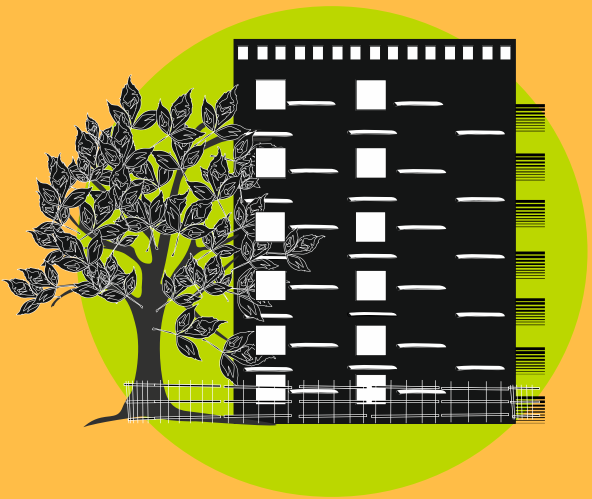

DRAFT IMPACT ASSESSMENT MODEL FRAMEWORK FOR THERMALLY COMFORTABLE HOMES

September 2023

Development of Thermal Comfort Action Plan 2050 and Thermal Comfort Performance based Design Standard cum Guidelines for Affordable Housing in India. [REF: 8338 0638]

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Contents

Executive Summary

The human perception of satisfaction with regards to the thermal environment is described as thermal comfort. Thermal comfort refers to conditions where a majority of people feel comfortable. For the perspective of improving comfort and satisfaction of occupants with respect to their indoor environment, thermal comfort is rated among them most important conditions. The constantly changing nature of thermal environment in the real-world challenges the human body's ability to regulate its core temperature within the required range for optimal health and productivity. The thermal indoor environment is regularly affected by both internal and external sources. These sources collectively influence the human perception of the indoor environment and subsequently the thermal comfort.

The proposed standard focusses on improving thermal comfort through low or no-cost passive design measures. The standard proposes three levels of achieving adequate thermal i.e., Level A, A+ and A++, with Level A meeting minimum levels of comfort and A++ meeting maximum levels of thermal comfort. This impact assessment models the proposed thermal comfort benchmarks; Level A, Level A+ and Level A++, to evaluate their impact relative to the Business as Usual (BAU) case. Among the building typologies, over 51% of the stock resides in Warm-Humid climate zone and 36% of stock in present in Composite climates, with the remaining 13% stock spread across Hot and Dry, Cold and Temperate zones. Based on these stock estimates, along with thermal comfort threshold levels from the analysis, the performance metrics for BAU and Level A, A+ and A++ have been outlined in the table below:

Comparative savings potential for Level A, A+ and A++ over BAU

Parameter	Level A	Level A+	Level A++
Energy Use (Billion Units)	28,823	32,679	35,834
Demand Avoided (TW)	48.74	54.49	61.04
GHG Abatement Potential ($mtCO_2e$)	23.06	26.14	28.67
Energy Use Cost Saving Potential (Lakh Crores INR)	86.49	98.03	107.50
Investment in Demand Infrastructure Savings (lakh crores INR)	201.31	227.81	261.38

Implementation of the standard will translate to a technical potential of saving over 28,000 BU of energy up to 2047 through Level A alone, while higher potential of savings for level A+ and A++ is possible. This translates to over 86 lakh crores INR worth of savings in energy use cost over the analysis time frame. The improved comfort level through meeting Level A requirements further provides a demand abatement potential of over 48 TW. It is clear from the analysis that implementing the standard has the potential to achieve significantly positive impact on the energy use as well as financial aspect. The detailed results in the impact assessment show that the different levels of comfort proposed in the standard are financially viable from the national perspective considering investment costs and electricity costs.

1 Background

The steady rise in population in India has made it the most populous country in the world, with a major proportion of the population residing in rural areas. However, recently, fast paced urbanization has led to exponential increase in migration from rural to urban areas, resulting in increase in the number of urban populations, especially in the economically weaker section of society. This has created a tremendous challenge to provide housing for all. This influx of population into urban centers coupled with climate change has exacerbated the situation by affecting the thermal comfort of habitants. Deviations in the thermal comfort condition of human beings in indoor environments is a primary concern in the context of climate resilience, sustainable growth and development. It becomes imperative to note that under such scenarios, lack of comfort leads to rise in the consumption of space cooling units in residential buildings.

Thermal comfort is of utmost importance in housing as it directly affects the health and well-being of building occupants. A comfortable indoor environment can enhance the occupants physical and psychological well-being, improve their productivity and reduce their stress levels. Additionally, providing thermal comfort in housing can also have broader socio-economic benefits. It is important to make sure that the solutions to provide thermal comfort in housing are not only comfortable but also affordable and energy efficient. Making the building thermally comfortable can help reduce energy consumption, which in turn can lower energy bills for occupants. While a degree of comfort can be achieved with passive design principles, this may not fulfill the adequate levels of required comfort which necessitates the use of mechanical means to achieve thermally comfortable conditions. While the goal is improving the living conditions focusing on comfort and affordability, this should not impact the environment. To achieve this, low-energy systems can be a critical aspect of comfort.

This standard has been developed to provide a design framework for the development of thermally comfortable and affordable homes. This standard presents design requirements to ensure minimum thermal comfort performance with a focus on affordability. This standard applies to buildings used for residential purposes and is applicable to buildings in the design stage or buildings undergoing alterations. The standard identifies three grades of thermal comfort;

- Level A: Provides minimum levels of thermal comfort
- Level A+: Provides certain levels of thermal comfort beyond minimum code requirements.
- Level A++: Provides maximum level of thermal comfort.

This report aims to explore the potential impact of meeting the mentioned levels of thermal comfort on different metrics. An attempt has been made to evaluate and understand the potential impact of implementation of the standard on energy use and savings potential, demand abatement potential and emission reduction potential. Further, financial impact of the standard in terms of potential reductions in energy use cost and demand infrastructure setup costs has been analyzed through a rigorous framework. All the analysis presented in this impact assessment report is based on 1BHK low-rise typology as reference. Further, for the analysis of EPI (kWh/m^2-year), availability of air conditioning has been provided during night time and during day time for 3 hours between March and October. The cooling set point has been set as 26 °C while the heating set point is set as 18 °C. The impact of adopting the standard on national energy use savings and potential financial benefits has been further categorized based on climate classification to outline regions in which climate conditions have the best potential to achieve the maximum benefits if the standard is implemented.

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2 Model Framework – 'Bottom-up' Approach

A bottom-up approach for estimating impact of Design Standard for Thermally Comfortable Homes is undertaken. The 'bottom-up' approach implies estimating the impact of the Design Standard on the lowest common denominator, in this case the dwelling unit, and scaling this impact at regional and/or national level.

This bottom-up model is expected to have 3 components.

1. Performance Component
2. Market Component
3. Analytical Component

Figure 1 outlines the components of the Impact Assessment framework and Table 1 provides detailed explanation of step-wise approach for each component.

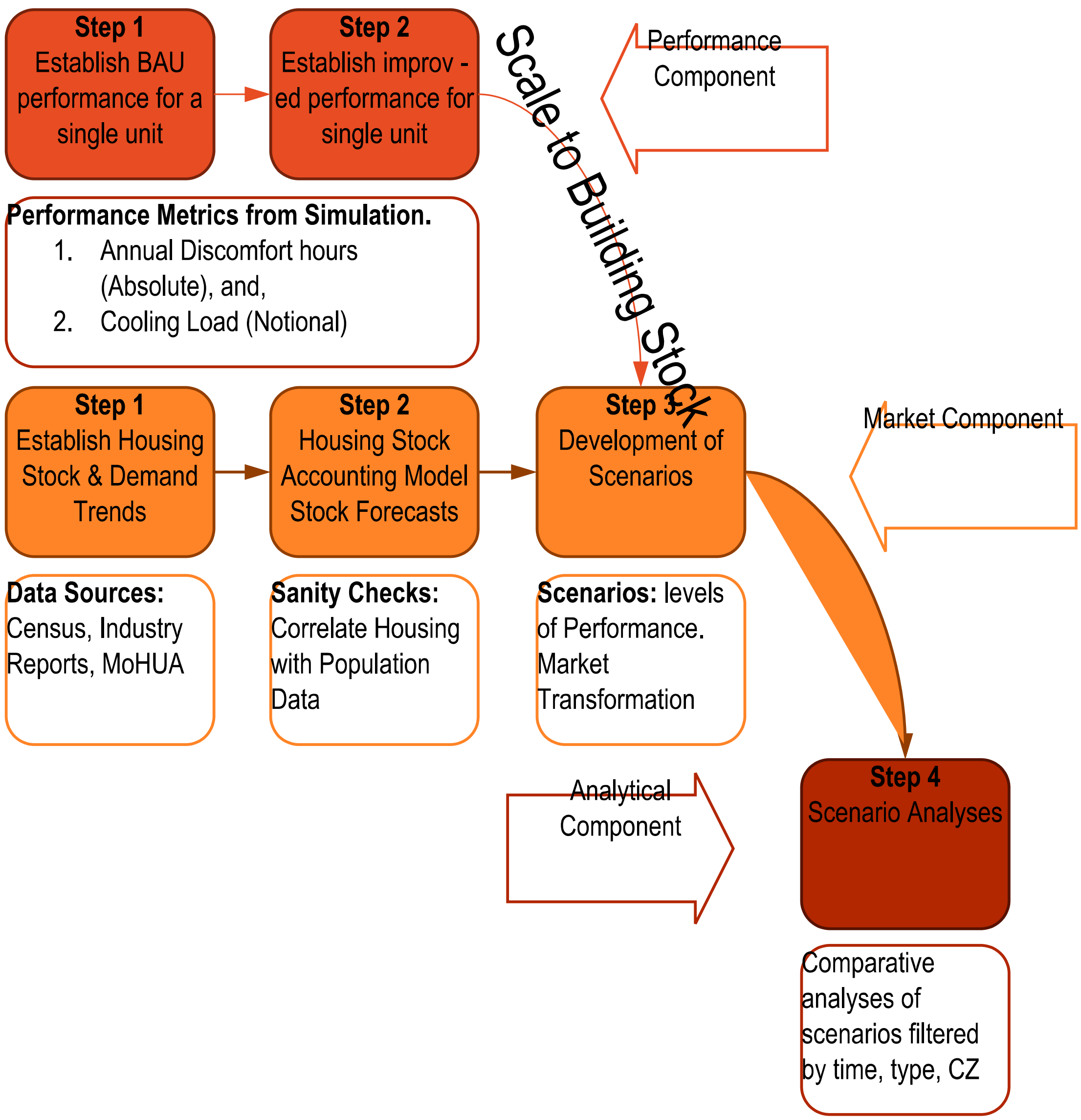

Figure 1 A step-wise approach indicates three components in the Impact Assessment Framework

Table 1 Step by step approach to performing impact assessment for Thermally Comfortable Affordable Housing.

