestration</b>
<b>4.2.1.1</b>	<b>U factors</b>
	Shall be determined for the overall fenestration product (including sash and frame) in accordance with ISO-15099
<b>4.2.1.2</b>	<b>Solar heat gain coefficient (SHGC)</b>
	Shall be determined for the overall fenestration product (including sash and frame) in accordance with ISO-15099. Exception: <ul style="list-style-type: none"> <li>• SHGC of the glass alone is an acceptable alternative</li> <li>• Centre of glass Shading Coefficient (SC) x 0.86 is an acceptable alternative</li> </ul>
<b>4.2.1.3</b>	<b>Air Leakage</b>
	Shall not exceed 5.0 l/s-m <sup>2</sup> for glazed swinging entrance doors and revolving doors. Shall not exceed 2.0 l/s-m <sup>2</sup> for other fenestration and doors
<b>4.2.2</b>	<b>Opaque Construction</b>
	U factors Shall be determined from default tables in Appendix C\$11 or data or procedures contained in the ASHRAE Fundamentals, 2005.
<b>4.2.3</b>	<b>Building Envelope Sealing</b>

	<p>The following envelope components shall be sealed, caulked, gasketed, or weather stripped to minimize air leakage:</p> <ul style="list-style-type: none"> <li>• Joints around fenestration and door frames.</li> <li>• Openings between wall and foundations, and between walls and roof.</li> <li>• Penetration openings of utility services through roof, wall and floors.</li> <li>• Site built fenestration and doors.</li> <li>• Building assemblies used as ducts or plenums.</li> <li>• Any other opening in the building envelope.</li> </ul>																																								
<b>5.2</b>	<b>Heating, Ventilation and Air Conditioning</b>																																								
<b>5.2.1</b>	<b>Natural Ventilation</b>																																								
	Natural ventilation shall comply with the design guidelines for natural ventilation in NBC 2005 part 8 5.4.3 & 5.7.1.1																																								
<b>5.2.2</b>	<b>Minimum Equipment Efficiencies for HVAC</b>																																								
	<p>Minimum equipment efficiencies are required to be met for all HVAC equipment. These include chillers, unitary air conditioner, split air conditioner, packaged air conditioner, and boilers. Cooling equipment shall meet or exceed the minimum efficiency requirements presented in Table 5.2. Heating and cooling equipment not listed in the table shall comply with ASHRAE 90.1-2004 §6.4.1</p> <p>Unitary Air Conditioner shall meet IS 1391 (Part 1), Split air conditioner shall meet IS 1391 (Part 2), Packaged air conditioner shall meet IS 8148 and Boilers shall meet IS 13980 with above 75% thermal efficiency.