Technical Report

GBPN
Global Buildings Performance Network

Building Policies for a Better World

MITIGATION POTENTIAL FROM INDIA'S BUILDINGS

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ACKNOWLEDGEMENTS

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FOREWORD

India doubled its floor area of buildings between 2001-2005 and is experiencing the fastest rate of growth in new building in the world. Based on 2005 data, by 2050, India will have added about 35 billion m^2 of new building floor area. Most of this growth will occur in urban residential buildings, a typology for which no energy performance regulations currently apply. At the same time electricity demand is expected to increase six-fold by 2030 to reach 30% of households that currently don't have electricity.

Without urgent development and implementation of policy packages that ensure the construction of energy efficient new buildings, and particularly new residential buildings, the energy required to provide thermal comfort and hot water to residential buildings could increase by a factor 8 by 2050. This translates to a potential growth in energy related GHG emissions of 1.2Gt of CO_2. However, it is technically possible to achieve deep energy savings and CO_2 mitigation.

As this report details, there are a range of actions being taken by the government and practitioners to address these issues – but the rate of urbanization, lack of performance data, and India's cultural and economic complexity presents a unique set of challenges to rapid implementation of the kinds of policy interventions necessary to achieve deep reductions in building energy consumption and associated CO_2 emissions. However, by following state-of-the art policy strategies and incorporating traditional and contemporary technology and ideas growth in energy consumption could be reduced to about a factor 2 increase by 2050.

The environmental benefits of more energy efficient Indian buildings and cities are important, but perhaps more significant are the potential social and economic benefits of reducing the energy dependence of homes and businesses. Reducing energy demand of buildings increases the choices people have in how energy services can be provided. This in turn improves the resilience and prosperity of communities. These qualities are the foundations for sustainable development in India.

GBPN is developing a range of programs to address the priority issues identified in this report and we look forward to working with partners in India and internationally to build the foundations of a sustainable energy path for Indian buildings. I therefore commend this report to you.

Peter Graham
GBPN Executive Director

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ACKNOWLEDGEMENTS

A large part of the research for this report comes from two major studies contracted by the GBPN. The GBPN commissioned the Lawrence Berkeley National Laboratory (LBNL), United States, to identify and analyse the best performing building energy policies implemented today and the Central European University (CEU) Center for Climate Change and Energy Policy, Hungary, to determine the best-possible CO_2 mitigation scenarios globally and in each of our target regions.

GBPN would like to thank the principal authors of the research reports and their teams: Dr. Mark Levine (principle author of the LBNL report) and Dr. Diana Ürge-Vorsatz (principle author of the CEU report). They were supported by excellent teams that deserve much credit.

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LIST OF ACRONYMS

3CSEP - Center for Climate Change and Sustainable Energy Policy
AAGR - annual average growth rates
ADaRSH - Association for Development and Research of Sustainable Habitats
BEE – Bureau of Energy Efficiency.
CEA - Central Electricity Authority
CEU - Central European University
CO$_2$ - Carbon dioxide
COA – Council of Architecture
CSE – Centre for Science and Environment
ECA – Energy Conservation Act
ECBC – Energy Conservation Building Code
ECO-III - Energy Conservation and Commercialization Project - Phase-III
EJ – Exajoules
ERB - High Efficiency Buildings
EU – European Union
GBPN – Global Buildings Performance Network
GDP – Gross domestic product
GHG – greenhouse gas
Gt – Gigaton
GRIHA - Green Rating for Integrated Habitat Assessment
HERS - Home Energy Rating System
IEA – International Energy Association
IGBC – India Green Building Council
kVA - kilovolts-ampere
kW – Kilowatt
kWh - Kilowatt-hour
LEED - Leadership in Energy & Environmental Design
LEED India - Leadership in Energy & Environmental Design for India
MNRE - Ministry of New and Renewable Energy
Mt - Million-ton
Mtoe - Million ton of oil equivalent
NBC - National Building Code
SDA - State Designated Agencies
SVAGRIHA - Small Versatile Affordable GRIHA
TDO - Town Development Offices
TERI - The Energy and Resource Institute
ULB - Urban Local Bodies
US -United States
USAID - United States Agency for International Development
USGBC – United States Green Building Council
WGBC – World Green Buildings Council

EXECUTIVE SUMMARY

India's Mitigation Potential

By 2050, it is projected that India will see an unprecedented escalation of floor area of around 400% (Urge-Vorsatz et al., 2012). Buildings are responsible for around 35% of India's total energy consumption, and this is increasing by 8% year-on-year (Rawal, Vaidya, Ghatti & Ward, 2012). It is imperative for the Indian building sector to manage its projected growth in a sustainable fashion. The growth of India's urban areas, both projected and existing, must be supported by clean energy solutions in order to manage the dramatic impact of energy consumption.

The future of India's building energy usage is unclear and will depend on the political will of the government and building sector stakeholders. Today's current trends show that, without a transformational change, energy consumption of buildings will increase to levels that are unsustainable and threatening to India's energy security. However, improving the energy performance of existing and new buildings can have a major role in managing energy and CO_2 emissions.

A scenario analysis commissioned by Global Buildings Performance Network (GBPN) and produced by the Center for Climate Change and Sustainable Energy Policy (3CSEP) of the Central European University (CEU) estimated that India's growth could easily see an increase in building energy consumption and CO_2 emissions of around 700% by 2050 if left unchecked. However, by following an ambitious path, this could be reduced to an increase of Gt of CO_2 of 200% (Urge-Vorsatz et al., 2012). Nevertheless, considering the growth of population, floor area, comfort levels and migration to cities, keeping CO_2 emissions under a 200% increase compared to 2005 levels will be a huge task.

Ambitious efforts are required to introduce state-of-the-art policies and technology to India so that the potential energy savings will not be missed. A large-scale market uptake of best practice, state-of-the-art policies and supporting packages are essential if India wants to secure its future energy needs.

Policy Framework in India

This report explores India's current political status regarding building performance. Following current practice will not reduce energy demand or associated CO_2 emissions from buildings. However, it has found that India has recently begun to show interest in improving the energy performance of its buildings. However, India needs a strong policy framework to put its ideas into action. This is, in part, complicated because of the division of responsibilities under its constitution. There are some areas that are controlled by the central government, with others being the responsibility of the individual states.

In 2001, the Government of India passed an Energy Conservation Act (ECA); The Bureau of Energy Efficiency (BEE) was then established in 2002 to advance policy with an emphasis on self-regulation and market ideals. The principal objective of the BEE is to moderate energy intensity of the Indian economy by delivering governance in buildings. In 2007, India approved its first building code that related to improved energy performance.

Energy Conservation Building Code (ECBC)

In 2007, the BEE released a nationwide commercial building energy-efficiency code, the Energy Conservation Building Code (ECBC) and revised it in 2008 to cover an extended number of buildings. In 2004 it was estimated that full compliance would realise energy savings of 1.7 billion kWh each year (Liu, Meyer & Hogan, 2010), the savings are now argued to be much greater than originally estimated (Kumar, 2013). To achieve this the ECBC must be adopted by the states; however, the code remains voluntary until it is adopted into the by-laws of the individual states.

The ECBC sets minimum energy standards for new commercial buildings or building complexes with connected loads that are greater than 100 kilowatts (kW) or 120 kilovolts-ampere (kVA) (Bureau of Energy Efficiency, 2011). In principle the ECBC applies to residential complexes with the same connected load. However, in practice the code is concerned largely with commercial buildings. This ECBC applies to large-scale commercial retrofits where the final air-conditioned space of the building is greater than 1,000 m^2.

The ECBC has yet to be adopted by most of India's states and therefore the majority of India's new commercial buildings are not built under the requirements of the ECBC. However, the BEE have outlined particular areas where the code could become mandatory, so far, two states (Rajasthan& Odhisha) have already mandated the ECBC, six others (Gujarat, Karnataka, Punjab, Kerela, Uttar Pradesh & Uttarakhand) have initiated the process and seven additional states (MP, Haryana, Chhattisgarh, Andhra Pradesh, Tamil Nadu, West Bengal & Maharashtra) have been identified as focus states by the BEE for the year 2012-13 (Chandiwala 2013).

Labelling and Certification

There are several voluntary building labelling and rating schemes used in India and their market uptake is slow. Most labelled buildings belong to governments or large corporations and most of these rating schemes are not designed primarily to rate the energy performance of buildings and do not provide consumption targets for new buildings (CSE, 2012).

Indian Green Building Council (IGBC) and Green Rating for Integrated Habitat Assessment (GRIHA) are the most popular in the marketplace and address many issues such as materials, water consumption, and environmental and human health, rarely including building energy use. The BEE's Star Rating System evaluates existing buildings based on operational energy use and is the only energy-use-specific building label used in India.

Considering rating and labelling systems in India are voluntary, the call for buildings to be compliant with a rating system requires motivation due to the perceived conception that green buildings require large investment. The Indian government, through incentives or subsidies, is now backing rating and labelling schemes. However, this calls for the performance data of the rated buildings to be accountable, transparent and reliable. It is very important for buildings in India to be monitored; this demonstrates that the rated buildings are of high performance.

Incentive Programmes

India has promulgated a variety of national incentives and financing schemes for energy-efficiency measures in industry yet only one national-level incentive scheme exists for buildings: the Ministry of New and Renewable Energy (MNRE) incentive programme for GRIHA-rated buildings. This programme provides incentives to several stakeholders involved in GRIHA projects and other certified projects in India.

Government financial incentives and public financing options are rare and still in early development. The financial industry seems to be far from a widespread uptake of efficiency financing. This is due to apprehensions about a lack of demand. There is very little is documented evidence regarding the outcomes of present building energy-efficiency incentives on actual building energy use (CSE, 2012).

What conclusions can be drawn?

Currently there is a building construction boom occurring in India that is predicted to continue into the long-term future. This research shows that following today's practices will not reduce energy demand or associated CO_2 emissions from buildings in India. Existing policies therefore need to be made much more ambitious.

With state-of-the-art technology and policy measures implemented, it will be possible to reduce the absolute final thermal energy use in the Indian building sector dramatically by 2050. The savings potential is more than 5 times greater than the energy used by buildings in India today. If no action is taken it is predicted that India may face a growth in thermal energy demand in buildings of around 700 % (20.6 EJ).

Although India has gradually started to introduce energy efficiency solutions in their building sector and the national government has designed an energy efficiency building code together with several tools and strategies to assist with local adoption, these efforts must be improved in order to realise the potential energy savings India holds. India's building sector must be supported by strong policies and packages that include multiple facets of development and up scaling of energy efficiency in both new and existing buildings.

Successful implementation of optimum energy codes is essential to provide India with comfort levels, energy security and CO_2 savings. Financial incentives should back up codes and labelling systems as part of an energy-efficiency policy package.

INTRODUCTION TO INDIA AND THE GBPN REGIONS

The GBPN and its four key regions

The building sector holds a huge potential to significantly reduce greenhouse gas (GHG) emissions. For this reason the Global Buildings Performance Network's (GBPN) mission is to significantly reduce GHG emissions associated with building energy use. The GBPN will work in the four regions – China, Europe, India and the United States – which collectively account for about 65% of the buildings sector's carbon mitigation potential globally (Urge-Vorsatz et al., 2012).

Importance of Building Energy Use to Reducing Global CO_2 Emissions

Confronted by climate change, countries around the world are searching for effective ways to reduce their GHG emissions. Buildings are the largest single contributor to global GHG emissions; accounting for around one third of the global final energy use and 30 per cent of global energy-related carbon emissions (Urge-Vorsatz et al., 2012).

The building sector can provide huge energy savings. New low-energy buildings and deep retrofits can offer cost, energy and emissions savings as well as comfort and health benefits. Retrofit strategies can also create important jobs.

Global energy use and CO_2 emissions have been growing continuously in the past decade, as seen in Figure 1.1. Trends in CO_2 emissions vary significantly around the world. Between the years of 1971 and 2009 emissions in India and China have increased rapidly with annual average growth rates (AAGR) of 6.6% and 5.5% respectively. This is much greater than the CO_2 emission rates in in the EU and US, which have increased with AAGR of 1.1% and 0.4%.

