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Technical Note

The "Warm Houses" program: Insulating existing buildings through compulsory retrofits

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ABSTRACT

The importance of insulating the existing building stock in the age of climate change and energy scarcity is well recognized, but effective public policies for doing so have not been forthcoming. This paper analyzes a novel approach pioneered by the city of Changchun in northeast China. Since 2010, the municipal authority has implemented a program to refurbish nearly half a million homes with wall and roof insulation and energy-efficient windows and doors. The success of this program is attributed to an assertive approach and an efficient, government-sponsored funding model. However, the program faces several challenges, including a lack of effective supervision, the negative impact on poor households, and ineffective energy-saving due to a lack of progress in heat-metering reform. This paper concludes by discussing the policy implications of this analysis.

Introduction

The building sector is a significant contributor to global climate change. Depending on the country, the sector accounts for 25–50% of final energy consumption and greenhouse gas emissions [1–3]. One particular challenge is upgrading existing buildings that have inadequate thermal insulation and high energy consumption because of winter heating and summer cooling [4]. Despite its significant energy-saving potential [5,6], thermal retrofitting of existing buildings is not being pursued on a large scale because of the presence of a number of barriers, including the technical complications of working with the composition and design of the structures already in place, the relatively high cost of refurbishment, the coupling of long payback time with the undervaluation of distant payoffs, competing priorities, unforeseeable risks, and the split incentives associated with rental housing [3,7–11].

To overcome these barriers, governments primarily rely on five types of policies: regulation, carbon pricing, subsidies, education, and benchmarking. Regulation includes creating building energy codes and making compulsory energy efficiency retrofits for houses undergoing major renovation [12,13]. Carbon pricing refers to the use of carbon taxes or cap-and-trade schemes to provide economic incentives for thermal retrofits [14–16]. Subsidies such as interest-free loans, grants, and full rebates are designed to support and encourage property owners to engage in retrofits [17,18]. Education efforts can include constructing low- or zero-carbon demonstration buildings, performing home energy audits, and providing information on matters such as the long-term benefits of energy retrofits and funding opportunities and technical know-how [19]. Benchmarking is the use of energy performance indexes as a communication tool, and it allows property owners to capitalize on their energy efficiency investment [1,20]. For instance, the EU introduced a scheme mandating the energy efficiency certification of buildings which includes an overall energy performance index stated in terms of energy consumption per unit of conditioned area [21].

Despite these policy interventions, actual progress has been disappointing even in developed countries where resources are more readily available. In Germany, where the federal and local governments have collaborated to improve building insulation, the existing residential building stock is being retrofitted at a rate of 0.8% a year, much lower than the 2% government target [7,12]. In this respect, researchers and policymakers are searching for new ways to address the challenge of retrofitting existing buildings. This paper describes and analyzes a novel policy approach that is being pioneered by the city of Changchun in China—a country that is not only the leading greenhouse gases emitter in the world but is also an important innovator in the area of energy conservation and low-carbon policies [22,23]. Evidence is drawn from a thorough review of policy documents and media reports, as well as from in-depth interviews with government officials and business managers. The analysis shows that the ambitious program is largely successful in meeting its objectives, although several challenges remain. Following an introduction and the presentation of background information

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about the program, this paper identifies the key success factors of the program. It then moves on to discuss the challenges of the program and potential solutions. The paper concludes by considering the wider policy implications of the findings.

Changchun's "Warm Houses" program

Changchun is a major city of approximately five million inhabitants. Located in northeast China, the city is well known for its long and harsh winters, and the temperature frequently stays below −20 °C. Thermal heating is not just a matter of comfort, but is essential to survival and dominates the energy use of the city. However, many buildings in Changchun, especially those built before the 2000s, are inadequately insulated because of a lack of effective building regulation, which has resulted in both inadequate indoor temperatures and energy waste. Like other Chinese northern cities, winter heating is provided by universal district heating, but most buildings do not have heat metering or temperature control mechanisms installed [24,25]. Residents of these buildings therefore lack the incentives and means to conserve heat. A recent survey conducted in Changchun reports a thermal energy consumption of 250 kWh/m^2/year—a figure that is substantially higher than both the national average and other cities of similar altitudes [26].

