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Capturing Energy-Saving Opportunities: Improving Building Efficiency in Rajasthan through Energy Code Implementation

Q Tan
S Yu
M Evans
J Mathur*
L D Vu

* Malaviya National Institute of Technology Jaipur

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Capturing Energy-Saving Opportunities: Improving Building Efficiency in Rajasthan through Energy Code Implementation

Qing Tan[a], Sha Yu[a], Meredydd Evans[a], Jyotirmay Mathur[b], Linh D. Vu[a]

[a] Pacific Northwest National Laboratory; [b] Malaviya National Institute of Technology Jaipur

Executive Summary

India has experienced rapid growth in building energy consumption in the past several decades, primarily due to extensive urbanization and economic growth. The total floor space of commercial buildings is expected to continue increasing through 2030 and beyond. In response to the challenge presented by increasing energy consumption in buildings, the Indian Ministry of Power launched the Energy Conservation Building Code (ECBC) in 2007. This model code sets minimum energy performance standards for large commercial buildings. As India's largest state by area, Rajasthan was the first to adopt the code with minor additions in 2011, through the Rajasthan Energy Conservation Building Directives (R-ECBD). R-ECBD is mandatory for commercial buildings in Rajasthan with a connected load of over 100 kilowatts or a contract demand of over 120 kilovolt-amps.

Since the adoption of R-ECBD, Rajasthan has taken several important steps in implementing the code. It set up the framework for R-ECBD implementation by incorporating code requirements in state and local building by-laws. Rajasthan also enhanced its capacity for R-ECBD implementation within local governments and the building industry by identifying training needs and conducting training sessions. In addition, state and local governments developed policy incentives for ECBC-compliant buildings. There are an increasing number of buildings that are complying with the code. Compliant buildings include new government buildings at the national and state levels, certified green buildings, large commercial buildings and other buildings that want to take advantage of the compliance incentives.

In collaboration with the Malaviya National Institute of Technology (MNIT), the Pacific Northwest National Laboratory (PNNL) provided significant support to facilitate R-ECBD implementation in Rajasthan. At the initial stage, PNNL helped develop an implementation roadmap with a training plan. Later, PNNL worked with MNIT to identify training needs and develop training materials to close capacity gaps. PNNL also worked with state and local governments to encourage their support for R-ECBD implementation. For example, the Rajasthan Renewable Energy Corporation Limited (RRECL) has taken PNNL's recommendation to offer annual awards recognizing exemplary buildings that comply with R-ECBD. In terms of institution establishment to facilitate code enforcement, PNNL recommended that Rajasthan use a third party assessor system. PNNL also cooperated with MNIT on pilot buildings and helped summarize lessons learned from the construction of the pilot buildings. The lessons are valuable

in removing barriers for R-ECBD implementation. They also highlighted the importance of capacity building and having a building product testing system. Figure 1 shows PNNL's contributions to ECBC implementation in Rajasthan.