Performance Component	Market Component	Analytical Component
Step 1 The Performance Component will establish baseline performance or a Business as Usual (BAU) scenario. This scenario will establish the performance of standard dwelling unit under a no intervention scenario, i.e., no introduction of Design Standard for Thermal Comfort. Anticipated metrics of performance include, • Annual Discomfort hours (Absolute), and, • Cooling Load (Notional).	**Step 1** Analysis of housing demand by region (state/climate zone) and typology will be compiled from secondary sources. Sanity checks will be conducted using population data sets.	
Performance data will be obtained from simulation of BAU case.	**Anticipated data sources include, Census 2011, National Commission for Population, Industry reports and MoHUA and MoHFW**	
Step 2 Similarly, the performance of a Thermally Comfortable Dwelling Unit, i.e., compliant with design standard will be evaluated for above mentioned performance metrics. Based on levels of performance outlined in the standard, several improvement scenarios may be evaluated.	**Step 2** A housing stock accounting model will be compiled. The stock accounting model will account for retirement of housing stock in the long term.	
Performance data will be obtained from simulation of various performance cases.		
	Step 3 Based on year-on year housing stock additional scenarios may be developed. In particular a Market Transformation Scenario may be modelled, which estimates gradual market transformation of BAU stock to Thermally Comfortable Stock over a period of time.	
		Step 4 The developed scenarios will be compared. The outcomes are anticipated to indicate performance outcomes by: • Typology • Climate Zone

		• State • Time slice Anticipated outcome metrics include, • Annual Discomfort hours (Absolute), and, • Cooling Load (Notional)

2.1 Residential Housing Stock

India is experiencing exponential growth in population, which coupled with rapid urbanization and increase in purchase power which has led to growth in residential stock. To carry out the impact assessment of the design standard, this exercise of estimating the growth in residential housing stock is an attempt to comprehend the residential building sector through various lenses. Based on the data from Census conducted in 2011 (Census 2011), the total urban residential stock in India was over 78 million households. The percentage state-wise distribution of number of households in 2011 has been presented in Figure 2.

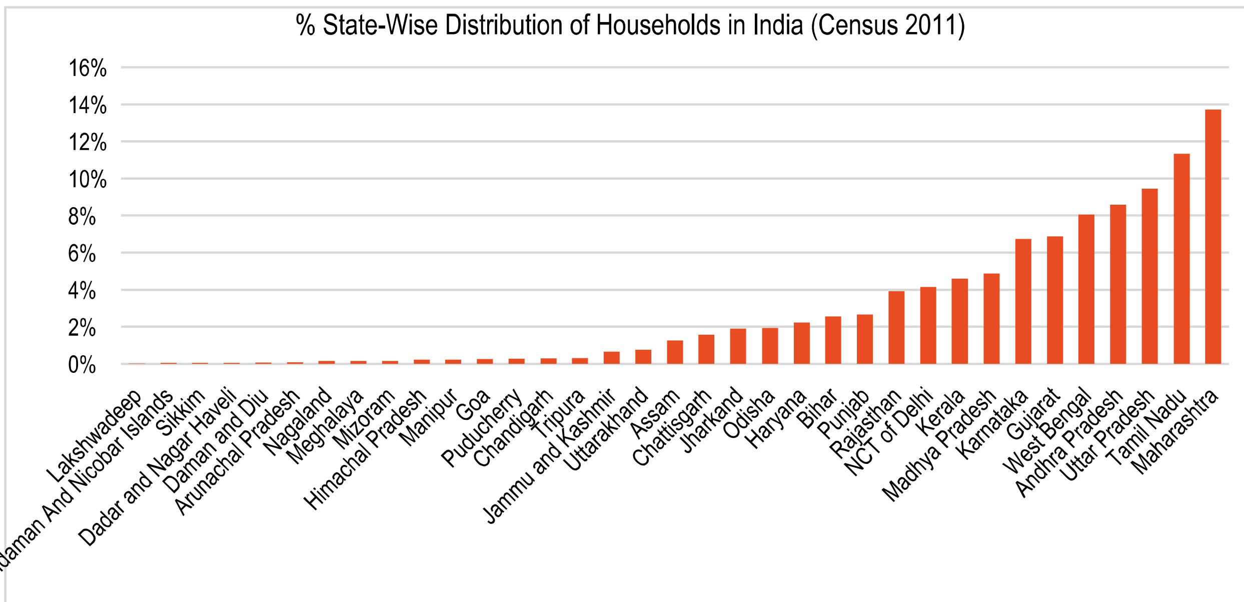

Figure 2 State-wise distribution of urban households in India (Census 2011)

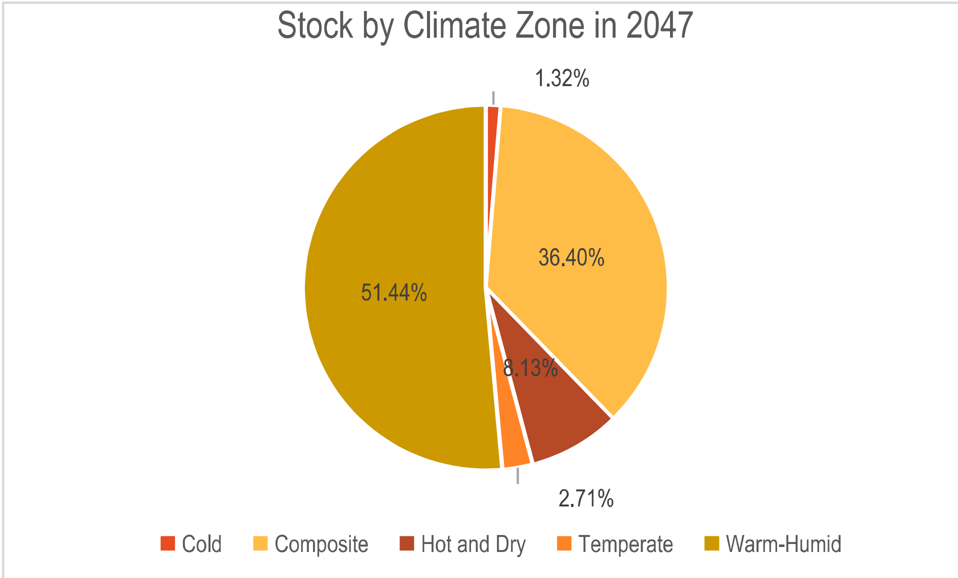

Figure 2 State-wise distribution of urban households in India (Census 2011)

2.1.1 Share of Economic Categories

To analyze the household stock at a granular level, the available stock data from Census 2011 has been classified under four economic categories i.e., EWS (annual income up to INR 3,00,000/-), LIG (annual income between INR 3,00,000 and INR 6,00,000/-), MIG I (annual income between INR 6,00,000/- and INR 12,00,000) and MIG II (annual income between INR 12,00,00/- and INR 18,00,000/-) (PMAY(U)). The classification of households into the four mentioned economic categories has been done on the basis of number of dwelling rooms in a household. Households with no executive room (NER) and one room (1R) dwellings have been listed under EWS category. Households with two dwelling rooms (2R) have been classified under LIG category while households with three dwelling rooms (3R) have been grouped under MIG I category. Finally, households with four and above dwelling rooms have been classified as MIG II income group households. Figure 3 highlights the categorization of percentage of households into different economic categories in states of India.

