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Developing Global Building Energy Efficiency Regulations for Net Zero Energy and Zero Carbon Buildings

Aggarwal,S.[1], Kaur,P.[2], Chani,P.S.[3]

[1]Ph.D. Scholar, IKG Punjab Technical University, Jalandhar Kapurthala Road, Punjab, India
[2]Professor and Director, I.K.G. P.T.U., Mohali campus-2, Punjab
[3]Professor, Head of the Department, Department of Architecture, I.I.T. Roorkee, Uttarakhand, India
E-mail: [1]ar2k14shikha@gmail.com, [2]inchargemohali.ptu@gmail.com, [3]prabhjot.chani1@gmail.com

Abstract—*Buildings use 40% of worldwide electricity generated and are responsible for one third of greenhouse gases being produced. India is 6th largest carbon dioxide producer in the world. As the economy grows, there is increase in commercial and business activities. Commercial buildings are responsible for about 7% of the total electricity consumption in the country. There are many rating systems for sustainable buildings that evaluate them during different stages of life. These rating systems vary in their criteria of evaluation widely leading to that some building is credited gold by one while disqualified or uncertified by another rating system. Similarly, there are many simulation tools used for evaluating energy performance of buildings for developing Net Zero Energy and Zero Carbon Buildings. These simulation tools vary in their criteria of evaluation of energy efficiency a building as a whole or element wise. Thus there is dire need of development of global energy efficiency regulations and codes which would set standards for achieving Net Zero Energy and Zero Carbon Buildings status across the world.*

Introduction

Buildings use 40% of worldwide electricity generated and are responsible for one third of greenhouse gases being produced. India is 6th largest carbon dioxide producer in the world. As the economy grows, there is increase in commercial and business activities. Commercial buildings are responsible for about 7% of the total electricity consumption in the country. There are many rating systems for sustainable buildings that evaluate them during different stages of life. These rating systems vary in their criteria of evaluation widely leading to that some building is credited gold by one while disqualified or uncertified by another rating system. Similarly, there are many simulation tools used for evaluating energy performance of buildings for developing Net Zero Energy and Zero Carbon Buildings. These simulation tools vary in their criteria of evaluation of energy efficiency a building as a whole or element wise. Thus there is dire need of development of global energy efficiency regulations and codes which would set standards for achieving Net Zero Energy and Zero Carbon Buildings status across the world.

International Green Building Rating Systems [3]

Many stringent sustainability benchmarks have been set internationally. The BREEAM (Building Research Establishment's Environmental Assessment Method) was first launched in 1990 in the UK. Then, the U.S. Green Building Council (USGBC) developed LEED (Leadership in Energy and Environmental Design) rating system in 2000. Other such assessment tools are as follows:

- GBAS- China's green building assessment method was introduced in 2006 and is a credit-based system.
- DGNB – founded by German Federal Ministry of Transport, Construction and Urban Development in June 2007.
- Green Star- Adopted by the Australian government.
- CASBEE – It is adopted by Japan

Indian National Codes:

In India, various national bodies have developed energy conservation codes and standards. It started with the National Housing and Habitat Policy in 1998, the Energy Conservation Act (ECA 2001), Integrated Energy Policy in 2006 and NBC Sustainability 2016 . These national bodies have developed three different building codes:

- **BIS developed National Building Code** to standardise the construction quality across the country [4].
- **BEE developed ECBC, (**the only national building energy code). It is currently voluntary establishes minimum energy efficiency requirements for building envelope, lighting, HVAC, electrical system, water heating and pumping systems.
- **Ministry of Environment and Forest (MoEF) developed the Environment Impact Assessment and**

Clearance (EIA). Builders and developers need to obtain an EIA clearance before construction [5].

- **The Energy Research Institute of India** has developed Green Rating for Integrated Habitat Assessment (GRIHA). The basic method defined by GRIHA requires the project team to compare the building's annual "Proposed Design Energy Consumption" to a standard value of the "Standard Design Energy Consumption" [6] [7] [8] . The energy assessment is based on ASHRAE Standard 90.1 for thermal comfort requirements in a commercial building and The Council of American Building Officials' Model Energy Code for residential buildings.