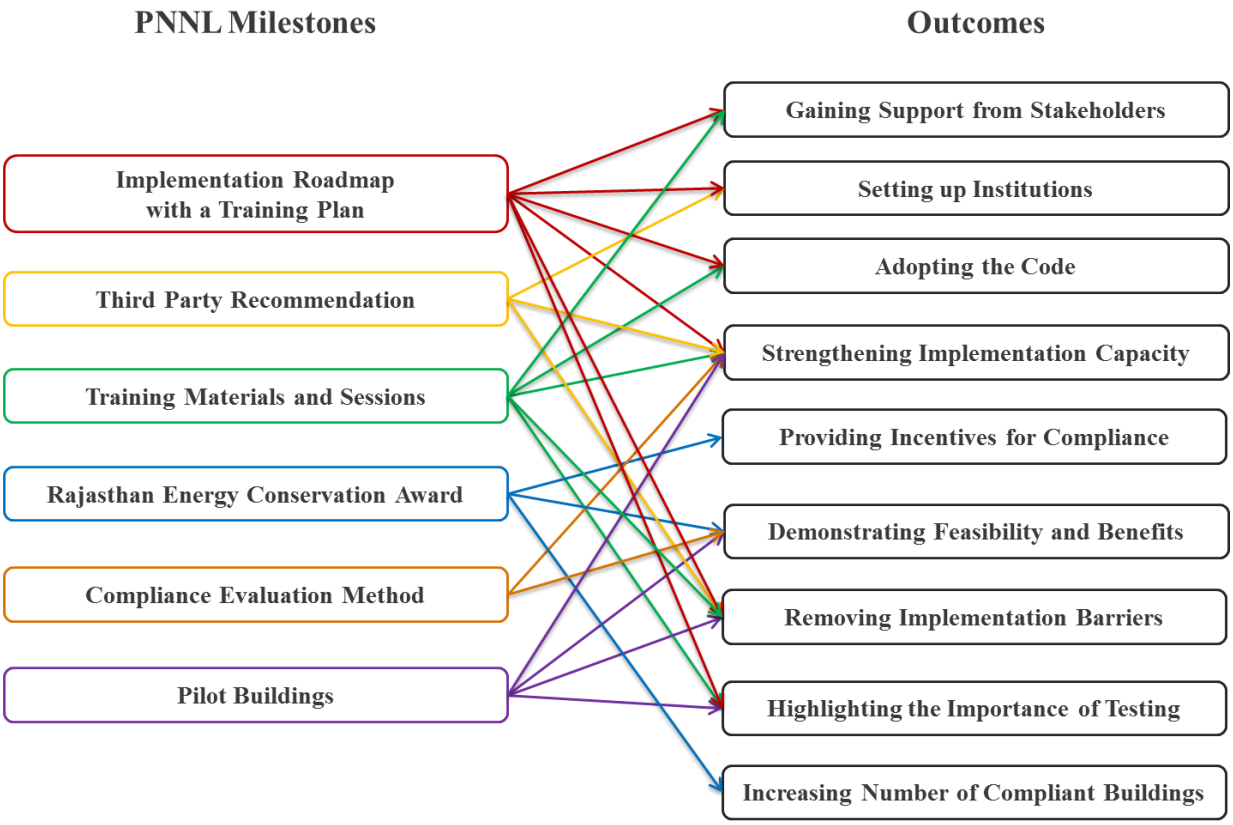

Figure 1 Overview of PNNL's Work and Progress of R-ECBD Implementation

Learning from the implementation of R-ECBD in Rajasthan, it is important for states and cities that implement ECBC to 1) use a stakeholder process to improve decision making, 2) adopt the code at the local level and add it to the building permitting process, 3) build capacity with training sessions, 4) enhance enforcement capacity by using a third party assessor system, 5) improve awareness and capacity within Urban Local Bodies, 6) use pilot buildings as learning tools and showcases of compliance and 7) roll out actual compliance checks to discourage non-compliance.

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Acronyms and Abbreviations

BEE	Bureau of Energy Efficiency
DOE	U.S. Department of Energy
ECBC	Energy Conservation Building Code
GRIHA	Green Rating for Integrated Habitat Assessment
HVAC	heating, ventilation and air conditioning
LED	light-emitting diode
LEED	Leadership in Energy and Environmental Design
MNIT	Malaviya National Institute of Technology
PNNL	Pacific Northwest National Laboratory
PV	photovoltaic
R-ECBD	Rajasthan Energy Conservation Building Directives
RRECL	Rajasthan Renewable Energy Corporation Limited
ULB	Urban Local Body

Contents

1.0 Introduction

India is experiencing a significant increase in building energy consumption linked to its rapid income growth and urbanization. The building sector accounts for 33 percent of total final energy consumption (Rawal, et al., 2012); and commercial buildings represent 28 percent of total building sector electricity use (Majumdar, 2014). Building energy use in India is likely to grow in the future given socio-economic trends. The total commercial floor space will grow to around 2 billion m^2 by 2030; that represents a 66 percent increase compared to today's figure of 659 million m^2 (Mathur, et al., 2014). Understanding how important it is to reduce the energy use of India's new construction, the Indian Ministry of Power launched the Energy Conservation Building Code (ECBC) in 2007. ECBC derives its legal authority from the Energy Conservation Act, and it sets standards on minimum energy performance for components of new commercial buildings within its scope[1]. The code covers energy efficiency of many energy-related building systems, including the building envelope, heating, ventilating and air conditioning (HVAC), interior and exterior lighting, service hot water and electric power and motors in each of the five climatic zones in India. The Indian Bureau of Energy Efficiency (BEE) estimated in its published ECBC Implementation Roadmap that implementing the code could reduce energy use in new buildings by 25 to 40 percent compared with today's average buildings in India (IRG Systems South Asia Private Limited; IT Power Consulting Private Limited, 2014).