</p> <table border="1"> <caption>Table 5.2.2-2 Chillers</caption> <thead> <tr> <th>Equipment Class</th> <th>Minimum COP</th> <th>Minimum IPLV</th> <th>Test Standard</th> </tr> </thead> <tbody> <tr> <td>Air Cooled Chiller &lt;530 kW (&lt;150 tons)</td> <td>2.90</td> <td>3.16</td> <td>ARI 550/590-1998</td> </tr> <tr> <td>Air Cooled Chiller ≥530 kW (≥150 tons)</td> <td>3.05</td> <td>3.32</td> <td>ARI 550/590-1998</td> </tr> <tr> <td>Centrifugal Water Cooled Chiller &lt; 530 kW (&lt;150 tons)</td> <td>5.80</td> <td>6.09</td> <td>ARI 550/590-1998</td> </tr> <tr> <td>Centrifugal Water Cooled Chiller ≥530 and &lt;1050 kW (≥150 and &lt;300 tons)</td> <td>5.80</td> <td>6.17</td> <td>ARI 550/590-1998</td> </tr> <tr> <td>Centrifugal Water Cooled Chiller ≥ 1050 kW (≥ 300 tons)</td> <td>6.30</td> <td>6.61</td> <td>ARI 550/590-1998</td> </tr> <tr> <td>Reciprocating Compressor, Water Cooled Chiller all sizes</td> <td>4.20</td> <td>5.05</td> <td>ARI 550/590-1998</td> </tr> <tr> <td>Rotary Screw and Scroll Compressor, Water Cooled Chiller &lt;530 kW (&lt;150 tons)</td> <td>4.70</td> <td>5.49</td> <td>ARI 550/590-1998</td> </tr> <tr> <td>Rotary Screw and Scroll Compressor, Water Cooled Chiller ≥530 and &lt;1050 kW (≥150 and &lt;300 tons)</td> <td>5.40</td> <td>6.17</td> <td>ARI 550/590-1998</td> </tr> <tr> <td>Rotary Screw and Scroll Compressor, Water Cooled Chiller ≥ 1050 kW (≥ 300 tons)</td> <td>5.75</td> <td>6.43</td> <td>ARI 550/590-1998</td> </tr> </tbody> </table> <p>In the above table, ignore the values for centrifugal Chillers. Instead, use the following:</p> <ul style="list-style-type: none"> <li>• COP 5 &amp; IPLV 5.5 for Centrifugal water cooled Chillers ≤ 530 kW (≤150 tons)</li> <li>• COP 5.55 &amp; IPLV 5.9 for Centrifugal water cooled Chillers ≥530 kW and &lt;1050 kW (≥150 tons and &lt;300 tons )</li> <li>• COP 6.1 &amp; IPLV 6.4 for Centrifugal water cooled Chillers ≥1,050 kW (≥300 tons)</li> </ul>	Equipment Class	Minimum COP	Minimum IPLV	Test Standard	Air Cooled Chiller <530 kW (<150 tons)	2.90	3.16	ARI 550/590-1998	Air Cooled Chiller ≥530 kW (≥150 tons)	3.05	3.32	ARI 550/590-1998	Centrifugal Water Cooled Chiller < 530 kW (<150 tons)	5.80	6.09	ARI 550/590-1998	Centrifugal Water Cooled Chiller ≥530 and <1050 kW (≥150 and <300 tons)	5.80	6.17	ARI 550/590-1998	Centrifugal Water Cooled Chiller ≥ 1050 kW (≥ 300 tons)	6.30	6.61	ARI 550/590-1998	Reciprocating Compressor, Water Cooled Chiller all sizes	4.20	5.05	ARI 550/590-1998	Rotary Screw and Scroll Compressor, Water Cooled Chiller <530 kW (<150 tons)	4.70	5.49	ARI 550/590-1998	Rotary Screw and Scroll Compressor, Water Cooled Chiller ≥530 and <1050 kW (≥150 and <300 tons)	5.40	6.17	ARI 550/590-1998	Rotary Screw and Scroll Compressor, Water Cooled Chiller ≥ 1050 kW (≥ 300 tons)	5.75	6.43	ARI 550/590-1998
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<b>5.2.3</b>	<b>Controls</b>																																								
<b>5.2.3.1</b>	<p><b>Time clock Control:</b> All mechanical cooling &amp; heating systems shall be controlled by a timeclock that:</p> <ol style="list-style-type: none"> <li>Can start &amp; stop the system under different schedules for three different day types per week</li> <li>is capable of retaining programming and time setting during loss of power for period of 10 hours ( check BMS programming)</li> <li>Includes an accessible manual override that allows temporary operation of the system for up to 2 hours</li> </ol>																																								