Types Of Regulations

There are five types of energy efficiency regulations that have been defined by various energy codes. These are as follows [9]:

1. **Prescriptive:** There are some specified values for building envelope components (U-value of walls, windows, roofs, etc.) and specifications of equipment and products (rated by energy stars) to achieve high energy savings.
2. **Trade-off:** Trade-off can be made of lower achieved energy values with higher achieved values of different building components. It usually is made between U-values for the building envelope and the HVAC energy consumption values.
3. **Model building**: A base model of a building is prepared and calculations are compared to the performance of the existing building or with the proposed building.
4. **Energy frame**: An energy framework is defined and the building performance is evaluated for its reduction in energy demand and energy consumption.
5. **Performance**: Energy performance of a building is evaluated on the basis of a building's overall consumption of energy (fossil fuel) and GHG emissions.
6. **Point system:** There are many building rating systems that certify on with point systems and provide incentives when buildings achieve high compliance. These codes are most common in Asia (e.g., Japan and Korea)
7. **Outcome –based code:** In this system, the new buildings regulate their energy consumption by issuing penalties for excessive energy use annually.

Analysis Of Building Energy Efficiency Policies For New Buildings [10]

Most of the international codes on building energy efficiency have long term targets of achieving zero or positive energy in new buildings. Global Buildings Performance Network with the support of sixty-four global building code experts from different regions who are working in international organizations compared twenty-five best international building energy efficiency codes and developed an interactive comparative tool to facilitate the analysis and comparison of best energy efficient practices. These codes were assessed on the basis of their approach towards achieving net zero energy in a building. These include holistic approach, dynamic approach, good enforcement, individual elements of performance and overall performance. Professional bodies like the regional hubs of GBPN, BPIE (Europe) , SHAKTI (India), And CSEP(China) also provided their review on the prevailing codes in respective regions.

The IPEEC countries have collaborated with the Global Building Performance Network (GBPN) and Pacific Northwest National Laboratory (PNNL) for effective implementation of building energy efficiency codes in countries like China, France, Germany, Russia, the United Kingdom and the United States which are the major stake holders of GHG emissions. Though different countries have different code requirements, there are some challenges that they all face commonly during implementation; financial priorities of the government, deficiency of systems for ensuring compliance with code requirements, development of programs for measuring the building performance, incentives to encourage code performance at local level, etc. The international agencies like the IPEEC Building Energy Efficiency Task group (BEET), GBPN, and PNNL along with the governmental and non-governmental building energy experts are working on finding solutions to these challenges.

The Paris Agreement On Climate Change:

The Paris Agreement on Climate Change gives a common legally binding agreement to hold global warming well below $2^{o}C$ with aspiration to achieve $1.5^{o}C$ integrated with frameworks for action on resilience and adaptation. In order to promote collective action consistent with the IPCC's findings some objectives were finalised [11]. They include that there should be secure ambitious reductions of emissions by at least 60% below 2010 levels by 2050 and legal binding mitigation commitments to achieve below 2°C objective.

A global review has to be conducted every five years for transparency and accountability of emissions reduction and related commitments and effective implementation of policies. According to the protocol, all G20 nations (accounting for more than 40Gt of CO_2 equivalent emissions in 2015 i.e. around 75% of global emissions) are expected to implement the objectives from 2020 onwards.

For the Protocol to be globally effective the following considerations have to be taken in account:

1. **Broad geographical coverage**: To achieve the emissions target (at least 40% domestic reduction), all parties (including G20 countries) except LDCs, need to put forward their INDCs latest by the end of the first quarter

of 2015 as per the requirements agreed in Lima. The targets should be well quantified and comparable.

2. **Mitigation Commitment**: To achieve the set targets at the Paris conference, each participating country must select and refine its mitigation commitment type according to its capabilities. The INDC shall demonstrate significant progress in mitigation targets and reduction of emission intensity over time. These countries have a historic base year or reference period. High income countries that have not set their targets under the Protocol shall have also to do so by 2025 and the emerging economies and middle-income countries are encouraged to do so before 2030.

Nearly 91 countries have prepared their Intended Nationally Determined Contributions (INDCs) based on their commitment, national programs and projects. To hold the global warming below 2^{o}C, the GHG emissions in 2030 shall be considered as peak value. To reach this goal all countries have to engage their building sector in climate responsive actions.

Developing countries like China and India need to implement policies that make their residents easily accept net-zero energy and carbon emission free building and use renewable sources of energy. These efforts shall generate economic, social and environmental benefits.