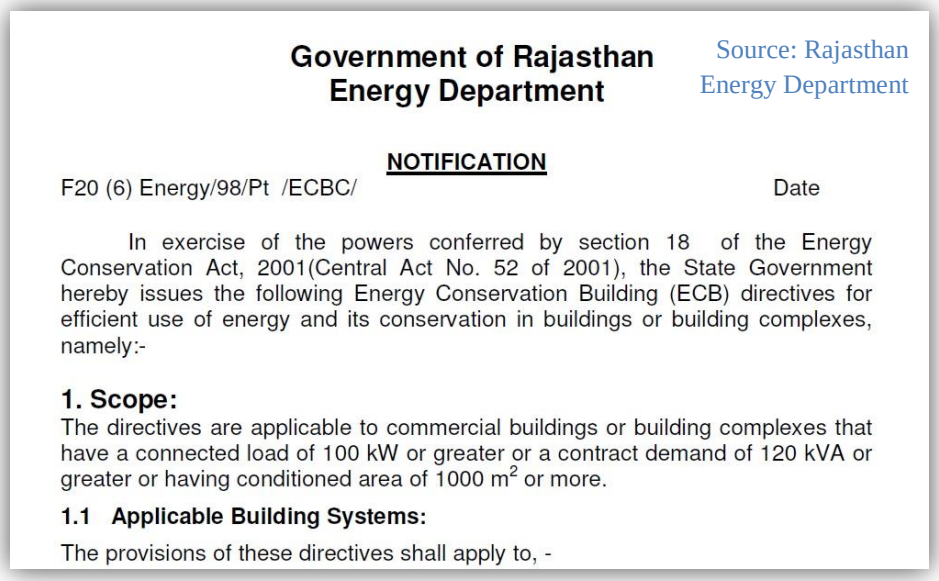
In terms of compliance, ECBC allows three approaches: the prescriptive method, the simple trade-off method and the whole building performance method. Under the prescriptive method, buildings have to comply with specific, applicable requirements set by ECBC, although there can be some flexibility among building envelope components through the simple trade-off option. Alternatively, the whole building performance method allows some building components to fall short of prescriptive energy performance requirements as long as the other components make up the loss by exceeding requirements; the energy performance of the building as a whole should be as good as or better than that of a standard ECBC-compliant building[2].

Rajasthan was the first state to adopt ECBC at the state level[3]. As the largest state in India, Rajasthan has a population of 69 million and an area of 342,000 km^2 (IRG Systems South Asia Private Limited; IT Power Consulting Private Limited, 2014). The state has a power generation capacity of over 17,000 megawatts with 38 percent from renewables[4] (Central Electricity Authority, 2015). Nevertheless, Rajasthan still suffers from chronic power shortages causing

[1] At the launch of ECBC, it covered new commercial buildings with a connected load of 500 kilowatts or greater or a contract demand of 600 kilovolt-amps or higher; later, in March 2010, the code was amended and the scope was expanded to new commercial buildings with a connected load of over 100 kilowatts or a contract demand of over 120 kilovolt-amps.
[2] A combination of all applicable ECBC requirements.
[3] Rajasthan made minor additions to ECBC, and the modified version is known as the Rajasthan Energy Conservation Building Directives (R-ECBD).
[4] Not including nuclear.

daily power outages of up to five hours for domestic consumers and industry (Indo-Asian News Service, 2014). Rajasthan has been making great efforts to enhance its energy efficiency, and adopting the Rajasthan Energy Conservation Building Directives (R-ECBD) is a critical component.

The U.S. Department of Energy (DOE)'s Pacific Northwest National Laboratory (PNNL) partnered with the Malaviya National Institute of Technology (MNIT) to facilitate R-ECBD implementation and enforcement in Rajasthan. PNNL worked with stakeholders in Rajasthan to develop an implementation roadmap with a training plan and to map out the institutional set-up for implementation (including the use of third parties). PNNL also provided recommendations on compliance mechanisms and built capacity at the local level in cooperation with MNIT. Moreover, PNNL partnered with MNIT on two pilot ECBC-compliant buildings. This report highlights the major progress to date with R-ECBD implementation and enforcement in Rajasthan and how DOE and PNNL have supported this process. The report also summarizes lessons learned for replicating the process in other Indian states and cities.



Government of Rajasthan
Energy Department

Source: Rajasthan Energy Department

NOTIFICATION

F20 (6) Energy/98/Pt /ECBC/ Date

In exercise of the powers conferred by section 18 of the Energy Conservation Act, 2001(Central Act No. 52 of 2001), the State Government hereby issues the following Energy Conservation Building (ECB) directives for efficient use of energy and its conservation in buildings or building complexes, namely:-

1. Scope:

The directives are applicable to commercial buildings or building complexes that have a connected load of 100 kW or greater or a contract demand of 120 kVA or greater or having conditioned area of 1000 m^2 or more.

1.1 Applicable Building Systems:

The provisions of these directives shall apply to, -

Figure 1 R-ECBD Notification Cover

2.0 Outcomes and milestones of ECBC implementation in Rajasthan

This section focuses on major outcomes and milestones in R-ECBD implementation in terms of compliance, the implementation framework, institution set-up, capacity and incentives. It also highlights how the MNIT pilot buildings showcased these achievements throughout the construction process.

