



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION



GOVERNMENT OF INDIA
**MINISTRY OF NEW
AND RENEWABLE ENERGY**



Promoting CST Integrated Buildings: Codes and Regulations

MNRE-GEF-UNIDO

“Promoting business models for increasing penetration and scaling up of solar energy”

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION



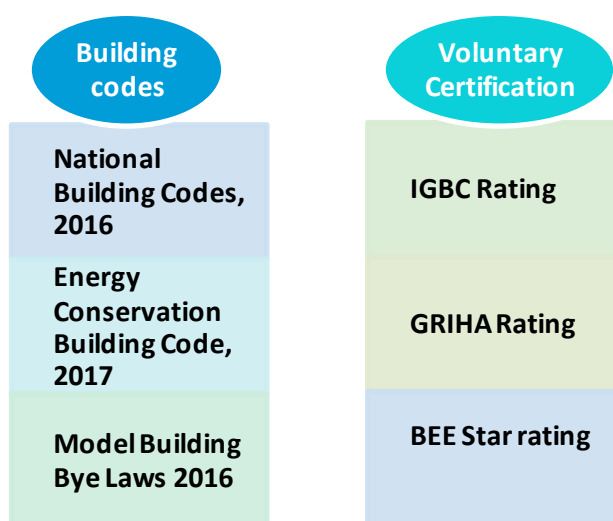
प्लांट कैंटीन
PLANT CANTEEN

Executive Summary

Decarbonization of the heating and cooling sector in buildings is one of major focus area to reduce GHG emissions, considering India's building sector contributes to more than 30%¹ of the total electricity consumed in the country. Numerous strategies, both voluntary and mandatory have been designed and implemented to ensure maximum penetration of clean energy sources for onsite energy consumption. On the regulatory side, building codes, sustainability protocols and byelaws have been effective in reducing energy consumption by 20-30%, while on the voluntary front, building owners are deploying renewables as part of gaining 'green brand recognition' by complying with renowned voluntary certification schemes.

These building energy codes and certification programmes stipulate the minimum energy performance levels for buildings and are accordingly modified as per improvements in technologies, scope and changing market dynamics through issuance of periodic amendments. These guidelines provide minimum compliance criteria for performance (such as onsite/off-site energy generation, capacity, area/zones, etc.), structural (such as loading, physical dimensions, occupancy, etc.), targeted category (such as residential, commercial, industrial, others), technology option (solar PV, Solar water heaters, Wind, Hybrid, solar thermal) and standards (such as BIS, IS) to be implemented. Although these building codes have been designed by central agencies in consultation with different stakeholders, the state level local agencies have been provided a certain degree of flexibility to develop regulations as per local demographics and to have their own institutional framework to ensure enforcement. While, the National Building Code of India (NBC) provides guidelines for all categories, Energy Conservation Building Code (ECBC) covers only mandates commercial establishments and Model Building Byelaws primarily targets residential and commercial buildings.

In terms of RE technologies acceptable for meeting green energy compliance for buildings, solar rooftop PV and solar water heating (SWH) form the most prevalent choices for adoption, owing to economies of scale, increased awareness, numerous historical successful precedents and declining costs. In this regard, concentrated solar thermal (CST) technologies have taken a backseat with a lack of clarity on its possible inclusion.



CST systems have a strong value proposition for specific industries, wherein there are numerous applications driven by hot water and steam generation requirements (including boiler based) presently reliant of fuel options such as diesel, oil and petroleum products. Within the regulatory framework, only NBC provides a brief mention of usage of CST technologies within the following application areas.

- Solar steam systems for cooking, laundry, etc through concentrated solar technology. Steam can be generated on the rooftop of buildings through the use of solar concentrators. Steam generated through such concentrators can be used to meet steam requirement for buildings, including energy

¹https://beeindia.gov.in/sites/default/files/BEE_ECBC%202017.pdf

demand for other applications such as for preheating/heating of air and disinfection/sterilization of instruments. Specifications of such systems shall be determined according to the availability of solar radiation, size and concentration ratio of the concentrator, ambient temperature and steam storage for off-sunshine hours. Wherever such systems are used/installed, attempts should be made to recover condensate or warm water after its application.

- Solar assisted refrigeration/air conditioning: It should be attempted to utilize solar energy to operate vapour absorption or vapour adsorption-based refrigeration/air conditioning systems

In general, it can be said that none of the building codes and regulations provide any clarity on deployment for CST technology to offset conventional energy and meet energy performance compliance. Hence, as a first step the regulatory agencies need to bring in CST within the

purview of these codes (exclusively highlighting CST as a technology option) and accordingly develop technical guidelines for implementation. Similarly, the green energy ratings need to include solar thermal in their certification system and set up new benchmarks for compliance in the data sheet, using solar thermal.

Based on stakeholder inputs, historical precedents to promote other RE technologies and some of the best practices adopted in the international arena, recommendations have been drafted to encourage CST deployments in the building sector as presented below.

Some of these recommendations are targeted through regulatory instruments by bringing about amendments in certain sections/clauses of existing building codes and regulations and possible inclusion areas in existing green building certification schemes. Others involve making it voluntary by incentivizing the process itself and increasing awareness levels. A mix of voluntary and regulatory actions is the way to increase deployments in the building space.

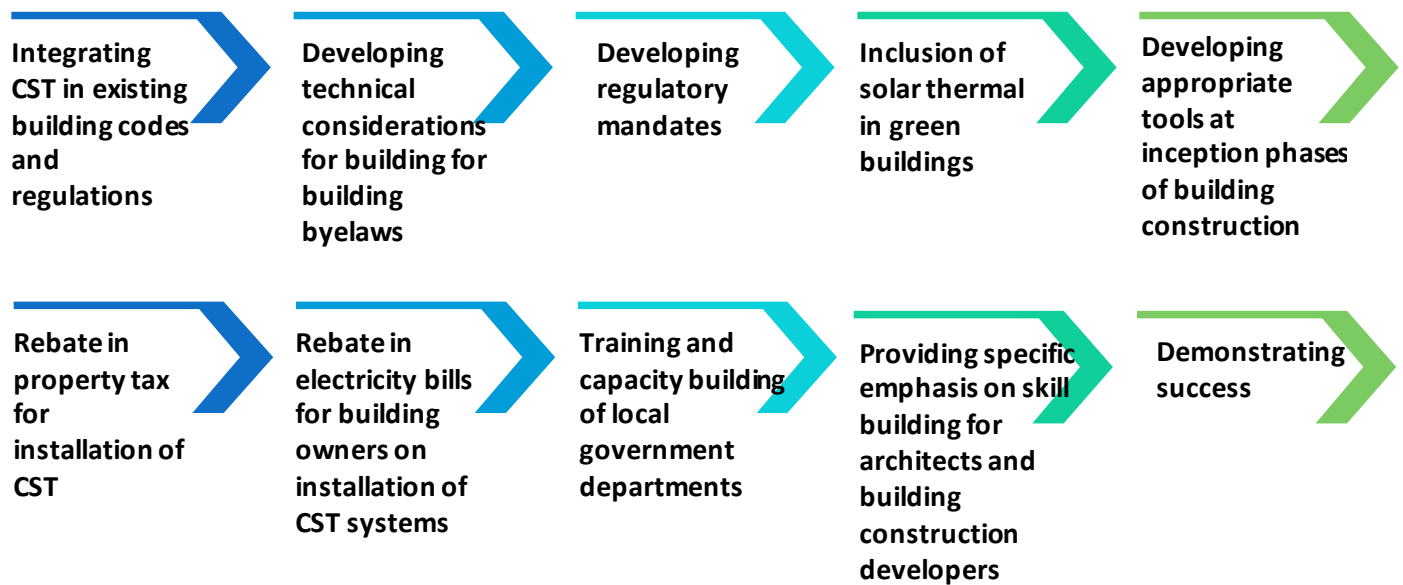


Table of Contents

| | |
|--|-----------|
| Executive Summary | 3 |
| 1. Introduction | 9 |
| 1.1. Analyzing the need of the assignment | 10 |
| 1.2. Importance of CST systems in building architecture | 11 |
| 1.3. Bringing relevant stakeholders on board | 12 |
| 2. Review of existing building byelaws and codes | 14 |
| 2.1. Building codes and regulations | 14 |
| 2.1.1. National Building Code (NBC)..... | 14 |
| 2.1.2. Energy Conservation Building Code (ECBC) | 16 |
| 2.1.3. Model Building Byelaw (2016)..... | 18 |
| 2.2. Key certification programmes | 19 |
| 2.2.1. Green Rating for Integrated Habitat Assessment (GRIHA) Rating | 19 |
| 2.2.2. Indian Green Building Council (IGBC) Rating..... | 21 |
| 2.2.3. Key International Green Rating Systems for Buildings..... | 23 |
| 3. Key recommendations for CST integration in buildings | 24 |
| 3.1. Integrating concentrated solar thermal (CST) in existing building codes and regulations | 25 |
| 3.2. Developing technical considerations for building byelaws..... | 27 |
| 3.2.1. Load bearing capacity assessment: Defining a key technical parameter | 28 |
| 3.3. Developing regulatory mandates for industrial sector..... | 29 |
| 3.4. Inclusion of solar thermal in green building certification..... | 30 |
| 3.5. Developing appropriate tools at inception phases of building construction- Pre-conceptualization | 31 |
| 3.6. Rebate in electricity bills for building owners on installation of CST systems | 32 |
| 3.7. Rebate in property tax for installation of CST..... | 32 |
| 3.8. Training and capacity building of local government departments..... | 34 |
| 3.9. Providing specific emphasis on skill building for architects and building construction developers | 35 |
| 3.10. Demonstrating success | 36 |
| 3.11. Miscellaneous | 37 |

List of Figures

| | |
|--|----|
| Figure 1: Estimated commercial sector area scale up..... | 10 |
| Figure 2: Key stakeholders at central and state level..... | 12 |
| Figure 3: Key building codes and regulations in India..... | 14 |
| Figure 4: Governance structure at central level for ECBC..... | 17 |
| Figure 5: State level implementation framework for ECBC..... | 18 |
| Figure 6: Key green building certification schemes in India | 19 |
| Figure 7: Final star rating achievable under GRIHA..... | 20 |
| Figure 8: Final star rating available under IGBC rating..... | 22 |
| Figure 9: Key technical and physical parameters in designing building codes..... | 27 |
| Figure 10: Training and Capacity building of local government departments | 34 |
| Figure 11: ECBC Compliance platform for commercial buildings..... | 36 |

List of Tables

| | |
|--|----|
| Table 1: Building reference guide by NBC for solar PV | 15 |
| Table 2: Load specification for floor | 15 |
| Table 3: Load specifications for roofs..... | 16 |
| Table 4: ECBC mandates for SWH..... | 16 |
| Table 5: ECBC mandates for RE..... | 17 |
| Table 6: Solar PV guidelines under building byelaw..... | 18 |
| Table 7: Point weightage for on-site and off-site RE energy system installation..... | 20 |
| Table 8: EE Credit 4 system for Green Factory Buildings..... | 21 |
| Table 9: EE Credit 5 system for Green Factory buildings..... | 21 |
| Table 10: Overall rating system for factory buildings | 21 |
| Table 11: EE Credit 3: Performance criteria for new buildings..... | 22 |
| Table 12: EE Credit 4: Performance criteria for new buildings..... | 22 |
| Table 13: Key international green building certification schemes..... | 23 |
| Table 14: Load bearing capacity assessment..... | 28 |
| Table 15: International policies promoting solar thermal property tax incentives | 33 |

