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Pricing district heating by marginal cost

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ABSTRACT

A vital measure for industries when redirecting the energy systems towards sustainability is conversion from electricity to district heating (DH). This conversion can be achieved for example, by replacing electrical heating with DH and compression cooling with heat-driven absorption cooling. Conversion to DH must, however, always be an economically attractive choice for an industry. In this paper the effects for industries and the local DH supplier are analysed when pricing DH by marginal cost in combination with industrial energy efficiency measures. Energy audits have shown that the analysed industries can reduce their annual electricity use by 30% and increase the use of DH by 56%. When marginal costs are applied as DH tariffs and the industrial energy efficiency measures are implemented, the industrial energy costs can be reduced by 17%. When implementing the industrial energy efficiency measures and also considering a utility investment in the local energy system, the local DH supplier has a potential to reduce the total energy system cost by 1.6 million EUR. Global carbon dioxide emissions can be reduced by 25,000 tonnes if the industrial energy efficiency measures are implemented and when coal-condensing power is assumed to be the marginal electricity source.

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1. Introduction

Since Swedish industries use two or three times more electricity than other European industries (Nord-Ågren, 2002), there is potential for reduced industrial electricity use. Instead of using electricity for non-electricity specific processes, district heating (DH) can be used. For example, electrical heating and drying can be converted to DH and compression cooling can be converted to heat-driven absorption cooling. A prerequisite for converting processes to DH is extensive DH grids, which is the case for Sweden. In addition, converting non-electricity specific processes to DH in an energy system containing combined heat and power (CHP) generation will lead to a greater potential to produce electricity. With the deregulation of the European electricity market, electricity generated in Sweden but sold in another European country could replace electricity produced with higher external costs. When accounting for electricity with marginal production and assuming coal-condensing power to be the marginal source, reduced industrial electricity use and more electricity production in Swedish CHP systems will lead to possibilities to introduce cost-efficient measures to reduce global emissions of carbon dioxide. Reduced use of electricity in Sweden will free capacity for the energy supplier that can be sold to other European countries.

With a deregulated European electricity market, the electricity price in Europe will most likely level out at an equilibrium price. Sweden is characterized as an energy dimensioned system where the electricity price varies over the year, while the electricity supply system in continental Europe is characterized as power dimensioned with the electricity price varying over the day. Since the Nordic market constitutes only a minor portion of the common European market, it is likely that the conditions on the European continent will be valid for the entire common European market and that electricity prices between Scandinavia and northern Europe will level out (SEA, 2006). Consequently, increasing electricity prices in Sweden in combination with high electricity use make it important for Swedish industry to focus on means to reduce the use of electricity and convert from electricity to other fuels or DH.

To face the threat of global warming, redirection of energy systems towards less use of fossil fuel is vital. Converting from electricity to DH is thus a measure towards sustainability as electricity use is replaced by electricity production. For industries to convert to DH from electricity or other fuel, the measure must be an attractive option for the management of the industry. This means that the price of DH must be at a level that makes the conversion economically interesting.

1.1. Marginal costs and pricing of DH

DH tariffs in Sweden usually consist of a variable heating cost, a flow cost and an additional fixed charge proportional to a subscribed capacity. Alternate cost pricing for the variable heating

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cost of DH is a common practise pricing policy. In the past the most common Swedish heating alternatives were electric and oil boilers, setting DH tariffs just below the cost for these alterative heating options (Sjödin and Henning, 2004). In recent years different kinds of heat pumps have come to be a price competitive alternative and in this comparison with heat pumps, the DH tariffs are usually higher which makes DH less favourable for consumers. In this study, the price setting of DH is analysed and pricing by marginal cost is examined as a method of pricing DH.

The marginal cost is often defined as the cost to produce the last unit, in this case the cost of a unit increase in DH. In energy systems with several production plants, the plant with the highest operational cost is the one that produces the last unit of DH. There are several ways to determine the marginal cost for DH depending on the allocation of joint costs. Sjödin and Henning (2004) discuss different methods of allocation depending on what the by-product of CHP generation is, electricity or heat. For heat-only boilers, the calculation of marginal cost is relatively uncomplicated and depends on fuel costs and efficiency. It becomes more complicated for CHP generation where the joint costs for electricity and heat generation can be split in numerous ways. Like Sjödin and Henning (2004), we chose the standard reference power plant method where electricity is considered a by-product. The heat cost is calculated as the plant's production cost (where the total efficiency of the plant has been considered) less the value of the produced electricity. The heat is considered the main product since there is a heat demand that needs to be met. Depending on the fuel costs, the electricity-to-heat ratio and electricity prices, the marginal cost for heat varies and can even be negative.