	<p>Exceptions to the above are:</p> <ul style="list-style-type: none"> <li>a) Cooling systems &lt; 28 kW (8 tons)</li> <li>a. Heating systems &lt; 7 kW (2 tons)</li> </ul>
<b>5.2.3.2</b>	<b>Temperature Control</b>
	<p>All heating and cooling equipment shall be temperature controlled.</p> <p>Where a unit provides both heating and cooling, controls shall be capable of providing a temperature dead band of 3°C (5°F) within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.</p> <p>Where separate heating and cooling equipment serve the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling.</p>
<b>5.2.3.3</b>	<b>Controls for Cooling Towers and Closed Circuit Fluid Coolers</b>
	All cooling towers and closed circuit fluid coolers shall have either two speed motors, pony motors, or variable speed drives controlling the fans.
<b>5.2.4</b>	<b>Piping &amp; Ductwork</b>
	<b>Pipe Insulation</b>
5.2.4.1	<p>Insulation exposed to weather shall be protected by aluminium sheet metal, painted canvas, or plastic cover.</p> <p>Cellular foam insulation shall be protected as above, or be painted with water retardant paint.</p>
5.2.4.2	Ductwork shall be insulated in accordance with the Table 5.2. of ECBC 2007
<b>5.2.5</b>	<b>System Balancing</b>
<b>5.2.5.1</b>	<b>General</b>
	<p>Construction documents shall require that all HVAC systems be balanced in accordance with generally accepted engineering standards.</p> <p>Construction documents shall require that a written balance report be provided to the owner or the designated representative of the building owner for HVAC systems serving zones with a total conditioned area exceeding 500 m<sup>2</sup>(5,000 ft<sup>2</sup>).</p>
<b>5.2.5.1.1</b>	<b>Air Systems Balancing</b>
	<p>Air systems shall be balanced in a manner to minimize throttling losses. Then, for fans greater than 0.75 KW (1.0 HP), fans must then be adjusted to meet design flow conditions.</p>
	<b>Hydraulic Systems Balancing</b>
	<p>Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses; then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions.</p> <p>Exceptions to above:</p> <ul style="list-style-type: none"> <li>a) Impellers need not be trimmed nor pump speed adjusted for pumps with pump motors of 7.5 kW(10 hp) or less,</li> <li>b) Impellers need not be trimmed when throttling results in no greater than 5% of the nameplate horsepower draw, or 2.2 kW (3 hp), whichever is greater.</li> </ul>
<b>5.2.6</b>	<b>Condensers</b>
<b>5.2.6.1</b>	<b>Condenser Locations</b>

	Care shall be exercised in locating the condensers in such a manner that the heat sink is free of interference from heat discharge by devices located in adjoining spaces and also does not interfere with such other systems installed nearby.
<b>5.2.6.2</b>	<b>Treated Water for Condensers</b>
	All high-rise buildings using centralized cooling water system shall use soft water for the condenser and chilled water system.
<b>6.2.1</b>	<b>Solar Water Heating</b>
	Residential facilities, hotels and hospitals with a centralized system shall have solar water heating for at least 1/5 of the design capacity. <b>Exception: Systems that use heat recovery for at least 1/5 of the design capacity.</b>
<b>6.2.2</b>	<b>Equipment Efficiency</b>
	Solar water heater shall meet the performance/ minimum efficiency level mentioned in IS 13129 Part (1&2) Gas Instantaneous Water heaters shall meet the performance/minimum efficiency level mentioned in IS 15558 with above 80% thermal efficiency. Electric water heater shall meet the performance / minimum efficiency level mentioned in IS 2082.
<b>6.2.3</b>	<b>Supplementary Water Heating System</b>
	Supplemental Water Heating System shall be designed to maximize efficiency and shall incorporate and prioritize the following design features as shown: a) Maximum heat recovery from hot discharge system like condensers of air conditioning units b) Use of gas fired heaters wherever gas is available c) Electric heater as last resort
<b>6.2.4</b>	<b>Piping Insulation</b>
	Piping insulation shall comply with § 5.2.4.1, ECBC 2007
<b>6.2.5</b>	<b>Heat Traps</b>
	Vertical pipe risers serving storage water heaters and storage tanks not having integral heat traps and serving a non-recirculating system shall have heat traps on both the inlet and outlet piping as close as practical to the storage tank
<b>6.2.6</b>	<b>Swimming Pools</b>
	Heated pools shall be provided with a vapor retardant pool cover on or at the water surface Pools heated to more than 32°C (90°F) shall have a pool cover with a minimum insulation value of R-2.1 (R-12) <b>Exception: Pools deriving over 60% of their energy from site-recovered energy or solar energy source</b>
<b>7.2</b>	<b>Lighting</b>
<b>7.2.1</b>	<b>Lighting Control</b>
<b>7.2.1.1</b>	<b>Automatic Lighting Shutoff</b>