List of Abbreviations

| | |
|--------|---|
| AEEE | Alliance for an Energy Efficient Economy |
| AP | Andhra Pradesh |
| BEAM | Building Environment Assessment Method-Hong Kong |
| BEE | Bureau of Energy Efficiency |
| BEP | Building Energy Passport |
| BIPV | Building Integrated Photo Voltaic |
| BIS | Bureau of Indian Standards |
| BREEAM | Building Research Environment Assessment Method |
| C&I | Commercial and Industrial |
| CII | Confederation of Indian Industry |
| CST | Concentrating solar thermal |
| DC | Designated customer |
| DGTCP | Director General Town and Country Planning |
| DPIIT | Department for Promotion of Industry and Internal Trade |
| EA | Energy and Atmosphere |
| ECBC | Energy Conservation Building Code |
| EE | Energy Efficiency |
| EMIS | Energy Management Information System |
| FY | Financial Year |
| GRIHA | Green Rating for Integrated Habitat Assessment |
| HAREDA | Haryana Renewable Energy Development Agency |
| HUDCO | Housing and Urban Development Corporation Ltd |
| HVAC | Heating, Ventilation, and Air Conditioning |
| IGBC | Indian Green Building Council |
| IT | Information Technology |
| LEED | Leadership in Energy and Environmental Design |
| MNRE | Ministry of New and Renewable Energy |
| MOHUA | Ministry of Housing and Urban Affairs |
| MoUD | Ministry of Urban Development |
| NBC | National Building Code |

| | |
|-------|---|
| NBCC | National Buildings Construction Corporation Limited |
| NISE | National Institute of Solar Energy |
| NMC | Nagpur Municipal Corporation |
| PV | Photo Voltaics |
| RE | Renewable Energy |
| REGZ | Renewable Energy Generating Zones |
| RPO | Renewable Purchase Obligation |
| SDA | State Designated Agency |
| SNA | State Nodal Agencies |
| sqm | Square Metres |
| SS | Sustainable Site |
| SWH | Solar Water Heater |
| TERI | The Energy and Resources Institute |
| ULB | Urban Local Bodies |
| UNIDO | United Nations Industrial Development Organization |
| UREDA | Uttarakhand Renewable Energy Development Agency |



1. Introduction

1.1. Analyzing the need for the assignment

Regulatory mandates in the form of building byelaws and building rules/codes have proven to be a significant driver in increasing the market penetration of any technology. Over the years, with rapid industrialization and urbanization, the Government of India has highlighted the intrinsic value of building in energy conservation and efficiency across the building sector in tackling the issue of climate change as part of its climate plan. There have been numerous revisions/amendments in the 'National building code (NBC)' and Energy Conservation Building Code (ECBC) at the central level, coupled with launch of numerous green building certification schemes, which promote uptake of clean energy measures. The same effect has also trickled down to states, wherein SNAs and local authorities are defining their own set of energy conservation measures as per localized demographics, in alignment with central vision. Internationally as well, building byelaws have been integral in mass level deployments (particularly in domestic and commercial space) of clean energy technologies across several countries.

In India, building sector has been a major contributor in the overall energy consumption and considering the projected increase in the floor area, population and thermal comfort levels, by FY 2050 India will have an unprecedented floor area escalation of almost 400%.² Additionally, the EIA³ projects that among all the regions of the world, the fastest growth in buildings energy consumption through FY 2040 will occur in India and is expected to increase at an average of 2.7% per year between FY 2015-FY 2040. Globally, as well the building sector emitted more than 33% of global energy related to CO₂ (10 Giga tonnes in FY 2019). Hence, there is a need to decarbonize the sector by deploying innovative clean energy measures in line with building design and architecture and at the same time ensuring compliance with regulatory norms.

The commercial sector floor area in 2017-18 is estimated to be 1160 million m² and is expected to grow 1.6x in the next decade to 1880 million m², and 2.7 times the size of 2017-18 to 3090 million m² by 2037-38.⁴

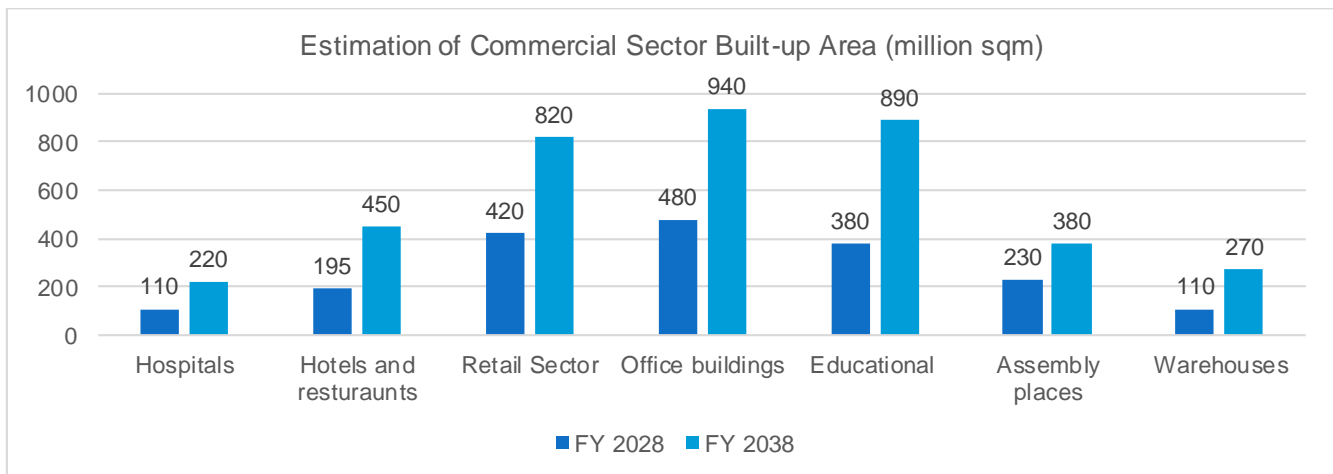


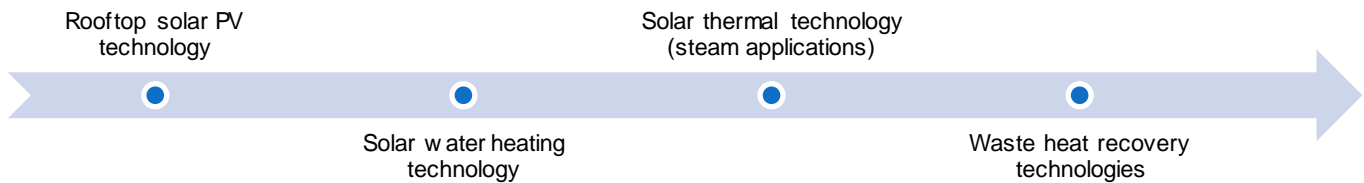
Figure 1: Estimated commercial sector area scale up

² <https://www.gbpn.org/activities/india>

³ <https://www.eia.gov/todayinenergy/detail.php?id=33252#:~:text=Buildings%20energy%20consumption%20represented%20about,consumpti on%20in%20India%20in%202015.&text=EIA%20projects%20that%20total%20delivered,growth%20rate%20among%20IEO%20regions.>

⁴ <https://www.aeee.in/wp-content/uploads/2018/09/Building-Stock-Modeling-Revised-pager.pdf>

In this regard, there have been gradual efforts undertaken to increase the purview of low carbon technologies in building energy efficiency through periodic review and revision process. Additionally, some of these building codes and regulations have been designed specifically for a given sector such as domestic, commercial or industrial space. Different types of buildings have large variation in terms of overall energy consumption, types of equipment/appliances used, seasonal variation in demand, end-use energy break-up and space availability for RE systems. Presently, the focus of these building byelaws has been on increasing adoption of following key RE technologies.



Out of these, solar PV and SWH technologies have garnered maximum interest from building owners, owing to increased awareness, economies of scale and easy integration process with buildings. Within solar thermal, segments such as the industrial, commercial and institutional have witnessed limited deployments on rooftop premises, owing to several roadblocks, particularly on the clarity in process and guidelines on regulatory front in the sector.

1.2. Importance of CST systems in building architecture

As discussed in the preceding sections as well, both SWH and solar rooftop technologies have been promoted in a big way through numerous regulatory mandates, building codes and innovative policy instruments. However, when it comes to concentrated solar thermal technologies, there have been very few installations and even fewer within the industrial sector. Hence, there is a need to understand what exactly is withholding the deployment of these technologies in the building sector, which is concerned one of the best technologies fit for segment due to following reasons.

- Benefits of onsite generation, which reduces the need to source energy from external sources thereby limiting line losses
- Multi-sector applicability over a large temperature range and hence an ideal replacement for conventional fuel options to support building efficiency
- Insulation- Industries buy insulated material to prevent sheds from getting over-heated from direct sunlight. By installing solar thermal system, the cost of insulation is being saved and the area below the system remains cooler
- Effective utilization of space- Many industries, hotels and hospitals have unutilized space on roofs, parking sheds and even on ground, which can be utilized productively through installation of solar thermal systems
- Compliance with environmental regulations and additional points in green building certification programmes, thereby leading to enhancing green image and more recognition
- Fuel diversification and improved energy security
- Easy retrofit possibility in buildings, in situations or processes which require heat in a flexible manner, particularly for smaller processes in industries. Also, when process temperature is higher, even then boiler feed water can be pre-heated, and fuel can be saved

Additionally, the mainstreaming of CST installations in building sector will result in other socio-economic benefits including CO₂ abatement, which will help India succeed in meeting its INDC commitments for FY 2030.

1.3. Bringing relevant stakeholders on board

A consolidated action on defining new regulation and building codes for the concentrated solar thermal sector will require a buy in from all relevant stakeholders in this ecosystem. The stakeholder matrix below presents the key agencies, which need to work in tandem to ensure universal acceptance for byelaws.

