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An equivalent marginal cost-pricing model for the district heating market

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HIGHLIGHTS

- Presents a new district heating pricing model.
- Provides both high market efficiency and sufficient investment cost return.
- Provides a competition mechanism for various products from different DH regions.
- Both of lower and higher price speculations are restricted in the new model.

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ABSTRACT

District heating pricing is a core element in reforming the heating market. Existing district heating pricing methods, such as the cost-plus pricing method and the conventional marginal-cost pricing method, cannot simultaneously provide both high efficiency and sufficient investment cost return. To solve this problem, the paper presents a new pricing model, namely Equivalent Marginal Cost Pricing (EMCP) model, which is based on the EVE pricing theory and the unique characteristics of heat products and district heating. The EMCP model uses exergy as the measurement of heating product value and places products from different district heating regions into the same competition platform. In the proposed model, the return on investment cost is closely related to the quoted cost, and within the limitations of the Heating Capacity Cost Reference and the maximum compensated shadow capacity cost, both lower and higher price speculations of heat producers are restricted. Simulation results show that the model can guide heat producers to bid according to their production costs and to provide reasonable returns on investment, which contributes to stimulate the role of price leverage and to promote the optimal allocation of heat resources.

1. Introduction

District heating plants can provide higher efficiencies and better pollution control than can localized boilers. They play an important role in the heating market. The heating market is limited to the area that is covered by the local heating district network. The character of the grids as natural monopolies prohibits the construction of parallel networks and, therefore, competition between different heating companies is limited. In certain countries, such as China and Ukraine, the degrees of heating marketization are low and the prices of district heating are regulated strictly (Lukoseviciu, 2008). Because it is regulated, the price of heating is not a guarantee of market efficiency and does not generate energy-saving enthusiasm among heat producers or users. By contrast, other countries, such as Finland and Sweden, have completely liberalized their heating markets and their district heating prices are deregulated. The heating market efficiencies in these countries are improved, but these countries continue to suffer from other problems, such as lower incentives for investment and maintenance (Aronsson and Hellmer, 2009). In certain of these liberalized countries, there have been suggestions to re-regulate the heating markets (Westin and Lagergren, 2002), which create uncertainty in those countries that are liberalizing or preparing to liberalize their heating markets. Much work remains and many problems should be solved before the goals of heating market reform will be achieved.

Pricing heating products is at the core of heating market reform. In fact, the pricing is always difficult, whether in the regulation or deregulation of the heating market (Linden and Peltola-Ojala, 2010; Poredoš and Kitanovski, 2002). The efficiency of the heating market should be considered when establishing the district heating price, in addition to the sufficiency of return on

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investment cost in heat generation, transition and storage. Many companies, government agencies and researchers have struggled with this problem.

In this article, bargaining between the heat producer and the network owner over pricing is discussed and a new method of pricing, the Equivalent Marginal Cost Pricing (EMCP) method, is presented to solve the problems discussed above. The EMCP model uses short-run and long-run marginal costs simultaneously. Based on this method, there is competition among heat producers through bidding for short-run costs, on the one hand, and price regulation from the administration through the Heating Capacity Cost Reference (HCCR), on the other. Competition among heat producers will create a more efficient heating market and the regulation of heating capacity by the administration will lead investment into the heating market. Heating market efficiency and sufficient return on investment may be realized simultaneously with EMCP model.

The structure of this paper is as follows. First, representative pricing methods for heating are briefly reviewed. Second, the theory of electricity value equivalent pricing is introduced into the heating market. In the third section, the EMCP model for district heating is presented. A case study is performed thereafter, and we make conclusions in the last section.

2. Representative heat pricing methods

As with the electricity market, district heating is a natural monopoly in which market forces are limited. However, the effect of market forces on district heating production is weaker than on electricity production because the heating network is smaller in scale and district heating schemes are often owned by a single entity. Worldwide, there are two basic types of heating markets, regulated and deregulated. In regulated heating markets, there is no competition between district heating and other heating options, and the district heating price is government regulated. By contrast, in deregulated heating markets, district heating competes freely with other heating options and the district heating price is derived in the market. It is difficult to determine which approach is best for the heating market. However, it is certain that the heating market cannot be liberalized fully or regulated fully; instead, it has gradually become the consensus that there should be free competition on the basis of control.