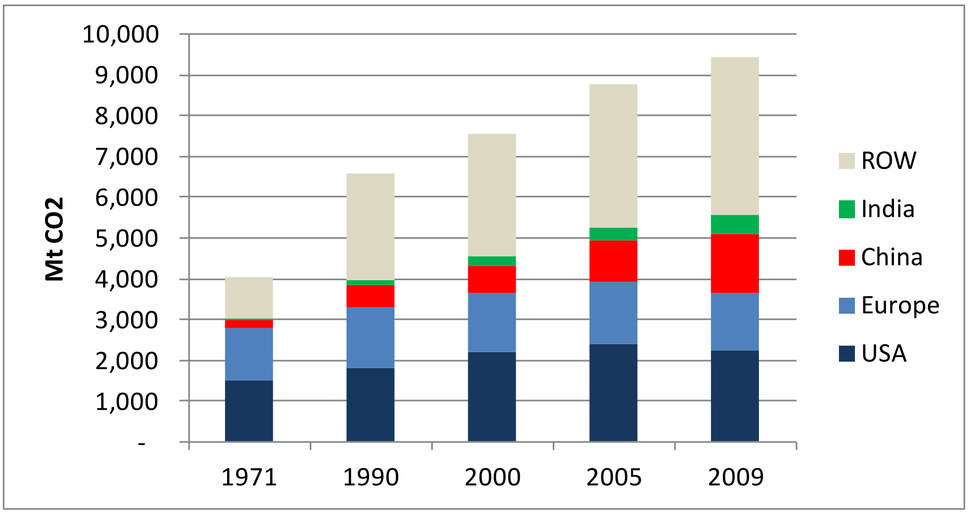


Figure 1.1. Building-sector CO2 Emissions for China, the EU, India, the US and the rest of the world. (Source: Regional emissions were calculated based on IEA data (IEA, 2011a).)

Global CO_2 Mitigation Scenarios

The GBPN commissioned the Central European University (CEU) 3CSEP, to determine the best-possible CO_2 mitigation scenarios globally and in each of the target regions. The study represents an extensive assessment of three future scenarios (Deep, Moderate and Frozen). These three scenarios have been developed to show the potentials of energy savings under the consequences of different policy settings. They are policy-relevant techno-economic scenarios that predict potential trends of building energy use (These scenarios are further described in the Annex 1).

Scenario Descriptions

By 2050 the global floor area is expected to have increased by 127% yet by 2050 it is still possible to have reduced global building final energy use by one third compared to 2005 (by 34% with space heating and cooling and 29% with water heating). The **deep efficiency scenario,** models how far today's state-of-the-art construction and retrofit know-how and technologies can take the building sector in reducing the growth of energy use, while also providing full thermal comfort in buildings.

On the other side of the spectrum, the **frozen efficiency scenario** demonstrates where the world would be without policy and market developments. This frozen scenario finds the startling consequences of inaction: the world's total final energy use will increase by 111%.

The median scenario, **the moderate efficiency scenario**, illustrates the change of building energy use between now and 2050 assuming full implementation of current policy trends and ambitions. Although it is still an ambitious scenario, the global final energy use will, nevertheless, increase by around half, 48%. This presents a significant gap between where ambitious policies of the world can take us (+48%) and where state-of-the-art technologies can take us (-29%) (Figure 1.2).

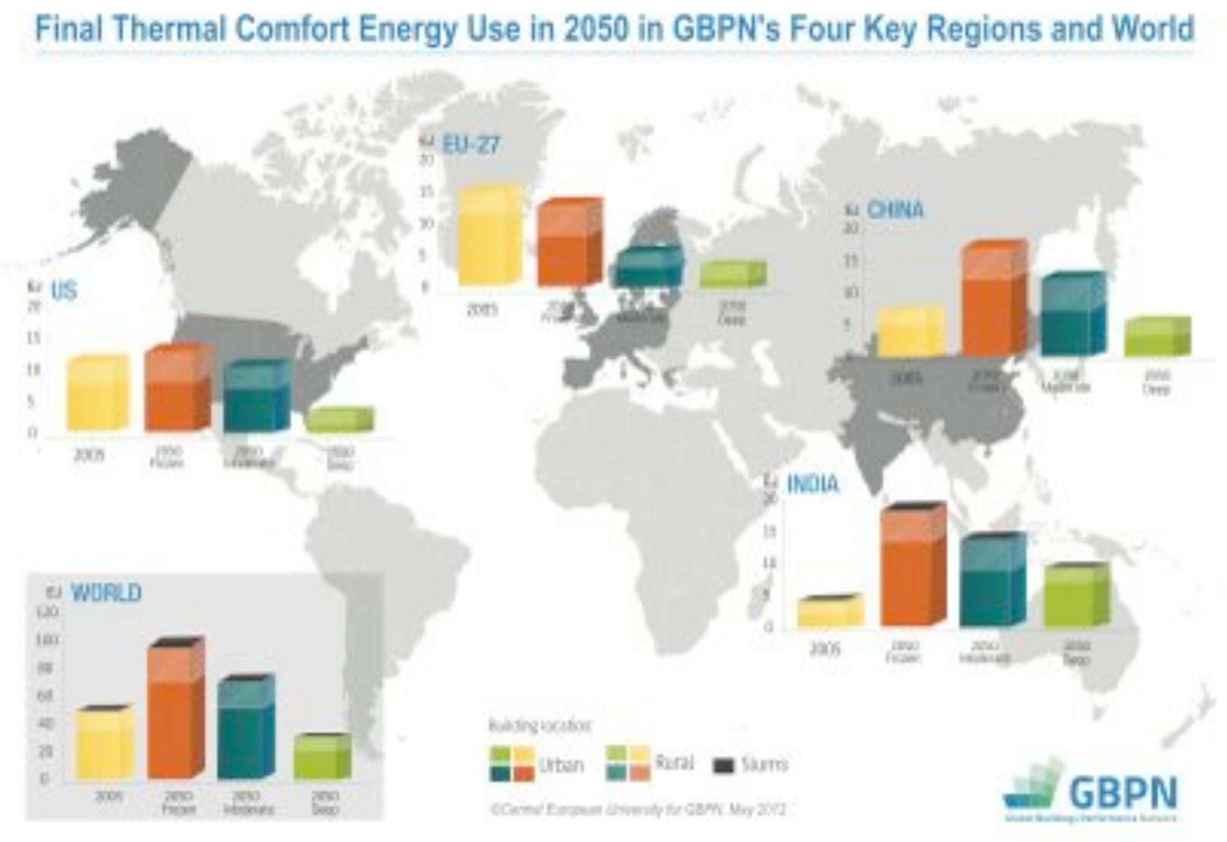


Figure 1.2. Final Thermal Comfort Energy in Rural and Urban Areas for world and four key regions

Under the frozen efficiency scenario, if current policy trends are continued as normal, the global thermal comfort energy levels are expected to increase by around 100 % by 2050 (compared to 2005 levels) Figure 1.2 presents global predictions of final thermal comfort energy use for the three different scenarios split between urban and rural areas.

Lock-in Effect

The lock-in effect is the difference between two scenarios of thermal use levels in 2050, the Moderate and Deep scenario, Figure 2.6. The IEA describe the lock-in effect as "the energy savings which are not going to be realized due to un-ambitious and insufficiently stringent energy requirement targets for buildings, building element and equipment (IEA, 2013).

The "lock-in" effect in the CEU report is a calculation of the difference in thermal energy use levels moderate and deep) in 2050 in relation to 2005. Figure 1.3 compares the three scenarios and demonstrates the major risk of the lock-in effect. The lock-in risks are high in each of the GBPN focus regions, ranging from 10% in the EU to around 400% in India for space heating and cooling use. This demonstrates the urgency of effective policy development in the building sector.

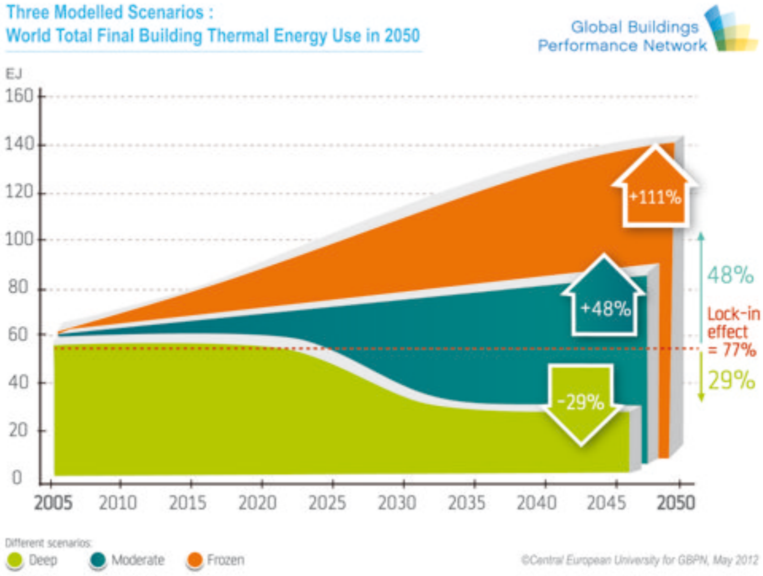


Figure 1.3. Global Lock-in Effect of the Three Scenarios.

The Outlook for India

India is facing a formidable challenge to increase its energy infrastructure fast enough to keep up with economic, social and demographic changes. The greatest relative growth in energy use in the four key regions is predicted to take place in India. It is imperative for the Indian building sector to manage its forecasted growth in a maintainable way.

Between now (2013) and 2050 rapid social and economic change combined with rising population will significantly increase the size of cities and place huge demands on the construction industry. The growth of urban areas (both existing and new) need be supported by clean and comfortable ways of living as India's rural population migrates rapidly into urban areas. This growth combined with improving levels of comfort will have a very dramatic impact on energy consumption.

By 2050 India will have seen an unprecedented escalation of floor area of around 400%. Considering the growth of population, floor area, and thermal comfort levels, keeping building CO_2 emissions under 200% of 2005 levels will therefore be a huge task. The growth in consumption will have a growing impact on the environment, but will also be responsible for other factors, such as India's energy security. Between 2012 and 2013, the Central Electricity Authority (CEA) indicates that India will see an electricity shortage of 9.3% and peak demand shortage of 10.6% (CEA, 2012).

The residential building stock holds the greatest savings potential by far; the three graphs below (Figure 1.4) show three scenarios of India's percentage growth in EJ in 2020, 2030 and 2050, split between commercial and residential buildings. If no actions are taken the residential building stock will increase its energy use by around 800% and CO_2 emissions by 840% compared to the baseline year of 2005.

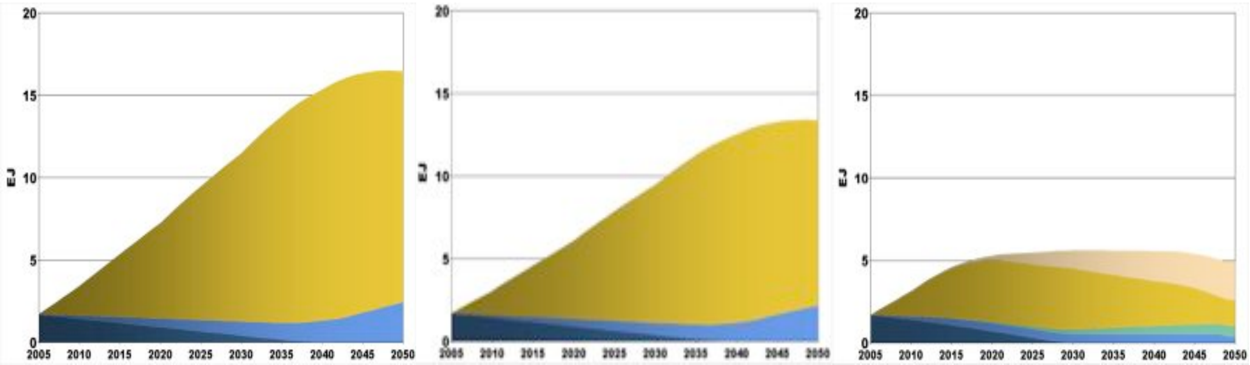


Figure 1.4. A Timeline of the Scenario Analysis of India's Final Energy (EJ) Demand in Space Heating & Cooling & Water Heating Compared to 2005.

The near-linear nature of the Frozen and Moderate Efficiency Scenarios come from the continuous long-term development of India's construction sector up to 2040 when this is expected to level off according to current analysis. As data improve, this will have to be re-analysed.

The residential sector consumes three times the electricity used by the commercial sector; this is due to the floor area being around 8 times greater (Levine 2012; Kumar, Kapoor, Rawal, Seth & Walia, 2010). If policy development continues at the current rate, the total building energy demand in India will increase to five times that of 2005 levels by 2050 (an increase of eight times will be seen in the residential sector) representing a lock-in of about 1.2 Gt of CO_2 emissions (Urge-Vorsatz et al., 2012).