2.1 Compliance

The Government of Rajasthan and Urban Local Bodies (ULBs) do not collect statistics on R-ECBD compliance, so there are no comprehensive numbers on compliance. However, several categories of buildings are complying with R-ECBD:

- New government buildings at the national and state levels;
  Under the supervision of the Central Public Works Department and the Rajasthan Public Works Department, all new large national and state public buildings in Rajasthan are mandated to comply with ECBC.
- Certified green buildings;
  Certified green buildings are in almost all cases ECBC-compliant. This includes buildings certified under the Green Rating for Integrated Habitat Assessment (GRIHA) and the Leadership in Energy and Environmental Design (LEED).
- Large or upscale commercial buildings that want to avoid the risk of non-compliance;
  Some ULBs like the Jaipur Development Authority have started to reject buildings that did not comply with R-ECBD. As a result, large or upscale commercial buildings (e.g. malls, luxury hotels and office buildings) are most likely to comply to reduce the risk of delays, and expensive fines and modifications.
- Buildings that want to take advantage of the floor area ratio incentive.
  The Government of Rajasthan and ULBs are offering incentives for buildings that comply with R-ECBD. One of them is the extra floor area ratio for compliant buildings that meet certain criteria. More details are explained in **Section 2.5 Incentives**.

Box 1 PNNL's contribution in ECBC implementation and compliance evaluation

In March 2014, PNNL published a report examining lessons learned from international compliance assessment, and provided recommendations to India on options for conducting compliance evaluations to further improve ECBC implementation (Yu, et al., 2014).

The two pilot buildings at MNIT also demonstrated ECBC benefits and helped remove implementation barriers found throughout the construction process. Moreover, the pilot buildings serve as an important source of lessons learned on compliance and enforcement by highlighting the importance of "Schedule of Rates", for example.

While increasing compliance is seen as the most visible and direct outcome of R-ECBD implementation in Rajasthan, there are milestones achieved in other aspects that have supported and enhanced the compliance. These include the implementation framework, institutions, capacity and incentives.

2.2 Implementation framework

In March 2011, four years after the launch of ECBC as a model national code for commercial buildings in India, Rajasthan adopted ECBC with minor additions. R-ECBD[5] became mandatory for large new commercial buildings[6] in September of the same year.

In September 2011, the Rajasthan State Pollution Control Board incorporated ECBC into the *Environmental Guidance Manual: Building and Construction Projects*. The manual serves as a source of clear and concise information that building or construction project stakeholders can reference to ensure that their projects meet construction requirements linked to the environment. The manual references *ECBC 2007* and the *ECBC User Guide*. It also reiterates important concepts and gives examples of good practices in design and construction.

Box 2 PNNL's role in building the implementation framework

In October 2011, PNNL and MNIT jointly hosted a stakeholder workshop in Rajasthan with support from U.S. DOE and the Rajasthan Renewable Energy Cooperation Limited (RRECL). 47 stakeholders participated in the workshop, including officials from BEE and state and local governments, building owners, developers, building industry professionals and research institutes. Discussion focused on R-ECBD implementation mechanisms, training needs and the local market for energy efficiency products. Apart from the discussion, PNNL and MNIT conducted a survey about stakeholders' opinions on R-ECBD compliance, training requirements and perceived obstacles in R-ECBD implementation. The workshop and the results of the survey provided a basic understanding of existing capacity and infrastructure for R-ECBD implementation in Rajasthan.

Utilizing insights gained from the stakeholder workshop and international best practices on energy code implementation, PNNL developed an R-ECBD enforcement roadmap for Rajasthan in February 2012, followed by a training plan. Taking into consideration RRECL's enforcement plan and local capacity, the purpose of the roadmap was to inform the Government of Rajasthan on the process of code implementation. It provides detailed recommendations on code enforcement in terms of the institutional framework, third party assessor involvement, training and product testing and rating. (Yu, et al., 2012)

[5] Just like ECBC, R-ECBD defines the minimum energy performance of the building, covering building envelope, HVAC system, service hot water supply, lighting and electric power. R-ECBD has requirements for the two climatic zones of Rajasthan: hot and dry and composite. Passive cooling systems could work well under the local climatic conditions and are therefore recommended under the code. Like in ECBC, R-ECBD allows for a choice between three compliance approaches, i.e. the prescriptive method, simple trade-offs and the whole building performance method.

[6] All new commercial buildings with a connected load of over 100 kilowatts, a contract demand of over 120 kilovolt-amps or an air-conditioned space of over 1,000 m^2 are covered by the code.

After R-ECBD went into effect, the State of Rajasthan realized that state implementation was not adequate; the key nexus of code implementation and enforcement lies at the local level, that is, the ULBs. In June 2012, Rajasthan amended the building by-laws to reference R-ECBD. The ULBs of several cities in Rajasthan, including Jaipur and Jodhpur, also added R-ECBD to the building approval process. Activities to adopt R-ECBD at the local level significantly improved R-ECBD implementation and enforcement in Rajasthan.

2.3 Institutions

Recognizing the importance of R-ECBD, the Government of Rajasthan and ULBs expressed their desire to support the implementation of R-ECBD at the state and local levels, respectively. ULBs have jurisdiction over compliance with local building by-laws. The Government of Rajasthan has also been considering forming and using a third party assessor system that has been proposed throughout India for ECBC enforcement and compliance in support of ULBs. Under the proposed framework, Indian third party assessors would be independent of building design and construction teams and would not belong to ULBs, but would submit reports to ULBs after conducting the design and construction reviews (Yu, et al., 2013).