There are presently many international organisations like the International Union of Architects (representing 1.3 million Architects world-wide), World Green Building Council, Architecture 2030 and the Prince of Wales Corporate Leaders Group that have collaborated to achieve the objective of achieving zero- emissions building sector by 2050.

The European Union

The EU accounts for 9% of global GHG emissions and has ambitious targets for reduction by 2030. The EU emissions declined by 19% between 1990 and 2013 which resulted in growth of the EU GDP by 45%. The EU's 2030 climate and energy framework shall further lead to decline in emissions intensity and strengthening of its economy by 50 %.

China

China accounts for 25% of global GHG emissions. It has two climatic zones (North and South). The regions of southern China are warmest. To meet this hot summer and warm winter (HSWW) climate, standards were developed in 2003 with the title “Design Standard for Energy Efficiency in Residential Buildings in the Hot Summer and Warm Winter Zones” by the Ministry of Construction of the People's Republic of China. The standards include various aspects for improving the energy efficiency methods by providing natural ventilation, shading, other passive cooling strategies, economic analysis of heating and cooling systems along with energy production techniques using renewable sources of energy. These codes refer mainly to one family and multiple family residential buildings. They are prescriptive in nature and have “custom budget” approach for compliance. [12].

England & Wales

England and Wales have cold climate and need heating system for majority part of the year. It has 2938 heating degree days and 60 cooling degree days. To meet this requirement standard were developed in 2010 with the title “The Building Regulations 2010 Conservation of fuel and power in new dwellings (L1A) and in new buildings” by the Department for Communities and Local Government. The standards are mandatory so that the Design Emissions Rate (DER) of CO_2 in the proposed building does not exceed the Target Emissions Rate (TER) for a base model. This code gives prescriptive and mandatory requirements for energy consumption by building systems like HVAC, hot water, lighting, etc. It also addresses the renewable energy sources and bioclimatic design parameters. It is mandatory to do simulation and calculation, air- tightness testing, thermal bridging and meet renewable energy requirements, pre-occupancy commissioning and meet the national target for zero carbon homes by 2016.

These codes are applicable to residential buildings (one family and multiple family), commercial buildings (Offices, Retail and wholesale, Hotels, Hospitals, Educational buildings) and public buildings (office, hospitals and educational buildings).

Public buildings that have floor areas more than 1000 sqm. are given Display Energy Certificates and have to submit Commercial Energy Performance Certificate before a completion of the project .

France

France has eight prescribed climate zones, 2435 Heating degree days and 261 cooling degree days. It needs heating system for most of the year. The national energy efficiency code has the title “Réglementation Thermique - RT2012” and was adopted in 2013 under the authority of Centre Scientifique des Techniques du Batiment. The code is applicable to residential buildings (one family, multiple family), commercial buildings (offices, retail, wholesale, hotels) and public buildings (offices, hospitals, educational buildings). The building systems that consume energy are: technical HVAC systems, ventilation, air tightness, thermal bridging, hot water, lifts, pumps, efficient lighting, etc. To reduce the energy consumption prescriptive requirements have been given for passive solar, cooling, natural ventilation, daylighting and solar energy production techniques.

India

India has five climatic zones: composite, hot and dry, warm and humid, moderate and cold. Since the climate is hot for most of the year in major parts of the country with 78 heating degree days and 3722 cooling degree days, the energy efficiency standards are cooling based. The code has title

"Energy Conservation Building Code (ECBC)" under the authority of Bureau of Energy Efficiency and was implemented in 2007. The code has set standards for commercial and public buildings with connected load greater than 500 KW or 600 KVA and is based on ASHRAE 90.1. It is a model code and has prescriptive as well as mandatory requirements for compliance. Trade –off approach is also described in the code to achieve the annual energy targets. [14]

New York City

The US accounts for 11% of global GHG emissions. The New York city has combined climate, moderate climate, 4 & 5 & 6 IECC climate zones. Since there are 2575 heating degree days and 706 cooling degree days, heating has to be provided for most of the year. The standards were adopted in 2010 under the title "New York City: Energy Conservation Code (NYCECC)" and was developed by NYS Department of State Division of Code Enforcement and Administration. It covers residential, commercial and public buildings. [15]

Singapore

Singapore has warm and humid climate with 3568 cooling degree days and no heating degree days. It requires cooling based HVAC system for thermal comfort of its occupants. The code has title "Singapore: code for environmental sustainability of buildings" and was adopted in year 2008. [16]

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