Focus on Residential Buildings in India

A massive growth in residential floor space expected to occur between now and 2050 and will require strong efforts to develop and enforce regulation for new buildings. The policy framework needs to be revised to ensure that appropriate and effective policies and measures are developed to support improved energy efficiency in buildings.

India's existing policies and measures give little attention to residential buildings. There is an urgent need to understand what the saving potential is and how it can be realised either through codes, incentives or guidelines that can encourage energy efficiency in high-rise and more formal low-rise residential buildings.

The rise in thermal comfort will be a crucial lever that influences India's access to emission reductions. Adaptive thermal comfort models can be designed and developed to follow India's natural climate as well as following model energy-efficiency codes. Thermal comfort could be achieved most cost-effectively if codes are packaged with fiscal and financial incentives and building rating and labelling schemes. The adoption of standards or guidelines should be designed to suit India's environment, i.e. using indigenous principles to develop rules for regulation.

INDIA’S MITIGATION POTENTIAL

Methodology

A 3CSEP High Efficiency Buildings (HEB) model was designed to analyse global and regional building energy use and CO_2 emissions. The performance of buildings in each scenario is evaluated using input values that are determined by the predicted efficiency of the building given the stated policy scenario. Apart from capturing the interplay of components, this approach allows for the continuous improvement of the analysis if new empirical data from various parts of the world become available. Accordingly, the calculations are made with the overall energy performance levels of buildings regardless of the measures applied to achieve it.

Floor Area

In developed regions a floor area increase is mostly driven by GDP, while in developing regions the increase is due to a rise in both population and GDP (see Figure 2.2). An additional population driver that relates more specifically to India is the disintegration of joint families due to urban migration. India’s conditions are unique as it is experiencing an economic and population growth at the same time, resulting in a double request for energy.

In India the predicted floor area growth is around 400% and it will be the most populous of the four key regions, Figure 2.1. Given those trends, by 2050, India will have the greatest share of the building stock. This will belong to new buildings; meaning most of the potential energy savings could come through the construction of new energy efficient buildings. This means that all new builds must have much higher levels of energy performance to achieve this potential.

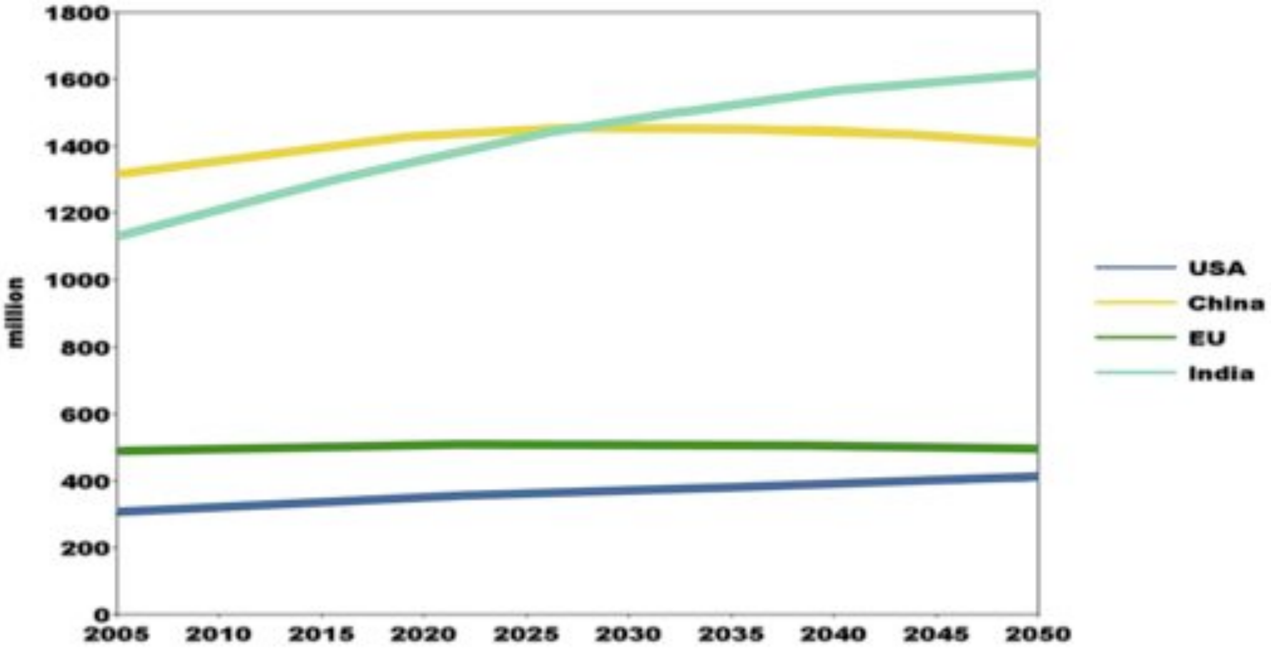


Figure 2.1. Population in China, the EU, India and the US

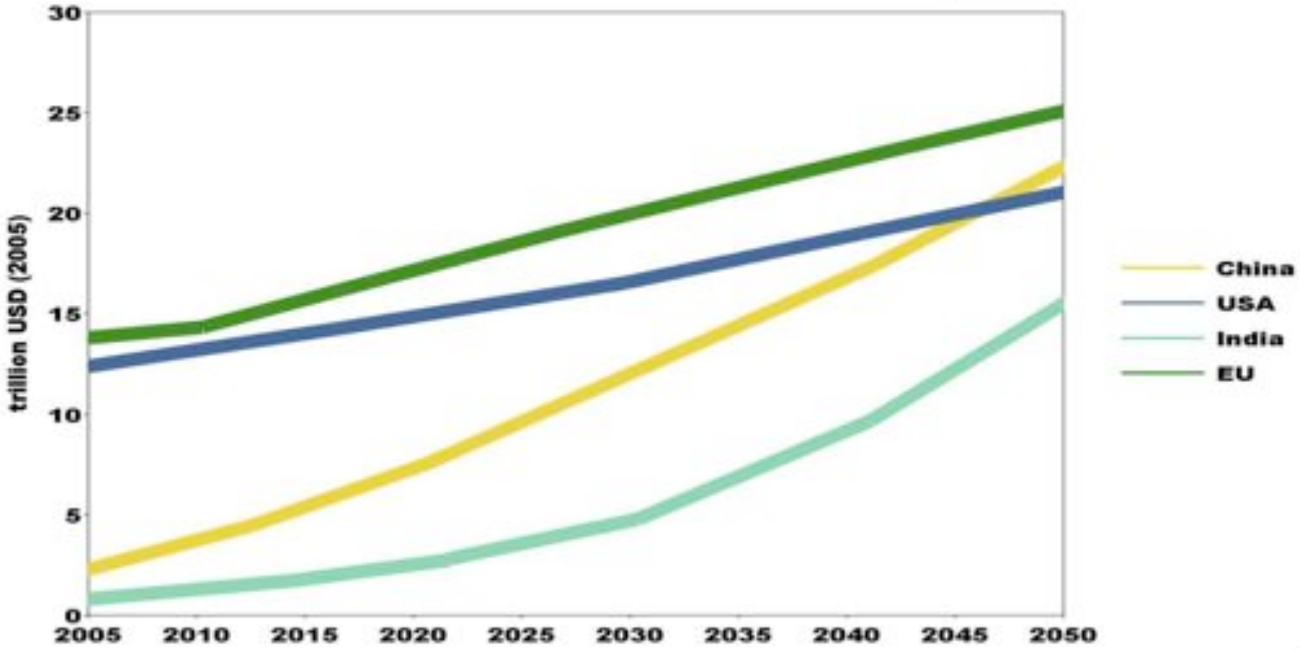


Figure 2.2. GDP in China, the EU, India and the US

Final Energy Uses

This study focuses on building thermal energy use (space heating and cooling and water heating) that accounts for around two thirds of the global final building energy use; space heating and cooling using more than half and water heating using around 10 -20%. This study does not include the remaining energy uses such as plug loads and lighting.

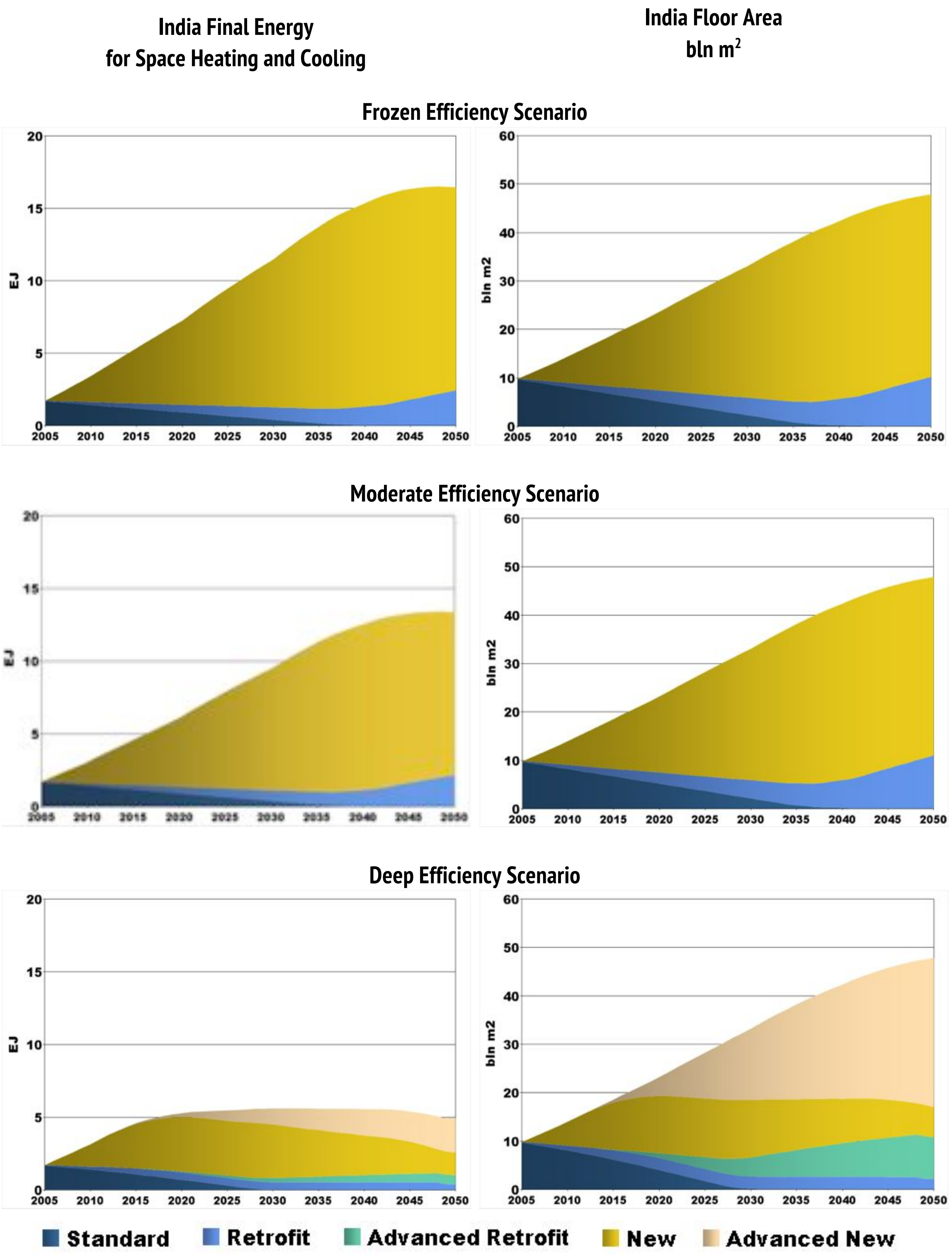
Final Energy Use for Space Heating and Cooling

Figure 2.3 displays the outcomes of final energy use for space heating and cooling (India's energy use will mainly come from space cooling) for the three scenarios in India. The results for the Deep scenario show a substantial potential to minimise energy use for these end-uses by 2050. Even under this deep scenario India's energy use will increase by around 200%. This is caused by an almost a four-fold increase in floor area by 2050 in relation to 2005 and higher standards of living.

The results found that energy used for space heating and cooling, in 2050 compared to 2005 levels, will increase by around 200% in the Deep scenario, around 700% in the Moderate scenario and if no action is taken (Frozen scenario) India's energy use will increase by 850%. India will be responsible for the most extreme increase in energy use among the four regions.

The yellow areas of these graphs demonstrate the contribution of the new building stock to thermal comfort energy use and floor area. The growth demonstrates the significance of having high-energy efficiency in all buildings that are built and renovated from the now on.