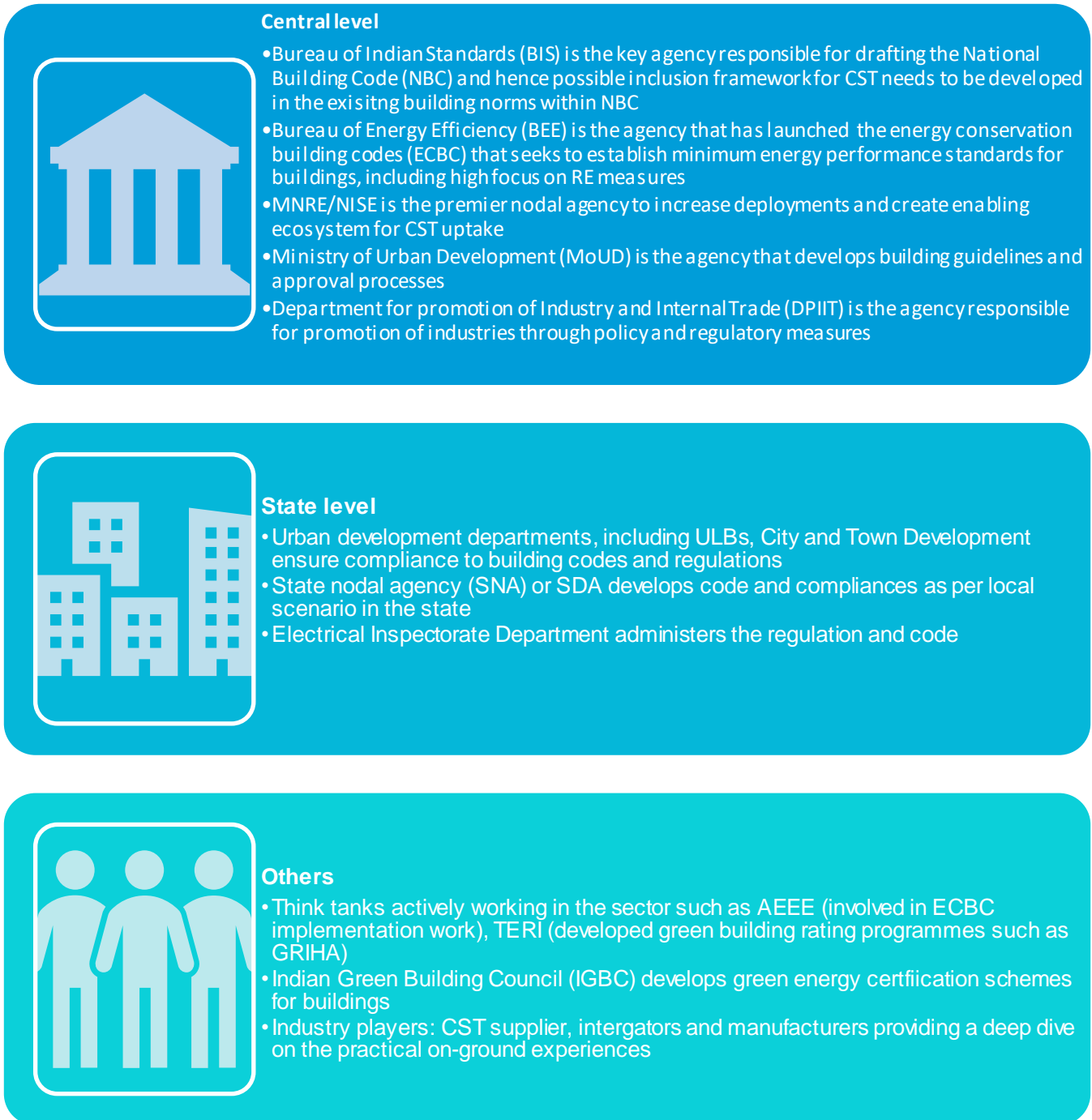


Figure 2: Key stakeholders at central and state level



2. Review of existing building byelaws and codes

Building byelaws serve as one of the biggest regulatory drivers to increase penetration of renewable energy-based installations and help build climate change resilience. This section provides a deep dive into the existing building codes and regulation in the country, along with major green energy certification programmes that have been adopted by the industry. While the codes and regulations are obligatory in nature, the certification is voluntary to enhance green image and gain recognition.

2.1. Building codes and regulations

The building codes and regulations in the country has foreseen numerous rounds of amendments to inculcate the changing dynamics around the green energy and possible inclusion of newer low carbon technologies. Presently, there are 3 major building codes that are critical from the point of view of building architecture and construction.

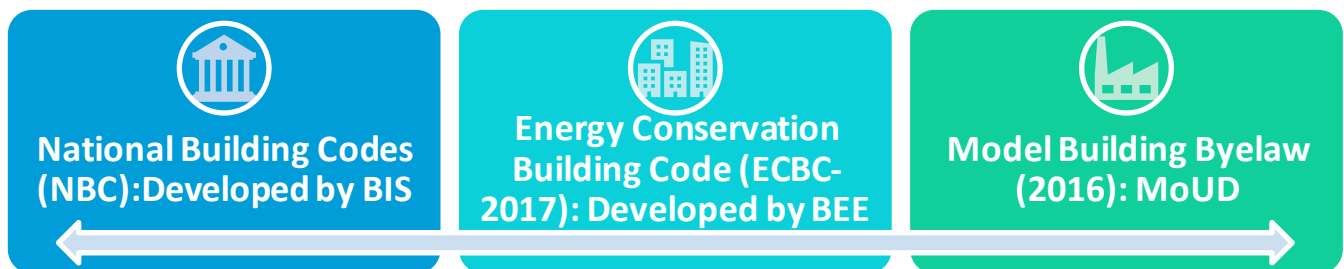


Figure 3: Key building codes and regulations in India

2.1.1. National Building Code (NBC)

The National Building Code of India contains administrative regulations, development control rules and general building requirements; fire safety requirements; stipulations regarding materials, structural design and construction (including safety); and building and plumbing services. The NBC also serves as a Model Code for adoption by all agencies involved in building construction works, be it the Public Works Departments, other government construction departments, local bodies or private construction agencies. The Bureau of Indian Standards (BIS) is responsible for the development of NBC, and the first edition of the NBC was published in 1970. In the later years, NBC has been revised as new construction techniques and buildings material became available, and its scope expanded to address new challenges, such as environmental sustainability. The latest NBC guidelines was shared by BIS in FY 2016 (Volume 1 and Volume 2)⁵. The focus areas for RE uptake have been analyzed below.

- *NBC, Volume I, Section 21.2.1 for Solar Photovoltaic Power Generation Energy System: All plots having size 500 m² and above shall install solar photovoltaic power generation system. This should also be encouraged for plots smaller than 500 m². The power generated may be used for in-house utilization or for transfer to the grid. The Authority shall have required provisions in the building byelaws and mechanism for required clearances and approvals. The Authority shall also specify minimum generation requirement. The following may be used as a guide.*

⁵ <https://bis.gov.in/index.php/standards/technical-department/national-building-code/>

Table 1: Building reference guide by NBC for solar PV

| Building Type | Plot Size | Generation requirement |
|---|-------------------|--|
| Business, educational buildings having a connected load of 30 kW and above | 500 sqm and above | 5 kWp or 5% of connected load, whichever is higher |
| Mercantile, hotels, motels, assembly, industrial and institutional buildings | 500 sqm and above | For buildings having connected load of: <ul style="list-style-type: none"> • 50-1000 kW-10 kWp or 5% of connected load whichever is higher • Above 1000 kW- 50 kWp or 5% of connected load whichever is higher |

- NBC, Volume I, Section 21.2.2 for Solar Water Heating System states that the Authority, considering the availability of solar energy for harnessing, shall decide the minimum capacity to be installed subject to a minimum of 25 litre per day hot water yield for each bathroom and kitchen. This includes institutional buildings, hostels for schools and colleges (with more than 100 students), training centers and assembly buildings.
- NBC Volume II, Section 11.6 titled 'Renewable Energy'⁶ focusses on
 - Solar steam systems for cooking, laundry, etc through concentrated solar technology. Steam can be generated on the rooftop of buildings through the use of solar concentrators. Steam generated through such concentrators can be used to meet steam requirement for buildings, including energy demand for other applications such as for preheating/heating of air and disinfection/sterilization of instruments. Specifications of such systems shall be determined according to the availability of solar radiation, size and concentration ratio of the concentrator, ambient temperature and steam storage for off-sunshine hours. Wherever such systems are used/installed, attempts should be made to recover condensate or warm water after its application.
 - Solar assisted refrigeration/air conditioning: It should be attempted to utilize solar energy to operate vapour absorption or vapour adsorption-based refrigeration/air conditioning systems.

While, there are well-defined constraints in terms of compliance for solar PV rooftop and SWH technologies based on performance, electric load consumption and area related aspects for different segments, there are no significant mandates or constraints associated with adoption of CST systems.

Another critical assessment area of the NBC is the Section 6 on 'Structural Design-Section 1: Loads, Forces and Effects', which provides an insight into maximum load which can be applied on the roof area of the building. On flat roofs, sloping roofs and curved roofs, the imposed loads due to use and occupancy of the buildings and the geometry of the types of roofs is given below.⁷

Table 2: Load specification for floor

| Type of Industrial Building | Floor specifications | |
|--|--|------------------------|
| | Uniformly Distributed Load (UDL): kN/sqm | Concentrated Load (kN) |
| Work areas with machinery/equipment | | |
| Light duty | 5 | 4.5 |
| Medium duty | 7 | 4.5 |
| Heavy duty | 10 | 4.5 |
| Boiler rooms and plant rooms | 5 | 6.7 |

⁶ <https://archive.org/details/nationalbuilding02/in.gov.nbc.2016.vol2.digital/page/n901/mode/2up?q=solar+thermal> (page 902)

⁷ NBC Volume I, Page 13, Part-6

Table 3: Load specifications for roofs

| Roof specifications | | | |
|---|------------------------------------|------|--|
| Roof Type | Imposed Load Measured on Plan Area | Load | Minimum Imposed |
| Flat Roof or curved roof with slopes up to and including 10 degree | | | |
| Access Provided | 1.5 kN/sqm | | 3.75 kN uniformly distributed over any span of 1 metre width of the roof slab and 9 kN uniformly distributed over the span of any beam or truss or wall |
| Access not provided for maintenance | 0.75 kN/sqm | | 1.9 kN uniformly distributed over any span of 1 metre width of the roof slab and 4.5 kN uniformly distributed over the span of any beam or truss or wall |

Additionally, to provide for loads incidental to maintenance, all roof coverings (other than glass or transparent sheets made of fiber glass) should be capable of carrying an incidental load of 0.90 kN concentrated on an area of 1250 mm² so placed as to produce maximum stresses in the covering. Loads due to rain, snow and dust have to be factored in separately.

2.1.2. Energy Conservation Building Code (ECBC)

Energy Conservation Building Code (ECBC) is a code that sets the minimum energy efficiency standards for design and construction buildings or building complexes that have a connected load of 100kW or greater or a contract demand of 120 kVA or greater and are intended to be used for ‘commercial purposes’. Energy-efficient design of buildings are encouraged keeping in view proper building function, comfort, health and/or productivity of the occupants, along with the economic considerations. Principally, ECBC defines the norms of energy performance and considers the climatic regions of the country where the building is located.

The code considers the five climates zones (hot dry, warm humid, temperate, composite and cold) present in India. The code is developed and revised in sequential manner. The first version of code, ECBC 2007 was launched in May 2007 and was last revised in 2017. The ‘electric power and renewable energy component’ was one of the major amendments included in ECBC 2017, as compared to ECBC 2007 guidelines. The key RE intervention covered under the purview of ECBC includes the following.