	<p>Interior lighting systems in buildings larger than 500 m<sup>2</sup> (5,000 ft<sup>2</sup>) shall be equipped with an <b>automatic control device</b>.</p> <p>Within these buildings, all office areas less than 30 m<sup>2</sup> (300 ft<sup>2</sup>) enclosed by walls or ceiling-height partitions, all meeting and conference rooms, all school classrooms, and all storage spaces shall be equipped with <b>occupancy sensors</b>.</p> <p>For other spaces, this automatic control device shall function on either a scheduled basis at specific programmed times. An independent program schedule shall be provided for areas of no more than 2,500 m<sup>2</sup> (25,000 ft<sup>2</sup>) and not more than one floor.</p> <p>Occupancy sensors that shall turn the lighting off within 30 minutes of an occupant leaving the space. Light fixtures controlled by occupancy sensors shall have a wall mounted, manual switch capable of turning off lights when the space is occupied.</p> <p><b>Exception: Lighting systems designed for 24-hour use.</b></p>
<b>7.2.1.2</b>	<b>Space Control</b>
	<p>Each space enclosed by ceiling-height partitions shall have at least one control device to independently control the general lighting within the space.</p> <p>Each control device shall be activated either manually by an occupant or automatically by sensing an occupant.</p> <p>Each control device shall control a maximum of 250 m<sup>2</sup> (2,500 ft<sup>2</sup>) for a space less than or equal to 1,000 m<sup>2</sup> (10,000 ft<sup>2</sup>), and a maximum of 1,000 m<sup>2</sup> (10,000 ft<sup>2</sup>) for a space greater than 1,000 m<sup>2</sup> (10,000 ft<sup>2</sup>).</p> <p>Each control device be capable of overriding the shutoff control required in 8.2.1.1 for no more than 2 hours</p> <p>Each control device be readily accessible and located so the occupant can see the control. Exception: The required control device may be remotely installed if required for reasons of safety or security.</p> <p>A remotely located device shall have a pilot light indicator as part of or next to the control device and shall be clearly labeled to identify the controlled lighting.</p>
<b>7.2.1.3</b>	<b>Control in Daylit Areas</b>
	<p>Luminaires in daylit areas greater than 25 m<sup>2</sup> (250 ft<sup>2</sup>) shall be equipped with either a manual or automatic control device that;</p> <p>Capable of reducing the light output of the luminaires in the daylit areas by at least 50%. Controls only the luminaires located entirely within the daylit area</p>
<b>7.2.1.4</b>	<b>Exterior Lighting Control</b>
	<p>Lighting for all exterior applications <b>not exempted in Table: 8.4</b>, ECBC shall be controlled by a photosensor or astronomical time switch that is capable of automatically turning off the exterior lighting when daylight is available or the lighting is not required</p>
<b>7.2.1.5</b>	<b>Additional Control</b>
	<p><b>Display/Accent Lighting.</b> Display or accent lighting greater than 300 m<sup>2</sup> (3,000 ft<sup>2</sup>) area shall have a separate control device</p> <p><b>Case Lighting.</b> Lighting in cases used for display purposes greater than 300 m<sup>2</sup> (3,000 ft<sup>2</sup>) area shall be equipped with a separate control device</p> <p><b>Hotel and Motel Guest Room Lighting.</b> Hotel and motel guest rooms and guest suites shall have a master control device at the main room entry that controls all permanently installed luminaires and switched receptacles</p> <p><b>Task Lighting.</b> Supplemental task lighting including permanently installed under shelf or under cabinet lighting shall have a control device integral to the luminaires or be controlled by a wall-mounted control device provided the control device complies with 7.2.1.2, ECBC 2007</p> <p><b>Nonvisual Lighting.</b> Lighting for nonvisual applications, such as plant growth and food-warming, shall be equipped with a separate control device</p> <p><b>Demonstration Lighting.</b> Lighting equipment that is for sale or for demonstrations in lighting education shall be equipped with a separate control device accessible only to authorized</p>