Traditional building practices in India have ancient vernacular methodologies. Can expertise from the past help the design of future buildings to achieve high comfort levels and low energy use?



India Final Energy
for Space Heating and Cooling

India Floor Area
bln m^2

Frozen Efficiency Scenario

Moderate Efficiency Scenario

Deep Efficiency Scenario

Figure 2.3. India final energy for space heating and cooling (left column) and floor area (right column) by vintage

Final Energy Use for Water Heating

The projected growth of population will cause a direct demand for energy used to heat water, and the growth in levels of comfort will further increase this demand. Nevertheless, there is a potential to limit this increase in energy use if efforts are put towards realising the deep scenario. The energy used to heat water will increase by only 16% in the Deep scenario whereas it will more than double in the Moderate scenario and increase by 400% in the Frozen Scenario, see Figure 2.4.

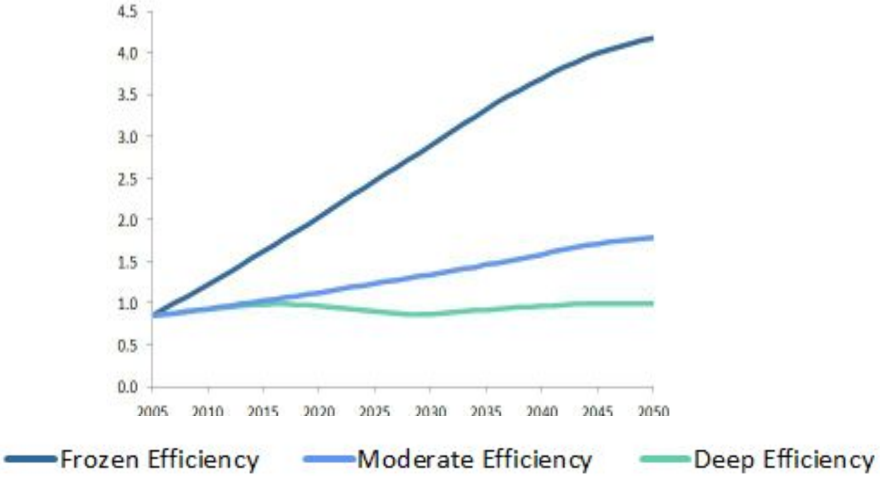


Figure 2.4. Final energy for water heating by scenarios in India

India has an advantageous climate, providing long days of sunlight for the majority of the year. This allows for solar energy in India to be a viable option to provide domestic hot water to a large proportion of the population. This will be a crucial way of reducing the energy demand for domestic hot water.

Final Energy Use for Space Heating & Cooling and Water Heating

It can be seen that space heating and cooling consumes much more energy than water heating. As a fast growing economy India will increase its thermal energy consumption (space heating and cooling and water heating) in all scenarios; however, the growth will be much less in the Deep scenario: the Deep scenario will increase in thermal energy use by 130%, Moderate by around 500% and Frozen by 700%, see the difference graphically below, Figure 2.5.

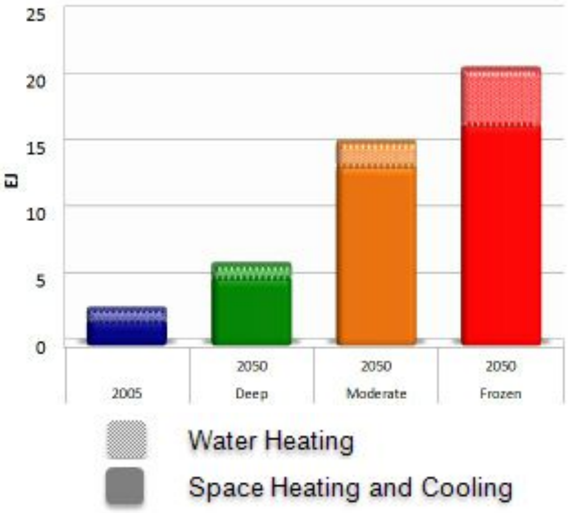


Figure 2.5. Final energy for space heating & cooling and water heating by end-uses in India

Lock-in Effect

The lock-in effect means the potential energy savings that will be missed for a very long time if technical improvements and policy efforts are not ambitious enough. The lock-in effect demonstrates the major risk that the building sector poses if present standards prevail; India will face a lock-in effect of more than 400%, Table 2.1. The major part of this lock-in is from new construction and in particular the residential sector (Urge-Vorsatz et al., 2012, Section 4.2, Table 3.1).

Table 2.1. Lock-in Effect in India and the world

Region	Space Heating and Cooling	Water Heating	Space Heating, Cooling and Water Heating
India	414%	94%	508%
World	80%	48%	74%

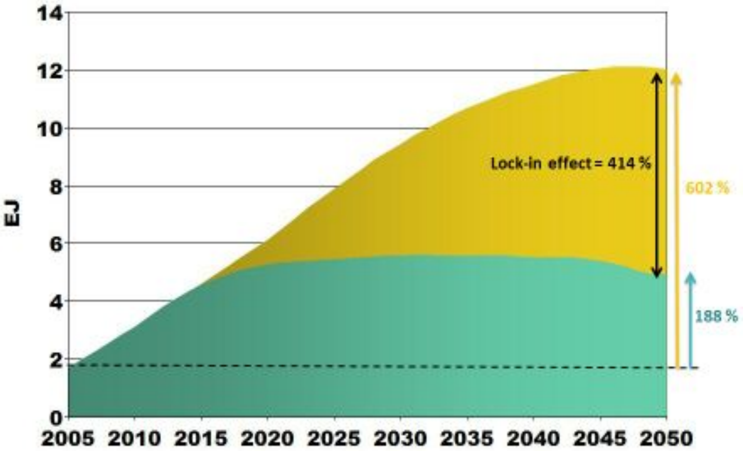


Figure 2.6. India lock-in effect for final energy use for space heating and cooling for Moderate Efficiency and Deep Efficiency scenarios

Energy Related CO_2 Emissions

Energy-related CO_2 Emissions from Space Heating & Cooling

Table 2.2 presents values of CO_2 emissions from space heating and cooling in 2005 compared to 2050 and the percentage difference of the three scenarios compared to 2005 in India and the world. India's CO_2 emissions from space heating and cooling will increase in all three scenarios; the increase under the deep scenario is around 200%. If the moderate scenario is followed India's Gt of CO_2 by 2050 will increase by around 700% (to 1.14 Gt CO_2).

Globally CO_2 emissions by 2050 to 2005 level will be reduced only under the Deep scenario, by 47% (3.3Gt). In the Frozen Efficiency and Moderate Efficiency scenarios global emissions will increase by 62% (4.3 Gt) and 19% (1.3Gt), respectively. Hence the importance of following the deep path and fast implementation of improved energy efficiency especially in the construction of all new buildings.

Table 2.2. Results for CO_2 Emissions from Space Heating and Cooling Energy Use India Compared to the World for All Scenarios

Region	**Baseline**	**Deep Efficiency**		**Moderate Efficiency**		**Frozen Efficiency**	
		Gt CO_2 2050	**Δ % to 2005**	**Gt CO_2 2050**	**Δ % to 2005**	**Gt CO_2 2050**	**Δ % to 2005**
India	0.15	0.42	188%	1.14	680%	1.39	858%
World	6.9	3.6	-47%	8.2	19%	11.2	62%

Energy-related CO_2 Emissions from Water Heating

Figure 2.7 present India's CO_2 emission dynamics from water heating energy use. Table 2.3 presents values for CO_2 emissions in 2005 and 2050 and the percentage difference for the three scenarios compared to 2005. CO_2 emissions grow in all scenarios, yet much more significantly in the Moderate and Frozen scenarios.

Table 2.3. Results for CO_2 Emissions from Water Heating for in India Compared to the World for All Scenarios

Region	Baseline	Deep Efficiency		Moderate Efficiency		Frozen Efficiency	
		Gt CO_2 2050	Δ % to 2005	Gt CO_2 2050	Δ % to 2005	Gt CO_2 2050	Δ % to 2005
India	0.07	0.22	223%	0.27	330%	0.3	387%
World	1.4	1.5	4%	1.7	21%	2.8	97%

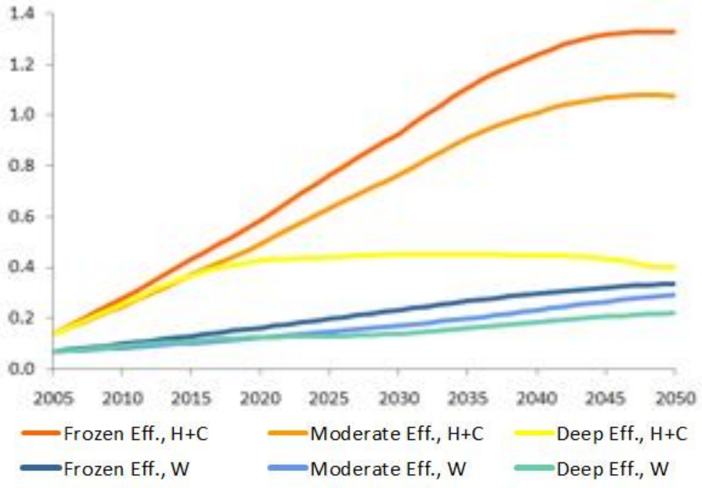


Figure 2.7. CO_2 emissions from space heating & cooling and water heating in India for all scenarios, Gt CO_2

Energy-related CO_2 Emissions from Space Heating & Cooling and Water Heating (Thermal Energy)

About 40% of global CO_2 emissions from thermal energy use can be sidestepped by 2050 if an ambitious rise in the use of current of state-of-the-art building technologies is achieved. By 2050, the CO_2 emissions from space heating & cooling and water heating in India is around 700% in the Frozen scenario, more than 550% in the Moderate and around 200% in the Deep.

Thermal energy is accountable for a very large proportion of CO_2 emissions in India in all three scenarios. The impact of CO_2 emissions from the building sector is more than twice as high in the frozen than in the deep scenario. This highlights the importance of taking actions that will move us towards the deep path.

Table 2.4. Results for CO_2 Emissions from Space Heating & Cooling and Water Heating for in India Compared to the World for All Scenarios

Region	**Baseline**	**Deep Efficiency**		**Moderate Efficiency**		**Frozen Efficiency**	
		Gt CO_2 2050	**Δ % to 2005**	**Gt CO_2 2050**	**Δ % to 2005**	**Gt CO_2 2050**	**Δ % to 2005**
India	0.212	0.637	200%	1.409	564%	1.7	701%
World	8.3	5.1	-38%	9.9	20%	14.0	68%

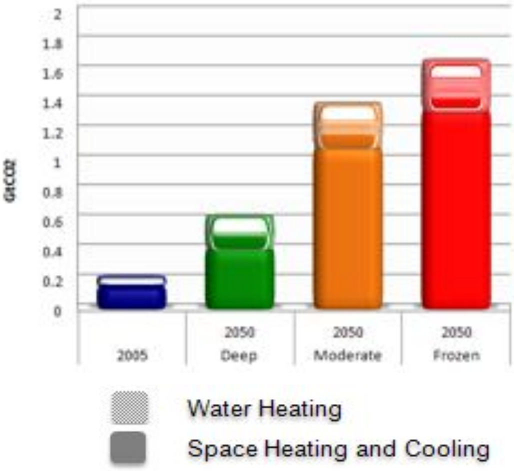


Figure 2.8. Total CO_2 Emissions from Space Heating & Cooling and Water Heating by End-uses in India

Data Quality in India

Building Performance Data

The quality of data around the world varies considerably; there are large data gaps, weaknesses, inaccessibility and inconsistencies that prevent accuracy when modelling. The GBPN data collection study presented a unique attempt to assess the quality of data in different building types in each of GBPN's regions (China, the EU, India and the US). This exercise was undertaken using a team of experts in each of the four regions as well as global modellers.

Data Quality Collection Methodology

The experts and modellers weighted the accuracy of building performance data for a specific region in a matrix that was divided into subsections of building type and building performance characteristics. The experts gave a weighting to each field. These weightings were divided into three groups that were used to determine whether a given weighing was considered as accurate. Table 2.5 below defines the accuracy groups.

Table 2.5. Weighting Accuracies of Matrix

Weighting Category	Accuracy Group
3.75 - 5.0	Reliable data
2.5 – 3.74	Data available with minor uncertainty
1.25 – 2.49	Partial Data with major uncertainty
0 – 1.24	Uncertain data

Data Quality Results

The response of the experts showed that the data used for modelling in India are frequently inaccessible. Although it was possible to estimate existing residential and commercial building data to give an understanding of how energy use is split by end use, the experts weighted the accuracy of data in India as being on average unreliable. Although commercial buildings were ranked as having more robust data than residential buildings, these data were still mostly found in the unreliable group. The difficulty of collecting data in India creates uncertainties in the energy performance data of buildings as well as on the building stock itself and the future development of this stock.