- Solar water heating (Minimum provisions for different classes of ECBC) applies to all major commercial sectors buildings (hotels, hospitals) in all climatic zones

Table 4: ECBC mandates for SWH

| | ECBC | ECBC+ | Super ECBC |
|----------------------------------|-------------------------|-----------------------------------|-----------------------------------|
| Floor Area < 20000 sqm | Floor Area > 20,000 sqm | Regardless of building floor area | Regardless of building floor area |
| At least 20% | At least 40% | At least 40% | At least 40% |

(Note: ‘%’ figure denotes the share of total hot water design capacity)

- Renewable Energy Systems
 - All buildings should have >25% of dedicated space (rooftop or the site) for installation of RE systems in the future
 - All buildings should have Renewable Energy Generating Zones (REGZ) for installing solar PV on rooftop or on site:

Table 5: ECBC mandates for RE

| ECBC | ECBC+ | Super ECBC |
|------|-------|------------|
| 1% | 2-3% | 4-6% |

(Note: '%' figure denotes the share of total electricity load)

Governance structure at central level with respect to the ECBC code implementation and compliance, the hierarchy is presented below.⁸

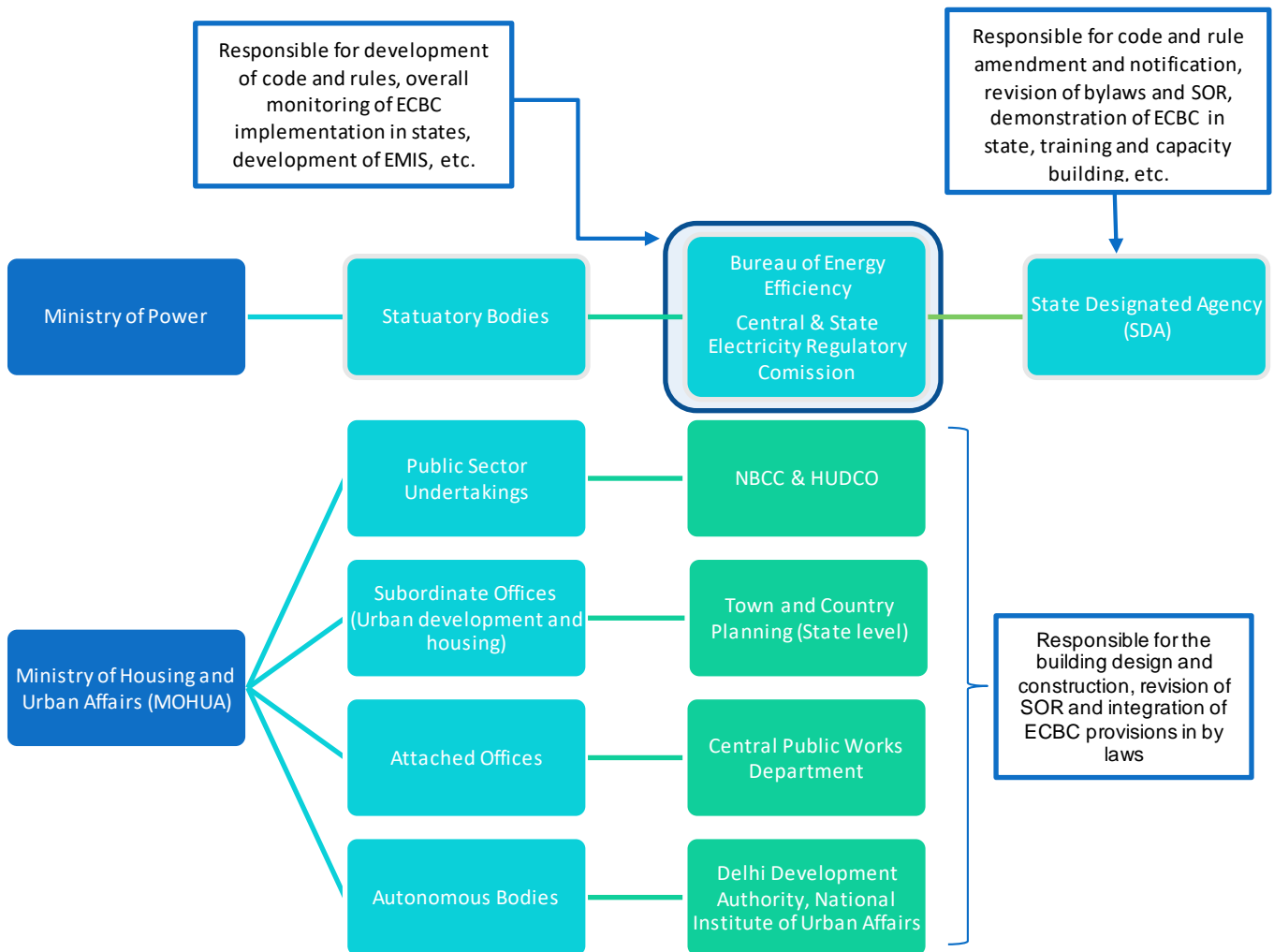


Figure 4: Governance structure at central level for ECBC

Governance structure at state level with respect to the ECBC code implementation and compliance, the hierarchy is presented next:

⁸ <http://mohua.gov.in/> & <https://powermin.nic.in/>

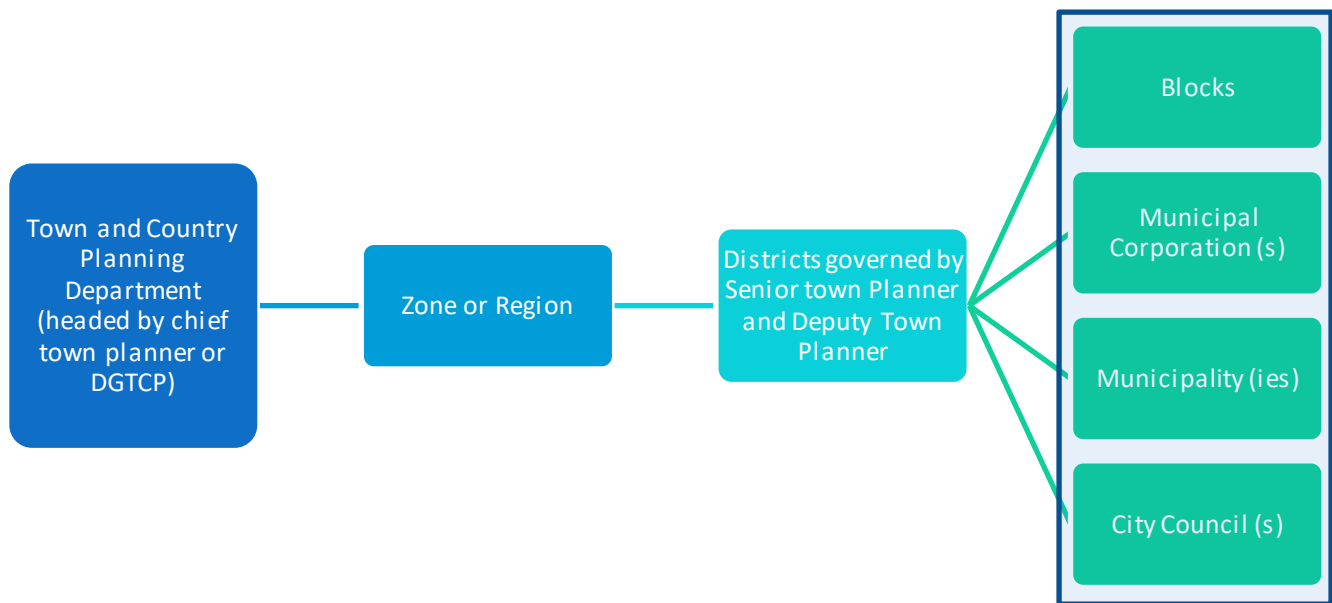


Figure 5: State level implementation framework for ECBC

More than 10 states have notified ECBC, namely Rajasthan, Odisha, Karnataka, Uttarakhand, Puducherry, A.P., Punjab, Telangana, Haryana and West Bengal. **However, the critical point to be noted that ECBC guidelines revised in 2017 are typically concentrated towards the commercial sector (does not include industrial segment). Additionally, concentrated solar thermal technologies are not specifically highlighted within the guidelines as an alternative in terms of meeting compliance with on-site renewable energy generation to be ECBC/ECBC+/Super ECBC compliant.**

2.1.3. Model Building Byelaw (2016)

The Model building byelaws-2016⁹ developed by MoUD for the guidance of state, urban local bodies, Urban development authorities, etc. also provide certain green norms/guidelines for buildings on plot sizes above 100 sqm. The ‘Chapter 10, titled Green Buildings and Sustainability Provisions’ of the Building bye-law lays down specific pointers for different RE technologies as indicated below.

- Solar rooftop PV Technology

Table 6: Solar PV guidelines under building byelaw

| Applicability plot area (Sqm) | Provisions for industrial sector and non-residential | Generation requirement |
|-------------------------------|---|--|
| Above 500 | <ul style="list-style-type: none"> • Installation of Solar Photovoltaic Panels | <ul style="list-style-type: none"> • Solar Rooftop¹⁰: Minimum 5% of connected load or 20W/sqft for “available roof space”, whichever is less |

- Solar assisted water heating technology applicable to commercial buildings such as community centres, banquet halls, educational institutions, hospitals, hotels, etc. Key pointers include:

⁹ <http://mohua.gov.in/upload/uploadfiles/files/MBBL.pdf>

¹⁰ Area provisions on roof top shall be @12 sqmt per 1KWp, as suggested by Ministry of New and Renewable Energy “available rood area” = 70% of the total roof size, considering 30% area reserved for residents’ amenities

- Load bearing capacity ≥ 50 kg/sqm (New buildings)
- Systems should conform to BIS specification IS 12933
- Capacity: The capacity of solar water heating system to be installed on the building of different categories shall be decided in consultation with the local bodies. The recommended minimum capacity shall not be less than 25 litres per day for each bathroom and kitchen subject to the condition that maximum of 50% of the total roof area is provided with the system

2.2. Key certification programmes

In addition to building bylaws and codes, several green building ratings systems have come into effect, which are voluntary in nature. They promote green concepts and techniques in the building sector to address issues such as energy efficiency, handling of waste and increase renewable energy penetration in buildings. The prominent green building rating systems available in India have been presented below¹¹.

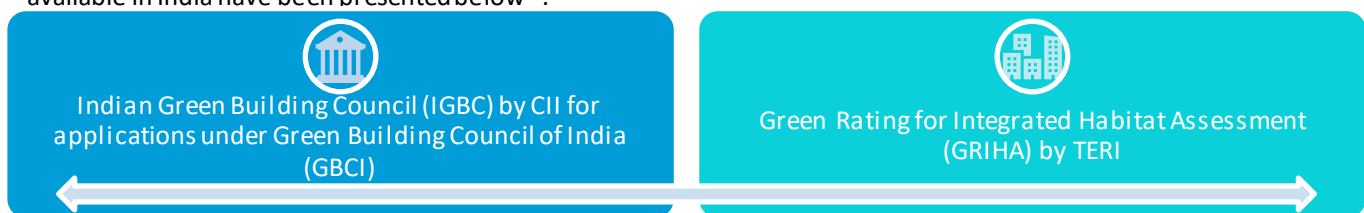


Figure 6: Key green building certification schemes in India

These voluntary certification schemes have been described in subsequent sections.

2.2.1. Green Rating for Integrated Habitat Assessment (GRIHA) Rating

GRIHA attempts to minimize a building's resource consumption, waste generation, and overall ecological impact to within certain nationally acceptable limits/benchmarks. It is a rating tool, originally designed by TERI, that helps people assess the performance of their building against certain nationally acceptable benchmarks. It evaluates the environmental performance of a building holistically over its entire life cycle, thereby providing a definitive standard for what constitutes a 'green building'¹²

The GRIHA v 2019 is the latest version of the rating system (launched in 2007, adopted by the Ministry), which consists of 10 environmental sections, further split into 29 criteria covering all requisite parameters to be addressed while designing green building. An additional section on 'Innovation' is also part of the rating system for going beyond to achieve sustainability. All new construction projects with built-up area more than 2500 sqm are eligible for certification under GRIHA V 2019. Different building categories included under the certification process include;

- Healthcare: Hospitals, Clinics, Medical colleges, Dispensaries
- Hospitality: Hotels, Guest Houses, Service Apartments, Community Visitors Centre
- Institutional: Universities, schools, colleges, R&D buildings, sports complexes
- Core and shell buildings: IT buildings/ data centers, co-working spaces, industries
- Residential buildings

¹¹ BEE Star rating has not been included in this assessment since it primarily includes ratings for equipment and appliances.

