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How to develop district heating in Finland?

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ABSTRACT

District heating is widely used in Finland. About half of the population live is district-heated buildings. Additionally, many industrial and public buildings are heated with district heat. In Finland, district heating is implemented efficiently. Average network and measuring losses are 10%. Through energy transition, urbanization and digitalization the Finnish district heating sector is facing new challenges.

This paper deals with how Finnish district heating should be developed during the next five years. Altogether 29 organizations, mainly companies, were interviewed and asked about the main challenges, the main opportunities, the foreseen vision and the required actions. Increased competition forces the energy companies to reconsider their business. The major development efforts should be focused on new production alternatives (including hybrid systems), services and data utilization. The development should also be performed in closer connection with the end users and clients. The new systems and solutions should be piloted in order to ensure their operation and to demonstrate their benefits. The municipalities should take a forerunner role in the piloting actions.

1. Introduction

District heating is widely used in Northern and Eastern Europe as well as in Russia and China (Fahl and Dobbins, 2017; Werner, 2017). District heating is especially well suited to dense urban areas. Through the years, district heating has evolved from three major aspects (Lund et al., 2014): 1) the temperature levels have decreased, 2) the energy efficiency has improved, and 3) the heat production methods have diversified. This process is still going on.

Moving away from fossil fuels, the so-called "energy transition", is a strategic target in the EU (European Commission, 2017a). Several European cities and towns have already started facing this challenge (e.g., (Energy Cities, 2014)). In the EU, district heating (where existing) is considered as one important option to decarbonize heating (European Commission, 2011). District heating and cooling (DHC) technology platform has also addressed this opportunity (DHC+, 2012). In addition, the Nordic countries are reducing the carbon intensity of heat supply through low-carbon, advanced district heating networks (IEA, 2015).

Urban energy systems are also experiencing digital transition (Zhang et al., 2017) as more and more data is available and data analytics is been developed. Increased digitalization also forces district heating companies to change (Deloitte, 2016) but additionally it offers numerous opportunities. For examples, such technologies as blockchains (Hwang et al., 2017; Mengelkamp et al., 2017) and Internet of Things - IoT (Song et al., 2017; Terroso-Saenz et al., 2017) can be utilized to offer clients new energy services.

Paiho and Reda (2016) assessed the future of district heating in Finland based on scientific literature. In addition, several recent scientific papers deal with important and interesting topics related to district heating in the Finnish context. Rehman et al. (2017a, 2017b), Paiho et al. (2017) and Rämä and Mohammadi (2017) studied solar district heating and seasonal heat storage in Finland. Abdurafikov et al. (2017) analyzed heating energy scenarios of a typical Finnish district heated area and addressed the potential of waste heat. Wahlroos et al. (2017) analyzed waste heat utilization from the perspectives of both the data center and district heating network operators. Wahlroos et al. (2018) analyzed the potential for data center waste heat utilization in the Nordic countries including Finland. Kirppu et al. (2017) evaluated carbon-neutral heat-only production technologies in a major district heating system in Finland. Leurent et al. (2017) investigated obstacles of a possible Loviisa 3 nuclear district heating. Rämä and Wahlroos (2018) studied effects of adding new renewable heat sources into an existing Finnish district heating system.

However, perspectives of the Finnish actors about the future of district heating have not been studied. This paper aims to fulfill this gap through systematic analysis of carried stakeholder interviews. In addition, this paper targets to answer which are the major challenges and

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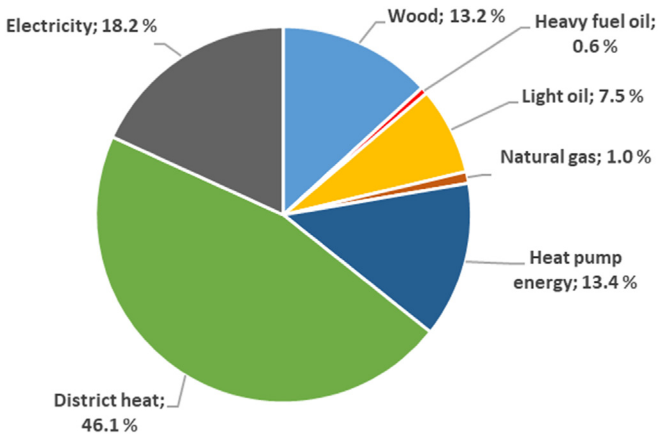

Fig. 1. Housing and service heat market share 2016 in Finland by energy sources (Energiateollisuus ry, 2017).