Figure 2.9 shows the result of the survey on data quality in the China, the EU, India and the US. The results of GBPN's research show the majority of India's building performance data as being either insufficient or missing.

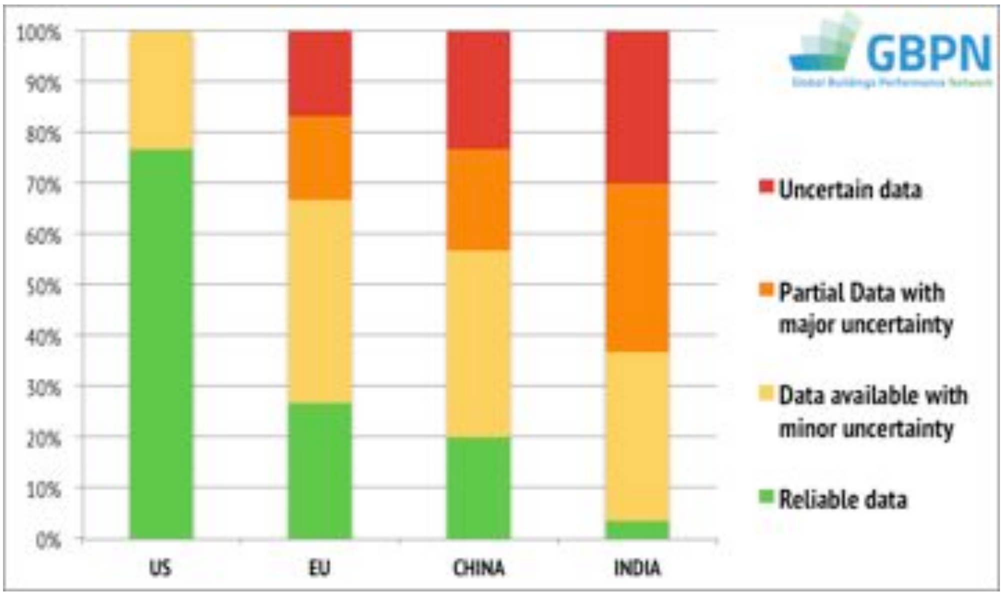


Figure 2.9. Survey of Data Quality in China, the EU, India and the US

Figure 2.10 presents India's building performance data; from this is it clear that, at present India has a very weak set of data. The only categories to be regarded with available data, scoring between 2.5 - 5 were:

- Floor area
- Existing building energy use
- Hot water
- Lighting
- Urban / rural split
- Fuel mix

Only one of the above parameters were deemed as having reliable data, urban / rural split. The remaining 8 out of the 15 categories were deemed as being inaccurate or partially available with major uncertainties.

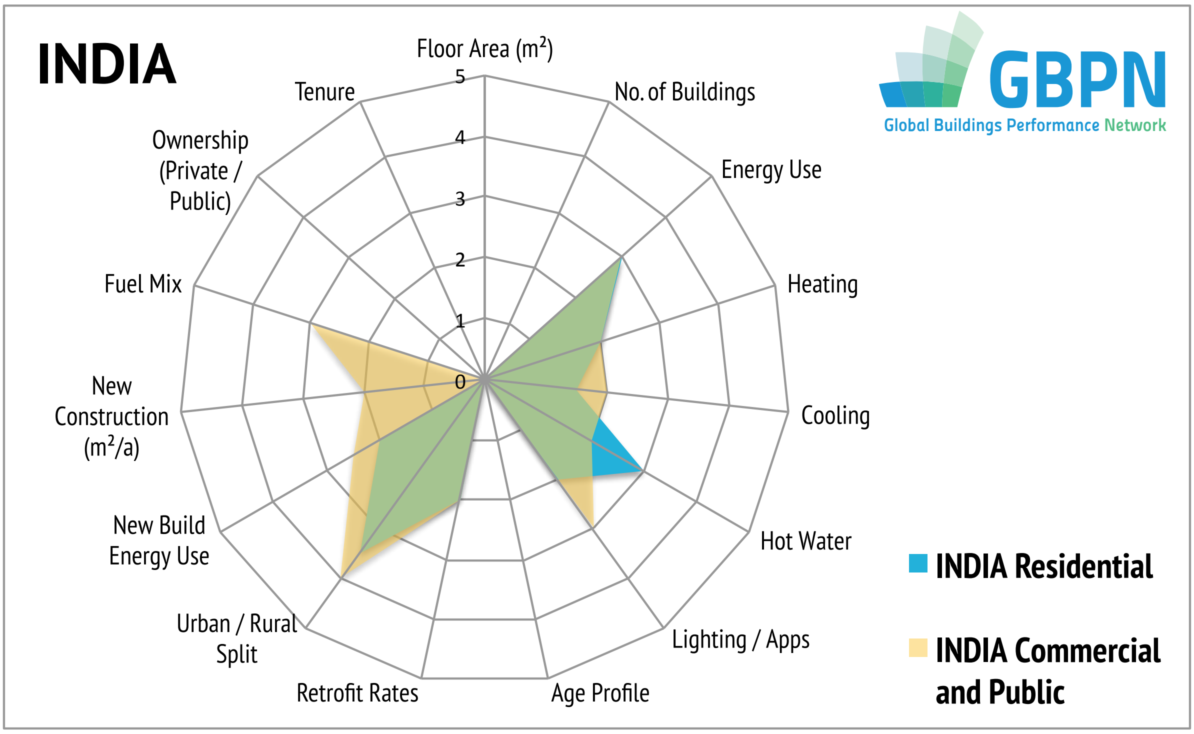


Figure 2.10. Commercial and Public vs. Residential Building Data in India

The yellow area (commercial and public) has stronger data compared to the residential data in all the parameters except two that are equal and one that is higher. Only one of the parameters for both commercial and residential had accurate data, four out of the fifteen parameters from the commercial building sector have available data with a weighting of 2.5-3.4. The remaining nine parameters, meaning the majority of the data, have a weighting that deems the data either unavailable or inaccurate. The residential sector has data that are even more inaccurate. The residential sector has data that are even less valuable – around 70% of the data are rated as insufficient.

Recommendations for Improving Data Quality in India

There is a great need for an improvement of data on buildings and their energy use globally; however, this is particularly the case in India, where much more data are needed in order to accurately assess the huge potential savings presented in the above chapters. Data vary from region to region leaving many unfilled gaps and uncertainties. In order to better calculate the potential energy savings in India's building stock, a clear differentiation of the different building types and energy use is needed. There is a need for data in India to be accessible this may mean they need to be translated.

A data quality survey was sent out to experts asking for their recommendations on how to improve the lack of high quality data in India; the general advice given was that:

- Certification should be used to improve data quality in India;
- Data should be collected locally, stored centrally and shared globally;
- Better data are needed to support stronger policies; and
- All actors should work together in improving data sets.

The lack of data in India might be linked to the lack of access to available data for modellers and global experts. It may also be due to data in India being distributed among the different actors in the individual states and not shared nationally, also to the building sector being unorganised at collecting data due to a lack of technology for sub metering. A more harmonised, collaborative and consistent approach is needed in order to ensure better data quality, collection and availability.

REVIEW OF INDIA’S BUILDING ENERGY-EFFICIENCY POLICIES

Building Use

India, in the past few years, has become the world’s third largest energy consumer, using 462 million tonnes of oil equivalent (Mtoe) total final consumption (IEA, 2012b). Coal remains the dominant fuel in India, accounting for 43% of primary energy mix.

Currently, the share of the population with access to electricity is around 75% (IEA, 2012) although electricity consumption per capita is low. Fossil-fuel-powered plants dominate India’s production capacity. As India’s energy demand increases alongside their fuel supply risks, this is due to their energy security being dependent on imported fossil fuels (Ahn & Graczyk, 2012). Another main concern is that India has long suffered from inadequate electricity generation capacity, resulting in annual nationwide electricity shortages of 9.3% and a peak demand shortage of 10.6% predicted for 2012–2013 (CEA, 2012-13).

While renewable energy capacity is rapidly increasing, India is still highly dependent on fossil fuels for electricity production. With the rapid expansion of electricity capacity, this trend is deemed unsustainable unless there is better balance to also address energy demand.

India’s building energy growth will determine it’s future energy demand; new construction should be of central concern regarding policies as the building floor area is expected to increase fourfold whilst the final thermal energy use could potentially increase by around 700% (Urge-Vorsatz et al., 2012). India’s cooling demand is much greater than its heating demand; this is electricity-based and therefore gives India a thermal energy profile unlike any of the other GBPN regions.

India’s commercial building stock is roughly 660 million m^2 where as their residential floor space is estimated to be around 8 billion m^2. Together residential and commercial buildings account for around 35% of total electricity consumption in India (Rawal, Vaidya, Ghatti & Ward, 2012), commercial accounting for 8% and residential accounting for 22%. The total commercial building stock has a much smaller physical footprint than the total residential building stock, this is due to there being a smaller number of commercial buildings (India Bureau of Energy Efficiency, 2009).

The price of energy varies among India’s social sectors. The residential electricity use is highly subsidized compared to the commercial sector. India subsidises its retail energy prices and this reduces the economic attractiveness of energy-efficiency in buildings. Although subsidies help there is also a requirement for expensive back-up diesel generators during India’s black out periods, that are occur frequently. The need for generators in order to electrify buildings should raise awareness of the importance of energy efficiency in buildings and encourage stakeholders to call for energy-efficiency programs. The strength of governance in India will be an important factor that will decide upon the pace of energy-efficiency uptake in buildings.

Building Codes

India’s National Building Code (NBC) was first implemented in 1970. The code includes regulations for structural, safety, and design measures however has not included any energy requirements until very recently. Since 1970 it has been updated five times by the Bureau of Indian Standards, most recently in 2005 (Bureau of India Standards, 2005). The NBC is a national instrument for providing guidelines that regulates construction activities. It serves as a model code that is to be adopted by all building sector stakeholders (government construction departments, local bodies, private companies) (Bureau of Indian Standards, 2005). Recently the NBC has drafted a new sustainability chapter called “Chapter 11: Approach to Sustainability”, this chapter covers energy efficiency in buildings and will be attached as an addendum to the existing NBC (Rawal, Kumar, 2013).

In order to compensate for the lack of energy demands in the building codes and to include energy efficiency as a priority for new buildings in India the Government of India passed an Energy Conservation Act (ECA) in 2001. Under the provisions of this, the Bureau of Energy Efficiency (BEE) was created in 2002 in a merger with the former Energy Management Centre. The BEE assists in the development of policies with a strong emphasis on self-regulation and market ideals (Bureau of Energy Efficiency, 2013). The principal objective of the BEE is to reduce energy intensity of the Indian economy by working with stakeholders to achieve an active and accelerated adoption of energy efficiency in all sectors (Bureau of Energy Efficiency, 2013). The BEE is responsible for improving energy efficiency by coordinating several regulatory and promotional functions.

One of the major regulatory functions developed by the BEE is an energy code that covers the conservation of energy in buildings (BEE, 2013). In 2007, the BEE released this nationwide commercial building energy-efficiency code, the Energy Conservation Building Code (ECBC) and revised it in 2008 to cover an extended number of buildings. The code remains voluntary until it is adopted into the by-laws of the individual states.

Energy Conservation Building Code (ECBC)

The ECBC is sets minimum energy standards to buildings or building complexes with connected loads that are greater than 100 kilowatts (kW) or 120 kilovolts-ampere (kVA) (Bureau of Energy Efficiency, 2011). The Code has primarily focussed on commercial buildings though, it is applicable to residential complexes with the same connected load as the commercial buildings. This ECBC applies to large-scale commercial retrofits where the final air-conditioned space of the building is greater than 1,000 m^2.

In 2004, during time of the ECBC development the BEE estimated[1] that full compliance of would amount to energy savings of 1.7 billion kWh's each year (Liu, Meyer & Hogan, 2010). The energy savings potential is now argued to be much greater than originally estimated (Kumar, 2013). However, the ECBC is not yet in full compliance, compliance rates are forecasted to increase gradually, 10% until 2013, 35% in 2015 and 65% by 2017 (Rawal et al., 2012).