¹² [https://www.grihaindia.org/about-griha#:~:text=With%20over%20two%20decades%20of,2007%20\(refer%20figure%201\).](https://www.grihaindia.org/about-griha#:~:text=With%20over%20two%20decades%20of,2007%20(refer%20figure%201).)

- Retail: Shopping complex, banquets, restaurants, multiplex, auditoriums

Withing the GRIHA, the points for renewable energy are included under section ‘Energy optimization’. Out of 100 points, a maximum of 5 points are provided for effective ‘RE utilization’ (Criterion 8). Additional, 5 points are there for innovation aspect. Within the RE segment there are 2 alternatives.

- **Alternate 1 (Onsite/offsite and offsite combination RE systems¹³):** Ensure installation of on-site and off-site RE energy system to offset a part of the annual energy consumption of internal lighting, HVAC, and domestic hot water systems as indicated below.¹⁴

Table 7: Point weightage for on-site and off-site RE energy system installation

| Day-time occupancy | | | | 24-hour occupancy | | | | Points |
|--------------------|--------|---------------------|-------------|-------------------|-------------|--------|------------------|----------------------------|
| 5-days a week | | | | 7-days a week | | | | |
| Institutional | Office | Healthcare facility | Hospitality | Office | Residential | Retail | Transit Material | |
| 5% | 5% | 1% | 1% | 1% | | 1% | 1% | Mandatory (on-site) |
| 10% | 10% | 3% | 3% | 3% | 10% | 3% | 3% | 1 |
| 15% | 15% | 5% | 5% | 5% | 15% | 5% | 5% | 2 |
| 20% | 20% | 7% | 7% | 7% | 20% | 7% | 7% | 3 |
| 25% | 25% | 10% | 10% | 10% | 25% | 10% | 10% | 5 |

- **Alternate 2 (Off-site RE system applicable for only non-residential buildings):** Demonstrate that 100% of the annual energy consumption of internal artificial lighting, HVAC, and domestic hot water systems is offset through off-site RE systems.

The final star rating system is based on following point system.

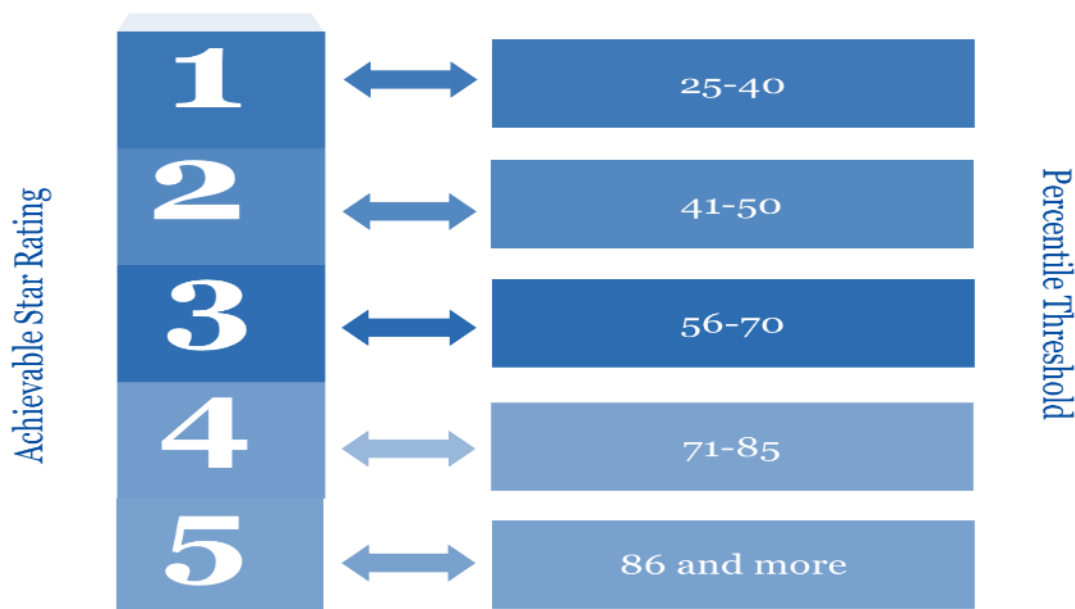


Figure 7: Final star rating achievable under GRIHA

¹³ All RE systems recognized by MNRE can be accepted under this criterion

¹⁴ <https://www.grihindia.org/sites/default/files/pdf/Manuals/user-manual1/mobile/index.html#p=79>

2.2.2. Indian Green Building Council (IGBC) Rating

This IGBC rating programme, part of Confederation of Indian Industries (CII) is a tool which enables the designer to apply green concepts and reduce environmental impacts that are measurable. The rating programme covers methodologies to cover diverse climatic zones and changing lifestyles. Presently, (as on 31 Dec 2020) more than 6,287 Green Buildings¹⁵ projects coming up with a footprint of over 7.75 Billion sq.ft are registered with the Indian Green Building Council (IGBC), out of which 2,126 Green Building projects are certified and fully functional in India. The key certification programmes run by IGBC include the following.

1. IGBC Green Factory Buildings is the first rating system developed exclusively for the industrial sector, covering both existing and new buildings and applicable to all sectors of industry and for all climatic zones for India. Within, this rating system there are exclusive points for on-site and off-site RE generation and captive generation, under EE-Credit 3, EE-Credit-4 and EE Credit-5 as described below.

- **EE-Credit 4 (On Site RE Generation):** Specific points are allocated to promote on-site RE power generation to meet energy consumption requirements for use within factory building. (excluding process load)

Table 8: EE Credit 4 system for Green Factory Buildings

| Percentage of annual non-process energy consumption | Points |
|---|--------|
| >=5% | 2 |
| >=10% | 4 |
| >=15% | 6 |

- **EE-Credit 5 (On Site RE Generation):** Specific points are allocated to promote off-site green power and wheeled to the building.

Table 9: EE Credit 5 system for Green Factory buildings

| Percentage of annual non-process energy consumption | Points |
|---|--------|
| 50% | 2 |
| 75% | 4 |
| 100% | 6 |

- **EE Credit 6 (Eco-friendly Captive Power Generation for Factory Building Requirement):** Specific points are allocated for deploying non-fossil based for meeting captive power generation requirements. A maximum of 2 points can be gained.

Overall rating system has been presented below.

Table 10: Overall rating system for factory buildings

| Certification level | Points | Recognition |
|---------------------|--------|--------------------------|
| Certified | 51-60 | Best Practices |
| Silver | 61-70 | Outstanding Performances |
| Gold | 71-80 | National Excellence |
| Platinum | 81-100 | Global Leadership |

¹⁵ <https://igbc.in/igbc/redirectHtml.htm?redVal=showAboutusnospin>

2. IGBC Green New Building Certification includes (but are not limited to) offices, IT parks, banks, shopping malls, hotels, airports, stadiums, convention centers, libraries, museums, etc. Within, this rating system there are exclusive points for on-site and off-site RE generation under EE-Credit 3 and EE-Credit-4 as described below.

- **EE-Credit 3 (Onsite RE-Generation):** There are specific points for on-site RE¹⁶ energy deployment (2-8 points), covering owner-occupied and tenant-owned categories. The table below highlights energy consumption requirements and points for owner-occupied.¹⁷

Table 11: EE Credit 3: Performance criteria for new buildings

| Percentage of on-site RE generated to the annual energy consumption | Points |
|---|--------|
| >=1 % | 2 |
| >= 2% | 3 |
| >=3% | 4 |
| >=4% | 5 |
| >=5% | 6 |

- **EE-Credit 4 (Offsite RE-Generation):** To achieve points under this category, it needs to be demonstrated that the project has invested in off-site renewable energy equivalent to at least 50% of the total annual energy consumption of the building.

Table 12: EE Credit 4: Performance criteria for new buildings

| Percentage of Off-site RE Generated to the Total Annual Energy Consumption | Points |
|--|--------|
| >=50% | 1 |
| 100% | 2 |

The overall rating system has been presented below.



Figure 8: Final star rating available under IGBC rating

¹⁶ RE sources include solar energy, wind power, biomass, etc. • Solar hot water systems cannot be considered as power generation source and cannot be subtracted from the total annual energy consumption of the proposed case

¹⁷ Tenant occupied can be accessed under IGBC Green New Buildings Rating System, Version 3

2.2.3. Key International Green Rating Systems for Buildings

A snapshot of the key certification schemes for green building across the globe has been presented below. Most of these rating systems do factor in solar thermal for gaining credits to gain improved recognition.

Table 13: Key international green building certification schemes

| Country/Region | Rating system/programme | Focus Area | Performance Parameters for renewables/clean energy/ energy efficiency |
|----------------------|--|---|--|
| United States | Leadership in Energy and Environmental Design (LEED) ¹⁸ | <ul style="list-style-type: none"> • New construction buildings • Core and shell • Existing buildings, O&M • Schools • Retail • Healthcare • Residential | <ul style="list-style-type: none"> • Energy and atmosphere (EA): Specific points are allocated RE production (1%, 3%, 5%, 10%) • Sustainable Site (SS): Heat Island Reduction: Points are awarded for shade with structures covered by energy systems involving solar thermal collectors |
| UK | Building Research Environment Assessment Method (BREEAM) ¹⁹ | <ul style="list-style-type: none"> • New construction (non-domestic) • In-use (non-domestic) • Communities | <ul style="list-style-type: none"> • Credits are allocated for deploying alternative heating sources that includes solar thermal with live data on energy generated and subsequent CO2 reduction |
| Hong Kong | Building Environment Assessment Method-Hong Kong (HK-BEAM) | <ul style="list-style-type: none"> • All building types, including mixed use complexes, both new and existing | <ul style="list-style-type: none"> • Credits under section 'Renewable and Alternative Energy Systems' are awarded for harnessing solar energy on building's roof, including on-site consumption. (does include PV/BIPV and solar thermal) |