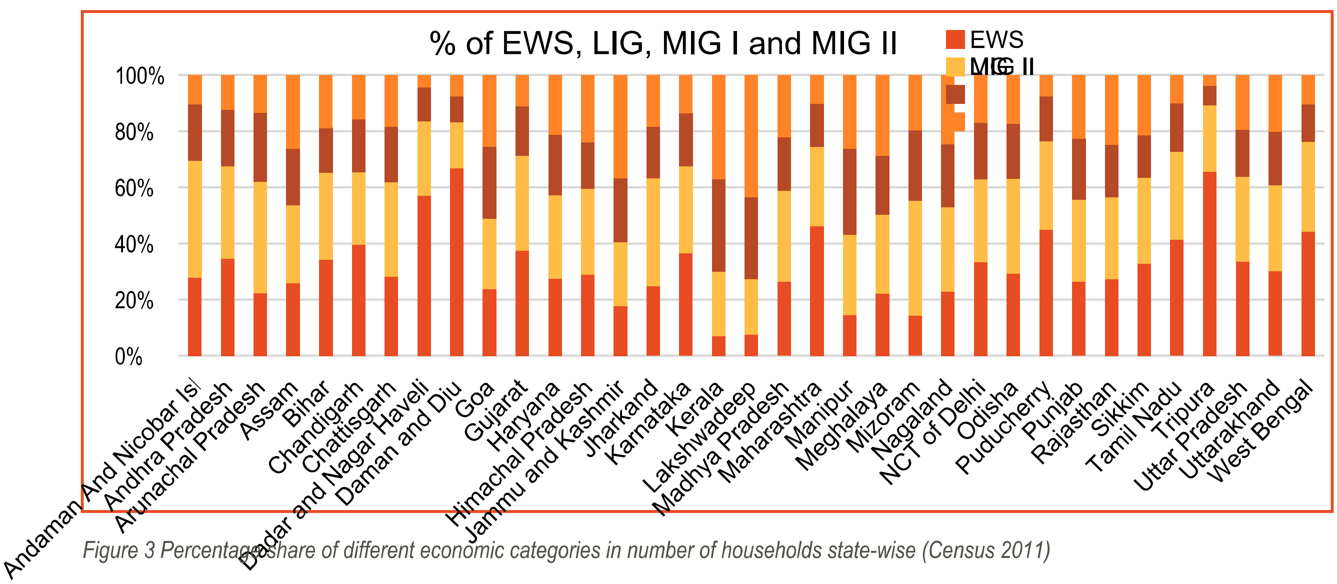

Figure 3 Percentage share of different economic categories in number of households state-wise (Census 2011)

2.1.2 Urban Household Stock Projections (2022-2047)

The growth rate of the number of households in India has been constantly decreasing. Based on the latest household data from Ministry of Statistics and Program Implementation (MoSPI), the growth rate between 2011-2012 was 2.2%. As per NITI Aayog IESS 2047 tool (version 3, 2023), the compound annual growth rate (CAGR) between 2012-2020 was 1.40%. To estimate the number of households between 2022 and 2047, projected growth in number of households has been referred from IESS 2047 to determine the 5-year CAGR between 2022 and 2047. IESS 2047 assumes four trajectories for growth of number of households in India namely;

i. Case 1 – number of households in the country are growing at a constant rate of 2.2% till 2047
ii. Case 2 – number of households in the country start declining post 2022 reaching 1.5% growth rate in 2047.
iii. Case 3 – growth rate of number of households in the country drop to 1% in 2047
iv. Case 4 – growth in the number of households in the country eventually reaches 0.5% in 2047

The projections for urban households and subsequently building stock have been estimated based on the four cases mentioned above. Figure 4 and 5 represent the 5-year CAGR and total number of urban households in India (millions) under the four cases considered.

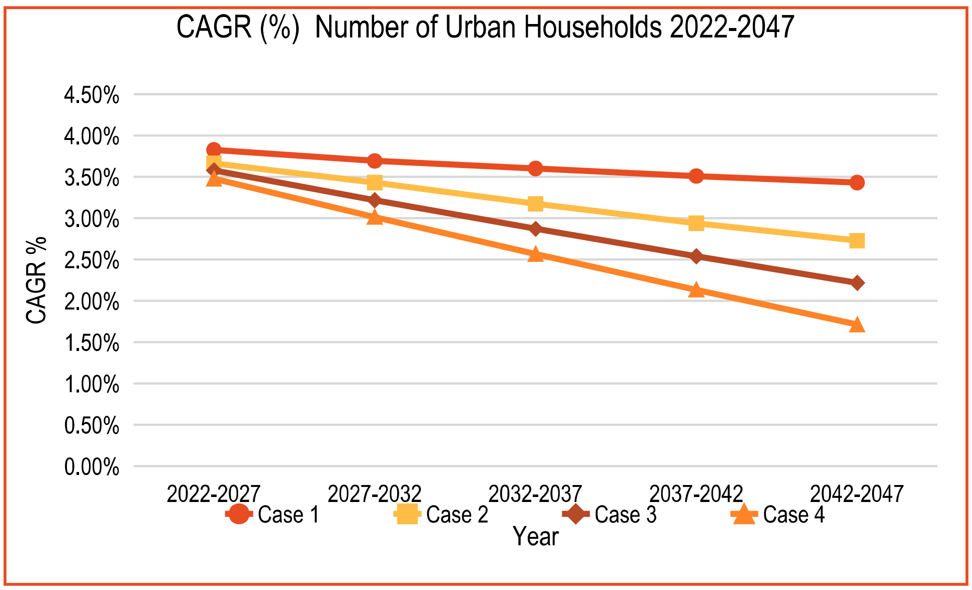

Figure 4 CAGR for number of urban households from 2022-2047 under four trajectories of growth rate

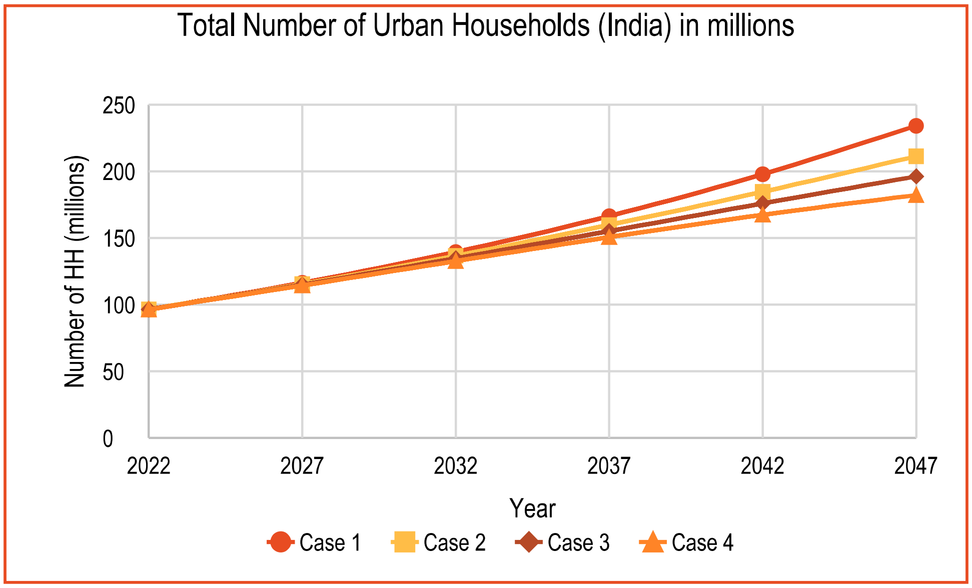

Figure 5 Total number of urban households in India (millions) between 2022-2047 under four trajectories of growth rate

Table 2 summarizes the number of households in India based on four considered trajectories of growth rate between 2022 and 2047

Table 2 Total urban households in India between 2022 and 2047 (millions)

Total Urban Households in millions (India)						
Cases	**2022**	**2027**	**2032**	**2037**	**2042**	**2047**
Case 1	96.49	116.40	139.53	166.51	197.85	234.20
Case 2	96.49	115.50	136.71	159.81	184.71	211.29
Case 3	96.49	115.02	134.74	155.22	175.93	196.31
Case 4	96.49	114.46	132.77	150.70	167.46	182.28

The projected number of urban households estimated in Figure 5 have been validated against IESS 2047 estimates of number of households for validation, and presented in Figure 6.

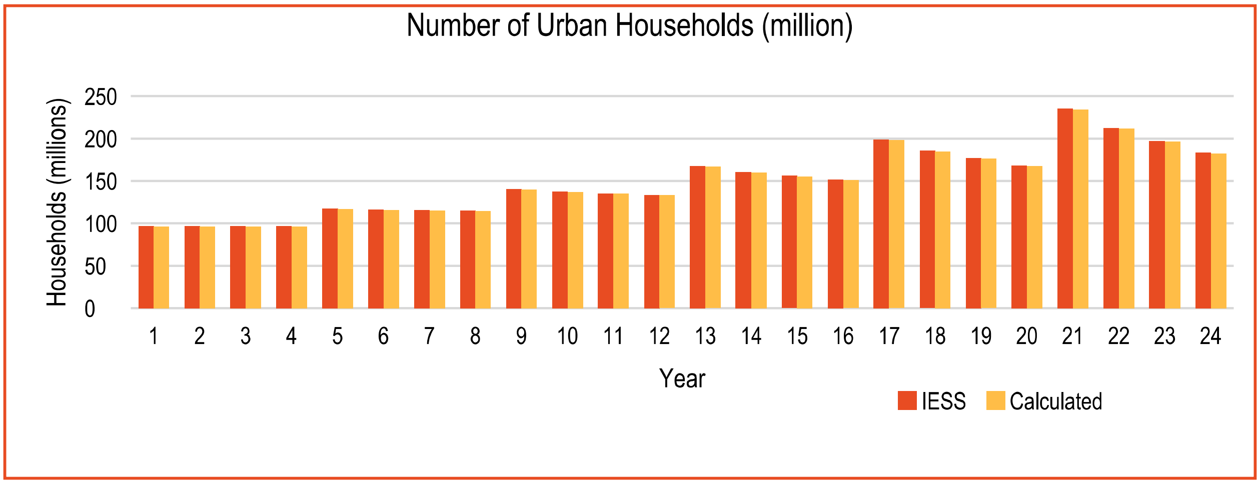

Figure 6 Projected urban households (millions) in India versus IESS estimates

2.1.3 Residential Floor Area Projections (2022-2047)

Based on the estimated number of urban households between 2022 and 2047, the projections for residential floor area for the same duration have also been estimated. Few critical assumptions have been taken to calculate the floor area projections and are listed below;

- The percentage of NER, 1R, 2R, 3R and ≥4R dwellings in total number of households have been assumed to be constant throughout the study period.
- For area calculations, minimum dwelling area, maximum dwelling area and average area has been determined. The assumptions for minimum area are based on General Building Requirement (MoHUA) where;
  - Minimum area of habitable room is equal to 7.5 sqm, area of kitchen is equal to 3.3 sqm and combined area of bath and W.C is equal to 2.8 sqm.
- The assumptions for maximum dwelling area are based on PMAY (U) guidelines limiting carpet area for dwelling based on income group.
  - For EWS, maximum carpet area of dwelling unit (DU) is 30 sqm
  - For LIG, maximum carpet area of DU is 60 sqm
  - For MIG I, maximum carpet area of DU is 160 sqm
  - For MIG II, maximum carpet area of DU is 200 sqm

The estimated residential floor area projections for 2022 – 2047 have been represented in Figure 7 and Table 3.