Box 3 PNNL's support regarding institutional set-up

Following the stakeholder workshop, the training sessions co-hosted by MNIT and PNNL and follow-up meetings with stakeholders, state and local governments began to work on the implementation of R-ECBD. During this process, the roadmap that PNNL helped develop provided insights regarding setting up institutions like a third party system and a product testing, rating and labeling system to ensure code compliance.

In February 2013, PNNL authored a White Paper suggesting utilizing a third party assessor system in India during the initial stage of code enforcement because of the government's limited capacity. The Alliance to Save Energy and the Brookhaven National Laboratory also reviewed and contributed to this report. The White Paper compared three different enforcement approaches: 1) through local government officials, 2) via third party assessors and 3) utilizing a hybrid system. The paper then addressed key elements of a third party enforcement system by reviewing best practices of other countries and jurisdictions. Elements discussed in the paper include countries' existing infrastructure for third party, qualifications, licensing requirements for those assessors, training and certification for assessors and checks and balances to ensure robust compliance. Finally, the White Paper summarized the progress in India in terms of establishing a third party certification system, and emphasized again the importance of checks and balances. By sharing international experience in third party certification system with BEE, the paper provided the technical grounds to create a national third party code enforcement system in India (Yu, et al., 2013).

From the perspective of stakeholders that are regulated by the code, actual compliance also requires reliable information on the performance of building components. According to simulation MNIT conducted on the building products used in its pilot buildings, manufacturers tend to overstate the energy performance of their products. To ensure better code compliance, PNNL and MNIT recommended that India build a robust product testing, rating and labeling system. Once built, the system could help standardize the market and enhance the effectiveness of ECBC.

2.4 Capacity

To ensure ECBC enforcement and compliance, there are 89 ECBC Master Trainers in India certified by BEE's "Train the Trainers" program, who could serve as third party assessors; 6 of them are in Rajasthan (Indian Bureau of Energy Efficiency, Global Environmental Facility and UNDP, 2016). In addition to the existing infrastructure, there are synergies between ECBC inspections and the work of LEED accredited professionals and GRIHA third party evaluators. With necessary ECBC trainings, these LEED accredited professionals and GRIHA evaluators could serve as ECBC third party assessors.

The capacity for ECBC implementation was also enhanced with the MNIT pilot buildings. Although the majority of implementation and enforcement jurisdiction falls under local governments, all public buildings, including MNIT pilot buildings, receive approvals from the central or state public works departments. PNNL and MNIT therefore worked to increase the capacity within these departments to facilitate the process. One of the MNIT pilot buildings, Prabha Bhawan, is able to accommodate more people for ECBC trainings after its retrofits and expansion. This helps enhance the impact of existing training activities by involving more trainees. The pilot building also contributes to capacity building by demonstrating live ECBC benefits on site. Moreover, MNIT conducted significant analysis and made the purchasing of building materials and equipment for the pilot buildings a business case. The business case could demonstrate the importance and feasibility of purchasing energy efficiency materials and equipment in public buildings, and therefore inspire other states and cities that set out for ECBC implementation to enhance their capacity. It could also encourage developers and building owners to use energy efficiency measures in future projects by demonstrating the benefits of ECBC.

Box 4 PNNL's efforts in building implementation capacity

PNNL assessed training needs for ECBC implementation and worked out a detailed list of training modules addressing needs of different stakeholder groups. The list was based on existing Indian training materials and U.S. best practices. It also summarized MNIT's feedback on training gaps learned from previous ECBC training programs.

PNNL and MNIT then developed training materials to close the gaps in conceptual understanding and compliance checking procedures which would have the most impact on ECBC implementation and enforcement. The materials that help build a conceptual understanding include 1) introduction to ECBC history, benefits, requirements, energy savings and successful cases, 2) calculation of U-value of walls and roofs, 3) applying M-factor for external shading devices on windows and 4) applying the trade-off method for envelope. In particular, PNNL developed *Codes 101*, which consists of clear but concise materials to brief ECBC. This course was adopted by ULBs in Rajasthan and used in trainings. *Codes 101* was also used in trainings in other states such as Gujarat and Andhra Pradesh. Materials related to compliance checking procedures include 1) section-wise compilation of mandatory building requirements to serve as checklist and 2) compliance evaluation procedures (Yu, et al., 2012).

As PNNL's project partner in Rajasthan, MNIT carried out ten ECBC training sessions primarily targeting building professionals and ULBs. The training sessions aimed to raise awareness about ECBC and to provide the basic requirements in the code. The first four trainings contained an introductory presentation on building energy efficiency and ECBC, discussion sessions on specific questions about ECBC and an exercise on ECBC specifications and compliance methods. Following BEE's request, MNIT shared the exercises used in these trainings with other Indian states. The remaining sessions aimed at accelerating code adoption at the local level by raising awareness among state and ULB officials. MNIT disseminated the information related to the building category of the Rajasthan Energy Conservation Award (see details in **Section 2.5 Incentives**) during ECBC training sessions, and used information about award winners as training materials.

