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# Improving building energy efficiency in India: State-level analysis of building energy efficiency policies

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ABSTRACT

India is expected to add 40 billion $m^2$ of new buildings till 2050. Buildings are responsible for one third of India's total energy consumption today and building energy use is expected to continue growing driven by rapid income and population growth. The implementation of the Energy Conservation Building Code (ECBC) is one of the measures to improve building energy efficiency. Using the Global Change Assessment Model, this study assesses growth in the buildings sector and impacts of building energy policies in Gujarat, which would help the state adopt ECBC and expand building energy efficiency programs. Without building energy policies, building energy use in Gujarat would grow by 15 times in commercial buildings and 4 times in urban residential buildings between 2010 and 2050. ECBC improves energy efficiency in commercial buildings and could reduce building electricity use in Gujarat by 20% in 2050, compared to the no policy scenario. Having energy codes for both commercial and residential buildings could result in additional 10% savings in electricity use. To achieve these intended savings, it is critical to build capacity and institution for robust code implementation.

## 1. Introduction

The buildings sector is booming in India; the country foresees 40 billion $m^2$ of new construction through 2050 (Chaturvedi et al., 2014). Building energy use today accounts for 33% of India's total final energy consumption, and is increasing at around 8% annually (Rawal et al., 2012). Driven by rapid income and population growth, this trend is expected to continue. How to curb the growth of building energy use while continuously improving people's quality of life has become one of the key challenges for Indian policy makers. In its recently released climate plan, the Government of India has highlighted the importance of building energy efficiency in its climate mitigation strategies (Government of India, 2015).

As more than half of India's floorspace is yet to be built, policies targeting energy efficiency in new buildings would be particularly impactful. The Government of India launched the Energy Conservation Building Code (ECBC) in 2007, setting the minimum energy efficiency requirements for new, large commercial buildings. In 2009, the Government of India enacted the National Mission for Enhanced Energy Efficiency as part of the National Action Plan on Climate Change. The Mission launched national programs to improve energy efficiency across various sectors, and further emphasized the significance of building energy efficiency and relevant policies including ECBC (Government of India, 2009). To achieve the intended energy savings, ECBC needs to be effectively implemented. ECBC was developed as a model code at the national level; it goes into effect and becomes mandatory when a state or local government adopts and implements it in the jurisdiction. Understanding the impacts and benefits of ECBC at the state level will greatly help states adopt the code and motivate them to implement it, and thus avoid locking in carbon-intensive infrastructure.

Although there are a few studies assessing the energy savings potential of ECBC, none of them provided a thorough analysis of ECBC impacts at the state level. Dhaka et al. and Tulsyan et al. used building energy simulation to assess energy saving opportunities through implementing energy conservation measures in ECBC, and found that implementing ECBC could result in up to 40% savings (Dhaka et al., 2012; Tulsyan et al., 2013). However, these studies only examined energy savings of a group of buildings for a given time; they did not consider long-term growth of the buildings sector nor long-term energy and economic savings of ECBC. Another group of studies estimated long-term building energy demand in India, but lacked detailed analysis of the impact of building energy policies (Chaturvedi et al., 2014; IEA, 2015; Ürge-Vorsatz et al., 2015). In addition, none of the

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previous studies assessed building energy use and policy impacts at the state level, although the state is often the jurisdiction to adopt and implement building energy policies. This study fills the gap in literature, using an integrated assessment approach to examine long-term evolution of the buildings sector and energy and economic impacts of ECBC at the state level.

This paper is structured as follows. Section 2 provides a comprehensive overview of building energy policies in India. Section 3 presents the methodology and the integrated assessment model used in this paper. Section 4 explains the design of scenario analysis. Section 5 discusses energy and economic savings of ECBC in comparison with other building energy policies, as well as strategies to improve ECBC implementation. Implications for future policy development and conclusions are presented in Section 6.

## 2. Building energy policies in India

### 2.1. Energy Conservation Building Code and green building programs

The Government of India has taken steps to improve energy efficiency in buildings. The enactment of the Energy Conservation Act in 2001 has led to the establishment of the Bureau of Energy Efficiency (BEE) and the development of ECBC. ECBC, launched in 2007, is the first building energy code in India. It applies to new commercial buildings with a connected load of over 100 kW-h or a contract demand of over 120 kV-amps. Buildings with a conditioned area of over 1000 $m^2$ generally fall under this category (ECO-III, 2009). ECBC prescribes minimum energy performance standards for the building envelope, heating, ventilation, and air-conditioning (HVAC) system, interior and exterior lighting, and service hot water in each of the five climatic zones in India. It also sets energy efficiency requirements for building electric power and motors. ECBC allows buildings to comply through three methods: prescriptive, simple trade-off, and whole building performance. While the simple trade-off method allows for trade-offs among envelope components, the whole building performance method is meant for flexibility within the entire building system as long as its overall energy performance is equivalent to or better than a standard ECBC-compliant building (ECO-III, 2009). All large national public buildings are now required to comply with ECBC. ECBC has been adopted in 7 states and 16 states are in the process of adopting ECBC (Indian Bureau of Energy Efficiency, 2016).