The Energy Conservation Act states that the ECBC is mandatory nationwide (Williams & Levine, 2012), however, the ECBC is to be incorporated into local directives before it is to be enforced. The ECBC has yet to be adopted by most of India's states and therefore the majority of India's new commercial buildings are not built under the requirements of the ECBC. However, the BEE have outlined particular areas where the code could become mandatory, so far, two states (Rajasthan & Odhisha) have already mandated the ECBC, six others (Gujarat, Karnataka, Punjab, Kerela, Uttar Pradesh & Uttarakhand) have initiated the process and seven additional states (MP, Haryana, Chhattisgarh, Andhra Pradesh, Tamil Nadu, West Bengal & Maharashtra) have been identified as focus states by the BEE for the year 2012-13 (Chandiwala 2013).

The ECBC is based on the US ASHRAE 90.1-2004 standard for this resembles the standard in numerous technical requirements. ECBC provisions concern:

1. Building envelopes (except non-air-conditioned storage space of warehouses);
2. Mechanical systems and equipment, including heating, ventilating, and air conditioning (HVAC) systems;
3. Service Hot water heating and pumping;
4. Interior and exterior lighting; and
5. Electrical power and motors.

It is assumed that BEE's Standards and Labelling Programme will regulate the final two concerns (Rawal, 2013).

When deploying the ECBC designers, builders, code officials and other stakeholders need time to build necessary capacity for its implementation. It has been suggested by some of India's energy efficiency experts that the code requirements can be broken down into tiers, differentiating the energy measures and implementing the ECBC in phases, thus allowing time for training and capacity building (Vaidya, Bharvirkar, Ward, et al., (2012).

Tiers that were recommended are based on enforcement option as per below (Rawal, Vaidya, Ghatti & Ward, 2012):

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[1] These estimated we made by the US AID ECO-III Project that supported the implementation of the ECBC.

- Tier 1 - Envelope related measures - To be enforced as part of the building permit process currently in operation. Include all requirements that are easy for market adoption, have high return on investment and are enforceable through the current building permit process. *Includes highest energy savings.*
- Tier 2 - HVAC related measures – Eventually to be covered by the Standards and Labelling program for equipment and appliances – the first star rating will be the minimum energy performance standard that corresponds with those specified in the ECBC. Enforcement Method. *Moderate Energy Savings.*
- Tier 3 – Lighting measures– To be checked by third party assessors. Additional measures that are more difficult to enforce. *Low energy measures.*

Building Code Implementation, Enforcement and Compliance

The subsections below describe ECBC implementation, enforcement and compliance.

Code Implementation

Local implementation of the ECBC comes in two phases:

- Develop nation specific building codes based on the ECBC building codes
- Enforcement of the codes.

The local states and local bodies have full authority over the code enforcement under India's Constitution. This means that the role of the central government is limited to coordinating and monitoring state activities and supporting development through funding schemes (Kumar, Kapoor, Rawal, Seth, & Walia, 2010).

Code Enforcement

Enforcement will take place at two bureaucratic levels.

- The Ministry of Urban Development (MoUD)
- Other concerned national agencies with jurisdiction over national government buildings can enforce the code in those buildings.

The State Urban Development Department of India will enforce urban local bodies as part of the building permit process.

The building owner / architect / developer are responsible for providing the compliance documents for verification by the Town Development Offices (TDOs). The TDOs will be responsible for "specifying permit requirements, code interpretations, approved calculation methods, worksheets, compliance forms, manufacturing literature, rights of appeal and other data to demonstrate compliance" (India Bureau of Energy Efficiency, 2009).

Demonstrating Compliance with the National Code

The energy performance is evaluated after construction. Compliance can be achieved in two ways;

- Prescriptive - Meeting the regulatory standards of the code for the material inputs of the building.
- Whole Buildings Performance - Demonstrating that the building will use less energy than a typical design of the same building type in the same climate zone.

The initial prescriptive approach obliges for the buildings construction and design decisions and materials / equipment to follow energy performance parameters (U-values, R-values, CoP, etc.). The prescriptive standard approach required a mixture of project receipts and on-site verification. These will ensure that materials as well as equipment at the site match those in permit application documents.

The whole building performance option simulates the energy performance as per actual design specifications, setting an energy budget for the building type, size, and other features. The performance based compliance method required a computer-aided energy simulation. The code has threshold characteristics that the computer modelling programmes must meet.

Compliance Tools for the National Code

A Whole Building Performance tool called “ECOnirman” was developed and funded by the US AID ECO-III Project to support developers and building designers in understanding the requirements of ECBC (U.S. AID India, 2011). It is a web-based tool made available through the BEE that allows stakeholders to input construction data and receive a calculation of the building design in terms of the ECBC’s mandatory and prescriptive and performance requirements (Vaidya, Melchert, Ghatti, et al, 2012). This tool can also perform optional checks of the “trade-off method” for the building envelope.

Challenges when Implementing the Code

Local governments in leading states have formed Steering Committees including academic and international experts, however, there are no apparent best-practice models for ECBC integration in India and these efforts remain experimental. As the ECBC moves towards being mandatory in India there is a need for a considerable amount of recruitment. Implementing the ECBC through Urban Local Bodies (ULBs) requires the skills of high-level administrators, programme officers and evaluators, informational personnel, and building inspectors.

The implementation of the ECBC in India has been hampered by shortage of building professionals who have been trained in energy-use issues in buildings. However there are some capacity building initiatives that are being undertaken in India. The US AID project in India is called “US AID Eco – III” and has provided the BEE significant support towards improving the ECBC by enhancing awareness and capacity building. These initiatives include workshops, user guides and tip sheets, voluntary rating systems, Some specific training activities are being planned at India’s architectural schools and specialised programmes are being developed on technical topics in many universities (Manu, Bajpai, Kumar et al,. 2010).

If the permit application process was more transparent and less complex, it is likely that the rate of code compliance would be much higher. Using electronic filling system that tracks the progress of applications or single-form, or using permits would improve the overall speed and ease of the application process. However, these programmes cannot promise to increase compliance, a crucial element in answering this problem may be increasing the penalties for non-compliance.

Labelling and certification

Although there is an increased consideration for buildings that have been certified as green or energy efficient, building labelling in India is still rare. India has several different building rating schemes; Indian Green Building Council (IGBC) and Green Rating for Integrated Habitat Assessment (GRIHA), are the most popular in the marketplace and address many issues such as materials, water consumption, and environmental and human health, rarely including building energy use. The BEE’s Star Rating System evaluates existing buildings based on operational energy use and is the only energy-use-specific building label used in India. The BEE has initiated formation of building component labelling program for windows, walls and roofs.

Considering that rating and labelling systems in India are voluntary, the call for buildings to be compliant with a rating system requires motivation due to the perceived conception that green buildings require large investment. Governmental subsidies and strong policy would encourage a large-scale uptake of green building rating systems.

Indian Bureau of Energy Efficiency Star Rating System

In February 2009, the BEE established the Star Rating scheme as an official system for labelling buildings based on energy use. It stands strongly linked to the ECBC, applying to commercial buildings with a connected load of 100kW or 120 kVA or greater. It is voluntary and its design was based on the ECBC. The label compares the building to similar buildings.

The Star Rating scheme is based on a five star ranking of the building (5 stars being the best). The label is easy to understand and is familiar to Indian consumers of home electronics. Figure 3.1 shows a diagram of the label, the starts in the red field indicate the ranking of the building in terms of its energy intensity (kWh/m^2/year) (BEE, 2013).

Figure 3.1. Star Rating for Buildings Label. (Source: Bureau of Energy Efficiency)

Star Rating Requirements

Candidate buildings are given an energy performance indicator after a full audit of the energy use; this is given after the building has been in operation for one year with full occupancy. The inspectors (State Designated Agencies (SDA) or BEE) review the building giving an energy intensity score that excludes electricity generated from on-site renewable sources (Liu, Meyer, & Hogan, 2010).

Star Rating Evaluation

The amount of energy savings from Star Rating is unknown and although BEE have certified only 110 buildings out of India's large building stock there are indications that these initial pilot stages of the star rating will begin to expand especially as benchmarks are made for more climate zones and building types.

India Green Building Council

LEED is an internationally acknowledged rating system, developed and monitored by the US Green Building Council (USGBC). The Indian Green Building Council (IGBC) manages LEED India[2]. LEED India standards address sustainable site development, water conservation, energy efficiency, materials selection, and indoor environment quality.

There are two LEED India commercial programmes:

- LEED India for New Construction (LEED INDIA-NC) - commercial buildings such as offices, institutional buildings, hotels
- LEED India for Core and Shell (LEED INDIA-CS) - rented commercial spaces in which the building occupants do not control aspects of the building's design and construction. Examples of buildings of this type are IT parks, malls and retail centres.

The IGBC have also developed several indigenous rating systems[3]:

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[2] Please find more information on LEED INDIA at: http://www.igbc.in

[3] Data about IGBC and IGBC rating systems are available on the IGBC website: www.igbc.in.

- IGBC Green Homes (these projects account for more than 50% of the Green building projects registered with IGBC, including LEED India projects.)
- IGBC Green Existing Buildings – Operation & Maintenance
- IGBC Green Factory Buildings
- IGBC Green SEZs (Special Economic Zones)
- IGBC Green Townships
- IGBC Green Landscapes

As on 2nd September 2013, over 2,175 green building projects amounting to over 1.61 Billion sq.ft of green building footprint are registered with IGBC.

IGBC Requirements
Meeting these LEED India benchmarks means complying with the minimum standards of the IGBC rating system. LEED India certification is achieved through a third-party certification process. The energy baselines in LEED India are from ASHRAE 90.1 standard (International Standard for Building Energy Performance) or from the ECBC. LEED India projects have to follow either the ASHRAE 90.1 standard or the ECBC.

LEED and IGBC Accredited Professionals
As of January 2013, over 650 USGBC - LEED Accredited Professionals (AP) were registered (GBCI, 2013) and 944 IGBC – AP (IGBC, 2013).

Green Rating for Integrated Habitat Assessment (GRIHA)

The Energy and Resource Institute (TERI) conceived GRIHA[4] in 2005 as a national rating system for green buildings; the Ministry of New and Renewable Energy (MNRE), the Government of India then adopted it. GRIHA is accepted it as the Government's preferred standard for rating green buildings in India. It is a "green building evaluation system" suitable for all climates and buildings in India (GRIHA, 2013). The purpose of GRIHA was to incorporate a variety of India-specific building code compliance requirements within one system, designing a green building standard that is designed to focus on building energy use. It is closely tied to India's climate and culture, including standards for India's different climate zones.

GRIHA certification is currently limited to commercial and institutional buildings with a minimum built area of 2500 m^2. A simplified rating system called the Small Versatile Affordable GRIHA (SVAGRIHA) has been developed and applies to smaller / residential buildings.

GRIHA Requirements
Compliance with GRIHA is achieved by following policy, construction, and operational requirements in 34 different categories. Similar to IGBC rating systems, some points are fundamental in attaining a GRIHA rating. GRIHA has a web-based evaluation tool that designers and project managers can use to appreciate qualitative and quantitative point decisions. The system also has guidance for professionals who are required to review each category of measures. Points are awarded temporarily until on-site justification takes place; three on-site validation visits are required.

GRIHA Evaluation
The Association for Development and Research of Sustainable Habitats (ADaRSH) estimates that GRIHA certification can result in savings of 40%–60% of electricity use and 40%–80% of water use compared to standard buildings (MNRE & TERI, 2010).

The Central Public Works Department of India, the construction arm of the central government, has adopted GRIHA as its official Green Building Standard (Kumar, 2010b). Under this programme, all new central government and public sector buildings will be constructed to meet the GRIHA Three-Star rating (Kumar, 2010). The 11th Five-year Plan (2007-2012) aimed to achieve GRIHA compliance in five million m^2 of built area (Kochar & Convenor, 2010). By the end of 2010, GRIHA had

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[4] Please find more information on GRIHA at: http://www.grihaindia.org/

trained around 400 professionals in 12 evaluator and trainer workshops (Tripathi, 2010). Once an individual has attended one of the workshops they can then undergo training to become a GRIHA Evaluator (equivalent to a LEED – AP). There are now, in 2013, around 300 GRIHA Evaluators in India.

The future for GRIHA appears promising; it will likely compete with IGBC for market dominance as government support continues to grow and the SVAGRIHA system is implemented in smaller buildings.

Challenges and Future Directions for Building Labelling Programmes

Different building labelling and rating schemes are in use in India, the voluntary nature of these means that the market uptake is slow. Most labelled buildings belong to governments or large corporations. This indicates a lack of market demand for labelled buildings among domestic, non-public building consumers. If affordable thermal comfort is to be a priority, the collection of building data needs to focus on the energy efficiency characteristics. Compliance practices, like that of GRIHA, are a rigorous way of guaranteeing that a building meets baseline energy-efficiency standards and code requirements.