PNNL provided technical support for the "Train the Trainers" program in Rajasthan. The program was launched by BEE to train building energy efficiency experts and certify them as ECBC Master Trainers. PNNL also provided knowledge expertise in the design and improvement of ECOnirman, building simulation software broadly used in India for ECBC compliance. ECOnirman allows users to understand in a simple way whether their building complies with ECBC. This helps mainstream ECBC compliance in India (Evans, et al., 2014).

2.5 Incentives

In addition to R-ECBD implementation, the Government of Rajasthan has initiated several energy conservation programs through RRECL, such as mandatory solar water heating for most commercial buildings (Government of Rajasthan, Energy Department, 2011), energy efficient street lighting (Government of Rajasthan, Energy Department, 2010), energy audit requirements for commercial buildings and the Rajasthan Energy Conservation Award. These initiatives target not only saving energy, but also raising people's awareness about energy conservation. Such awareness will provide significant help in creating a conducive atmosphere for R-ECBD implementation.

In September 2014, the Jaipur Development Authority announced an incentive scheme for ECBC-compliant buildings: an extra 5 percent of floor area ratio will be provided for green buildings equal to or above 5,000 m^2 in area. The buildings can choose to demonstrate their green qualifications with R-ECBD compliance, a GRIHA 4 Star rating (which also requires ECBC compliance) or a LEED Gold certification (which in almost all cases would be ECBC-compliant)[7].

To incentivize R-ECBD compliance in buildings, RRECL took PNNL's recommendation and added buildings that comply with R-ECBD as an eligible sub-category for the Rajasthan Energy Conservation Award. Every year on Energy Conservation Day, December 14, the Award recognizes large commercial buildings that comply with R-ECBD and have extraordinary energy performance as exemplary models (Rajasthan Renewable Energy Corporation Limited, 2016).

Figure 2 Birla International School Received the ECBC Award from the Energy Minister of Rajasthan

3.0 Pilot ECBC-compliant building

To demonstrate ECBC implementation, MNIT collaborated with PNNL to construct two new pilot buildings, namely the Design Center or Prabha Bhawan (Figure 3) and the Lecture and Theater Complex. Prabha Bhawan has already been completed and occupied. PNNL worked with MNIT to summarize lessons learned from the construction of Prabha Bhawan.

[7] In order to obtain the extra floor area ratio, the green buildings also need to have parking and landscaping (if applicable) compliant with the provisions of the current regulation and have all the required provisions met as per the building regulations. The provisions were added in Regulation 19.7.21 of the Jaipur Development Authority (Jaipur Region Building) Regulation 2010.

Figure 3 Prabha Bhawan

Prabha Bhawan complies with R-ECBD through the whole building simulation approach. The work in the building consists of retrofitting the existing ground floor and constructing two additional floors. The air-conditioned space of Prabha Bhawan increased from 4,000 m^2 to 11,300 m^2. It can accommodate additional occupants and is able to hold more group activities like ECBC training sessions. Key features of the building include (Mathur, et al., 2015):

- Good envelope insulation with advanced technologies in the roof and walls;
- Double-glazed windows with integrated shading to allow natural light in while limiting solar heat gain;
- Energy efficiency light-emitting diode (LED) lighting; interior design to allow deep penetration of natural light; lighting controls to maximize use of daylight;
- HVAC system with controls that automatically works as needed to save substantial energy; the system also has insulated ductwork to reduce cooling losses;
- Rooftop solar photovoltaic (PV) system with an installed capacity of 157.5 kilowatts (Figure 4).

Figure 4 Rooftop Solar PV System

Prior to construction, it is critical for the investor to understand the economic feasibility and return before adopting energy efficiency measures. Therefore, MNIT conducted a payback analysis[8] to inform decision making. For example, the payback periods for wall and roof insulation were assessed over a range of insulation levels (for example 1-inch insulation would pay for itself in 3.2 years, when 2-inch insulation would take 9.2 years to pay for itself).

[8] All energy efficiency measures were considered as a group due to their inter-related impacts on effectiveness and payback. Factors taken into account in the payback period calculation include air conditioning capacity reduction and avoided cost from adopting the measures. Due to the large number of combinations of measures and the complicated procurement process in public buildings, only typical examples of payback analysis is given.

3.1 Benefits of ECBC implementation in the pilot building

a. Energy benefits

The pilot building demonstrated 30 percent savings in energy consumption compared to a standard ECBC-compliant building, which means that the pilot building exceeds the standard ECBC compliance by 30 percent via the whole building performance approach. If the power generation by the solar PV plant is counted, the building would probably save 50 percent in total over a standard ECBC building.

