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Energy efficiency outlook in China's urban buildings sector through 2030

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HIGHLIGHTS

- We use a bottom-up modeling approach to quantify emission reduction from efficiency programs.
- Heating and cooling are the main focus of this study.
- We find that building codes lead to 17% reduction compare to the baseline.
- Other programs analyzed concern district heat, building labeling and retrofits of buildings.

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ABSTRACT

This study uses bottom-up modeling framework in order to quantify potential energy savings and emission reduction impacts from the implementation of energy efficiency programs in the building sector in China. Policies considered include (1) accelerated building codes in residential and commercial buildings, (2) increased penetration of district heat metering and controls, (3) district heating efficiency improvement, (4) building energy efficiency labeling programs and (5) retrofits of existing commercial buildings.

Among these programs, we found that the implementation of building codes provide by far the largest savings opportunity, leading to an overall 17% reduction in overall space heating and cooling demand relative to the baseline. Second are energy efficiency labels with 6%, followed by reductions of losses associated with district heating representing 4% reduction and finally, retrofits representing only about a 1% savings.

1. Introduction

As part of its 11th Five-Year Plan (FYP) from 2006 to 2010, the Chinese government set for the first time a binding target for energy efficiency by requiring a 20% reduction in energy intensity per unit of gross domestic product (GDP) from 2005 to 2010 and began initiating sector-specific policies and measures to support further reductions in energy and carbon dioxide (CO_2) intensity through 2020. China has set continuing binding targets of 16% and 17% reductions in energy and carbon intensity per unit of GDP respectively, for its 12th Five-Year Plan (FYP) period from 2011 to 2015. More recently, on June 2015, China restated in its "intended nationally determined contribution" (INDC) its previously announced goal to peak its emissions around 2030 and lower the carbon intensity of GDP by 60–65% below 2005 levels by 2030.

In light of these recent binding targets, evaluating and quantifying the impact of different policies in different sectors become increasingly important, both to guiding the development of near-term policies and prioritizing between them. While targets constitute an essential framework for action, energy savings originates from the implementation of policies and programs at the sectoral level. The goal of this paper is to quantify the significant contribution that can deliver specific energy efficiency programs in the building sector and quantify these impacts measured against energy savings target allocation. Description of 'best practice' energy efficiency building programs and policies implementation is available in Levine et al. (2012). Li and Shui (2015) provide a recent analysis of programs and policies implemented in the building sector in China. Policies considered include (1) enforcement of existing building codes and (2) increased penetration of district

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heat metering and controls, (3) increased penetration of high efficiency district heating generation and distribution, (4) promotion of building labeling programs and (5) existing building retrofits.

The past decade has seen the development of various scenarios describing long-term patterns of China's future energy consumption and GHG emissions. Some of the most notable of these include the International Energy Agency (IEA)'s World Energy Outlook 2013, (IEA, 2013), China's Energy Research Institute (ERI) (CEACER, 2009) and McKinsey & Company (McKinsey & Company, 2009). In general, the models used in these assessments provide interesting discussions and insights on understanding China's medium and long term energy and carbon emission trajectory from the macro-level. These modeling studies take a top-down or hybrid approach with primarily economic-based drivers. More recently, Yu et al. (2014) developed a detailed building energy model to insert in an integrated assessment framework. While this allowed a more robust analysis of trends in that sector, the building end-use technologies representation is too limited to quantify the impacts of building energy efficiency programs. Similarly, the recent IEA's publication on Building Energy Use in China done jointly with Tsinghua University (IEA, 2015) provides great insights on data for key cities and gives a useful description of emerging technologies but does not assess specific policies and programs impacts.

By contrast, the approach taken by Lawrence Berkeley National Laboratory (LBNL)'s China 2050 Model (Zhou et al., 2011a) is to forecast sector energy consumption as driven by the diffusion of various types of equipment; the performance, saturation, and utilization of which has a profound effect on energy demand. Using this bottom-up model, LBNL has undertaken various studies to perform retrospective and prospective sectoral and cross-cutting policy impact evaluation and to develop medium- and long-term outlooks for low-emissions pathways (Zhou, 2011a, 2007, 2012). Recently, Xiao et al. (2014), developed a bottom-up model to assess the carbon abatement potential and marginal abatement cost (MAC) of 34 selected energy-saving technologies/measures for China's building sector.

