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Research of heat metering development situation and application effect evaluation model in China



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HIGHLIGHTS

- A comprehensive carding of heat metering development in China was conducted.
- An application effect evaluation model was established.
- Verification was presented between model result and result given by the government.
- Some suggestions with good maneuverability have been proposed.

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ABSTRACT

In spite of over 10 years of heat metering promotion in China, there still lays a certain gap between actual application and expectation. In this paper, the author conducts a comprehensive carding of China's current situation of heat metering in the aspects of policy, price, application area, technical roadmap, product quality and so on. An application effect evaluation model is established based on the geometric mean weights method. Assignments and weights of factors in the model are achieved via multi-agent wide range of questionnaires. Comparisons are made among model results, results published by Liu Xin and the results released from the Ministry of Housing and Urban–Rural Development of the People's Republic of China (MOHURD), which proves rationality and high accuracy of the model established in this paper. Evaluation results show that application of heat metering in 2012 requires improvement with the score pegged at 60.7. It is suggested that policy support from national government should be strengthened, the impact of policies released by provincial government be curbed and heat metering pricing be increasingly reasonable. Application conditions of different metering techniques routes need to be clarified and relevant standards need to be revised to improve the operation.

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1. Introduction

The issue of energy-saving heating has attracted growing attention in the society under the background of global warming and prevention of air pollution. Relevant researches have been carried out in different aspects all over the world, such as renewable energy heating, cogeneration, etc. (Peter et al., 2013; Biaca et al., 2014). Among them, heat metering has long been considered as an important energy-saving measurement and its practical application effect has also attracted worldwide attention (Siggelsten, 2014; Olmos et al., 2011). In recent years, two important instructions, the *Energy End-use Efficiency and Energy Services Directive* (2006/32/EC) as well as the *Energy Saving*

Directive (2012/27/EU), have been released by the European Union as its promotion on European heating metering work (European Parliament, 2012; Sarah, 2012). In the Directive (2012/27/EU), all condominiums must be installed with separate heating metering devices to measure heat consumption and hot water consumption (European Parliament, 2006, 2012). According to Simon Siggelsten's analysis of individual metering and charging in Swedish, it has been shown that only 21 in 109 respondents considered IMC cost-effective for their housing cooperative (Siggelsten and Olander, 2013). Keith Routledge and Jonathan Williams assessed the cost-effective rate of heat metering in the UK by two methods and reached the conclusion that heat metering in existing dwellings was not cost effective, except for older houses with greater savings (Aaron Gould Heat Strategy & Policy Department of Energy and Climate Change, 2012). It is thus clear that the development of heat metering around the world are not well balanced and the

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application results also vary by region.

Studies of heat metering of China began before 1990s and got popularized around the country after having entered into the 21st century. During the course of countrywide promotion in the past decade, two important milestones could be recognized. One is that eight ministries including MOHURD jointly issued the *Guidance on the Pilot Work of Urban Heating System Reform* in 2003, which marked MOHURD's supervision on heating metering and charging. The other is the implement of the *Code for Acceptance of Energy Efficient Building Construction (GB 50411-2007, 2007)*, which required the installation of indoor temperature adjustment devices and thermal control metering devices with mandatory provisions (Code for acceptance of energy efficient building construction, 2007). Energy conservation supervision and inspection have been organized by MOHURD since 2009 according to this specification and the *Regulation of Heat Metering Technique* (released in 2009), in which heat metering has been emphasized.

Many scholars have addressed factors regarding applications and restrictions of heat metering. Jing Zhao et al. studied energy-saving benefits of heat metering in northern China based on a multi-index comprehensive evaluation method (Zhao et al., 2009a, 2009b). Yan Ding et al. discussed achievements of heat metering for existing residential buildings in northern heating regions of China, such as environmental protection effects, improvement of indoor environments and heating systems, investment guidance effects as well as promotion of relevant industries (Ding et al., 2011). Shilei Lu analyzed the financing challenges in the transformation of existing residential building's heating metering in China, listing important factors as differing retrofit and other priorities of various stakeholders, timing and methods of payback on investments, potential investors' lack of access to risk analysis, uncertainty about benefit sharing, and the need for revisions in policies governing retrofits and energy contracts (Lu and Feng, 2014).