> *"The project is an example of a well-structured approach towards achieving energy efficiency…. In current times, the decrease in energy usage is a very important aspect of building industry. An institute like MNIT has set an example by doing this project."*
>
> Sunit Mathur, General Manager of RRECL

b. Other benefits

ECBC-compliant buildings have fewer operating costs, less connected load, reduced demand charges and reduced capacity of the transformer, panel, circuit breaker and other equipment. Meanwhile, an ECBC-compliant building like Prabha Bhawan serves as a showcase and an opportunity for learning about ECBC implementation. As a major ECBC training venue, the building stands as a concrete example of ECBC benefits. The building also provides occupants with comfort, good lighting and a modern and prestigious feeling because of the new, ECBC-compliant features.

> *"Light is an important factor for comfortable working in a computer lab. The long hours of concentrating on a computer screen are less stressing due to the quality of light inside the labs."*
>
> Sanjay Rajpal, Central Computer Center of MNIT

3.2 Lessons learned from the pilot building on improving the compliance process

- Updating the "Schedule of Rates" to standardize and streamline procurement

  Procurement for public projects like Prabha Bhawan could be complicated. MNIT found that not all materials and equipment needed for ECBC compliance were available on the "Schedule of Rates", or list of pre-approved products for government procurements. This turned out to slow the procurement of LED lighting and affect the procurement of other ECBC-compliant materials in Prabha Bhawan. BEE has since been working with the Central Public Works Department to update the "Schedule of Rates" to include more energy efficiency materials and equipment. This has removed a major barrier for ECBC implementation across India because all government buildings are required to make procurements from the "Schedule of Rates". However, public buildings would still face the challenge of purchasing energy efficiency materials not listed in the "Schedule of Rates", as most energy efficiency measures typically have low life-cycle costs but high upfront costs (Evans, et al., 2014). This requires timely, continuous updates and improvement of the "Schedule of Rates".

- Building a robust product testing, rating and labeling system

  As demonstrated by MNIT's own simulation of windows considered for installation, manufacturers may overstate the energy performance of materials and equipment. Other building projects have encountered similar problems with other energy efficiency materials and equipment. It is thus necessary to build a robust system to test, rate and label construction products (Evans, et al., 2014). In addition to improving code compliance, such a system could stimulate the advancement of energy efficiency technologies by providing clear market information on which materials perform best. In sum, testing, rating and labeling materials could help significantly improve building energy efficiency in India in the long term.

Figure 5 Concrete Used in Prabha Bhawan

- Enhancing the capacity within the central and state public works departments

  Prabha Bhawan is a public building. All central and state government public buildings in Rajasthan now have to meet ECBC requirements. Public buildings receive approval from the central or state public works departments instead of from local governments. As Rajasthan and other Indian states roll out ECBC implementation, there will be more public buildings like Prabha Bhawan that need to comply with the code and in turn more requests for building approval. In order to mainstream ECBC implementation in India, it is necessary to build and increase capacity for ECBC implementation within the central and state public works departments (Evans, et al., 2014).

- Developing the business case for material and equipment purchases

  MNIT helped build the business case for purchasing energy efficiency materials and equipment through analysis and clear documentation. Such information could be helpful in future public building construction projects. The business case of Prabha Bhawan has been disseminated through reports and ECBC training sessions to people across India. This raises awareness about ECBC and helps other building developers understand the options and benefits of ECBC-compliant technologies. As India moves forward with ECBC implementation and constructs more ECBC-compliant buildings, having business cases of these buildings could largely serve as useful references to inform decisions and eventually broaden impact.

4.0 Conclusions

4.1 Summary and next steps

Rajasthan was the first state in India that adopted ECBC in March 2011 (a.k.a. R-ECBD), and R-ECBD became mandatory in September the same year for covered new commercial buildings. PNNL has been working with its partner, MNIT, to support the implementation and enforcement of R-ECBD. In September 2011, the Rajasthan State Pollution Control Board integrated ECBC into its *Environmental Guidance Manual: Construction and Building Projects*. In 2012, Rajasthan amended building by-laws to reference R-ECBD and ULBs added it in the building approval process. Currently the responsibility of code compliance enforcement falls under ULBs, while a third party assessor system is used for most public and green buildings.

Moreover, Rajasthan exerted a great deal of efforts to build capacity for code implementation. This included increasing awareness among government officials and creating an R-ECBD award as an incentive. The Jaipur Development Authority also created a program to reward qualified ECBC-compliant buildings with extra floor area ratio. The "Train the Trainers" program has been training ECBC Master Trainer candidates to ensure enforcement capacity, while existing LEED accredited professionals and GRIHA third party evaluators are available as potential enforcement infrastructure.

