

**Final Progress Report**  
**Sustainability Science Program**  
**Term: September 1, 2013 – August 1, 2014**

**Name:**  
Xiaoqi Xu

**Your field:**  
Building Energy

**Your degree program, institution and graduation date:**  
PhD, Department of Civil Engineering and Engineering Mechanics, Columbia University, July 2013

**Faculty host at Harvard name and department:**  
Henry Lee, Harvard Kennedy School of Government

**Description of SSP-related research activity, including a title:**  
A quantitative evaluation of the policy options to increase residential building energy efficiency in China

**Abstract:**  
Increasing energy efficiency in the built environment can make significant contributions to meeting sustainability goals. However, few studies provide a quantitative evaluation of the scope for reducing energy consumption in residential buildings in developing countries or an assessment of the feasibility various policies to catalyze these reductions. This work fills the gap by systematically quantifying (1) the energy savings catalyzed by every existing policy instrument aimed at improving energy efficiency in the residential sector in China; (2) the additional energy savings that could be realized by strengthening the current policies; and (3) the relative feasibility advantages of each policy. Results show that each policy instrument has a different relative advantage, while collectively they are able to exert significant future impact on China's energy outlook. A continuation and enhancement of current policies will save 12.6-14.3% and 20.6-24.1% energy consumption, respectively, in the urban residential sector for the next ten years compared with a business as usual forecast. The outcome of the study will equip policy makers and other stakeholders to weigh policy instrument against each other in a systematic, quantifiable manner and gauge the magnitude of energy conservation opportunities in the urban residential sector for China, and serve as a guidance for comparable developing countries.

**Identification of the problem you address:**  
To curb increasing energy consumption in urban residential buildings, the Chinese government has accelerated the introduction and expansion of building energy policies in the eleventh and twelfth five year plans. Up to now, instruments in use involve regulations, market-based incentives, fiscal instruments, and information measures. Understanding the impact of various program initiatives in reducing energy use is important in order to insure that Chinese decision makers select the most cost effective and efficient mix of policies. However, studies that evaluate this range of policies to make the comparison possible have been lacking. The presenting study defines a scope that encompasses every existing policy targeted at energy efficiency in urban residential buildings, and aims to fill this knowledge gap.

**Key question asked about the problem:**

1. How big are the energy savings catalyzed by every existing policy instrument aimed at improving energy efficiency in the residential sector in China?
2. How big will the additional energy savings that could be realized by strengthening the current policies be?
3. How does the comparative feasibility advantage of each policy compare with each other, including cost-effectiveness, co-benefits, operational capacity and political support?

**The methods by which you answered that question:**

This study follows a methodology that derives from an eight-step policy analysis approach. First, all major policies promulgated in the urban residential sector targeted at building energy efficiency are reviewed. They are classified into four categories, i.e. regulations, market-based incentives, fiscal instruments, and information measures. Second, we compute the efficiency, future impact, and cost-effectiveness through data collection or our own estimation for each policy instrument, and evaluate its co-benefits, operational capacity, and political feasibility for future. Then we compare the above policies across these six criteria to reveal their comparative strengths, and forecast energy outlook afforded by them and make final recommendations.

**Principle literature upon which the research drew:**

- Policy analysis methodological studies, e.g. Bardach, E., 2011. A practical guide for policy analysis: the eightfold path to more effective problem solving. Sage.
- China's government documents on building energy, including statistical yearbook, and news release.
- International reports on building energy policies, e.g. Global Energy Assessment by International Institute for Applied Systems Analysis, and IPCC reports.

**Empirical data acquisition description:**

The overall policy evaluation process is conducted relying on engineering modeling, economic analysis, and other literature estimates. With the exception of appliance standards, for which we adopt a bottom-up approach by collecting basic product registration records, we are able to obtain intermediate data from various sources to complete the quantification of specific policy instruments.

**Geographical region studied:**

China. Implications for comparable countries.

**Recommendations that might be relevant for your problem:**

This paper allows policy makers to compare policy instruments against each other in a systematic, quantifiable manner, and consequently facilitate a wise choice of policies suitable to every specific situation depending on the government's budget, expectancy of the impact, and operational considerations. The future energy saving prospect created for both a continuation and an expansion of the current set of policies will empower policy makers and other stakeholders to gauge the magnitude of energy conservation opportunities in China's urban residential sector. Overall the presented research is expected to inspire discussions and contribute to scholarship and practice of building's sustainability development in China and comparable developing countries.

**A description of the final product(s) you have/are aiming to produce:**

I presented this work at the International Conference on Energy and Management held at Bilgi University in Istanbul, Turkey on Jun 5-7, 2014, and the STPP-ETIP All Staff Meeting of HKS Belfer Center for Science and International Affairs. We aim to submit it as an original article to a peer-reviewed journal, e.g. Energy Policy.

**Description of major other intellectual or professional advancement activities over the past academic year:**

1. Two studies conducted during PhD got published: (1) **Xu, X.**, Culligan, P.J., and Taylor, J.E. (2014). "Energy Saving Alignment Strategy: Achieving Energy Efficiency in Urban Buildings by Matching Occupant Temperature Preferences with a Building's Indoor Thermal Environment," *Applied Energy*, 123:209-219; (2) **Xu, X.**, Taylor, J.E., and Pisello, AL. (2014). "Network Synergy Effect: establishing a synergy between building network and peer network energy conservation effects," *Energy and Buildings*, 68:312-320.
2. Prepared for job interviews and received an offer (Junior Associate) from McKinsey & Company (Greater China Office)

**Please list citations for reports, papers, publications and presentations that built on your fellowship research:**

1. **Xu, X.**, Anadon, L.D., and Lee. H. (under preparation). “A quantitative evaluation of the policy options to increase residential building energy efficiency in China,” planned submission to Energy Policy
2. Huenteler, J., Santen, N., Surana, K., Xia, D., and **Xu, X.** (under preparation). “A tour of distributed electricity systems in five major economics and opportunities for policy research,” planned publication as Belfer Center Discussion Paper at Harvard Kennedy School

**Please describe any collaborative activities with other SSP Fellows that you are involved with.**

NA

**Principal collaborators outside Harvard (list name and institution):**

NA

**List any awards or grants that you have received this year for the current or coming year. Please provide details regarding title of award, financial amount, and date of award:**

NA

**If you are moving to a new position, please list your contact information there:**

McKinsey and Company, Beijing, China

[xiaoqi\\_xu@mckinsey.com](mailto:xiaoqi_xu@mckinsey.com)