	personnel
<b>7.2.2</b>	<b>Exit Signs</b>
	Internally-illuminated exit signs shall not exceed 5 W per face
<b>7.2.3</b>	<b>Exterior Building Grounds Lighting</b>
	Lighting for exterior building grounds luminaires which operate at greater than 100W shall contain lamps having a minimum efficacy of 60 lm/W unless the luminaire is controlled by a motion sensor or exempt under §7.1 of ECBC. Efficacy of Lamp (with or without ballast) is the lumens produced by a lamp/ballast system divided by the total watts of input power (including the ballast), expressed in lumens per watt.
	<b>Electrical Power</b>
<b>8.2.1</b>	<b>Transformers</b>
<b>8.2.1.1</b>	<p><b>Maximum Allowable Power Transformer Losses</b></p> <p><b>Table 8.2.1.1:</b> Maximum allowable losses for Dry type distribution transformers with highest voltage for equipment 24kV, at 50% and 100% of the load</p> <p><b>Table 8.2.1.2:</b> Maximum allowable losses for oil filled distribution transformers with highest voltage for equipment 36 kV, at 50% and 100% of the load (2X1500kV)</p> <p>Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating</p> <p>The transformer must be selected such that it minimizes the total of its initial cost in addition to the present value of the cost of its total lost energy while serving its estimated loads during its respective life span</p>
<b>8.2.1.2</b>	<p><b>Measurement and Reporting of Transformer Losses</b></p> <p>All measurement of losses shall be carried out by using calibrated digital meters of class 0.5 or better accuracy and certified by the manufacturer</p> <p>All transformers of capacity of 500 kVA and above would be equipped with additional metering class current transformers (CTs) and potential transformers (PTs) additional to requirements of Utilities so that periodic loss monitoring study may be carried out</p>
<b>8.2.2</b>	<b>Energy Efficient Motors</b>
	<p>All permanently wired polyphase motors of 0.375 kW or more serving the building and expected to operate more than 1,500 hours per year and all permanently wired polyphase motors of 50kW or more serving the building and expected to operate more than 500 hours per year shall have a minimum acceptable nominal full load motor efficiency not less than <b>IS 12615 for energy efficient motors.</b></p> <p>Motors of horsepower differing from those listed in the table shall have efficiency greater than that of the next listed kW motor.</p> <p>Motor horsepower ratings shall not exceed 200% of the calculated maximum load being served.</p> <p>Motor nameplates shall list the nominal full-load motor efficiencies and the full-load power factor.</p> <p>Motor users should insist on proper rewinding practices for any rewind motors. If the proper rewinding practices cannot be assured, the damaged motor should be replaced with a new, efficient one rather than suffer the significant efficiency penalty associated with typical rewind practices. Certificates shall be obtained and kept on record indicating the motor efficiency</p> <p>Whenever a motor is rewind, appropriate measures shall be taken so that the core characteristics of the motor is not lost due to thermal and mechanical stress during removal of damaged parts.</p>

<b>8.2.3</b>	<b>Power Factor Correction</b>
	All electricity supplies exceeding 100 A, 3 phase shall maintain their power factor between 0.95 lag and unity at the point of connection
<b>8.2.4</b>	<b>Check Metering and Monitoring</b>
	Services exceeding 1000 kVA shall have permanently installed electrical metering to record demand (kVA), energy (kWh), and total power factor The metering shall also display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current. Services not exceeding 1000 kVA but over 65 kVA shall have permanently installed electric metering to record demand (kW), energy (kWh), and total power factor (or kVARh). Services not exceeding 65 kVA shall have permanently installed electrical metering to record energy (kWh).
<b>8.2.5</b>	<b>Power Distribution Systems</b>
<b>8.2.5.1</b>	<b>Power Distribution system losses</b>
	The power cabling shall be adequately sized as to maintain the distribution losses not to exceed 1% of the total power usage Record of design calculation for the losses shall be maintained.