Factors influencing the application effect of heat metering remain in multiple aspects, such as metering device quality, water quality of heating system, users' intention on energy consumption and so on. At present, the test cycle of calorimeter durability test in China is 300 hours, which followed the European heat meter standard released in 1997 (EN 1434-1997). The durability testing requirements of heat meters in European now has increased to 2400 h according to the latest standard released in 2007. Short-time detection also contributes to the high fault rate in Chinese heat meters. Effect was well enough to run the heating system and heating measures related to the management level. The effect of heat metering is also related with the heating system and the operational management. Bernt Svensson and Jerker Delsing investigated different kinds of heat meters at four sample stations, finding that deviation of the meters is related to flow rates in the pipes. This result is more reliable if the Reynolds number is closer to 10,000 (Svensson and Delsing, 1998). Baoping Xu found that the users' attitudes toward heating metering and charging system are the key to successful reform of heat metering through behavior survey on the valve adjustment of a residential area's household heat metering in Tianjin, China (Xu et al., 2007).

Currently, Chinese scholars have made lots of achievements in the study of application status and constraints of heat metering. It will play an important role in promoting development of heat metering in the future with quantitative analysis conducted on the application effect of heat metering.

Studies have shown that quantitative understanding can be got to some extent through questionnaire survey. Iana sent out questionnaires to 2000 households, the analysis result of which showed significant differences in the response rates from different types of residences, different income areas of the city as well as in the most preferred ways of receiving information feedback (Iana

et al., 2012).

Authors, taking application effect of heat metering as the objective, conducted a comprehensive carding of the current situation of heat metering in China in the aspects of policy, price, application area, technical route, product quality and so on. An application effect evaluation model has been established based on the geometric mean weights method. Assignments and weights of factors in the model have been reached via multi-agent wide range of questionnaires. The application results of heat metering in China are quantitatively evaluated as the reliability and validity of the questionnaires have been testified. Comparisons are made among model results, results published by Liu Xin and the results released from the Ministry of Housing and Urban–Rural Development of the People's Republic of China (MOHURD) for validation, including comprehensiveness, rationality and accuracy validations of established model.

The aim of this paper is to establish an evaluation model for heat metering application effect in different provinces via subjective evaluation and objective evaluation. The result can be direct quoted by the MOHURD for annual heat metering inspection, and also can be principal evidence for the government to find out which is the weakness part among all the policies. Then, the more strong policy can be drawn up.

2. Model design

The author conducted a comprehensive carding of the current situation of heat metering in China in the aspects of policy, price, application area, technical roadmap, product quality and so on. According to the current situation and the geometric mean weights method, an application effect evaluation model has been established.

2.1. The development of heat metering in China

2.1.1. The policy released by central government

Over the past decade, heat metering has been treated as an important task promoted by the Chinese central government. The *Guidance on Urban Heating System Pilot Work* ([2003] No. 148), jointly issued by the eight ministries (MOHURD, the National Development and Reform Commission, Ministry of Finance, Ministry of Personnel, Ministry of Civil Affairs, the Ministry of Labor and Social Security, the State Administration of Taxation, the State Environmental Protection Administration) on July 21, 2003, pointed out that reform pilot of urban heating system need to be carried out in the northeast, north, northwest, together with Shandong province, Henan province and other regions of China, which marked the official launch of the process of Chinese heating system reform. The *Opinions on Further Promoting the Urban Heating System Reform* ([2005] No. 220) released by the eight ministries on December 6, 2005 further clarified the following two important tasks: one is to promote commercialization and monetization of heating gradually; while the other is to vigorously promote energy conservation and heating system, to steady implement the heat metering and charging system, finally to realize energy saving of both heat supply part and heat users. The *Opinions on Promoting the Heat Metering* issued by MOHURD on June 28, 2006, proposed that new heating system must meet the technical requirements of heat metering and energy saving of existing non-energy-efficient building and reform pilot of heat metering system need to be carried out since 2006. The goal, technical measures and requirements of heat metering were clarified at the same time. June 3, 2007, the *Notice of the General Office of the State Council on Issuing the Comprehensive Program of Work on Energy Conservation* ([2007] No.15) was forwarded by Xinhua News Agency, which clearly

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