The initial attempt to improve energy efficiency of the existing building stock in Changchun started in 2008 following the initiation of a national-level policy. The policy was initiated by the Ministry of Housing and Urban–Rural Development to encourage the retrofit of existing buildings, and it mainly consisted of a subsidy of 55 RMB/m^2 (8.8 USD/m^2) for severely cold regions and 45 RMB/m^2 (7.2 USD/m^2) for cold regions. In the first two years (i.e., 2008 and 2009), the uptake of the program was very limited in Changchun as the incentives proved to be insufficient to persuade property owners to retrofit their buildings. The poor rate of implementation can also be attributed to the fact that most residential buildings in Changchun are apartments rather than detached houses; therefore, it can be very difficult for homeowners to obtain consent in a timely manner from every homeowner in an apartment building.

After two years of ineffective implementation, a significant breakthrough was achieved. The breakthrough was driven by strong political commitment from the provincial government and in particular from the new provincial party secretary whose arrival in late 2009 coincided with the coldest winter Changchun experienced in over five decades. In that winter, complaints about insufficient heating skyrocketed by approximately 80%. The adverse weather exposed the problem of insufficient heating in Changchun, and prompted the provincial government to make improving the quality of heating a top government priority. Interestingly, energy scarcity and climate change are not a key concern. Rather, this is a case of local governments finding a "coincidence of agenda" between climate and local issues [27]. Table 1 shows the increase in pace and scale of the program. In 2010, 1,115 residential buildings with a combined floor area of 6.1 million m^2 were refurbished. To put this figure in perspective, Changchun's total floor space for residential buildings at the end of 2009 was 75 million m^2. Therefore, the program successfully retrofitted over 8% of the city's entire existing residential building stock in one year. In 2011, a total of 2287 buildings, or over 14% of the 2009 building stock, were retrofitted. By the end of 2013, a building floor area of 39 million m^2, or 52% of the building stock at the end of 2009, had been renovated. Given that Changchun has an average living space per household of 95 m^2, the program has refurbished approximately 427,758 homes. The pace of refurbishment is unlikely to slow down in the next few years. The latest goal is to retrofit all existing buildings without proper insulation by 2018.

Success factors

Two factors are crucial to the success of the "Warm Houses" program. First, the local governments have taken an assertive approach to building renovation. Every year, a refurbishment target is announced by the municipal government and each district government within the municipality is responsible for selecting buildings to undergo renovation. After determining which buildings will be renovated, the municipal government finds contractors to carry out the renovation. In this government-led model, the role of homeowners as decision-makers is minimized. In fact, the program is compulsory; once a building is chosen by the government for renovation, its owners do not have the right to opt-out. The transfer of decision-making responsibilities from property owners to the government is crucial in overcoming several key barriers, including conflicting demands on homeowners' time and financial resources and the difficulty of collective actions.

A further benefit of the government-led approach is the standardization of insulation retrofit. Through standardization, the government is able to conduct comprehensive retrofits rather than superficial, single-measure retrofits that can only deliver minor improvements. Four key sources of thermal leakage are addressed: external walls, doors, windows, and roofs. The external walls of the buildings are insulated with solid-foam blocks (Fig. 1). Existing doors and windows are replaced with energy-efficient doors and windows. Water-proofed, sloped roofs are added to the original flat roofs to improve energy efficiency and provide a water- and snow-shedding function. Finally, the buildings are repainted to improve the appearance of the buildings (Fig. 2). Table 2 lists the key technical specifications of the program. To put these figures in context, the specification is only slightly less stringent than the Residential Building Energy Conservation Design Standards for Severe Cold Zones (JGJ26-2010) that aim to achieve a 65% rate of energy saving for new buildings (e.g., the limit for window heat-transfer coefficient for new buildings is 2.5 W/(m^{2}K) in JGJ26-2010, compared to 2.8 W/(m^{2}K) in the retrofit specification). In other words, the retrofit program equips existing buildings with comparable energy conservation performance to new buildings.