- 6.5.13 Drip or sprinkler systems to be used for irrigation. Cut sheets of the irrigation equipment showing technical specifications, copy of purchase order and dimensions to be maintained for GRIHA certification documentation.
- 6.5.14 Certificate indicating use of treated water for construction along with a test report of the water used for construction. Narrative on the initiatives on water use minimization, indicating all sources of water used for construction.
- 6.5.15 Narrative indicating the quantum of solid waste generated during the construction activity and the storage facility for segregated inert and hazardous waste before recycling and disposal. Layout (location in drawing format) and photographs of the storage facility for segregated inert and hazardous waste. The capacity of the storage facility has to be provided.
- 6.5.16 Narrative along with photographs and plan indicating locations and capacity of central waste collection and segregation area.
- 6.5.17 Narrative indicating the plan and arrangement with local dealers for recycling of waste materials generated.
- 6.5.18 Details of plan and design of the organic waste treatment plant along with capacity for the disposal of bio-degradable waste. Narrative indicating generation and reuse of by-products from the organic waste treatment plant.
- 6.5.19 Narrative on the type of waste water treatment system being employed. Drawings with specifications of the system indicating the capacity of waste water treated. Narrative should also indicate quantum of treated water generated along with the use/disposal steps.
- 6.5.20 Narrative on disposal and reuse of other by products such as sludge. Quality checking frequency and sampling plan of the waste water treatment plant.

- 6.5.21 Narrative describing the measures adopted along with photographs for safety and sanitation facilities for construction workers.
- 6.5.22 Narrative describing the measures adopted along with photographs for air pollution prevention measures.
- 6.5.23 A list showing each type of HVAC and refrigeration equipment's/systems, their numbers and type of refrigerant used along with the manufacturers brochure clearly stating the type of refrigerant being used in their products. Purchase order and BOQ to be in record.
- 6.5.24 Proof of inclusion of specific clause in the contract document of the system supplier for commissioning (installation and test run) of all electrical and mechanical systems.
- 6.5.25 Copy of the fully documented O&M manual/CD/ Multimedia/ Information brochure enlisting the best practise for O&M of the building systems. The name and address of the manufacturer/supplier of the respective system, owner/builder to be given to the occupants or to the service/facility management group at the time of occupation.
- 6.5.26 Software analysis, Cut sheets/specification sheets, purchase order and BOQ demonstrating the percentage reduction in embodied energy with the use of low energy materials/efficient technologies.
- 6.5.27 Document to demonstrate the use of aforementioned technologies in the relevant floor plans with clear dimension and enlisting of specifications.
- 6.5.28 All insulation to be used in the building shall be CFC and HCFC free. Technical Sheet, purchase order and BOQ to be maintained.
- 6.5.29 All HVAC and refrigeration equipment shall be CFC free. Technical Sheet, purchase order and BOQ to be maintained.
- 6.5.30 The fire-suppression systems and fire extinguishers shall be halon free. Technical Sheet, purchase order and BOQ to be maintained.
- 6.5.31 The project shall meet the on-site water reuse requirements in its annual water requirements for domestic use, buildings, landscape and utilities by using the stored rainwater on site and by the use of treated water on site for maximum available GRIHA thresholds. Documentation shall be maintained in the form of narratives, calculations, drawings and photographs.
- 6.5.32 Separate Dedicated resting rooms and toilets to be provided for the service staff. Service staff population can be determined as 5% of total fixed project occupancy. Sanitary fixtures to be determined as per the following baseline.

Fixtures	Male Occupants	Female Occupants
Water closets	1 per 25 occupants	1 per 15 occupants
Washbasins	1 per 25 occupants	1 per 25 occupants
Urinals	For 1 - 6 occupants :0 For 7 - 20 occupants :1 For 21 – 45 occupants:2 For 46 - 70 occupants :3 For 71 - 100 occupants :4 For 101 - 200 occupants :4+3% For over 200 occupants :4+2.5%	NA



## 6.6 Building level GRIHA certification Requirements

The contractor shall ensure the execution and proper documentation of each building for the following points for GRIHA certification compliance for building related GRIHA criterions.