Zhou et al. (2012) performed a retrospective analysis of impacts based on actions taken during the 11th Five Year Plan and presented a bottom-up methodology of energy end-use demand to quantify the achievements of building energy efficiency policies during the 11th FYP. The study concluded that with this portfolio of policies, the Chinese government was on track to save 90 Metric Tons Carbon Equivalent (Mtce) by the end of 2010, or 90% of its goal. The majority of those savings (62 Mtce) were achieved by the successful tightening of enforcement of existing building codes.

The current study applies and expands this bottom-up methodology to the question of future savings potential in the building sectors if current policies are continued and strengthened. Using LBNL's China 2050 Model business as usual (BAU) scenario, this study estimates the energy savings potential for 5 programs in the residential and commercial building sectors and provides a detailed analysis of the end-use technologies savings assessments used as assumptions in the model.

This paper is divided into five sections. Following this introduction, Section 2 presents the policies to be evaluated and summarizes the impacts of these policies during the 11th FYP. Section 3 describes the methodology for forecasting energy end use demand and Section 4 describes the assumptions and parameters used to construct each policy scenario. Results and conclusions are shown in Section 5.

2. Buildings efficiency policies in China

The purpose of the current study is to look forward to ways of achieving as yet uncaptured savings from energy efficiency policies in the building sector. Taking a long-term view, we model the potential savings from an aggressive set of policies targeting conventional, well-known energy efficiency technologies, in order to show feasible energy and emissions reductions versus Business as Usual (BAU) by 2030. The approach is to look at those measures that are judged feasible to implement in China in the near to medium term, with technologies that are already available on the market and that are cost-effective. For this reason, the results may be considered to be conservative.

The current analysis focuses on policies that target space heating and cooling energy. Lighting and appliances policies are not covered here. The impact analysis covers the five following policies:

- Accelerated Building Codes (Residential and Commercial) – Building codes affect new building heating and air conditioning loads by increasing the requirement of insulation of the building shell and heating, ventilation and air conditioning (HVAC) system efficiency. The policy considered is an acceleration of the update of building codes in China, towards alignment with levels defined by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), and subsequent updating of those codes through 2030.
- District Heat Metering and Controls (Residential) – Historically, district heat feeding residential buildings in China was not metered or controllable by residences, leading to significant heat waste. Controls and metering are standard on new buildings. The policy considered fills gaps in controls and metering through retrofits of existing buildings to allow for reduction of heating use by residents. This policy does not affect commercial buildings, which are generally fitted with heating controls and metering by default.
- District Heating Efficiency Improvement (Residential and Commercial) – This policy is defined by increased penetration of high efficiency district heating generation and distribution. Improvements considered are (1) increased plant efficiency (2) reduction of thermal losses in pipelines and (3) increased pumping station efficiency.
- Energy Efficiency Labels (Residential and Commercial) – This policy assumes increased construction of 5-star buildings as defined by the Ministry of Housing, Urban-Rural Development's (MoHURD) Building Energy Efficiency (BEE) labeling program. The BEE label evaluates buildings on a scale of one (least efficient) to five stars (most efficient) in terms of energy efficiency, with a focus on HVAC system efficiency, compulsory standard compliance, and optional building efficiency measures.
- Retrofits (Commercial) – This policy assumes an increased number of commercial building retrofits. Retrofit measures include improved building envelope (insulation, windows, shading and air-tightness), controls, and heating systems (boilers) in commercial buildings. Commercial buildings usually have larger internal heat load intensity (from lighting, equipment, occupants) compared with residential buildings and therefore the heating retrofit may not be that effective compared with a residential building.

3. Building energy end use modeling

This study uses the baseline scenario called *Continued Improvement Scenario* (CIS) of the China Energy Model described in Zhou et al. (2011a).

LBNL's approach to modeling energy demand growth and reduction potentials uses a bottom-up approach which characterizes energy usage at the 'technology' level (McNeil et al., 2008, 2013; Zhou et al., 2011a). The model includes the following