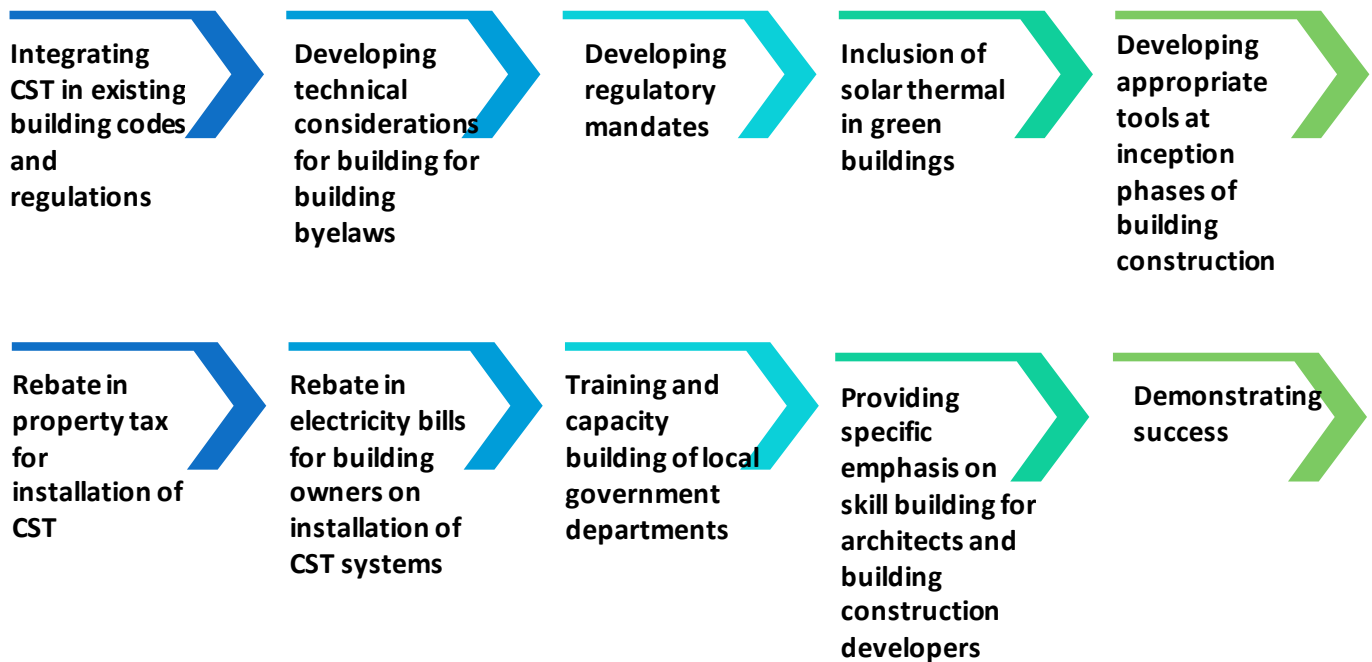
¹⁸ https://www.usgbc.org/sites/default/files/LEED%20v4%20BDC_07.25.19_current.pdf

¹⁹ <https://byggalliansen.no/wp-content/uploads/2018/07/BREEAM-NOR-Engl-ver-1.1.pdf>



3. Key recommendations for CST integration in buildings

Undertaking progressive steps towards increasing the penetration of green energy mix in the overall energy consumption of building can result in significant energy savings. Although, industries and commercial establishments in India are largely reliant on grid electricity for meeting captive energy requirements, there are certain niche building sectors, where still conventional fuels such as oil, petroleum, diesel are being deployed for heat/steam related applications. Herein lies opportunity for concentrated solar thermal technologies to foster by adopting appropriate regulatory instruments and increasing the purview of existing building codes and certification programmes to be more inclusive for CSTs. The key recommendations for developing an enabling ecosystem for CST proliferation through building byelaws have been presented below.



3.1. Integrating concentrated solar thermal (CST) in existing building codes and regulations

Presently, the National Building Codes universally applicable across the country (developed by BIS) does not include a specific a dedicated section or guidelines for concentrated solar thermal technologies as there are for solar PV rooftop and solar-water heating technologies. The same is the case with Energy Conservation Building Code (ECBC), which does not cover CST technologies exclusively, while provides mandates for Solar PV and SWH. Hence, there is a need to integrate CST within the main framework of the building codes, leading to more alternative options for building owners to consider to offset conventional fuel options and ensure environmental compliance.

Possible inclusion areas, under different sections of NBC and ECBC have been indicated below.

- Within *National Building Code, Volume 1, Section 21 'Electrical and allied installations', Sub-section 21.2 'Solar Energy Utilization'*, a separate sub-section 21.2.3 titled 'concentrated solar thermal heating' should be added specifying building type, area validity and generation/capacity requirement (similar to PV and SWH) based on industrial best practices, BIS standards and research studies covering feasibility for adoption. Accordingly, structural design, safety and other factors for industrial spaces can be taken up. Additionally, options can be given to the beneficiary/building owners in terms of meeting hot water compliance through concentrated solar thermal as well, instead of only non-concentrating SWH. (*Keyword CST to be included*)
- Within *ECBC 2017²⁰, Section 7- Electrical and Renewable Energy Systems, Sub-section 7.2.8 'Renewable Energy Systems'*, the definition of 'Renewable Energy Generating Zone (REGZ)' should include concentrated solar thermal technology for meeting the ECBC/ECBC+/Super ECBC compliance. Presently, ECBC is technology agnostic for RE, but measures compliance in terms of power i.e. 'minimum electricity generated in REGZ'. Here, CST needs to be integrated in one of the following ways.
 - Amendment in Section 5.2.9 'Service Water Heating', Sub-section 5.2.9.3 'Other water heating system': The section specifies solar water heating requirements for hotels and hospitals across all climatic zones and the key standards, and technologies that can be employed. Precisely it states²¹ following mandate;

To comply with the Code, Hotels and Hospitals in all climatic zones and all buildings in cold climate zone with a hot water system, shall have solar water heating equipment installed to provide for:

- *at least 20% of the total hot water design capacity if above grade floor area of the building is less than 20,000 m²*
- *at least 40% of the total hot water design capacity if above grade floor area of the building is greater than or equal to 20,000 m²*

Currently technologies covered include gas fired heaters, electric heaters and heat recovery from air condenser. Within this mandate, CST technologies can be integrated to provide alternative option for meeting water heating requirements. Accordingly, Section 5.2.9.2 'Heating Equipment Efficiency' can be revised to include CST based standards, already designed by BIS.

- Heat delivery from CST system in Kcal can be converted into kWh and can be considered as a technology option in meeting the annual energy requirement of the building for ECBC.
- Developing dedicated section under 'solar thermal zones' for those commercial and institutional enterprises having a considerable floor area (area > 20,000 sqm) and steam requirements for applications such as cooking, laundry, boiler feedwater, etc. (For example, a minimum of 10-15% of roof area for generation of thermal energy can be exclusively reserved for CST installations)

As per one of the leading CST players, hot water requirements drive the space allocation. 50% of hot water consumption using CST for hospitals and hotels acts as a good mandate as an alternative to SWH

As per NISE, it will be more feasible to amend building codes and regulations related to hot water generation, once CST system is sold at a price of SWH. Currently, the CST systems are not very mature or popular and at the same time cost 3-5 times of a SWH system

²⁰ https://beeindia.gov.in/sites/default/files/BEE_ECBC%202017.pdf

²¹ ECBC 2017, page 48

3.2. Developing technical considerations for building byelaws

One of the pre-requisites for inclusion of CSTs as an important technology option within the RE mix is to have a well-defined framework, which provides clarity on how best to integrate these solutions within the building codes and guidelines. The design of regulatory byelaw framework for concentrated solar thermal (CST) technologies will depend upon host of factors relating to physical, technical, mechanical, natural phenomena and legal compliances with respect to alter nations in existing building codes. Some of these key parameters, which require further analysis have been presented below.

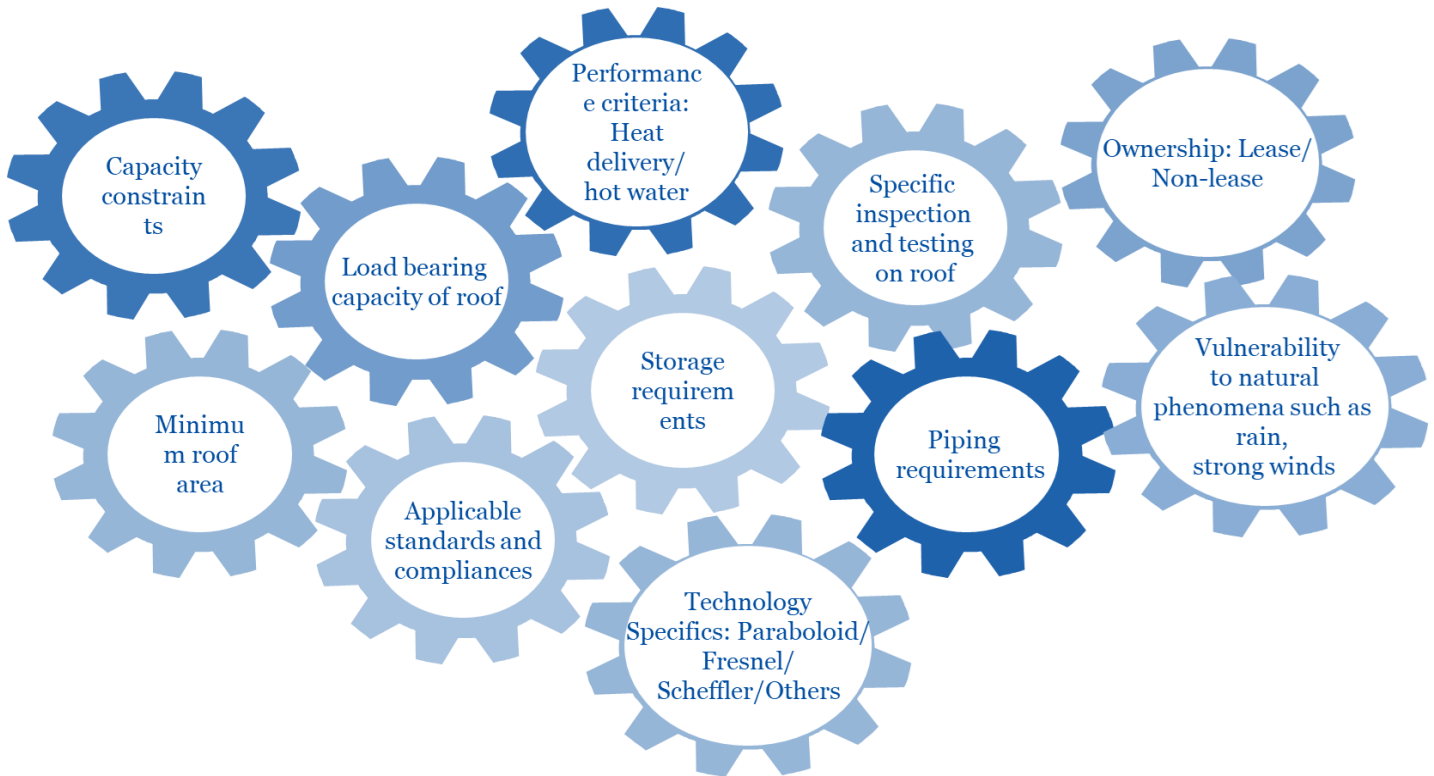


Figure 9: Key technical and physical parameters in designing building codes

The absence of such technical guidelines and specifications for City Town and Planning officials, ULBs, including other local state level departments on CST installation for different categories of buildings can lead to a number of ill-effects. Some of these include;

- Undersized systems and low potential realization
- Risk to health and safety of the building construction (considering imposed load, snow load, dust load, wind load, etc.)
- Lower system performance/system generation, owing to actual building construction
- Promotion of widespread low-quality products, rather than standardized industry accepted products
- Damage to the CST installation or related BOS, owing to natural phenomena
- Difficulty in conducting O&M related activities

3.2.1. Load bearing capacity assessment: Defining a key technical parameter

One of the critical parameters in design of the building codes is the element of ‘load bearing capacity’. The CST system needs to be designed in such a manner that the imposed load on the roof area is less than the load bearing capacity of the roof to avoid the collapse of the building. CST manufacturers generally do not put much effort into the structural analysis and generally take advice from civil engineers/external consultants to meet compliance in case of large projects on roofing. But, ideally speaking a flat concrete roofing forms the best-case scenario for CST deployment. Metallic sheets and asbestos may not be a viable proposition, considering the brittle ness and heavy weights of the system.