- 6.6.1 CO<sub>2</sub>, temperature and RH sensors to be installed in the buildings as per GRIHA certification requirements. Narrative along with the technical sheet, purchase order and BOQ to be maintained.
- 6.6.2 Peak heat gain through building envelope (for each AC building individually) should meet the GRIHA Building Envelope Peak Heat Gain Factor thresholds as mentioned below. Compliance shall be shown through energy simulation output results.

<b>GRIHA Thresholds for Building Envelope Peak Heat Gain Factor (W/sqm)</b>	
Climate	Threshold
Composite/Hot & Dry	40
Warm and Humid	35
Moderate	30

- 6.6.3 100% of outdoor lighting fixtures (lamps + lamp housing) shall meet the luminous efficacy requirements of GRIHA certification requirement (All lamps + lamp housing must demonstrate luminous efficacy of at least 75 lumens/watt.). Narrative along with the technical sheet, purchase order and BOQ to be maintained.
- 6.6.4 EPI to be considered for the admin, academic and other blocks shall be no less than 54 and for staff housing and hostel shall be no less than 42 to demonstrate a reduction of 40% from the base case as defined in GRIHA v 2015. Compliance shall be shown through energy simulation output results.
- 6.6.5 On-site/Off-site renewable energy system installation to offset 25% of the annual energy consumption of internal artificial lighting and HVAC systems to achieve maximum GRIHA requirement. Documentation shall be maintained in the form of Narratives, calculation technical sheet, purchase order and BOQ.
- 6.6.6 Analysis to be done to meet 75% daylight requirement in each building by either achieving the space wise daylight factor defined in SP-41 or by achieving a mean Daylight Autonomy requirements (300 lux or more in other blocks and 100 lux in residential blocks) over the total living area for at least 75% of total annual analysis hours (8 am to 6 pm each day, 3650 hours in a year). Documentation shall be maintained in the form of narratives, calculations, analysis results, drawings and technical sheet purchase order and BOQ of glass.
- 6.6.7 Shading (Requirement: All fenestration must have appropriate shading to block the direct solar radiation at building level from March-October months. Compliance shall be shown through any one of the following approach
- Skin sections/plans with VSA/HSA angles for different time of the year for each fenestration or shading design.
  - Annual/daily 3D animation (sketchup, revit etc) for different fenestration
  - Sun path generated for bottom of the fenestration
  - Through energy simulation output showing zero sunlit hours or zero direct solar radiation on fenestration
- 6.6.8 Artificial lighting design to fall within limits (lower and higher range limits) as recommended space/task specific lighting levels as per NBC and to meet a minimum uniformity ratio of 0.4. documentation shall be maintained in the form of technical sheets, purchase order, BOQ, calculation, drawings and narratives.
- 6.6.9 The project shall achieve the thermal comfort requirements of NBC OR ASHRAE 55 OR requirement of Indian Adaptive Comfort Model.

- 6.6.10 The indoor noise levels shall meet the acceptable limits as specified in NBC and key noise source on site (like DG sets, chiller plants etc.) shall have sufficient acoustic insulation as per NBC norms.
- 6.6.11 Meet the minimum requirements of ASHRAE Standard 62.1–2010, Sections 4–7, Ventilation for Acceptable Indoor Air Quality (with errata), or a NBC for quantity of fresh air
- 6.6.12 Cut sheets of the water fixture showing flow rate at 3 bar pressure, copy of purchase order and dimensions.

