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Framework conditions for Nordic district heating - Similarities and differences, and why Norway sticks out

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ABSTRACT

The district heating (DH) sectors differ considerably among the Nordic countries: DH is an important contributor to heat supply in Denmark, Finland and Sweden, but in Norway it plays only a minor role. In this study, we compare historical, economic, jurisdictional, political and geographical framework conditions for DH and assess their impacts on the development of DH in the Nordic region. DH is subject to national and municipal regulations, with tax and subsidy schemes that are complex and vary between the countries. The total fuel prices induce differences in fuel distribution. Electricity is competitive, both in DH and individual heating in Norway. This study further suggests, by comparing the impacts and implications of differences in cost components in a model plant, that differences in profitability is currently small between the Nordic countries. However, historical and geographical factors, such as local commitment and differences in infrastructure, constitute the major difference in the penetration of DH. Adaptability, in terms of fuel flexibility, is important for the industry's survivability and electricity prices are crucial for the development of DH. Energy efficiency measures and competition from residential heat pumps are the industry's largest challenges.

1. Introduction

District heating (DH) is defined as distribution of thermal energy in the form of steam or hot water from a central source of production through a network to multiple buildings or sites [1]. DH is used for space heating and tap water systems; hence, a water-borne heat distribution system is prerequisite in buildings served by DH. DH generation comes from a variety of fuels, such as waste incineration, waste heat, wood chips, coal, gas, oil, or electricity in electric boilers (EBs) or heat pumps (HPs) [2]. Whereas heat-only (HO) plants solely rely on boilers or HPs to provide heat for the DH network, combined heat and power (CHP) plants also produce electricity, which increases the efficiency compared to boiler-based plants.

There are many advantages of DH. DH plants can utilize local energy sources and a variety of fuels, including some that otherwise would be wasted, so it increases the efficiency of energy production [3]. A positive external effect of utilizing domestic fuels is that it stimulates economic growth locally [4]. Due to fuel flexibility, DH has served, since the oil crisis in 1974, as a means to reduce oil dependency, and since the 1990s, as a means of reducing greenhouse gas emissions [5].

In reviewing previous studies in this field, we found no comparative studies of framework conditions for DH in the Nordic countries and no studies attempting to explain why DH markets took different directions. A. Lake et al. [6] reviewed literature concerning DH, and included historic, economic and policy factors, but for DH in general and for predicting its future role. M. Wissner [7] described regulation of DH in general, with a focus on price regulation. S. Akhtari et al. [8] reviewed previous work on the economic feasibility of biofuel-based DH, but they were also not country-specific. A. Colmenar-Santos et al. [5] presented the status and future prospects of DH in EU-28, with a focus on CHP. A few studies have compared Nordic countries in different aspects. R. Fazeli et al. [9] compared energy demand for space heating in the Nordic countries, and presented the history of individual heating (IH) in each Nordic country, but with the aim of revealing the best method for estimating fuel demand. A. Aslani et al. [10] compared policy frameworks for renewable energy, including DH, in the Nordic region. Apart from A. Chittum and P. Østergaard [11], who presented policies for DH in Denmark, most studies have looked at

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specific framework conditions and evaluated the effect of these, and mostly for one specific country or specific affected actors. For example, T. Unger and E. Ahlgren [12] evaluated the impact of green certificates on Nordic countries; A. Chittum and P. Østergaard [11] evaluated heat planning in Denmark; and H. Sjølie et al. [13] assessed policies for promoting bio-energy in Norway. Quite a few studies have included a historic presentation of the development of DH. S. Werner [14], P. Westin and F. Lagergren [15], L. di Lucia and K. Ericsson et al. [3] and D. Magnusson [16] presented the development of DH in Sweden; B. Sovacool [17] did the same for Denmark; M. Forbord et al. [18] and E. Trømborg et al. [19] for Norway; and S. Helynen [20] for Finland, but the latter three with a focus on bio-energy. Some studies also present the status of DH at the time of their writing: A. Gebremedhin [21] presented the DH picture in Norway; S. Paiho and F. Reda [22] in Finland; S. Werner [14] in Sweden and P. Østergaard and A. Andersen [23] in Denmark.

The objectives of this study are to describe both the development and the current position of DH in the Nordic countries, analyse the differences in costs and revenues affecting the profitability of investment in and operation of DH, and assess the economic and operational impacts of the dfferences in costs and revenues. Finally, we aim to discuss the impacts of other framework conditions for DH and some policy implications for the development of the DH sector.