As discussed in previous section, the National Building Code 2016 has provided a mandate of ‘1.5 kN/sqm’ as the load bearing capacity of the roof for any imposed load on a plan area, bearing in mind the overall structural strength and safety measures. Defining ‘new CST specific load bearing structural standards’ may not be practically feasible considering the following key aspects relating to the technology.

- Multiple variants with multiple technologies, along with different weights and pressure exerted, leading to difficulty in standardization
- Different types of roofing (RCC/tin/other metal sheets) and sloping
- High degree of customization based on application, leading to variation in number of dishes and in turn changes in overall load exerted
- Lack of technical expertise on actual weight load calculations, may lead to a compromise for health and safety
- Actual loading of roof may be affected by external load variations owing to dust, snow, rain, etc.

Hence, it is recommended that rather than developing new benchmarks, the CST manufacturers need to customize their system and define the payload of the system in compliance with the NBC existing mandates. For this, proper due-diligence work involving structural analysis and weight-load calculations need to be conducted by the CST players, with support from civil engineers and external consultants.

In terms of technology, it is suggested that for deployment on roof, technologies with comparatively lower system weight and modular system sizes with smaller aperture area be taken up, which can be distributed across the roof to uniformly scatter the load. A possible list of recommended technologies has been presented below.

Table 14: Load bearing capacity assessment

| Case | NBC mandated load requirement for roofing | Cross sectional area of the structure on which dish is placed | Maximum CST System weight, including weight of structure (Assuming $g=10 \text{ m/s}^2$) | Type of roof | Recommended viable technologies |
|--------|---|---|---|--|---|
| Case 1 | 1500 N/sqm | 1 sqm | 150 kg | <ul style="list-style-type: none"> • RCC-flat roof should be mandated for deployment | <ul style="list-style-type: none"> • Scheffler • CPC • PTC |
| Case 2 | 1500 N/sqm | 2 sqm | 300 kg | <ul style="list-style-type: none"> • Metallic roofing may be permitted for lighter weight installations (such as CPC based) • Asbestos should be permanently avoided | <ul style="list-style-type: none"> • CPC • Paraboloid (structural strength may need to be expanded) |

ILLUSTRATIVE

- In case the system strength is greater than roof strength, columns/beams should be used for mounting systems
- Scheffler
- PTC

(Note: Arun Dish, weighing in excess of 3000 kg may not be suited for installation of rooftop, however other technologies may be customized to meet the building code compliance. Factors such as snow, dust and wind loads need to be accounted for separately)

In general, it can be said that the current imposed loading prescribed under the NBC should be sufficient for most type of CST applications except for some technologies like the parabolic dish engines and Arun, since these systems are much heavier and have a concentrated installation base, unlike other systems whose load can spread over an area. Additionally, in case the system load is much greater than the roof strength, CST players use load bearing columns/beams for mounting their systems. These load bearing columns/beams have a much higher loading capacity than the roof and facilitate easy installation. In general, most of the CST players follow an array based installation approach, rather than installing a large concentrated dish at a single place, which helps in load distribution.

As per one of the leading CST players, installation of CST systems on roof has not been any challenge as long as the roofing is flat. As such we have not faced any compliance issues when it comes to meeting load bearing capacity standards as our dishes are small and we can spread the load on the roof

Hence, with numerous possibilities of customization in the segment it is in best interest for CST players to modify system design/technology and adopt NBC guidelines. **MNRE approved CST manufacturers should send their technical drawing and calculations to the building's engineer and commence installation process, post his approval.**

As per one of the MNRE approved CST manufacturer, on the load bearing capacity front, the roofing should be designed to take the wind load of the system, with an additional margin of 20% for safety.

As per one of the MNRE approved CST manufacturer, there are many technologies, but the Scheffler technology is the best suited for roof installation, due to size, weight and static focus. Also, roofing for the building can be mandated to be only be concrete based.

As per leading CST manufacturer, we do conduct load assessment studies in-case the buildings are of older construction (more than 7 years typically) but for newer constructions we generally proceed with the just the civil drawings of the load bearing beams, The weight is also spread across a large area so we typically do not face loading limit issues

As per one of the MNRE approved CST manufacturer, dishes with collector area less than 20 sqm should be ideally allowed for rooftop installation

3.3. Developing regulatory mandates for industrial sector

Regulatory mandates in the form of solar thermal heat obligation (along the lines of RPO for solar PV) have the potential to stimulate demand for CST technologies in industrial segment. Specific strategies can be designed for developing stipulations as presented below.

- Industries employing conventional fuel boilers in buildings can be mandated to meet certain portion of heat requirement through solar thermal.
- A strategy based on fuel cost should be used for mandating certain industries for uptake of CSTs. Industries having lower energy costs can be mandated to switch over to CSTs and procure fixed quantum of heat
- States showcasing interest in the sector (such as Karnataka), and proactive in promoting RE in the state, specifically in the building sector (having mandates for SWH as well as notified ECBC as per local landscape) can be used as a pilot state for developing regulatory mandates for select industry types. So far ECBC does not cover industrial installations and only caters to commercial establishments. Hence, framework to mandate particular industry types can be developed for such states to encourage CST-integrated industrial units.

As per NISE, MNRE can look to develop regulatory mandate for industries such as dairy and textile that have typical heat load profile which can be addressed using CST

As per leading CST player, minimum energy consumption mandates of the order of 5% on auto and 10% on pharma/leather and food processing should be imposed on heat requirements for replacement through CST deployment

As per NISE, taking queue from PAT scheme for mandating and defining certain 'designated customer (DCs)', based on energy consumption, enough land area/roof area, financial capacity, non-fossil fuel-based generation can be instrumental. Such programme can be initiated in phases on a pilot basis.

3.4. Inclusion of solar thermal in green building certification

The most recognized green building certification schemes implemented in India such as the GRIHA and IGBC Rating provide special credits/points for onsite and off-site renewable energy-based generation, when the particular building type consumes above a certain % of energy through renewables. In these rating systems, the primary focus has been on promoting 'RE-power generating' alternatives and no specific emphasis on promoting 'RE-heat' technology options.

- As aforementioned, within the GRIHA 2019 rating system, the points awarded for RE are included under section 'Energy Optimization-Criterion 8'. Firstly, the definition of RE here should specifically include CST technologies under its purview, specially under the category of points awarded for Alternate-1 'On-site RE generation', which states '*ensure installation of on-site and off-site RE energy system to offset a part of the annual energy consumption of internal lighting, HVAC, and domestic hot water systems.*'

Secondly, this definition should also be revisited, so that the scope of services can be expanded to include steam generation activities within the onsite RE generation. The statement can be revised as;

"Ensure installation of on-site and off-site RE energy system to offset a part of the annual energy consumption of internal lighting, HVAC, domestic hot water systems and steam generation applications (using concentrators)." This will also lead to innovative usage of roof area and allow for additional points to be gained under 'Innovation category' by building owners.

- The same is the case with IGBC green ratings system, wherein EE Credits are provided for RE based generation and captive generation involving non-fossil fuel usage for new building category as well as factory buildings. Here again, specifically concentrated solar thermal technology is not highlighted as one of the alternatives to gain credits under EE-Credit 3

(new building category) and EE-Credit 5,6 (factory building category) for on-site RE generation, including captive power needs for non-process based annual energy consumption²².

Hence, it is recommended that either the IGBC creates a 'new EE-Credit category' for RE-Heat applications and includes CST as a component in it, or necessary amendments can be made in existing EE Credit categories to include CST steam generation within captive building requirements.

As per leading CST player, at least 20% of total thermal requirements across industries employing boiler of capacity of at least 1 ton should be mandated to be met by solar thermal equipment or systems for feedwater heating or preheating

3.5. Developing appropriate tools at inception phases of building construction, Pre-conceptualization

Developing adequate design tools to estimate energy performance and architectural impact during the initial design concept phase is extremely critical for informed decision making for building owner. The compliance with both construction codes and energy related norms is required and the lack of concrete customized tools/framework to gauge the impact of CST technologies may deter building planners and investors from adopting these technologies. Hence, tools aimed at ascertaining possible short term and long-term impact of such technologies needs to be designed to provide user comfort. Such a tool needs to be visualized as part of a confidence building exercise to bring clarity in terms of,²³:

- Building aesthetics and changes in architectural appearances
- Energy and fuel savings
- Cost-economics and profitability
- Contributions to sustainability protocols and certifications
- Appreciation in property rates
- Reduced impact on grid
- Improvement in livability index, including comfort and well-being
- System degradation

As per NISE, a tool has to be developed to validate the claims made by the manufacturers to avoid problems of under sizing. A public document indicating necessary due-diligence guidelines (with 20-30% deviation) can help increase confidence of investor/beneficiary

Additionally, architects and building planners need to reserve spaces for developing innovative concepts involving CST deployments, for effective solar thermal usage.

As per leading CST player, for a new building design a concept of 'solar farming' can be used, where in pumping of solar thermal energy can be prioritized for important applications

²² CST does find applications for non-process-based applications such as cooking, hot water, air conditioning, etc.

²³ <https://task56.iea-shc.org/Data/Sites/1/publications/2020-07-Task56-Building-Integrated-Solar-Envelopes--Current-Status-and-Actions-Needed.pdf>

3.6. Rebate in electricity bills for building owners on installation of CST systems

Concentrating solar thermal systems have substantial upfront costs of the systems, whereas the savings made are over the long term. Even though considering the medium and long terms, these technologies provide significant savings, building owners are hesitant to invest high amounts of money upfront for installation. In this regard, providing financial incentives in the form of rebates in electricity, can help reduce the operating costs for a given building. Such instruments have been successful in the past for promotion of specific RE technologies such as solar-water heaters (SWH) at regional level²⁴.

Case study

Electricity bill rebate scheme (Solar rebate)-Karnataka, India

In India, the state government of Karnataka is giving a rebate in electricity bill for domestic users at the rate of Rs 0.5/unit of electricity consumed, subject to a maximum of INR 50 per month on installation of Solar Water Heaters. This rebate however is applicable for domestic category, if the capacity of SWH in such group housing/apartment shall be 100 litres per household.

Similar initiatives have also been taken up by HAREDA (Haryana) and UREDA (Uttarakhand) to promote SWH in residential areas. Along similar lines, SNAs of different states can roll out programme which provides rebates for establishments, under C&I category, which deploy CST systems for energy consumption requirements of the building. There are 2 possible ways of providing such rebates.

- a) **Fixed rebate:** A fixed rebate for different categories of buildings deploying CST systems such as:
- Industrial Sector: INR X/unit, subject to maximum of INR Y
 - Commercial sector: INR Z/unit, subject to maximum of INR A

ILLUSTRATIVE

For pilot purposes, a fixed rebate of INR 0.5/unit for industrial installations and INR 0.25/unit for commercial buildings can be used.

- b) **Variable rebate/performance driven rebate:** A variable rebate for different categories, depending upon the performance of the CST system can also be provided. A framework for benchmarking would need to be designed.