Present building labels have highly visible targets. This can create consumer awareness of labelling systems thus allowing for them to evolve and advance. However, the co-existence of the many labelling schemes along side a low-demand market is likely to cause confusion. Competition among labels increases the need for supporters to utilise significant resources before the real estate market is able to exploit the informational value that labels offer.

The Indian government, through incentives, are now backing rating and labelling schemes. This calls for the performance data of the rated buildings to be accountable, transparent and reliable. It is very important for buildings in India to be monitored; this will demonstrate that the rated buildings are of high performance.

A major challenge for the multiple labelling systems in India is that there is no standard baseline for them to compare to. For example, the ECBC is not yet implemented in most states and there are no standards for formal residential buildings. This leaves a major uncertainty in knowing whether these labelling systems really do ensure that buildings are “green”.

Incentives

Government financial incentives and public financing options are rare and still in early development. Most incentives found in India focus on appliances, renewable energy, and energy-efficient light bulbs, rather than on energy-efficient space-conditioning measures and are in the form of rebates.

However, recent incentive programmes have been experimenting with tax concessions for buildings that integrate energy efficiency and renewable energy. Funds appear to be sourced from government tax assets however, Haryana state and a some others are beginning to use state energy conservation funds as requested by the Energy Conservation Act of 2001 (Government of Haryana Department of Economic and Statistical Analysis, 2011; Limaye, Nataraian, Kumar, Lalnad, & Tharakan, 2008).

MNRE Incentive Scheme: ‘Energy-efficient solar/green buildings’

India has promulgated a variation of national incentives and financing schemes for energy-efficiency measures in industry yet only one national-level incentive scheme exists for buildings: the Ministry of New and Renewable Energy (MNRE) incentive programme for GRIHA-rated buildings. The following incentives have been granted to several stakeholders involved in the GRIHA-NRS projects (CES, 2012):

- **Building Owners** - Reimbursement of 90% of the registration-cum-rating fee for projects up to 5000 sq. m. built-up area with minimum 3 star rating & for projects > 5000 m^2 built-up area with minimum 4 star rating.

- **Architects / Design Consultants** - Rs. 2.5 lakhs[5] for projects up to 5000 m^2 built-up area with minimum 3 star rating & Rs. 5 lakhs for projects > 5000 m^2 built-up area with minimum 4 star rating.
- **Municipal Corporations / Urban Local Bodies** - Rs. 50 lakhs to Municipal Corporations & Rs. 25 lakhs to other Urban Local Bodies that announce rebate in property tax for Green Buildings & make it mandatory to get the new buildings under Govt. & Public Sector rated under GRIHA.
- **Awards** - Awards of Rs. 50 lakhs to Municipal Corporation & Rs. 25 lakhs to other Urban Local Body who performs best.
- **Annual Awards** - To 5 stars rated buildings under GRIHA.
- **Activities** - Up to Rs. 2.00 lakh for each activity to specialised institutions for organising workshops/ seminars/ training / publications/ awareness campaigns, etc.
- **Scheme** - presently confined to commercial and institutional buildings including housing complexes with minimum built area of around 2500 m^2 Release of incentives will be made by MNRE on reimbursement basis through GRIHA Secretariat after validation of Star Rating Post - Construction by the National Advisory Committee of GRIHA.

Building-Integrated Renewable Incentives

The MNRE and many state governments offer incentives for the adoption of building-integrated renewable energy technologies. These incentives include partial assistance with preparation of detailed project reports for building projects with energy-conscious designs, which can include both energy-efficiency and renewable energy measures. The MNES (renamed MNRE) provides partial assistance for preparation of detail project reports (DPR); these incentives are 50% of design preparation costs to 200,000 Rs.

Solar Water Heating Systems is one of the components covered under ECBC to enhance energy performance of the buildings. Many state and city governments offer property tax rebates and other incentives for properties that install and use solar heating and lighting systems. For example, the Hyderabad state government offers a 10% rebate to builders who choose solar heating and solar-powered lighting systems when upgrading buildings (Jaiswal, Vedala, & Bilolikar, 2010).

Financial Incentives

Several Indian banks are offering financing incentives for both green buildings and technologies (Levine, et al., 2012):

- **State Bank of India** offers a 0.5% interest rate subsidy for certified IGBC projects.
- **State Bank of Mysore** offers an interest reduction for energy-efficient, green housing, renewable energy, and waste management projects. These projects are eligible for small interest concessions at this bank.
- **Industrial Credit and Investment Corporation of India Bank** offers a Home Financing program that reduces processing fees for customers who purchase IGBC-certified buildings.
- **Bank of Maharashtra and ING Vysya Bank** offer Housing Mortgage products offered under the Eco-Housing Pune Program that offers a 0.5% rebate on prevalent interest rates, 1% interest rate subsidy on certain efficiency equipment and appliances (solar water heaters, efficiency lighting, refrigerators, and air conditioners). However only 35 out of 10,000 new buildings that have been built in the past 5 years in Pune have received the for Eco-Housing label (Kulkarni, 2013).
- **The National Housing Bank (NHB)** pre-qualify energy-efficient housing for mortgage loans in India. The NHB is supported by The Energy and Resources Institute (TERI). TERI (in association with the German Federal Bank KfW) is working on a computer-based energy-efficiency assessment toolkit for the NHB of India to use to pre-qualify energy-efficient housing for mortgage loans (TERI, 2012). The NHB have also signed an agreement with IGBC and is offering mortgage loans for IGBC Projects.

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[5] 1 lakh = 1,00,000 Rupee (INR) = 1,861 USD = 1,380.77 EUR = 1,195.85 GBP = 11,599.16 CNY
Exchange Rate of Indian Rupee retrieved from: XE - Universal Currency Converter (live currency and foreign exchange rates). Available at: http://www.xe.com/ucc/convert/ [Accessed: 13/02/13.]

Challenges with Financial Mechanisms

Financial mechanisms are fundamental in order to increase market adoption of energy-efficient building technologies as well as customer awareness campaigns. Financial mechanisms are crucial in reducing the market barriers related to the up-front costs for energy efficiency. At present, there are few financial incentives and those that exist do not focus on the energy intensive areas of a building – the heating and cooling systems.

Currently the one main financing incentive is not strong enough to support a full market uptake of new energy efficient buildings, the MNRE should be expanded. Otherwise there is a huge requirement for stronger financial incentives. Overall, much stronger financial incentives and bank financing support for whole-building efficiency efforts will be needed to push market demand to heights required for widespread building energy efficiency measure uptake. Incentives should target multiple actors in the building sector.

Indicators

This section summarises the indicators and issues of best practices found with India's building energy codes, building energy labels and building energy incentives.

Building Energy Code Indicators

The BEE developed the national commercial building energy code, ECBC. This represents an initial effort by India to tackle the issue of their rapidly increasing energy use in commercial buildings. The implementation process is targeted so that local governments can adapt to the national ECBC.

The Indian government is putting its efforts into building the ECBC capacity of pre-professionals and mid-career professionals. Several web-based software tools have been advanced to ensure that building owners understand their building's energy use intensity and designers understand whether their projects comply with the ECBC. The new building science curriculum program is being developed by the Indian government to train students and professionals to incorporate energy efficiency related modules (both mandatory and voluntary) into architectural and engineering universities (Manu, Bajpai, Kumar, et al., 2010).

Building Energy Label Indicators

The US AID ECO – III team partnered with the BEE to collect reliable data on commercial buildings in 2008. They collected data on more than 860 different types of commercial buildings in order to provide a basis for performance based rating systems, primarily the BEE Star-labelling system, gave an impetus to IGBC and GRIHA (to a lesser extent). In 2010, this detailed analysis provided the first benchmarking indicators for India's commercial building sector (US AID, 2013a).

Locally relevant labelling systems such as GRIHA and IGBC are the most common in India. The GRIHA system is more closely linked with typical Indian buildings, for example it concerns reducing the demand for cooling. GRIHA is supported at national and state level yet is still rarely mandatory. Four states require for governmental buildings to have a GRIHA rating and the national governments requires for all new governmental buildings to be compliant with the GRIHA rating system.

The international status of LEED-labelling increases the appeal of their certified buildings; this develops the visibility of green building labelling systems and thus, expands the LEED market appeal. Labelling programs can offer targeted training on energy-efficient design and operations; both GRIHA and IGBC have together trained around 600 professionals.

Building Energy Incentive Indicators

Incentives and financing mechanisms for building energy efficiency are seldom found in India. The MNRE's GRIHA-based incentive scheme acts as a means of increasing awareness through concurrently targeting multiple actors in the building supply chain. The package provides incentives for developers, proprietors, and administrators, all of whose support is essential at this initial stage in increasing the market adoption. However, for the first time in history, the government are supporting rating schemes with incentive/subsidy schemes (CSE, 2012).

Issues

Energy Code Issues

Although two states have already adopted their by-laws to be ECBC compliant, making it mandatory for all new, large-commercial buildings to comply with the Code, there is no documentation of this and hence there is no precedent, guidance or fast-approach for other cities to follow suit (Khosla, Vedala et al., (2012). The current efforts should be documented and promoted to set precedential examples; the developed strategies should be instructive of the variant needs and limitations of local governments.

Although the ECBC does cover a small part of the residential sector, the majority does not apply and their energy and emissions savings potential are not addressed. Residential buildings, which represent the largest share of India's future building stock, have no dedicated building code: this must become a national priority.

Considering the residential building stock is anticipated to increase its CO_2 emissions by 840% by 2050, the lack of code development is an issue. Urban areas are rapidly expanding, as is the energy intensity within. Energy shortages are already being experienced in India, hence, if nothing is done to regulate the residential stock energy shortages are likely to occur more often.

Building Label Issues

There is a lack of data regulation of Indian buildings. The presence of multiple labelling systems can rouse consumer confusion especially during these initial stages of energy-efficiency adaption in India, when consumers are mostly unaware of building energy use issues. Although LEED-certified buildings do have a data collection mechanism, it is self reported and therefore the reliability is unknown although these are subject to public scrutiny. GRIHA and Energy Star rated buildings upon operational energy use yet most of the current labelling systems do not take this into account. There is no legally binding way of knowing whether the labelled/rated buildings are delivering their intended goal.

Incentive Issues

Governments offer the most secure of incentive program while the financial industry seems to be far from a widespread uptake of efficiency financing. This is due to apprehensions about a lack of demand. There is very little is documented evidence regarding the outcomes of present building energy-efficiency incentives on actual building energy use (CSE, 2012). This absence of follow-up and monitoring of the projects may hinder the green incentive schemes.

Project developers are hesitant of the costs of efficiency, and the real estate market normally does not realise the value of higher efficiency buildings. Economic benefits are required to be more transparent and available for those who are interested; specifically data on energy cost savings, rental and sale premiums, and occupant comfort benefits.

Conclusion of India's Energy Efficiency Policies

India has gradually started to include energy efficiency solutions in their buildings sector; however, the implementation of building codes that target energy efficiency is still at an early stage. The national government has designed an energy efficiency building code together with several tools and strategies to assist with local adaption. Implementation of the ECBC is only beginning to pick up speed; it is adopted for commercial buildings in two out of the 28 states. The ECBC does not include low-rise residential buildings even though single-family residential buildings and low-rise apartment buildings are expected to experience the greatest increase in floor area of all buildings types by 2050, see Figure 2.5 (Urge-Vorsatz et al., 2012).

A model energy code for residential buildings, and other measures targeting residential buildings, should compliment the ECBC in order to target all buildings and especially the areas where the largest potentials can be realised. A building energy efficiency code for residential buildings should, however, be highly adapted to India. This means it must be prepared for the complexity of implementation as well as being developed for the Indian administration system. As starting point, energy efficiency codes for residential buildings should focus on the more formal part of the sector in terms of high-rise and low-rise residential buildings with apartments.

Capacity building must expand in order to develop the means to implement the code at a larger scale. Initial steps in capacity building have been put in place yet for full-scale market adoption all stakeholders, especially governments, must make an advanced effort. Tools for training students at university as well as professionals must be further developed and disseminated. India is in need of experts, to be inspectors, designers and other political stakeholders in order for the ECBC and other efficiency and comfort codes to be enforced well. More documentation of current, progressive energy efficiency activities would aid in promoting energy efficient buildings and provide evidence for demand.