The second key success factor is having an efficient and government-sponsored funding model. Table 3 shows the expenses and funding sources of a typical building retrofit project in Changchun. The total cost of the project is 153.71 RMB/m^2 (24.58 USD/m^2), or approximately 14602.45 RMB (2336.20 USD) per home. This figure

Table 1
Targets and achievements of Changchun's "Warm Houses" program.

	Targets (10,000 m^2)	No. of building retrofitted	Total retrofitted floor areas (10,000 m^2)	Numbers of homes retrofitted (est.)
2008	100	n/a	90	9474
2009	100	n/a	63	6600
2010	200	1155	610	64,211
2011	500	2287	1080	113,684
2012	1000	1702	1221	128,526
2013	1000	n/a	1000	105,263

Fig. 1. Buildings undergoing insulation retrofits in Changchun.

Fig. 2. Before (left) and after (right) retrofits.

is substantially lower than the thermal renovation costs reported from other locations for three reasons. First, an economy of scale is achieved by the ambitious scale of the project. Moreover, the government pursues a whole-neighborhood approach where entire residential neighborhoods consisting of several dozen apartment buildings are refurbished at the same time to save money and time. A typical project from start to finish can take as little as two months. Second, retrofitting apartments is cheaper than renovating detached houses. Third, China has a cheap labor force, which the government exploits to lower the cost of this project.

Originally, the program was financed by homeowners with the help of government subsidies. Now, the government is a key financial contributor. While the central government's contribution remains the same, the input from local (provincial, municipal, and district) governments has become the key segment. The financial contribution of the central, provincial, municipal, and district governments are 22.8%, 48.8%, 14.9%, and 7.5%, respectively. Homeowners are required to contribute relatively little (6.1%), and this contribution mainly covers a portion of the window replacement cost. This government-sponsored funding model is very expensive for the government, and is only possible with the contribution from all levels of government. For example, the municipal government of Changchun budgeted 1.3 billion RMB for the implementation of this program in 2014, which is the sixth largest expenditure

Table 2
Technical specification of thermal retrofits.

Item	Standard
Wall and roof thermal insulation	
Material	Expanded polystyrene (EPS)
Thickness (external walls)	70–80 mm
Thickness (roofs)	120 mm
Density	18 kg/m^2 or higher
Heat-transfer coefficient	0.039 W/(m^{2}K) or higher
Tensile strength	0.1 MPa or higher
Compressive strength	90 kPa or higher
Dimensional stability	0.3% or lower
Energy efficient doors and windows	
Material (frame)	Unplasticized polyvinyl chloride (uPVC)
Heat-transfer coefficient	2.8 W/(m^{2}K) or lower
Air infiltration rate	1.5 m^3/(m^{2}h) or lower

Table 3
Expenses and funding sources of a typical building retrofit project in Changchun.

Item	RMB/m^2 (USD/m^2)	Ratio (%)
Expenses		
Administrative and design	4.00 (0.65)	2.6
Wall insulation	74.88 (12.19)	48.7
Wall painting	11.69 (1.90)	7.6
Roof insulation and water proof	32.11 (5.23)	20.9
Door and windows	31.03 (5.05)	20.2
Funding sources		
Central government	35.00 (5.7)	22.77
Provincial government	75.00	48.79
Municipal government	22.94	14.92
District government	11.47	7.46
Homeowners	9.31	6.06

investment project of the year. However, the generous funding is crucial to the program's success because many homeowners who are financially constrained would have no means of paying for the retrofits otherwise.