As per one of the leading CST players, use of CST in buildings should be incentivized for industries that use high cost imported fuels-diesel/LPG, through provision of fuel price rebates and continued accelerated depreciation

3.7. Rebate in property tax for installation of CST

Provision of rebates in property tax to commercial and industrial units can be used as an effective tool for promoting CST installation in buildings. In India, several urban local bodies (ULBs) in Pune, Mumbai, Chandigarh, Delhi and Bangalore have

Case study

Rebate in property tax (Solar rebate)-Nagpur, India

Nagpur Municipal Corporation (NMC) earlier provided an incentive of 5% on general tax rebate (one of the components for property tax) for houses having solar power systems. In order to further incentivize the uptake of RE, in Jan 2020, this rebate was increased to 10% and is now applicable to entire property tax

²⁴ <https://cescmysore.karnataka.gov.in/info-2/Incentive+Benefits/en>

been providing a rebate in property tax to housing and individual property owners, in the range of 5-10%, who install renewable energy systems.

However, internationally, there have been steps undertaken by government agencies in providing exemptions up to 100% for renewables, including solar thermal usage for process heat applications. Some of the key examples have been enlisted below.

Table 15: International policies promoting solar thermal property tax incentives

| Area | Eligible RE/other technologies | Applicable Sectors | Incentive Amount |
|---------------------------------------|---|---|---|
| Texas, USA²⁵ | Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat , Solar Photovoltaics, Wind (All), Biomass, Solar Pool Heating, Wind (Small), Anaerobic Digestion | Commercial, Residential and Industrial | <ul style="list-style-type: none"> • 100% renewable energy systems property tax exemption |
| California, USA²⁶ | Solar water heat, Solar space heat, solar thermal electric, solar thermal process heat , solar PV | Commercial, Residential and Industrial | <ul style="list-style-type: none"> • Property tax exclusion (100% of system value; 75% of system value exemption for dual-use equipment) |
| North Dakota, USA²⁷ | Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat , Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Wind (Small), Geothermal Direct-Use | Commercial, Residential and Industrial, Agriculture | <ul style="list-style-type: none"> • 100% RE property tax exemption for a period of 5 years post installation |

Similar incentives in property tax should be provided to building owners in India for promoting solar thermal process heat applications within the commercial and industrial segments. In this regard, a framework for the tenure and the percentage of exemption needs to be designed with the concerned stakeholders.

²⁵ <https://programs.dsireusa.org/system/program/detail/173/renewable-energy-systems-property-tax-exemption>

²⁶ <https://programs.dsireusa.org/system/program/detail/558/property-tax-exclusion-for-solar-energy-systems>

²⁷ <https://programs.dsireusa.org/system/program/detail/160/renewable-energy-property-tax-exemption>

3.8. Training and capacity building of local government departments

Lack of technical expertise and know-how at regional level, associated with CST deployment in buildings is also another area of concern. There are well defined guidelines in building codes and byelaws for installation of solar PV and SWH technologies, which is being successfully implemented by various local level departments in the state through proper knowledge transfer activities conducted by SDA. When byelaws for a newer technology such as CST are drafted, it is essential to have buy in from these departments, since the actual on-ground implementation as well as monitoring in terms of compliance will be actually carried out by them. Hence, training and capacity building of state officials is a must for actual roll out of the programme. In this regard, some of the areas of support include the following.

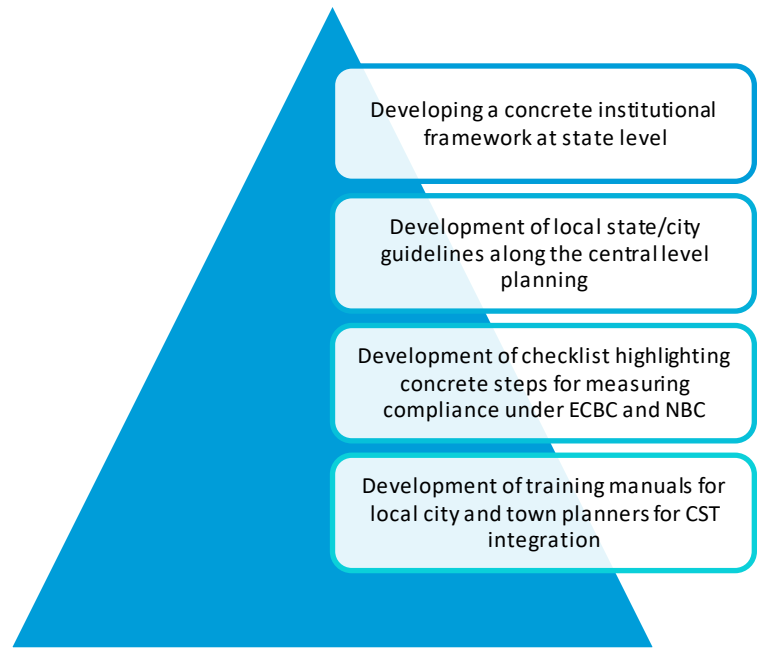


Figure 10: Training and Capacity building of local government departments

- **Developing a concrete institutional framework at state level for CST implementation:** A well-coordinated streamlined institutional framework forms the backbone for creating an efficient ecosystem for market penetration or promotion of any technology. In such a framework, the roles and responsibilities of each institutional body needs to be defined to ensure successful dissemination of knowledge transfer and desired impact across all levels. The institutions not only need to perform day-to-day task, but at the same time plan out activities for the future and look for strategic partnerships or collaboration opportunities with counterparts in other countries. Improving outreach to local levels and engaging participation forms one of the foremost responsibilities of such a framework.
- **Development of local state/city guidelines along the lines of central planning for implementation of CST byelaws:** The possible amendments in ECBC and NBC building codes will need to be effectively translated at state level, based on potential, local building architecture and construction practices. States, that have already notified ECBC can amend the guidelines and include CST technology in their existing framework by defining appropriate technical and regulatory guidelines, after conducting proper technical due-diligence work in consultation with city/state level town/industrial planning agencies.
- **Development of checklist highlighting concrete steps for measuring compliance under ECBC and NBC for state agencies:** Once the local CST byelaws have been drafted, it is essential to have a guidance document to ensure a thorough measurement of compliance by building owners. This monitoring activity by state level officials will also lead to development of possible modifications in existing framework and innovative recommendations for enhancing compliance. A flowchart indicating a list of key approvals and clearances, including necessary documentation required also needs to be developed by the SDA.
- **Development of training manuals for local city and town planners for CST integration:** A number of state officials involved in city/town planning and implementation framework would have familiarity with SWH technologies, but would not have familiarity with the concepts and technical attributes for CST system. Hence, it is essential to have in place a consolidated training manual for integration of different CST technologies in the buildings

In addition to the above highlighted awareness and capacity building needs, a special emphasis should also be made on training the CST manufacturers themselves on aspects not directly related to their subject matter, but critical from health and safety perspective. This includes technical assessment studies related to ascertaining the civil and structural strengths of roofs, including the weight load calculations.

As per NISE, most of the manufacturers are not aware about the building codes and regulations and mostly see if roof is concrete and can withstand load of the system. Detailed civil assessment is usually outsourced to a civil engineer/consultant, prior to project uptake.

3.9. Providing specific emphasis on skill building for architects and building construction developers

In general, practicing architects and building planners usually require additional learning about these issues if they need to venture into integrated solar thermal building design. There is also some degree of resistance as solar thermal systems are not considered building / architectural components, but technical devices with complex designs and plethora of technologies. In order to understand the benefits of their investment, city and town developers should also have some awareness of solar energy systems. Without basic information, there is no proper confidence in these solutions, and this in turn leads to low interest. Hence, over the long term introducing specific short courses about these technologies at the university stage itself is considered an important step.²⁸

Knowledge of technologies by introducing specific courses about these technologies during university studies

Availability of architecturally oriented information (handbooks/ seminars etc.)

Availability of simplified computer tools for architects for design and sizing

Some of the essential elements that can be taken up as part of this course/handbook/computer tools include the following.

- ✓ **Relevant building codes and regulations from NBC and ECBC, specifically catering to CST, including related components (storage, piping, boiler, etc.)**
- ✓ **Key technical considerations for CST integration, covering;**
 - *What are specific constraints in terms of reservations associated for amenities to open spaces for C&I buildings?*
 - *What minimum area should be allocated to CST in industrial and commercial roofing? Any capacity (kWth) related aspects that can be designed?*
 - *What special modifications need to be done at the building premises for CST installation? What factors need to be revisited again for project scalability (capacity increase)?*
 - *How does physical dimensions such as length, width and height for high rise/low rise of the building picture into CST integration process? Are there specific margins/gaps which cannot be utilized and have to be left vacant?*
 - *How does CST build into the aesthetics of the building architecture?*

²⁸ https://task41.iea-shc.org/Data/Sites/1/publications/T41A1_Survey_FinalReport_May2012.pdf

- *What kind of structural testing is done to ascertain load bearing capacity of roofing for maximum safety? How exactly are elements such as wind/dust/snow loads accounted for?*
- *What kind of roofing material is ideally suited for such installations?*
- *What kind of applications can such systems be deployed for meeting heat requirements in buildings?*
- *Can some minimum performance criteria be attributed to CST system installation on industrial roofing such as hot water/heat delivery?*
- *How exactly CST systems can be planned for in existing buildings, wherein space availability may be limited?*
- *What specific rules can be defined for ownership or tenant-based buildings?*
- *Are there any specific considerations to be adopted to connect ancillary CST requirements (pipes, storage tank, etc) on industrial roofing?*
- *What kind of technical specification should be designed for CST systems to ensure resilience against natural calamities (snow, wind)?*
- *How are health, fire and safety risks affected with CST integration?*
- *What specific requirements related to insulation can be developed?*
- ✓ **List of key acceptable standards for structural design, fire and safety, building material**
- ✓ **International best practices from the building sector based for innovative approaches**

3.10. Demonstrating success

Ensure performance monitoring of solar thermal integrated buildings. Making this performance data available related to energy savings, CO2 reduction, etc. in the public domain will help in building confidence in the technologies and its increased deployment in buildings. Bureau of Energy Efficiency (BEE) in consultation with international expert from Croatia and Russia, developed Energy Monitoring Information System (EMIS) for monitoring web based ECBC compliance, i.e. 'Building Energy Passport' (BEP).²⁹ (highlighted below)



Figure 11: ECBC Compliance platform for commercial buildings

²⁹ <http://www.ids-pl.com/energy-efficiency.php>

Solar thermal technology can be integrated within the existing 'Electrical and Renewable Energy' tab to showcase performance parameters of CST system and depict how exactly it is assisting in meeting compliance across a given category in commercial buildings. However, solar thermal forms a very small component in the overall scheme of ECBC and critically does not include industrial buildings in its mandate.

In this regard, knowledge dissemination activities should also be triggered through sharing of successful case studies for CST-integrated building designs, which will prompt other building owners to participate and develop innovative projects. The case studies should concentrate not only the benefits, but also on the technical specifications and design attributes.

3.11. Miscellaneous

- Development of innovative business models to integrate CST systems with buildings to act as a competitive alternative option to other RE technologies
- Incentivizing the creation of RE uptake ready buildings: Planning solar thermal integration with building construction as an integral component of building design ensures optimal implementation and operation of the system, reduces the cost of the system and facilitates easy maintenance during later stages.
- There is an urgent need to bring in further uniformity and coherence between building codes like NBC, model building bylaws, ECBC, etc. to prevent confusion in guidelines suggested by each code and facilitate easier implementation of renewable energy related measures. Also, purview of some of these building codes and regulations needs to be expanded to also target the industrial sector. (*Currently ECBC mandates only certain specific installations such as commercial installations*)



Vienna International Centre · P.O. Box 300 · 1400 Vienna · Austria
Tel.: (+43-1) 26026-0 · Email: info@unido.org
www.unido.org