Several types of buildings in Rajasthan are complying with the code. In particular, large commercial buildings are taking a lead, mainly because some ULBs have started to reject non-compliant buildings and the building owners and developers do not want to risk delays. MNIT has been testing ECBC implementation in two pilot buildings on its campus: Prabha Bhawan and the Lecture and Theater Complex. The completed Prabha Bhawan complies with R-ECBD using the whole building performance method. In fact, it saves 30 percent more energy than a standard ECBC building even without counting the on-site generation from its rooftop solar PV system, which saves extra 20 percent of energy. It features various energy efficiency measures such as roof insulation, efficient windows, daylighting, a variable refrigerant flow air-conditioning system and a rooftop solar PV plant. The experience of constructing the pilot buildings has demonstrated the feasibility and benefits of ECBC compliance, removed implementation barriers by facilitating the update of the "Schedule of Rates" and highlighted the importance of product testing system.

Throughout the process, DOE and PNNL contributed in many ways. First, PNNL worked with MNIT to organize a stakeholder workshop supported by DOE and RRECL to gain inputs from government officials and building industry professionals on code implementation mechanisms right after the code adoption in Rajasthan. In 2012, PNNL helped develop an R-ECBD implementation roadmap with a training plan for the Government of Rajasthan to provide detailed recommendations in major aspects of code implementation, based on local capacity and RRECL's enforcement plan. Second, PNNL coordinated with MNIT in developing training

materials to close gaps in conceptual understanding and compliance checks. The training program *Codes 101* has helped dozens of ULBs learn about ECBC. PNNL's partner, MNIT, organized ten training sessions for ULBs and professionals to increase awareness about R-ECBD and to provide information on code specifications. Since then, certified Master Trainers have trained ULBs throughout the state using *Codes 101*. Third, PNNL developed a White Paper on using a third party assessor system for ECBC enforcement. The White Paper recommends using a third party assessor system to more rapidly build compliance capacity. The paper also provides international experience in using such a mechanism in code enforcement. Finally, PNNL collaborated with MNIT to summarize code implementation experience and lessons learned from the pilot buildings. Rajasthan will share the wisdom gained from the MNIT pilot buildings with other projects, cities and states that implement ECBC.

4.2 Implication and impacts

The R-ECBD implementation process in Rajasthan to date provides useful lessons in many aspects for other Indian states on adopting and implementing ECBC, including the compliance mechanisms, implementation framework, institutional set-up, capacity building and incentives. The following are key notes taken from Rajasthan's experience:

- State-level code adoption should involve a stakeholder process
  The stakeholders should include government officials, building owners and professionals from the building industry. This could help the government better understand the local situation, including training needs and the local market for energy efficiency products. Such information could enlighten strategy development for code implementation and enforcement.
- Local-level adoption is key to implementation
  State-level code adoption is necessary but not adequate. The majority of jurisdiction for enforcement falls under ULBs, therefore ULBs need to adopt ECBC in their local building by-laws and add it as part of the building approval process to ensure concrete implementation.
- Training and capacity building are critical
  Training plays a very important role in raising awareness about ECBC and building capacity. By introducing ECBC and its benefits, training could help enhance local governments' support for code adoption. Training sessions targeting building industry professionals and ULBs could contribute to increasing the capacity for compliance and enforcement, which will facilitate ECBC implementation significantly.
- A third party assessor system is highly recommended
  Using third parties in the compliance process can build capacity rapidly. It can also reduce concerns from ULBs about excessive workload. International experience provides several examples of how to build robust checks and balances into a third party system to ensure that code enforcement is properly executed.

- ULBs' role in enforcing compliance is significant
  In spite of third parties' important assistance, improving awareness and capacity of ULBs is indispensable in terms of code enforcement. ULBs need to review third parties' inspection reports and may conduct random checks themselves. They also need to understand the code to push for adoption and robust compliance. This requires the enhancement of capacity within ULBs.
- Learning from pilot projects can strengthen understanding capacity
  Pilot buildings can serve as showcases of energy efficiency measures and demonstrate to stakeholders the various benefits of ECBC-compliant buildings. Additionally, lessons learned could be summarized and disseminated to other jurisdictions or building projects covered by the code, thus providing concrete technology ideas and business justification for building developers.
- Actual compliance checks can be a strong incentive
  As is evidenced by large commercial buildings in Rajasthan, the fact that ULBs are starting to reject non-compliant buildings is directly encouraging compliance. This can be a useful tool because developers of large buildings typically have significant investments that they want to recover. Delays in constructing or occupying a building, along with costly repairs or fines, can dip into developer profits.

Rajasthan will continue benefiting from R-ECBD compliance and keep improving energy efficiency in its buildings sector. DOE and PNNL, together with PNNL's local partner, MNIT, have provided strong technical support and contributed significantly to Rajasthan's success stories. Building on DOE and PNNL's work, the U.S. Agency of International Development is now working in Rajasthan to further enhance the implementation of R-ECBD. During the Climate Change Conference in Paris last year, India also committed to implementing ECBC and improving building energy efficiency in its Nationally Determined Contributions. This is creating a major push for ECBC adoption and compliance throughout India. More states are learning from Rajasthan's experience to adopt and implement ECBC at the state and local levels.

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