1.2. Objective

The aim of the study is to analyse the effect on industries and the local DH supplier—Tekniska Verken AB—in the Linköping region when marginal costs are applied as DH tariffs. We study how pricing according to marginal cost for DH will affect the industries in the region when energy efficiency measures are introduced. The industrial energy costs, the local DH supplier's marginal costs and system cost as well as emissions of carbon dioxide are analysed.

The studied case consists of the local DH supplier and eight industries connected to the local DH grid. For the industries, energy audits have been conducted in order to find out their potential energy use changes with the purpose of making energy use more efficient and less electricity dependent. The energy efficiency measures suggested in the energy audits include for example, changing lightning fixtures and switching from compressed air tools to electric tools. Other suggestions that have an impact on the DH use are converting from compression chillers to DH-driven absorption chillers and from electrical heating to DH. These potential changes in the energy use affect the industrial energy cost depending on input data, which are stipulated in different scenarios (see Fig. 1). For the local heating supplier the DH demand for the region has been modelled in an optimisation model called MODEST. In MODEST, the local energy system has been optimised and results of this optimisation include both plant operation and marginal costs. The marginal costs are then used as input data for the DH tariffs in Scenario 5 (see Fig. 1). For Scenario 6, modified marginal costs, where a utility investment in the local energy system is included, are used as DH tariffs (see Fig. 1). Further, the effect on the local DH supplier when the industries implement the suggested energy efficiency measures is also studied. This is done by calculating the system costs in MODEST. Finally, the impact on CO_2 emissions when changing the industrial energy use is analysed.

2. Case study

Linköping, located about 200 km southwest of Stockholm, is Sweden's fifth largest city with about 140,000 inhabitants. The local DH supplier in Linköping is the municipally owned Tekniska Verken AB. The district energy utility produces about 1700 GWh heat annually and the maximum heat demand for the region is about 500 MW. In addition to the DH system, a district-cooling network is also managed by Tekniska Verken AB. Of the annual district cooling demand of 30 GWh, 60% is supplied by DH-driven

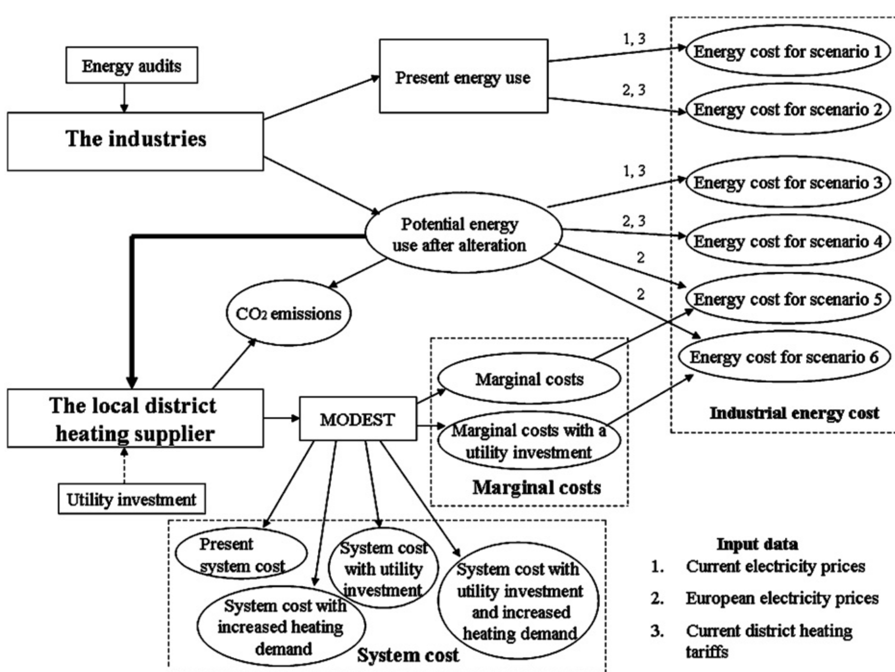

Fig. 1. Methodology of the study.

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