In addition to ECBC, there are voluntary programs to encourage the development of efficient and sustainable buildings, such as the Green Rating for Integrated Habitat Assessment (GRIHA), BEE Star Rating, and the Leadership in Energy and Environmental Design (LEED).

GRIHA is a building rating program that is widely implemented in India. It is applicable to new buildings with floorspace of over 2500 $m^2$. Eligible buildings include offices, retail buildings, institutional buildings, hotels, hospitals and healthcare facilities, and multi-family high-rise buildings. The rating system includes 34 criteria in site planning, resource utilization and conservation, building operation, as well as innovative designs. GRIHA evaluates a building's performance throughout its life cycle based on nationally accepted energy and environmental principles, and aims to minimize the environmental impact of buildings and promote green building development (GRIHA India, 2016a). The program is executed by the GRIHA Council, which was founded by the Energy and Resources Institute with the support of the Indian Ministry of New and Renewable Energy (GRIHA India, 2016b). There are currently 700 projects on record that are registered with the GRIHA system (GRIHA India, 2016c).

BEE Star Rating is a voluntary program to assess and rate energy performance of existing commercial buildings. The buildings are rated on a 1- to 5-star scale based on their operational energy consumption (i.e. energy consumption per unit of floorspace per year), where 5-Star represents the most energy efficient buildings. Currently, there are about 150 buildings rated by the BEE Star Rating program (BEE, 2016).

LEED, the green building rating certification system, evaluates a building based on multiple aspects, including sustainability, water efficiency, energy, resources, indoor environmental quality, and innovation, and throughout the building's planning, construction, maintenance, and operation. LEED certification can be applied to all types of buildings, ranging from homes to commercial office buildings. The number of LEED certified buildings increased rapidly in India in the past few years. In 2015, India ranked 4th on the list of countries with LEED certified buildings (Gray, 2015).

Both ECBC and green building programs can help improve building energy efficiency, but they work in different ways. ECBC, a model building code, sets the minimum energy efficiency requirements for new commercial buildings and as such removes the inefficient buildings from the market. It helps push the buildings market to be energy efficient. Green building programs and BEE Star Rating system are voluntary programs that help pull the buildings market to reach higher efficiency levels. While ECBC applies to a broad set of buildings, voluntary programs target high-efficiency buildings which only make up a small share of the entire building stock. In other words, green building programs alone might result in a large number of inefficient buildings, although the number of high-efficiency buildings would increase. Given that India would add 40 billion $m^2$ of floorspace between now and 2050, having a robust building energy code is critical (Chaturvedi et al., 2014).

### 2.2. ECBC implementation in Gujarat

An assessment of ECBC impacts can inform policy makers and help relevant stakeholders understand the energy savings potential and economic benefits of ECBC, and motivate them to implement ECBC. Here we conduct an integrated assessment of ECBC impacts, using Gujarat as an example.

Gujarat is one of the fastest growing states in India, with rapid economic growth, urbanization, and building floorspace expansion. Gujarat's per capita GDP was $2100 in 2014,[1] 45% higher than India's national average (Indian Ministry of Statistics and Program Implementation, 2016). The share of urban population in Gujarat increased from 37% in 2001 to 43% in 2011, higher than India's average urbanization rate of 31% in 2011 (Gujarat Directorate of Economics and Statistics, 2011). This rapid growth of urban centers also brings big demand for new construction (Gujarat Housing Board, 2008, 2016). In the long term, the floorspace to be built in India through 2050 would more than double that of today (Chaturvedi et al., 2014). New construction is the most cost-effective point in a building's life cycle to integrate energy efficiency features. Developing energy efficient new buildings would help avoid locking in carbon-intensive infrastructure and set the path towards a sustainable future. The State of Gujarat is in the process of adopting ECBC, and understanding the impacts of ECBC is critical to policy development and implementation. In particular, how much savings would ECBC generate? How does ECBC interact with other building policies? And to what extent does the level of implementation matter? This study examines the evolution of the buildings sector in Gujarat and addresses these questions through an integrated assessment approach.

## 3. Methodology and data

### 3.1. Global Change Assessment Model

We use the Global Change Assessment Model (GCAM) in this study. GCAM is a global integrated assessment model that links energy,

[1] Costs in this paper, if not specified, use the 2010 U.S. dollars.