Paper Title : Modelling the long term economic implications of buildings efficiency in China

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1 Introduction

This paper attempts to investigate an optimal decision on buildings energy efficiency (BEE) improvements in a dynamic building stock in a northern city in China over the period 2005-2030 based on modelling approach. A dynamic buildings stock is considered over several decades to address the issues of buildings thermal rehabilitation and supply infrastructure renewal since the old equipments must be decommissioned and retired when reaching lifetime limit (20-30 years in general). We simulate different scenarios in which a variety of investment strategies relating to building energy performance enhancement and supply technology choice are considered in different time scale. The results of our quantitative analysis show that the current BEE standards implemented in China is a suboptimal decision and thus need to be upgraded immediately. Efficiency standard equivalent to the Swedish building code is a predominant strategy in most scenarios simulated, implying that BEE enforced in China needs be improved by 50% or more in terms of heating intensity reduction. Inclusion of carbon price in the economic simulation favours the enhanced BEE strategy. Also, we show that high-efficient buildings infrastructure can facilitate the transition towards climate-friendly supply technologies such as CCS, NGCC or biomass heating in the Chinese cities by 2020 since considerable benefits can be created compared with business as usual through reduced capital costs of investment and operation charges. In contrast, incremental costs of adopting new supply technologies will be significantly higher for inefficient building stock where the local authority will have more difficulties to finance the infrastructure renewal and technological innovation in the future.

2 Methodology

2.1 Analysis framework

The study uses a case-study approach by simulating a series of scenarios of BEE adoptions and choice of supply technologies in a Chinese city (Tianjin) over the period 2005-2030. We employ a bottom-up approach to modelling the scenarios of adopting different BEE standards in the city of Tianjin and investigating both environmental and economic implications. Storylines (Scenarios) are elaborated based on LEAP-model to examine the different probable BEE development trajectories in order to identify the optimal building energy efficiency advancement trajectory that should be pursued in the Chinese city.

2.2 Parameterisation of determining variables

2.2.1 Trend of increase in the buildings in Tianjin

Total existing housing stock of Tianjin was 152 million square meters in 2005. At present about 55% of existing houses in Tianjin were constructed before 1990(more than 15 years), this is generally the low-rise housing with brick-laid structure. Per capita floor area is expected to approach 30 square meters by 2020 and approximately 35 square meters per capita in 2030.

2.2.2 Energy demand in buildings

Buildings consist of residential and commercial buildings in the model. Two types of residential buildings (low-rise and high-rise) and five categories of commercial buildings (hotel, office, public buildings, school and education institutions, commercial centres) are considered in the model.

2.2.3 Heating and hot water consumption in residential sector

Residential heating intensity is calculated by using a simplified steady-state heat transfer equation, more technical details of thermal calculation in the Chinese building sector are provided in recent literature(MOC, 95; Lang, 2004; Jiang et al., 2007).

2.2.4 Commercial sector

Heating and water consumption intensities in commercial buildings used in the model are based on the reference values in MOC (2002). Also, data supplied by Jiang *et al*.(2007) and Zhou *et al.*,(2007)are taken into account to complement the MOC's values when necessary.

2.3 Scenarios

Five BEE standards implementation scenarios have been simulated in the model, denoted by REF (the current TJ-2004 building code), A2(gradually tightened energy savings objectives), TJ-RT2005 and TJ-SWE, LC. The three later ones are equivalent to the current French, Swedish and Passivhaus with transition to high efficiency performance respectively. Lastly, a scenario of retard in implementation— "ParCom" is also simulated to illustrate the consequence of inaction in buildings[1]. In reference scenario, heat supply infrastructure development will follow the official objective specified in the official government documents: 1. Tianjin city general heat supply planning; 2. city CHP heat supply scheme, and 3. Tianjin Binhai New Area heat supply plan.

2.4 Technological progress

The method of experience and learning curve (IEA, 2000; Nemet, 2005) is applied to efficient energy supply, clean coal and carbon management technologies such as IGCC, NGCC and CCS are considered in the model.

2.5 Alternative or low –carbon energy supply technology options

A variety of array of alternative energy supply technologies exist regarding carbon emission mitigation in power and heat generation plants. CCS, fuel-switching and renewable hearting are considered in alternative scenarios from 2020.

3 Results and discussions

3.1 Yearly cost trajectory

Under the baseline scenario (TJ2004), yearly cost will more than triple, increasing from 8.94 billion RMB per year to nearly 29 billion RMB in 2030. The annual cost in the scenarios of RT05 and SWE will fall below that of TJ2004 by 2012-2015. It means that if the local authority decides to upgrade the current TJ2004 to RT2005 or SWE, finance appears not to be a major barrier to implement the higher efficiency standard since considerable revenue can be created. To avoid painful sharp jump in current year operation costs such as in the ParCom scenario, upfront buildings energy performance and quality of construction are of critical importance and should never be ignored, otherwise the city would be trapped into a vicious circle: lower efficient buildings results in costly operation and thus less financial capacity could be formed to invest in low-carbon technologies to mitigate carbon emissions in the future.

3.2 Cumulative Cost scenarios in different energy supply options

The simulation shows that the RT2005 and SWE are predominantly the best choices under all of the plausible assumptions on the major economic variables and the prospect for carbon price.

3.3 Implications for decarbonising energy supply

Chinese local governments should anticipate the potential costs of decarbonising the energy supply associated with low carbon technologies, CCS and GS scenarios have been examined. The situation of failure in implementation of BEE policies will be preoccupant if the city decides to opt for low-carbon supply systems from 2020 under carbon emission constraints. The costs associated with these backstop technologies will soar in the less efficient cases. The simulated results imply that efficient buildings scenarios have more flexibility in facilitating the technological transition in energy supply, contrarily to the sharp increase in costs in the starting year of new technology penetration in the less efficient scenarios. It is found also that CCS option is generally much more cost-effective than fuel-switching option.

[1] This scenario is named as "ParCom" in which we assume simply that each year, about 75 per cent [1] of new construction complies with TJBEEDS 2004 while the rest one-quarter fails to respect the regulation before 2015, and then all new construction will comply with the TJBEEDS-2004 from 2016 as a result of technical diffusion of efficient construction practice and endogenised technological learning, implying a continued reduction in costs associated with BEE enhancement measures.

4 Conclusion

The quantitative examinations confirm that it is judicious to update the current BEE mandatory requirements to minimise the latent demand rise and associated social costs in the future. The option value of "wait to see" strategy to deal with the uncertainty is particularly risky in the sense that the whole infrastructure could be trapped in irreversible process of lock-in dilemma and would entail enormous difficulty in retrofitting the historical energy-greedy urban heritage under cost and institutional constraints even tougher than today. The city would find itself in extremely difficult situation about the capacity in financing new and low-carbon supply technologies (CCS, fuel switching or renewable heating) with a large quantity of historical low efficient buildings stock in the future as a result of irreversibility. In contrast, it will be much easier for local authority to find financial resources by allocating the "benefits" offered by cumulative reduction in operation costs with a high efficient building stock, a prerequisite to the success of transition to low-carbon economy in the next decades.

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