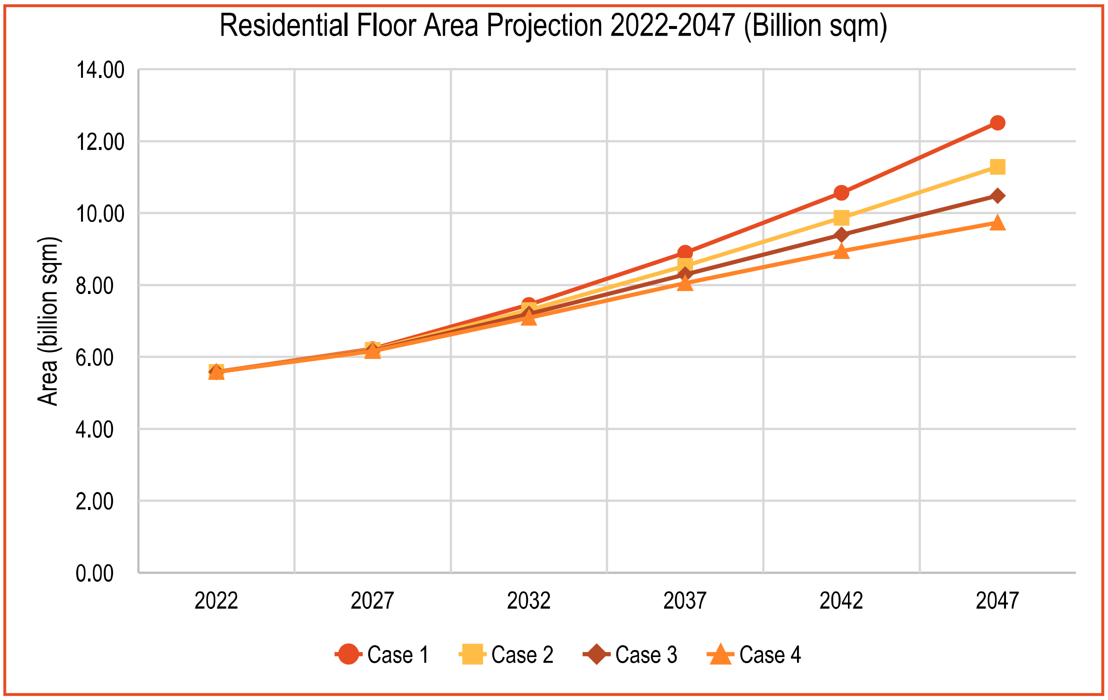

Figure 7 Residential floor area projections (billion sqm) for 2022 – 2047

Table 3 Residential floor area under four trajectories from 2022 – 2047 in billion sqm

Year	Case 1	Case 2	Case 3	Case 4
2022	5.58	5.58	5.58	5.58
2027	6.22	6.20	6.18	6.16
2032	7.45	7.30	7.20	7.09
2037	8.90	8.54	8.29	8.05
2042	10.57	9.87	9.40	8.94
2047	12.51	11.29	10.49	9.74

The derived projections for urban residential floor area for 2022 – 2047 has been validated against NITI Aayog's IESS data on urban residential floor area (IESS 2047), and comparative representation has been presented in Figure 8.

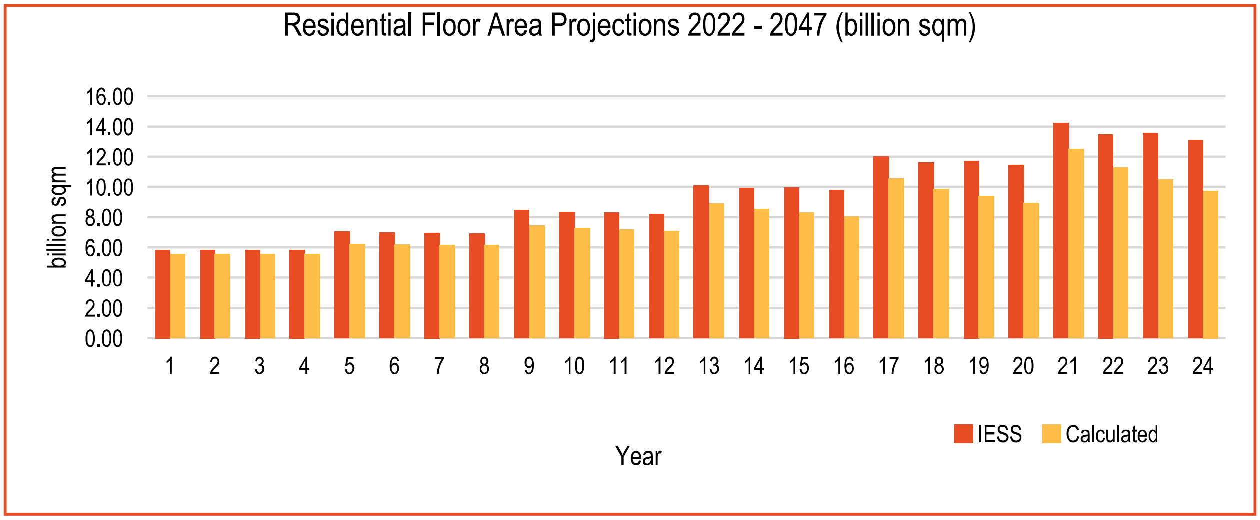

Figure 8 Projected urban residential floor area (billion sqm) versus IESS estimates for 2022 – 2047

The projections for residential housing stock have been estimated through critical assumptions based on literature review of government documents, reports and past data. The same has been validated against latest IESS 2047 projections to assess the suitability of the projections.

2.1.4 Projections of Residential Housing Stock for Affordable Housing

The primary beneficiaries of affordable housing policy are the urban poor from EWS and LIG communities. Based on projections for residential housing numbers up to 2047 presented in earlier sections, a state-wise distribution of expected number of households from the EWS and LIG communities is presented in Figure 9.

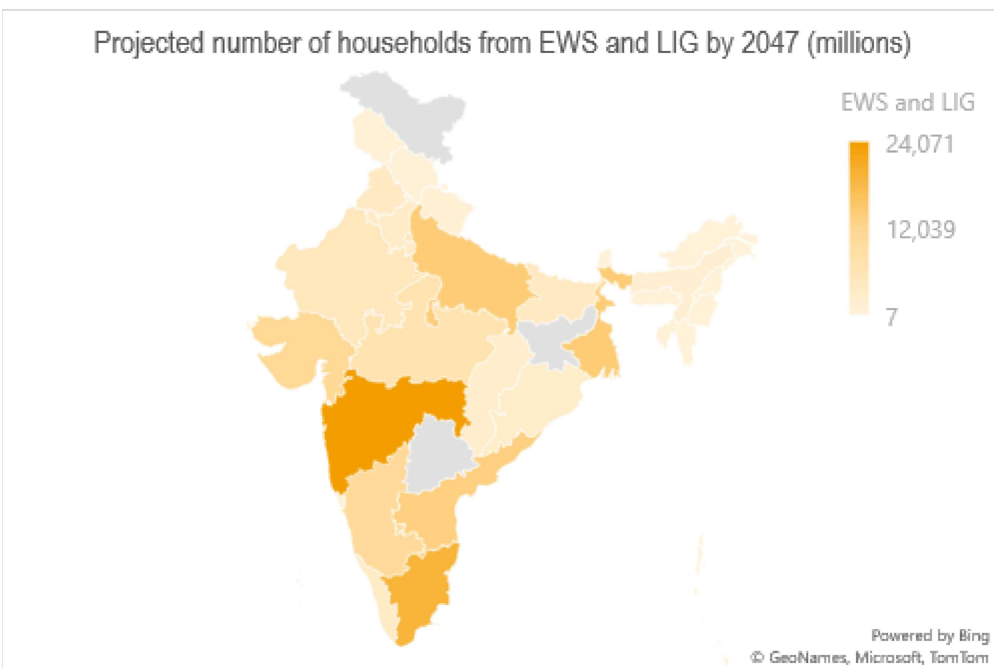

Figure 9 Projected number of households from EWS and LIG communities in 2047

From Figure 9, it can be seen that it is expected that states such as Maharashtra, Uttar Pradesh, Tamil Nadu, Andhra Pradesh (including Telangana), West Bengal etc., will comprise of the maximum population from the urban poor/migrant communities. These communities will be the prime focus of any policy development focused on affordable housing.

2.1.5 PMAY (U) Progress

The Pradhan Mantri Awas Yojana-Urban, has been implemented since June 2015 and aims to provide affordable and climate resilient housing to the urban poor for their socio-economic upliftment. The scheme has been proposed to cover the entire urban area of the country. Under this scheme, a large number of houses have been sanctioned in all states of the country, with a major portion of the sanctioned houses now completed as per latest data.