Product pricing is one of the key elements of heating market reform. There are currently two representative methods in heating product pricing. The first is the cost-plus method, which is mainly used in regulated heating markets. The other is the marginal-cost pricing method, which is often utilized in deregulated heating markets.

In the cost-plus method, all costs associated with the heating product are added to the tax charged and a specific profit margin to determine the final price. Cost-plus pricing offers a number of advantages to sellers, buyers and regulators, such as simplicity, flexibility and ease of administration. It is used widely in countries such as China and those of Eastern Europe, as shown in Table 1, in which the heating markets are regulated (Lukosevicius, 2008; ERRA, 2011). However, the cost-plus method is usually based on the historical data of real plants and does not cover all of the costs. Moreover, because the profit allowed is typically derived from total costs, there is an incentive to inflate costs and thereby increase profits (Poputoaia and Bouzarovski, 2010). Companies that are efficient and manage to reduce their costs are punished with lower profits (Meyer and Kalkum, 2008; Korppoo and Korobova, 2012). Therefore, the cost-plus method offers no incentives for suppliers to lower costs or find faster, cheaper and more efficient ways of producing heating products. The cost-plus method may promote investment to a certain extent but cannot enhance the efficiency of the heating market simultaneously.

The marginal-cost method is often used in deregulated heating markets (Difs and Trygg, 2009; Rolfsman and Gustafsson, 2003; Sjödin and Henning, 2004). Marginal cost is the cost of the last unit produced, which, in this case, is the cost of a one-unit increase in district heating. In addition, there is short-run marginal cost (SRMC) and long-run marginal cost (LRMC). Investment is fixed for SRMC and variable for LRMC. SRMC and LRMC will be equal if the suppliers' installation mix is optimal (Rolfsman and Gustafsson, 2003). Optimal heating prices should equal the SRMC of district heating generation, from a societal perspective. These prices reflect the scarcity of resources in society and are the best means for optimal resource allocation (Sjödin and Henning, 2004). However, marginal-cost pricing is based on ideal market theory. In reality, because of various constraints, marginal-cost pricing is difficult to achieve and its effects are difficult to guarantee, particularly in natural monopoly markets. The heating market is a typical natural monopoly market; however, marginal-cost pricing of heating products may be approximately achieved through unregulated market bidding. For example, in Sweden and Finland, as shown in Table 1, DH companies are assumed to work in a businesslike manner and are consequently free to set prices (Ericsson and Svenningsson, 2009; Hansson, 2009; Kostama, 2011). The lack of control in market bidding may lead to unintended consequences that result from emphasizing market efficiency and neglecting investment guidance. Thus, the opening of the electricity markets in Sweden has led to a lower interest in investment and maintenance (Westin and Lagergren, 2002). Furthermore, the 2001 California electricity crisis may also be a lesson for the heating market because there are many similarities between the electricity and heating markets.

3. Electricity value equivalent pricing theory

Theoretical analyses of the electricity market occurred earlier than in the heating market and these analyses are therefore more mature than those of the heating market. Although the development of the electricity market is marked by lessons learned from failed policies, theoretical studies of the electricity market are good references for research into the heating market (Gatautis, 2004; Nast et al., 2007; Söderholm and Wårell, 2011).

For a long period of time, the electricity market has remained in a competitive phase that is influenced by economies of scale and government regulation. There are two major markets in this phase, the investment market and the trading market. Return on investment depends on the competitive behavior of the trading market. However, to ensure market efficiency, the goal of the operation of the trading market is the minimum of product cost less investment cost. To solve this problem, Maosong Yan proposed the Electricity Value Equivalent (EVE) pricing theory for a pure power-generation market. The theory has good performance for market efficiency, return on investment and economic equity (Maosong, 2003a, 2003b).

In EVE pricing theory, the generators are loading, and electricity products are priced by the following three steps:

(1) Load duration curve
The electricity load curve for the next day may be established based on historical and experiential information. The Load Duration Curve (LDC) may be constructed by arranging the load from high to low without considering the time sequence of the load, as shown in Fig. 1(a), where T represents utilized hours of load each day ($T_1 = 24$ h), X represents load power (kW), and Q represents electricity quantity (kWh).