When considering the framework conditions for DH, it is relevant to bring in the consumer side, and compare DH to alternative heating systems. We thereby compare the heat costs of different options for IH in the different countries, to be able to discuss the competitiveness of DH in the market for heat.

This study aims to identify the framework conditions that have been and are most significant for the past, current and future development of Nordic DH. Future developments can benefit from this view of the past and present, firstly due to the large share of heat demand covered by DH, secondly for the role of DH in the transition to energy systems increasingly supplied by renewable energy sources (RES), and thirdly due to the contribution of DH to social welfare.

Chapter 2 presents the data collection, the categorization of the data and the preconditions for the analysis of the quantitative data in this study. In chapter 3, we first present the historical development and status of Nordic DH, then go on to describe its current framework conditions. The third part of chapter 3 presents the economic framework conditions, which Nordic DH systems are facing. In the fourth part of chapter 3, the economic framework conditions are included in a presentation of a model plant. The fifth and last part of chapter three presents a study of the costs of different alternatives for IH. In chapter 4, we discuss the impacts of economic and other framework conditions on Nordic DH. Additionally, we discuss the further development of Nordic DH and suggest implications of this study. In chapter 5, we present conclusions of the study.

2. Method and data

2.1. Data collection and categorization of the framework conditions

This study is based on a qualitative review of framework conditions for DH in the Nordic countries and a quantitative data collection of economic parameters, such as fuel prices, DH prices, labour costs, taxes and subsidies. The qualitative approach has been applied to identify, structure and explain the effects of the different framework conditions. The quantitative approach is conducted in Excel and aims at quantifying the effects on the model plant's profitability by applying the different countries' fuel prices and different country's revenues and costs such as heat prices, fuel prices and tax schemes. The framework conditions were collected through an extensive review of national regulations, public reports and statistics, through desk research and correspondence with national parties and authorities in the Nordic countries.

We use the 2015 average DH price to compare the profitability of the model plant in the different countries, and the 2016 average DH price to compare alternatives for IH with DH. The average DH prices come from the countries' official statistics. Enova provides information about the investment subsidy for DH plants based on RES [24]. The wood chip price is taken from the industry association in Denmark, the official statistics bureau in Finland, and the national energy authorities in Norway and Sweden [25–28]. The fuel oil price is assumed to be homogeneous for all countries, and is taken from the European commission [29]. The taxes are taken from the national tax or customs authorities and excise legislation [30–34]. The fuel cost for IH is derived from private fuel traders, while taxes come from each country's tax authorities. The labour cost levels come from Eurostat's annual labour cost data [35], and the exchange rate used is an annual average of the exchange rates provided by the national banks [36–38].

The historical factors brought up in this study are a compilation from reviewed literature, public reports and releases by industry associations. The status for the Nordic countries combined, as presented here, is a result of data collection from public statistics, industry associations and national energy authorities.

Many different framework conditions affect the DH sector, slightly or significantly, depending on the market structure. The framework conditions may affect different components of the DH system, such as fuel, technology or DH consumers. Some framework conditions may have a positive or negative impact on the operation of DH plants, while others affect investment decisions. Some of the framework conditions are specific to the DH sector, while other framework conditions affect the DH sector indirectly by being means for other aims. The different framework conditions may be implemented at a local level, such as the electricity grid tariffs or mandatory connection; nationally, such as tax or subsidy schemes; bilaterally, such as the green certificate scheme; or at an international level, such as EU legislation and commitment to reduction of CO_2 emissions. The framework conditions may be jurisdictional; a political priority; an external effect of instruments for other targets; or factors out of the DH enterprises' control, such as geographical factors.

The focus in this study is on identifying framework conditions that affect investment decisions and the operation of existing DH plants. We separate the framework conditions into three main categories: historical framework conditions, economic framework conditions, and other framework conditions that affect the DH sector. Historical framework conditions are framework conditions that have influenced the development of the DH sectors in the Nordic countries. Economic framework conditions include financial framework conditions, such as taxes and subsidies, and quantifiable external framework conditions, such as fuel costs (including electricity and natural gas grid tariffs) and labour costs. The category "other framework conditions" includes framework conditions on the consumer side and framework conditions whose impact on DH we cannot as easily measure; it is thus analysed qualitatively. Table 1 presents a selection of framework conditions that are quantifiable or mentioned in the literature as drivers or barriers for DH.

2.2. Preconditions

For the model plant, investment costs are used from M.