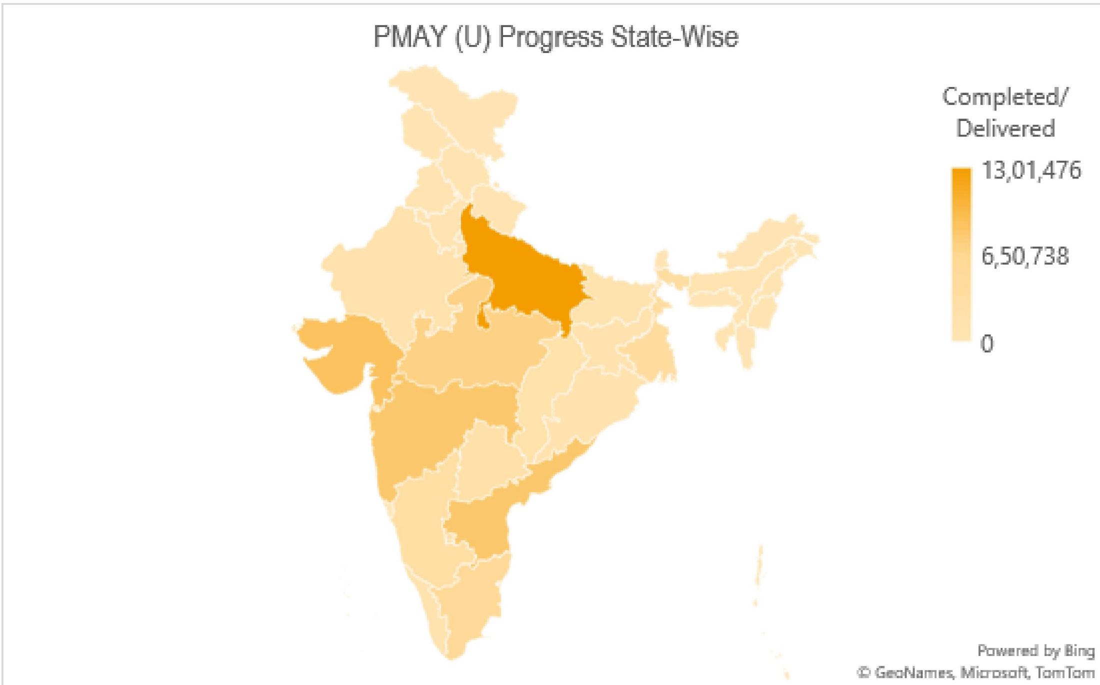

Figure 10 PMAY (U) state-wise progress as on 14th August 2023 (Source: PMAY(U)-Progress)

As per the latest data presented in Figure 10, it can be seen that primarily those states with highest number of EWS and LIG communities, as per Census 2011 and household projections, have recorded the highest number of completed houses. Uttar Pradesh, Maharashtra, Gujarat, Andhra Pradesh and Madhya Pradesh have seen the fastest progress in both sanctioning and completion of affordable housing projects. Throughout India, a total of over 118 lakh houses have been sanctioned under this scheme, with over 76 lakhs completed and delivered to the EWS and LIG communities.

2.2 Scenarios and Performance Parameters

Four performance scenarios have been modelled across different climate zones, namely;

1. BAU: The Business as Usual (BAU) case is representative of the current building stock. The BAU case assumes prevalent construction practices.
2. A: The A case outlines the minimum effort required to meet the comfort levels corresponding to "A" compliance.
3. A+: the A+ case outlines thermal comfort and energy performance beyond code minimum code requirements.
4. A++: The A++ case outlines maximum levels of thermal comfort achievable or best available technology scenario representative of maximum achievable thermal comfort.

For each of these scenarios, performance benchmarks of Energy Use Intensity (EUI) in kWh/m^2-yr, Peak Energy Demand (PED) in kW/m^2 has been compiled from extensive building performance analysis across climate zones. For reference, Table 4 indicates performance benchmarks for all scenarios for 1BHK typology in Composite climate zone.

Table 4 Performance benchmarks for 1BHK low rise typology in Composite Climate

Metric	Units	BAU	A	A+	A++
Energy Use Intensity (EUI)	kWh/m^2-yr	128.4	88.9	82.2	76.2
Peak Cooling Energy Demand	kW/m^2-yr	0.14	0.08	0.07	0.06
Peak Heating Energy Demand	kW/m^2-yr	0.07	0.04	0.04	0.03

2.3 Performance Metrics

Different performance metrics have been used to assess the impact of this standard on national energy consumption and financial impact of the proposed standard, mentioned hereafter.

2.3.1 Comfort Hours Improvement

The number of comfortable hours (C_{hours}) are the number of hours the indoor operative temperature falls within the 80% acceptability range. 80% acceptability range is defined as deviation of 3.6 °C around the neutral temperature (T_{neut}).

(1)

(2)

Improvement in comfort hours for each scenario is then determined with respect to the comfortable hours achieved using BAU scenario in the analysis. The comfort hours for each scenario have been determined without considering air conditioning in the residential unit, to assess the impact of passive design measures on the improvement in comfort of the occupants.

2.3.2 Energy Performance Metrics

All the scenarios model 100% building stock with respective benchmark. For example, 'A+' scenario models 100% stock with 'A+' performance benchmarks. Using equations (2) to (8), benchmark performance and stock information provides energy use, emission and energy demand metrics. For the calculation of GHG emission savings, the emission factor is assumed to be equal to 0.00082 tCO_2e. (CEA, 2022)

National Energy Use and Savings

(3)

(4)

National GHG Emissions and Abatement Potential

(5)

(6)

National Peak Energy Demand and Abatement Potential

(7)

(8)

2.3.3 Financial Performance Metrics

Along with performance metrics, the model evaluates financial savings in the national context. The model makes use of cost parameters to evaluate the cost of energy use and incremental cost of setting up thermal power-based infrastructure. In addition to this, the model allows updating financial parameters including respective cost escalation rates and discount rates as well. The cost of constructing stock in respective year and demand savings offset by energy efficiency are computed as Capital expenditure while the cost of energy use for stock is computed as operating cost. The cost of energy use and demand generated, along with cumulative savings for each scenario can be determined through equations (9) to (12).

Energy Use Cost and Savings Potential

(9)

(10)

Investment in Demand Infrastructure Savings Potential

(11)

(12)

The financial impact assessment has been conducted using certain assumptions. The tariff has been assumed to be equal to Rs 3/ kWh, considering tariffs across different states of the country (CEA, 2021) and taking into consideration that the analysis is conducted for 1BHK low -rise, which normally will consume electricity in the assumed tariff range. Furthermore, the cost of setting up a coal based thermal power plant is assumed to be Rs 40,000 per kW of energy demand.

3 Outcomes

The compiled impact assessment considers a time frame of 2022-2047, till the 100th year of Independence. Only new building stock entering the market within this time frame has been used for the analysis. Business as Usual (BAU) has been set as the baseline scenario for comparison with proposed A, A+ and A++ scenarios. The performance of residential building stock has been evaluated in context of national energy use and savings. This report highlights energy and financial performance across metrics introduced in Section § 2.3. The outcomes of the impact assessment have been categorized on the basis of Energy Savings potential and Financial Savings potential.

3.1 Comfort Hours Improvement

The relative improvement in comfortable hours achieved is tabulated in Table 5. Level A shows relatively good improvement in comfort hours over BAU, while significant improvement can be observed for Level A++. In terms of climate conditions, maximum improvement in comfortable hours was observed for Cold climates due to relatively low year-round temperatures, followed by Composite climate.

Table 5 Comfort hours improvement over BAU

Climate	Level A	Level A+	Level A++

Cold	28.7%	37.3%	54.4%
Composite	18.6%	29.3%	41.4%
Hot and Dry	14.5%	19.4%	23.9%
Temperate		11.4%	13.6%
Warm-Humid	8.8%	12.7%	15.3%

3.2 Energy Savings Potential

The outcomes of implementation of A, A+ and A++ have been compared against the Business as Usual (BAU) scenario. It is expected that A++ will provide significant improvement in energy use savings as well as emission reduction along with demand abatement potential. However, this improvement in energy use savings for each case needs to be seen in the perspective of financial performance as well.

3.2.1 Energy Use Savings

The energy use savings for all scenarios over BAU case has been presented in Figure 11. The Level A scenario indicates cumulative savings of over 25,000 BU till 2047, while Level A++ scenario has a technical potential of over 35,000 BU compared to BAU scenario.

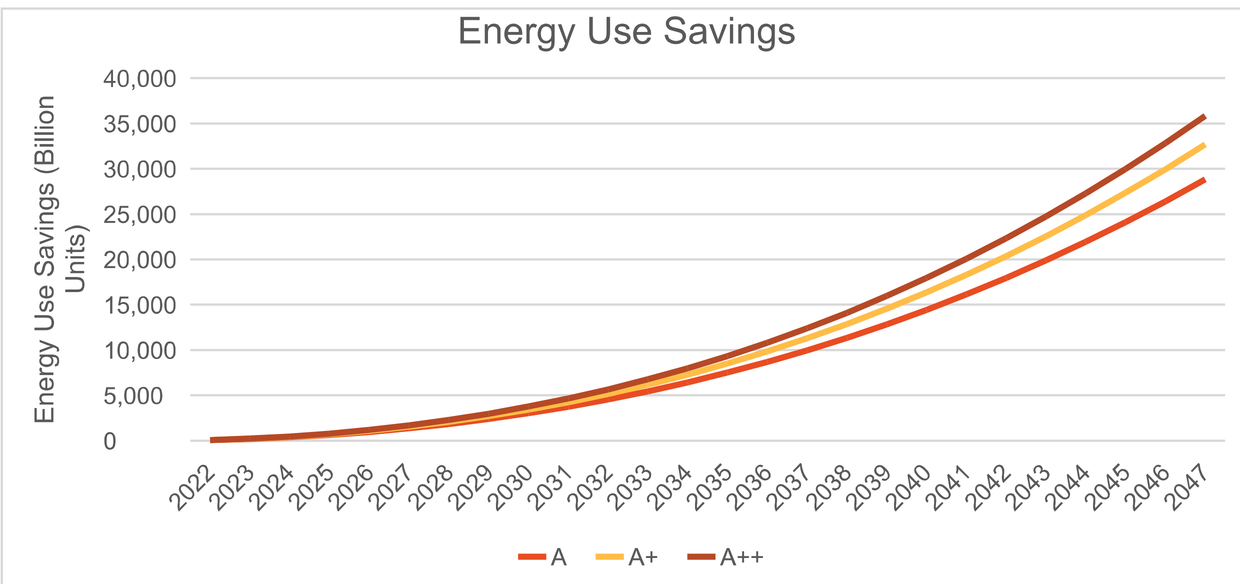

Figure 11 Energy savings potential for A, A+ and A++ over BAU

In terms of climate zone, a major portion of the country is spread across Composite and Warm and Humid climate. The technical potential of the code to achieve energy use savings across different climate zones of the country is represented in Figure 12. Maximum potential for savings is possible in Warm and Humid as well as Composite climate zones. The least potential for energy use savings is expected in Cold climates, owing to lower EPI and lower residential stock.