Although there are many labelling programmes, they may benefit by consolidating. This seems to be hampered as IGBC and GRIHA appear to be competitors and the Energy Star programme deals with operational energy use has yet to realise significant market demand. The current labelling packages should have a bigger focus on going beyond minimum standards, set for example by the ECBC. Labelling systems should aim for buildings to achieve the highest standards that available technologies will permit.

Financial incentives should back up codes and labelling systems as part of an energy-efficiency package also including both training and information activities. The current MNRE is not complete or strong enough to support a significant market uptake of energy-efficient buildings. The MNRE should be expanded to support certification and should provide incentives depending on the depth of the energy efficiency of the project. India’s financial and bank incentives must also be strong enough to support a full, widespread market uptake of energy-efficiency in new buildings. These incentives should provide support for all stakeholders in the building sector.

The lack of labelled products that are efficient hampers the market up-take of energy efficiency in India. Programmes for the certification of products can help to overcome this barrier, the Indian government should develop labelling systems that stimulate demand.

Currently there is a building construction boom occurring in India that is predicted to continue into the foreseeable future. Indian building construction must be supported by strong policies and packages that include multiple facets of development and up scaling of energy efficiency in both new and existing buildings. Successful implementation of optimum energy codes is essential to provide India with comfort levels, energy security and CO_2 savings.

GBPN RECOMMENDATIONS & CONCLUSIONS

GBPN Conclusions

Conclusion: The Importance of Saving Energy in India

The biggest population growth in the GBPN regions is expected to take place in India and similarly, the biggest floor area growth will be in India. As result the biggest comparative growth of energy use in buildings in the four regions is predicted to take place in India. There is therefore a huge potential to reduce energy use and CO_2 emission in the Indian building sector. With state-of-the-art technological and political measures implemented it will be possible to reduce the growth of final thermal energy use in the Indian building sector by 2050 dramatically. If no action is taken (the 'frozen' scenario), India will face a growth in thermal energy demand in buildings of almost 700 % (20.6 EJ) whereas; if India shifts to following a 'deep' scenario this will limit the growth to around 130 %. This savings potential is more than five times greater than what India uses in buildings today.

New buildings and their energy efficiency are fundamental in reducing the energy consumption of India's buildings. Most of the buildings that will be standing in 2030 are still to be built. Less than a fifth of the buildings that will be standing in 2050 are already built today.

The additional demand for electricity that the growing floor area will need will intensify the current power shortage situation in India. Without an effort to reduce the energy intensity and increase the energy efficiency of buildings, India will undoubtfully face an increase in their power shortage problems; however, energy efficient buildings present a unique opportunity to resolve this problem. The main present problem faced is the lack of mandatory regulation in most regions. Since most of India's cities are not covered by an efficiency code, there is a big risk of a lock-in effect that will cause huge amounts of energy to be unnecessarily used.

Conclusion: How Can Indian Buildings Save Energy?

Building energy standards are the most potent of all policies in reducing energy use from the heating and cooling of new buildings. Standards in other regions have shown to be cost-effective and to have a very large impact on energy consumption of buildings over the whole lifetime. Therefore, a major step towards a market transformation of energy efficiency in buildings will be for India's states to adopt codes and guidelines that push for energy efficiency in all new buildings.

India's national energy building code (ECBC) that concerns commercial buildings (and large residential buildings over three-stories) should be adopted and implemented as a mandatory minimum standard in all states. It is important that the ECBC gets implemented in all states of India. For this to happen a strong support for training and enforcement regimes must be set in place.

Further codes or guidance must be developed for all types of residential buildings. These codes should however, be fully adapted to Indian buildings (climate and technology development) and implementation should focus mainly on heating, cooling, ventilation and hot water preparation. System should be laid out to reduce capacity problems in the inspection of these codes by focusing on elements that can be enforced based on simple training.

An initiative for residential buildings should start with the most formal part of the sector such as high-rise and low-rise residential apartment buildings. The existing coverage from ECBC for large residential buildings needs to be complimented by an adoption of building codes that requires for minimum standards of energy efficiency for residential buildings that is well adapted to the Indian context (in terms of climate, development and tradition).

For the more informal part of the residential sector it might be more appropriate to set guidelines that are supported by encouragements or incentives as well as information and training activities.

There are a number of actions that can be taken to hasten the local code adoption process:

- Forming networks that compose of experts and specialists in the field of energy efficiency in buildings;
- Encourage awareness and training programmes within local governments that will help with the implementation process;
- Enact benchmarking practices through a building's utility bills to collect data that can be used for comparisons;
- Provide energy efficiency incentives that focus on building energy performance; and
- Ensure regional learning by sharing information on international best practices.

Once these codes are implemented and enforced well they should that be regularly updated. These updates should take the latest development designs, new technologies and cost effectiveness of such measures in to account. Codes should help to push the boundaries of energy performance and provide for a large uptake of new energy efficiency measures.

Mandatory compliance of building codes needs to be supported by other policies and incentives. Building codes should therefore be a key element in a policy package for new buildings which also includes other policies such as certification, finance / subsidy schemes, general incentives, training and information activities as well as public demonstration or procurement policies.

Energy performance requirements in building codes act as the foundation for the market transformation of energy-efficiency in buildings and also as the baseline of minimum efficiency standards for voluntary label and incentive schemes. These building codes should be adapted to suit the Indian climate, and the regional development of the construction industry.

New buildings should spur energy efficiency in existing buildings. Programs should ensure that existing buildings get improved before HVAC systems get installed. Policy packages should ensure that existing buildings follow new buildings trends towards higher levels of energy performance and efficiency as well as the uptake of renewable energy; this should include enhanced labelling, requirements for renovation, refurbishment or improvements and financial measures or incentives that encourage owners of existing buildings to upgrade their buildings. Public buildings should play a significant role in demonstrating best practices, procurement of good products and for training purposes.

Finally, India needs to learn from its own past and from the good examples of locally adapted bioclimatic buildings, which exists in all parts of India. The way that these have traditionally overcome climatic conditions should be studied and used for further development of fully climate-adapted architecture. Many of the principles of these buildings are still relevant today and should be encouraged through codes and policy packages.

How can GBPN help?

GBPN's Mission

As buildings account for around 40 per cent of the global final energy use and 30 per cent of global energy-related carbon emissions, it is clear that this sector has the potential to bestow huge energy savings.

"GBPN's mission is to support the implementation of a 'deep' path of energy savings and carbon reductions in buildings."

It is possible to realise the savings potentials offered by the "deep" path if today's state of the art technologies and policies become standard practice within the next ten years. To successfully move building energy policies to pursue the 'deep path' requires global collaboration. The GBPN strategy calls for both global and local collaborations in order to demonstrate the global significance of sharing local best practices. This is facilitated by action with its hubs and partners in China, the EU, India and the US.

GBPN will do everything possible to provoke a transformational change in the building sector, highlighting the importance of mainstreaming state-of-the-art policy practices and building performance. Action is required now and GBPN are committed to creating more effective collaboration amongst all stakeholders in the building sector. The deep path calls for all stakeholders to push for ambitious, long-term building performance targets that are based on today's best practices.

GBPN's Presence in India

GBPN are in partnership with Shakti Sustainable Energy Foundation, India's Climate Foundation dedicated "to helping India strengthen its energy security while transitioning to a low carbon economy" (Shakti, 2013). The Shakti Foundation and GBPN have devised a programme of activities specially adapted to India's economic and demographic context, aiming to reduce the energy demand of the Indian building stock. Their goal is to encourage the uptake of new technologies and improve the new building stock's energy performance in India.

GBPN & Shakti Foundation – Data Collection

GBPN's primary concern in India is to work with the Shakti Foundation to improve code development through the adoption of robust energy models, data and analysis. The team will support government programmes on benchmarking and labelling of buildings in order to create a repository of up-to-date energy data. This will improve data access to modellers and in turn provide accurate information to stakeholders in policy development. GBPN will gather and share best practices and precedents of good data collection.

GBPN & Shakti Foundation - Residential Buildings

India's residential building sector holds such a massive savings potential it cannot be ignored – GBPN's mission is to create a case for residential energy efficiency guidelines, particularly high-rise and multi-family formal buildings. GBPN plan to support the development of a policy pathway for low-energy buildings in India by integrating specific indigenous methodologies and international best practices.

An in-depth desk study will be undertaken to assess the current data quality of the residential building sector and compile any existing research. This work will be used to design a set of guidelines and minimum standards for new residential buildings in India, focusing on the more formal part of the building sector: high-rise and multiple units.

Shakti Foundation – ECBC

The Shakti Foundation is looking to improve and strengthen the ECBC and support its implementation and enforcement in India's key growth states. The intention is that 50% of all applicable buildings will be ECBC compliant by 2016. This compliance rate would achieve a reduction of 15,000 Gwh by 2016. The initiative will facilitate mandatory adoption of the ECBC and focus on strengthening the code, keeping it inline with best practices. The team will support further development of ECBC knowledge by creating a resource website to be used as a dissemination network for cross learning between states and agencies involved in the ECBC.

GBPN - Collaboration & Networking

With its global structure and regional hubs the GBPN is well suited to support local development through international best practices. The GBPN network will work for increased international collaboration and for learning from global best practices in order to stimulate state of the art in each of the regions, and for the establishment of networks to support energy efficiency in buildings and the uptake of renewable energy.

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ANNEX SCENARIOS

Scenarios in the Central European University, Best Practice Policies for Low Carbon & Energy Buildings, report 2012, commissioned by GBPN.

Three scenarios (described briefly in section 2.2) are considered for energy use dynamics –a very ambitious, a moderately ambitious, and a “business as usual”. These scenarios investigate what buildings can achieve to mitigate climate change through the various opportunities.

Deep Scenario
This scenario demonstrates how far today’s state-of-the-art construction and retrofit know-how and technologies can take the building sector in reducing energy use and CO_2 emissions, while also providing full thermal comfort in buildings. In essence, we determine the techno-economic energy efficiency potentials in the building sector.

In this scenario, exemplary building practices are implemented worldwide for both new and renovated buildings. Over the 10-year period from 2012 to 2022 advanced buildings are widely proliferating in all regions, replacing conventional new and retrofit buildings on the market. . The transition period allows markets and industries to prepare for the large-scale deployment of the high efficient building construction technologies, materials and know-how. Necessary ambitious enabling policies can also be implemented and the vital supporting institutional framework introduced. After 2022, most renovations and newly built structures will be of a very high-energy efficient design as exemplary buildings in the same (or a similar) climate zone. For regions where the best building design practices have not yet been proven, e.g. in most of the developing world, the energy consumption figures for each building category.

Moderate Scenario
The rationale for this scenario is to illustrate the development of the building energy use tacking into account current policy initiatives, particularly implementation of Energy Building Performance Directive (EPBD) in the EU and building codes for new buildings in other regions.

The scenario assumes an accelerated renovation rate (i.e. annually reconstructed buildings) to reflect that many countries recognized the importance of the quick implementation of energy-efficient retrofits and energy-efficient building codes. In all regions retrofit rates start to increase from the level of 1.4% in 2005 and reaches “accelerated” levels by 2020, and stay unchanged afterwards. These “accelerated” rates are different in different regions. For the key regions the following values are used: US and EU-27 – 2.1%, China – 1.6% and India – 1.5%. However, these accelerated retrofit buildings and new constructions still result in far lower efficiency levels than what is achievable with state-of-the-art solutions (hence, the name is Moderate Efficiency scenario).

New buildings are built to approximately regional code standards in existence at the time of this study; renovations are carried out to achieve approximately 30% energy savings from the existing stock average, as opposed to the state-of-the-art that reach 90% of savings in some climate and building types, as demonstrated by best-practices.

Frozen Scenario
It is important to emphasize that because of recent advances in scenario science, baselines are constructed only for exceptional use when it is unavoidable that one must have a baseline. Therefore, this scenario, will not receive the level of effort and rigor that the mitigation scenarios do.

Frozen Efficiency scenario assumes that the energy performance of new and retrofit buildings do not improve as compared to their 2005 levels and retrofit buildings consume around 10% less than standard existing buildings for space heating and cooling, while most of new buildings have higher level of energy performance than in Moderate scenario due to lower compliance with Building Codes. Retrofit rates are assumed to be constant throughout the analysed period at the level of 1.4%. Advanced new buildings are assumed only in Western Europe (namely Germany as 5% and Austria as 10% of the new building stock) and their share in the new building stock does not change over the time. Advanced retrofit buildings are not considered for all regions.

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Building Policies for a Better World

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About GBPN The Global Buildings Performance Network (GBPN) is a globally organised and regionally focused network whose mission is to advance best practice policies that can significantly reduce energy consumption and associated CO_2 emissions from buildings.