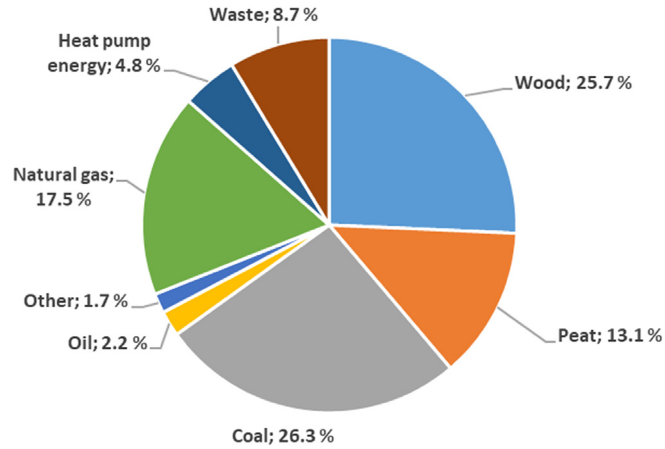

Fig. 2. Fuels used for production of district heat and electricity related to district heat 2016 (Energiateollisuus ry, n.d.).

opportunities of district heating in Finland, which vision is foreseen to be achieved, and which actions should be taken to achieve the vision. The remaining sections of this paper are organized as follows. Section 2 describes the status of district heating in Finland mainly based on statistics. Section 3 introduces material and methods used in the study. Section 4 presents the results and discusses the findings. Section 5 concludes the study including also policy implications.

2. District heating in Finland

2.1. Heating in Finland

The market share of district heating companies was 46% in 2016 (Energiateollisuus ry, 2017). Other heat sources in market were electricity, heat pumps, wood, light oil and natural gas respectively, see Fig. 1. The ground-source heat has increased its market share quickly during the past 10 years. In 2015, the ground-source heat became the most used heat source (37.5%) in single-family houses (Tilastokeskus, 2018).

Approximately 2.7 million people lived in district-heated buildings in Finland in 2016 and 2500 new customers joined district heating network (Energiateollisuus ry, 2017). In other words, half of the population of Finland utilizes district heating. According to Vainio et al. (2015), the population will grow in urban municipalities (9%), in dense populated municipalities (4%) and fall in countryside (−5%) from year 2010 to 2025. This means that more people will move to locations where district heating network is available.

It is predicted that the total consumption of heat in Finland will decrease during upcoming years due to decrease in housing stock and due to increase in energy efficiency of housing, e.g., (Abdurafikov et al., 2017; Vainio et al., 2015). The regulation of nearly zero-energy buildings (Oikeusministeriö, 2017) affects the new construction during the up-coming years.

2.2. Production of district heating in Finland

In 2016, the total district heat production in Finland was 38.5 TWh_{th} (Statistics Finland, 2017) and district heat demand 33.4 TWh_{th} (Energiateollisuus ry, 2017). The production increased 10% (Statistics Finland, 2017) and demand 12% (Energiateollisuus ry, 2017) of the previous year. The district heat demand in Finland has increased almost linearly since 1970 and then reduced recently by approximately 5 TWh_{th}. The production of the district cooling has also increased since the year 2000 up to todays 205 000 MWh_{th}. In 2016, the district cooling in Finland was produced with heat pumps (51%), compressors (25%) and by absorption (24%) (Energiateollisuus ry, 2017).

CHP (Combined Heat and Power) plants produced approximately 75% and separate production 25% of district heat (Finnish energy, 2018). The share has not considerably changed during the present decade. Coal and wood-derived fuels were the main fuels in district heat production in 2016 (Energiateollisuus ry, 2017; Statistics Finland, 2017), see Fig. 2. Renewable fuels covered 32% of the production (Energiateollisuus ry, n.d.) and utilization of renewable fuels increased by 7% from the previous year (Statistics Finland, 2017). However, the utilization of fossil fuels also increased by 7% from the previous year (Statistics Finland, 2017). Some 37% of fuels were counted to CO_2 neutral and 54% of them were domestic. The oil utilization in the district heat production has decreased from its dominant position in 1970's to only 2.2% use today (Energiateollisuus ry, 2017). The utilization appears to further decrease since heating plants mainly use oil as back-up fuel. In addition, the utilization of natural gas and coal is decreasing due to demand of increasing renewable energy production (Energiateollisuus ry, n.d.).

In 2016, industrial plants produced 52.9 TWh_{th} of heat (Statistics Finland, 2017). An unrecorded share of that production supported local district heating networks. The production increased a little. Renewable fuels produced more than 70% of the industrial heat. The largest industrial heat user was forest industry that utilizes own fuels such as residual liquors and other wood-based fuels in its production. However, in chemical and forest industry part of the heat consumption is applied to statistics as direct fuel consumption and is not, thus, included to production statistics (Statistics Finland, 2017).

The number of waste burning plants has increased during the present decade in Finland. Four new waste burning plants introduced in 2012, and after that one is put to operation, two are yet under construction and environmental license has been applied for one (Pöyry Management Consulting, 2015). The heat from waste burning plants is delivered to district heating. According to Pöyry (Pöyry Management Consulting, 2015), the waste burning will have 8% share in district heat production by 2020.

One of the advantages in district heating systems is that they can use wide variety of local fuels (Paiho and Reda, 2016). Heat production with renewable fuels has increased exponentially during the last three decades and it reflects to CO_2 emissions of district heating that have almost halved since 1980's (Energiateollisuus ry, 2017). Since the heating network itself has typically a large heat storage capacity, there is a great potential to increase variable renewable energy sources such as solar heat to district heating systems (Hannula and Hakkarainen, 2017) and few examples of such hybrid systems can already be found in Finland (Hakkarainen, 2016). The customers may also use hybrid heating systems in which district heating is either substitute alternative for heating (e.g. with a ground-source heat pump) or the main heating