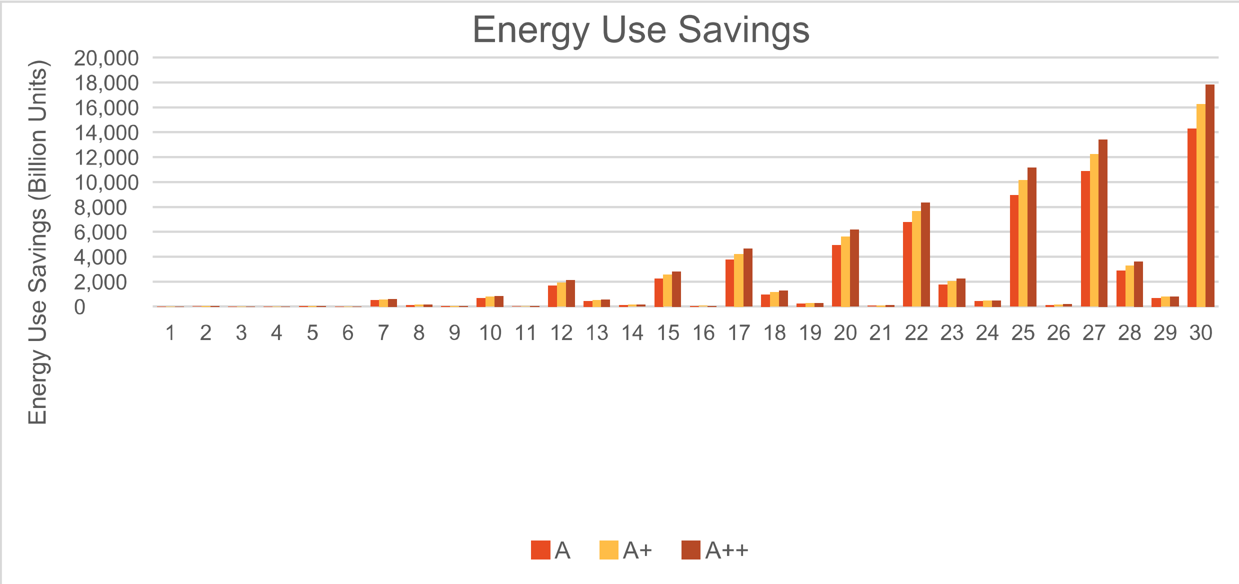

Figure 12 Energy savings potential for A, A+ and A++ over BAU for different climate zones

3.2.2 Demand Abatement Potential

The code shows a technical potential for both cooling and heating demand abatement potential, in Levels A, A+ and A++ over BAU scenario. The national cooling and heating demand abatement potential for Levels A, A+ and A++ is presented in Figures 13 to 16. Level A provides a cooling demand abatement potential of up to 50 TW and up to 11 TW of heating demand abatement potential.

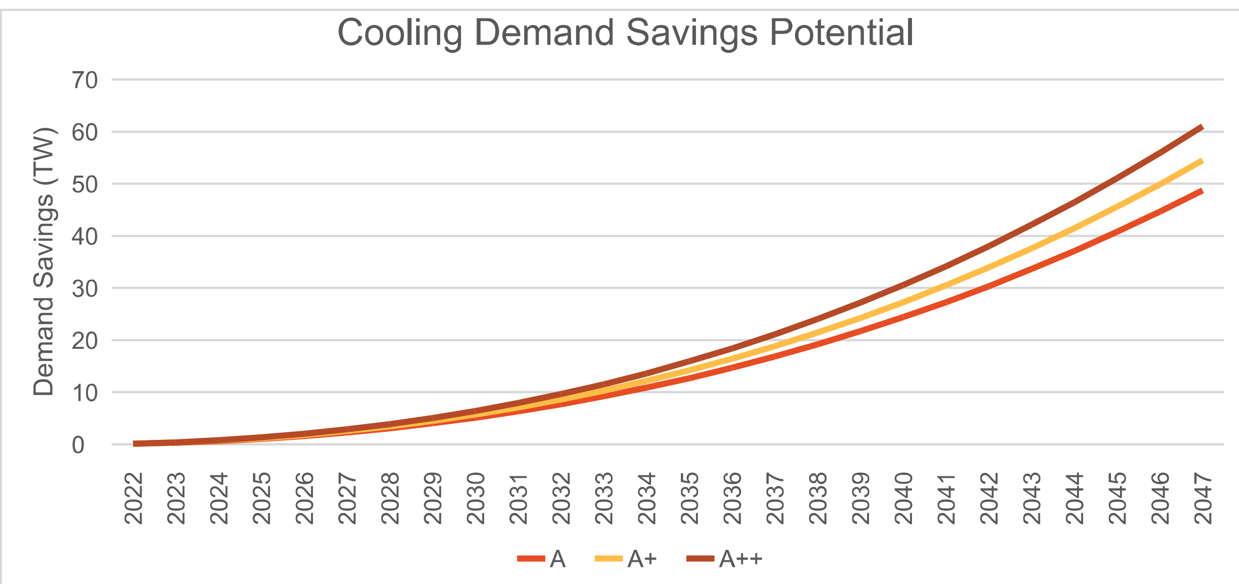

Figure 13 Cooling demand saving potential for A, A+ and A++ over BAU

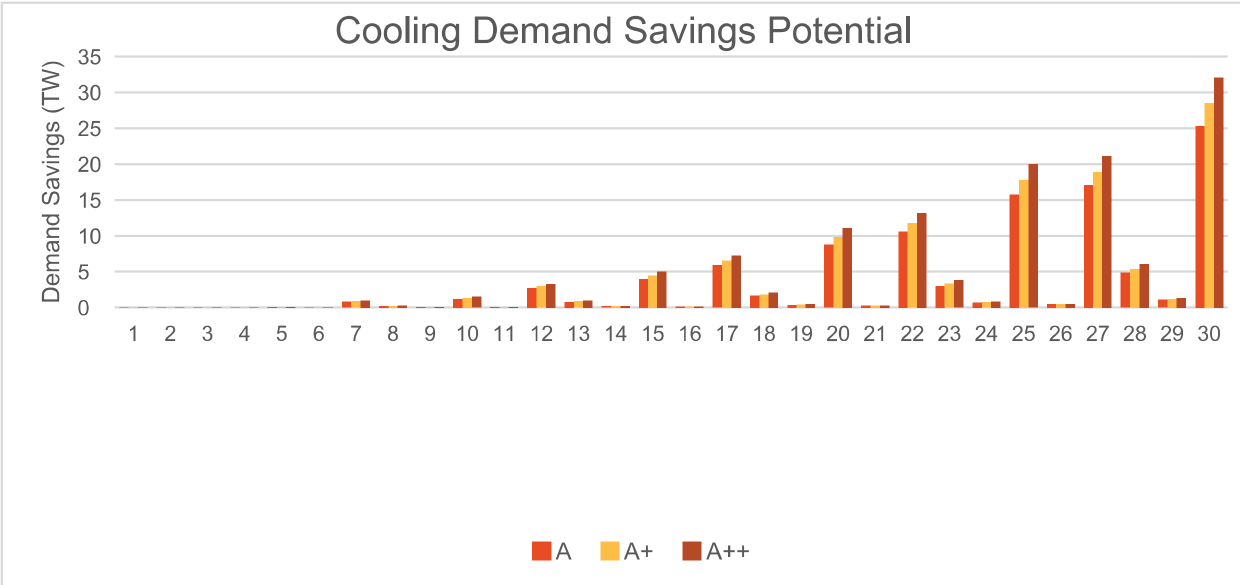

Figure 14 Cooling demand saving potential for A, A+ and A++ over BAU for different climate zones