Key challenges and solutions

A key challenge of the "Warm Houses" program is ensuring the quality of renovation. The outsourcing of work to private companies has introduced a principal-agent problem that is exacerbated by a lack of effective supervision. Although the government has established inspection teams to conduct randomized checks, effective monitoring has been difficult because of the large scale of the project. Consequently, some companies exploit the information asymmetry to maximize their profit by cutting corners or skipping important steps to speed up the process, which often leaves behind many problems and issues. In a recent survey of participants in Changchun, Yu [28] found that 27% of the respondents were dissatisfied or very dissatisfied with the program. The survey also found that the implementation of the policy was a main source of discontent. A particularly common complaint is about water leaks due to the low quality and hasty work on wall and roof insulation. Presently, the government is strengthening its institutional capacity for conducting post-inspections and clean-ups, although the effectiveness of such measure remains to be seen. While the government should continue conducting both pre- and post-inspections, it should also acknowledge the role of the public in quality control. The homeowners whose homes are being renovated are best situated to monitor and report misdeeds. Yet, the government has failed to utilize the public as an enforcement force through establishing effective channels for reporting misbehaviors. Much like freight companies that list phone numbers on their trucks in order to encourage the public to report reckless drivers, the government can benefit from relying on affected third parties as its watchdogs.

The second challenge is that people who live in old houses are predominately from a low socioeconomic background. Although homeowners only need to pay a small share of renovation costs under the government-sponsored model, that small share can still be a significant sum for the poor. As a result, many poor households choose not to install energy-efficient windows, which lowers the overall effectiveness of insulation retrofits. Considering that the cost of window replacement is but a small part of the retrofits, the government should make it completely free and distribute the additional cost among the different levels of government.

The third challenge is ensuring that energy is actually being conserved. As mentioned previously, the local government stresses the merit of the program's ability to improve people's livelihood through improving indoor temperatures. Justifying the program as a response to insufficient heating rather than as a means to address energy scarcity and climate change has proven to be a very effective legitimization tactic. However, this approach has also diverted attention away from the goal of energy conservation. Consequently, the focus of implementation has been entirely placed on improving the thermal insulation of buildings, whereas the installation of heat metering and temperature control has been very much neglected and left in the hands of district heating companies that lack incentives to carry out the reform at their own expense. As a result, very few of the buildings that received a retrofit have had heat metering and temperature control systems installed, and those that did have not used them. Therefore, residents do not have the means or incentives to reduce heating to conserve energy post-renovation. If a home overheats the only available option is to open windows in order to let the heat out. Hence, although there is compelling evidence that refurbishment increases the indoor temperature, the effectiveness of the program in the context of energy conservation is less certain. The interviews with Changchun's district heating companies also reveal that no additional saving has been achieved through the program [29]. It is therefore imperative for the government to integrate heat-metering reform into the current retrofit program.

Conclusion

What lessons can be drawn from the "Warm Houses" program for wider audiences outside China? First, this case study demonstrates that an effective approach to retrofitting existing housing stock is possible. In particular, a more assertive and government-driven approach can provide better results than the current neoliberal policy convention that primarily relies on subsidies and information campaigns. Of course, not all governments can adopt the same strategy because of financial and institutional constraints, but the success factors and challenges identified in this study can help guide the development of a locally appropriate response. Second, this study illustrates the importance of focusing on the local co-benefits of thermal retrofits. Much of the political rationale and legitimacy of the "Warm Houses" program is derived from pressing local issues, especially poor indoor temperature, rather than global environmental issues such as climate change and energy security. The production of localized discourse is essential, especially for governments in developing countries that are not required to act on greenhouse gas mitigation. However, governments adopting such an approach should also be aware of the inherent risks of diverting attention away from climate change and energy objectives. Third, thermal retrofitting alone is not enough to promote energy saving, and provisioning households with the means and incentives for energy saving is important. At the broadest level, this case study echoes Gram-Hanssen's

argument [3] that building inhabitants should not be treated as an afterthought and that it is important to consider how practices of everyday life and practices of building retrofitting are linked in different ways.

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