**Flow rate at 3 bar pressure for each fixture to achieve 50% water use reduction**

WC(Full Flush) :	6 LPF
WC(Half Flush) :	3 LPF
Urinal:	1 LPF
Kitchen Faucet :	5 LPM
Lavatory Faucet :	5 LPM
Showers :	5 LPM

- 6.6.13 Design for universal accessibility should be done in a way that it is compliant with NBC Annexure B - Accessibility In Built Environment For Persons With Disability in each block excluding staff housing. Following points shall be ensured:
  - Appropriately designed preferred car park spaces having an easy access to the lift lobby
  - Easy access to the main entrance of the building
  - Braille and audio assistance in lifts for visually impaired people
  - Uniformity in floor level for hindrance-free movement in common areas & exterior areas
  - Main walkways/ pathways with adequate width in exterior areas
  - Restrooms (toilets) in common areas designed for differently abled people
- 6.6.14 Separate Dedicated resting rooms and toilets to be provided for the service staff. Service staff population can be determined as 5% of total fixed project occupancy. Sanitary fixtures to be determined as per the following baseline

Fixtures	Male Occupants	Female Occupants
Water closets	1 per 25 occupants	1 per 15 occupants
Washbasins	1 per 25 occupants	1 per 25 occupants
Urinals	For 1 - 6 occupants :0 For 7 - 20 occupants :1 For 21 – 45 occupants:2 For 46 - 70 occupants :3 For 71 - 100 occupants :4 For 101 - 200 occupants :4+3% For over 200 occupants :4+2.5%	NA

- 6.6.15 Narrative along with photographs and plan indicating locations and capacity of multi-coloured bins post occupancy in each building.
- 6.6.16 Cut sheets/specification sheet/ commercial brochure, BOQ and purchase order of all materials used for interior finishes for flooring, door window framing and false ceiling/partition/furniture indicating 70% of the total quantity of material in each category is low energy product. Proper documentation in forms of narrative, calculations and drawings to be maintained.
- 6.6.17 Double glazed units to be installed in the entire project with a SHGC of less than or equal to 0.25 for a wall window ratio of maximum 40%.

6.6.18 Cut sheets/specification sheet/ commercial brochure indicating bonding resins used in wood/agri-fiber products are urea formaldehyde free for all wood/agri-fiber product used in the finishing materials along with their BOQ and purchase order.

6.6.19 Drawings and documents showing location of all energy and water meters and submeters as per following GRIHA requirements:

- **Energy**-(Should be two way communicable)

Meters:

- Utility grid
- On-site renewable energy system
- Diesel Genset, Gas Genset etc.
- Each building level

Sub-meters:

Commercial/Institutional:

- HVAC central plant- AHU, Cooling tower, Chillers (BTU meters) and/or distributed units (split/window ACs)
- Lighting (Indoor and outdoor)
- UPS
- Basement parking lighting

Residential:

- For Basement Parking Lighting, Community/Recreation center, Water pumping, Outdoor Lighting
- Lifts and common areas

- **Water**-

Meters:

- Municipal Supply
- Bore well
- Treated water outlet from STP
- Captured rainwater
- Each building level

Sub-meters:

- Irrigation
- Cooling Tower
- STP/WTP/ETP
- Each apartment/commercial tenant

6.6.20 Cut sheets/specification sheet/ commercial brochure indicating low VOC levels compliant with GRIHA baseline for paints, adhesives and sealants as mentioned below along with their BOQ and purchase order.

Limits for low-VOC content in interior paints

Paint applications	VOC limits (grams of VOC per litre)	
Interior coatings	Flat	<50
	Non-flat	<150
Exterior coatings	Flat	<200
	Non-flat	<100
Anti corrosive	Gloss/ semi gloss/ flat	<250

Limits for low-VOC content in adhesives in interior applications

Architectural adhesive application	VOC content limit (g of VOC/litre)
Wood Flooring	100
Industrial/rubber flooring	60
Ceramic tile	65
Structural glazing	100
Multi-purpose construction	70
Sub-floor	50
Wall boards/panel	50
PVC welding	285
Adhesive primer for plastic	250
Structural wood member	140
Sub-specific use metal to metal	30
Wood	30
Fibre glass	80
Plastic foams/porous materials (except wood)	50

Limits for low-VOC content in interior sealants

Sealant Application	VOC Content limit (grams of VOC per litre)
Architectural/roadways	250
Single-ply roof material installation/repair	450
Others	420
Sealant Primer applications architectural non-porous	250
Sealant Primer applications architectural porous	775
Other sealant primer applications architectural	750