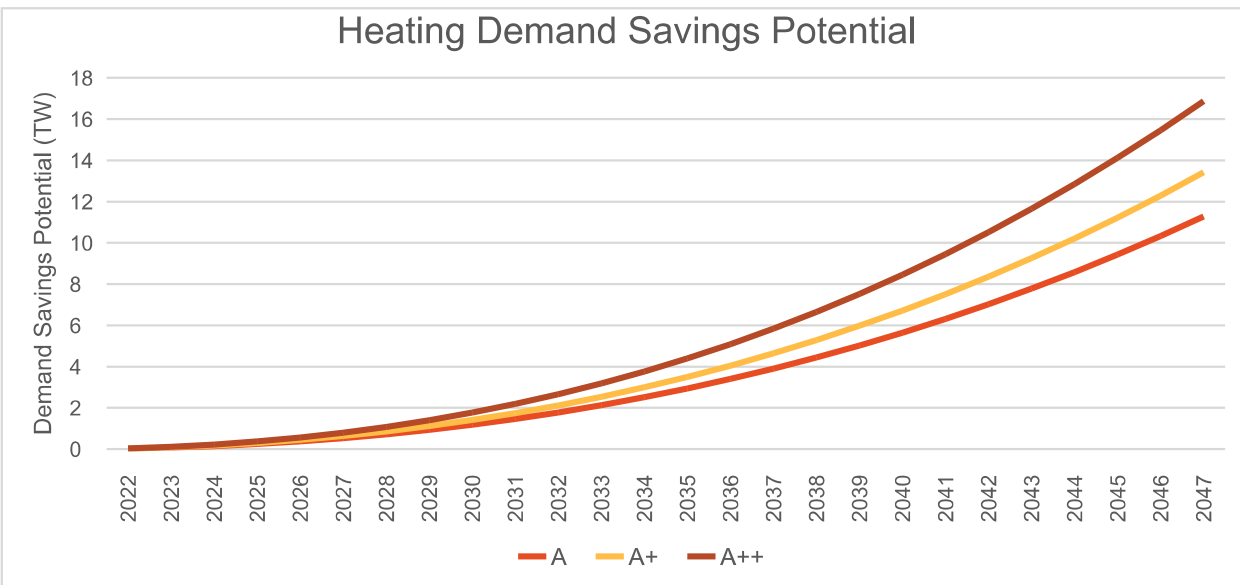

Figure 15 Cooling demand saving potential for A, A+ and A++ over BAU

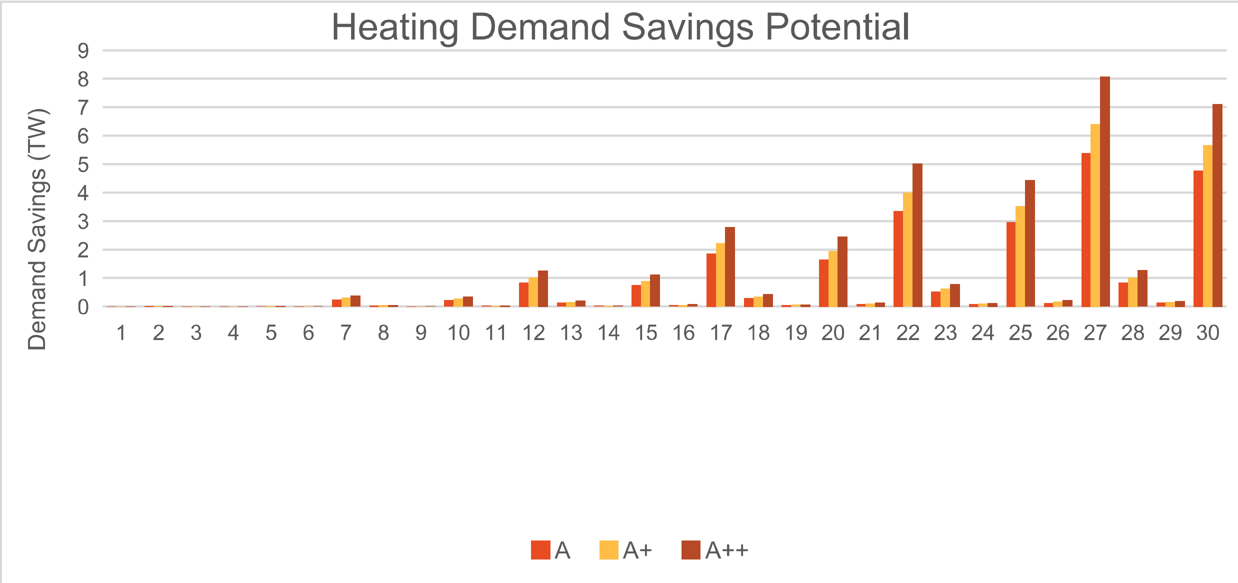

Figure 16 Cooling demand saving potential for A, A+ and A++ over BAU for different climate zones

In terms of climate classification, similar to Energy Use savings, the highest demand abatement potentials are seen across Composite and Warm-Humid climates. Higher cooling demand abatement potential of Level A of up to 27 TW in 2047 is seen in Warm-Humid climate, while Composite climate is expected to achieve a higher heating demand abatement of 7 TW by 2047.

3.2.3 GHG Abatement Potential

Figure 17 highlights the potential for Levels A, A+ and A++ to achieve cumulative reduction in emissions over the BAU case up to 2047. Reductions in emissions over BAU case is possible due to potential savings in Energy use, seen in Figure 11. The GHG abatement follows a similar trend as Energy Use savings. The Level A scenario is expected to achieve emissions reductions up to 24 mtCO_2e by 2047.

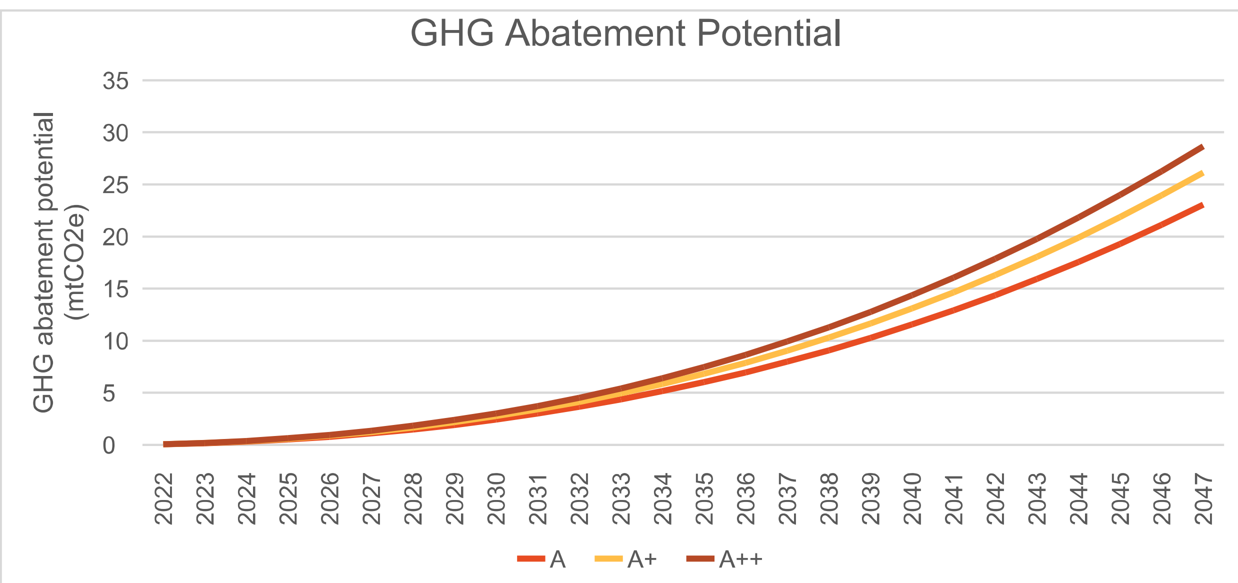

Figure 17 GHG emissions abatement potential for A, A+ and A++ over BAU

3.3 Financial Savings Potential

The outcomes for energy savings potential project Level A++ as the scenario of highest savings potential. While level A++ outperforms other scenarios in terms of energy savings and emissions abatement, financial implications are likely to affect its uptake. In this section, financial metrics such as energy use cost (operational costs) and demand infrastructure setup costs (capital costs) have been explored along with potential improvement in savings to outline to financial benefit of the standard. The financial analysis assumes all energy use as electricity based. Furthermore, for calculating the demand infrastructure savings, the source of power is assumed to be coal based thermal power plant.

3.3.1 Energy Use Cost Savings

Level A++ eclipses all other scenarios in terms of energy use cost savings owing to maximum potential of energy use savings, which can be seen in Figure 18. Energy use cost savings across all scenarios over BAU have been represented in the figure.

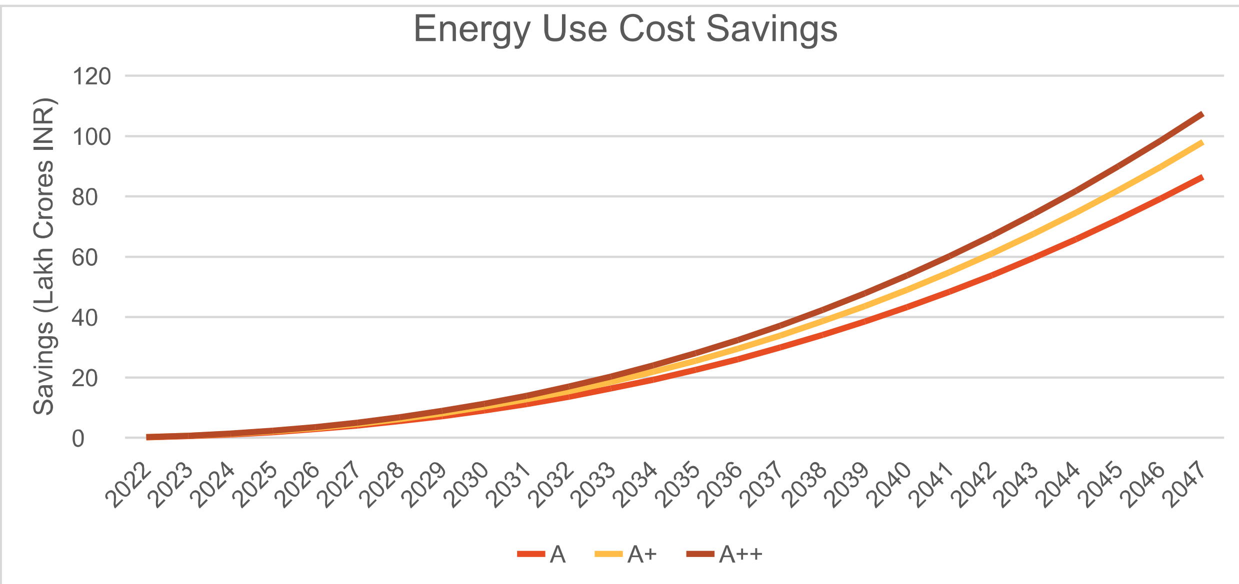

Figure 18 Energy use cost savings potential for A, A+ and A++ over BAU

Nearly identical monetary savings potential can be seen in Composite and Warm-Humid climates in Figure 19, while Cold and Temperate climates have negligible impact on the energy use savings potential.

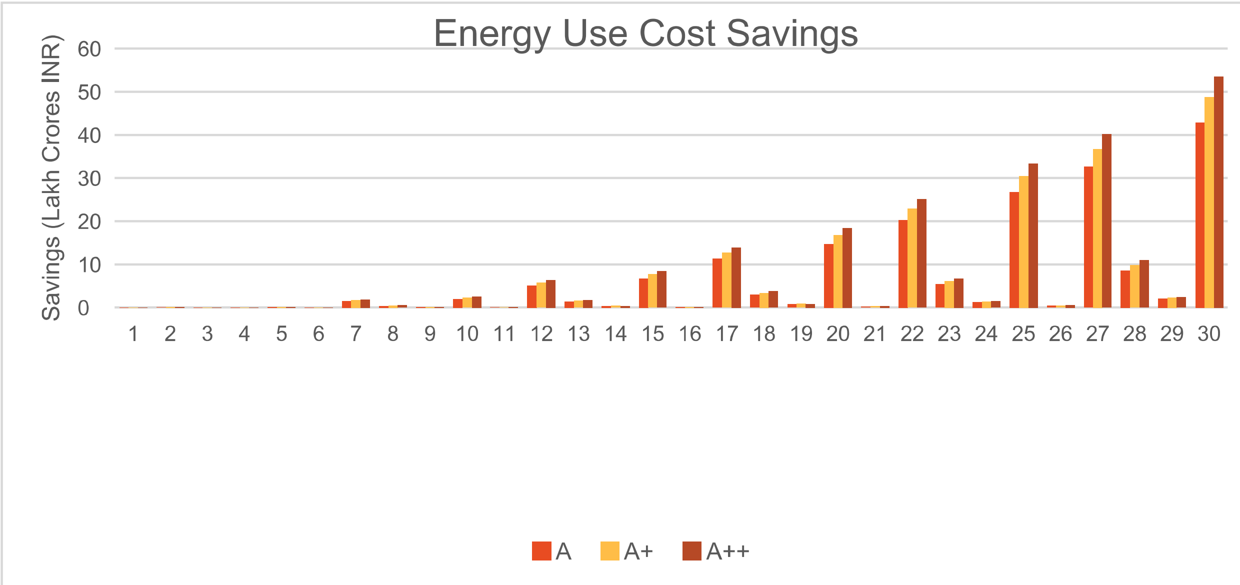

Figure 19 Energy use cost savings potential for A, A+ and A++ over BAU for different climate zones

3.3.2 Demand Infrastructure Cost Savings

The demand infrastructure savings represent the cost of infrastructure avoided due to demand reduction. The demand infrastructure savings have been determined on the expected yearly incremental demand and presented in Figure 20. Up to INR 200 lakh crores of savings is expected up to 2047.

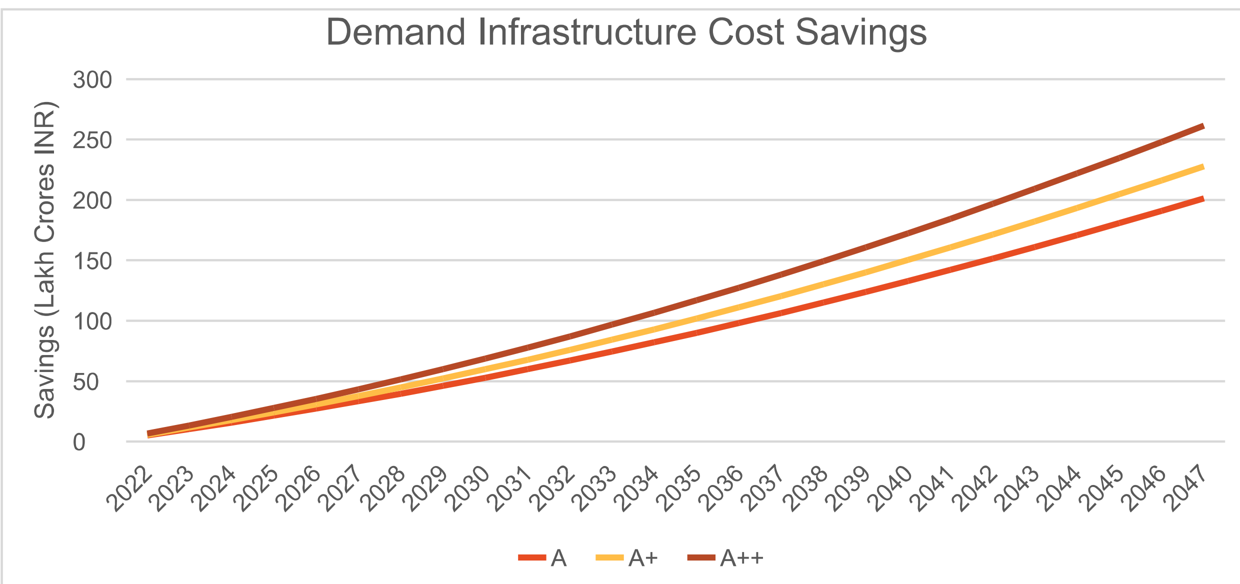

Figure 20 Demand infrastructure cost savings potential for A, A+ and A++ over BAU

In terms of climate zone, maximum savings in investments can be expected for Warm-Humid climate, followed by Composite climate zone. The comparative savings potential is presented in Figure 21.

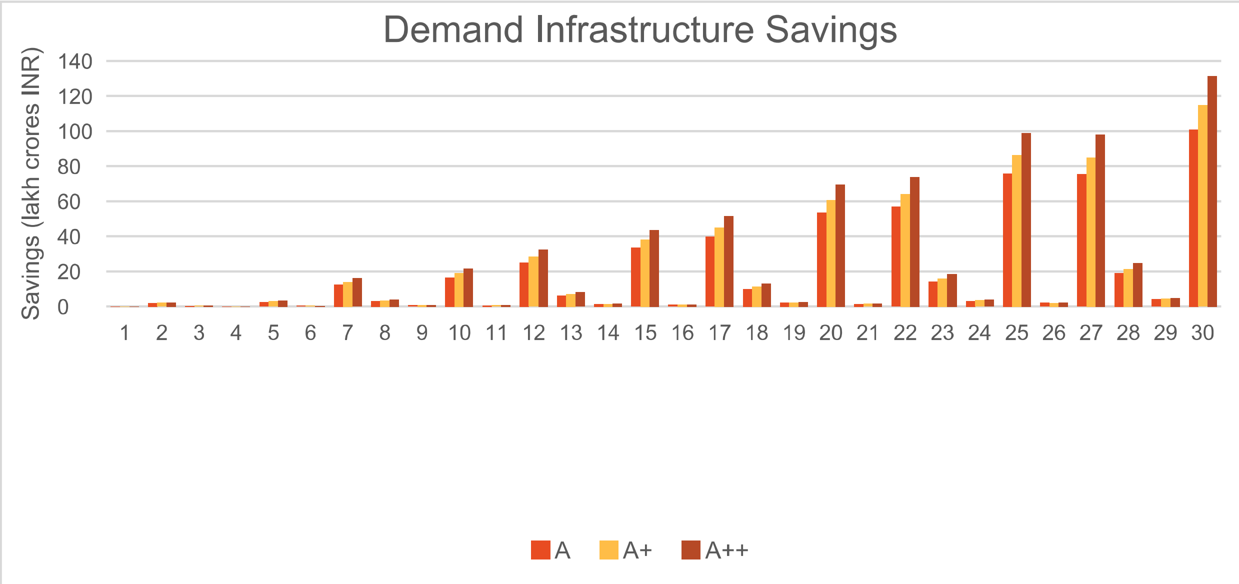

Figure 21 Demand infrastructure cost savings potential for A, A+ and A++ over BAU for different climate zones

Conclusion

The outcomes of the impact assessment conducted for 1BHindicate that implementing Level A code compliance will help achieve energy use savings of up to 29,000 BU by 2047, with a cooling demand abatement potential of 50 TW. The BAU and Level A energy use performance and potential savings are compared and presented in Table 6.

Table 6 BAU and Level A comparative performance and savings potential

Parameter	Unit	2047		
		BAU	Level A	Savings Potential
Energy Use	Billion Units	79,743	50,920	28,823
GHG Emissions	$mtCO_2e$	63.80	40.74	23.06
Energy Demand	TW	99.07	50.34	48.74

Outcomes by categorization indicate that in Warm-Humid climate and Composite climates, maximum potential of energy savings and demand abatement can be achieved, presented in Table 7.

Table 7 Outcomes by categorization

Parameter	Units	Climate Zone	Savings Potential
Energy Use Savings Potential	Billion Units	Warm-Humid	14,228
Energy Demand Abatement Potential	TW	Warm-Humid	25.30

The impact assessment carried out indicates that Level A implementation scenario provides return on investment within the time frame of the analysis. Level A++ provides the maximum potential for energy use savings, emission reduction, demand abatement and financial savings in the analysis time frame.

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