THIRD-PARTY ACCESS TO DISTRICT HEATING NETWORKS

A report to Finnish Energy

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EXECUTIVE SUMMARY

District heating accounts for about 46 % of the total heat demand in Finland and is extensively utilised in urban areas. District heating companies typically operate the whole value chain of heat production, distribution and sales. Approximately one third of all district heat produced in Finland is annually purchased from other (third-party) producers, such as industrial CHP plants and waste heat sources. The supply of the heat produced by other producers to the network, so called third-party access (TPA), is currently based on voluntary agreements between the third-party producers and district heating companies.

The possibility to open the networks for third-party production with more transparent conditions has been discussed on national and also on EU level lately. The European Commission proposed in the revised Renewable Energy Directive that Member States should adopt measures to ensure non-discriminatory access to District Heating and Cooling (DHC) systems for heat or cold produced from renewable energy sources and for waste heat or cold, to be able to directly supply the heating or cooling to the customers. However, Council of the European Union and European Parliament have declared that the proposal of the Commission should not be deployed. Instead, they suggest that for inefficient DHC systems, the TPA should be based on so called single-buyer model, or the renewable share of production can be increased by other means.

Third-party access has been presented as a means to improve energy efficiency by utilising waste heat and to increase renewable energy. However, these targets are already promoted by other policy measures, such as emissions trading, energy taxation and building codes. Because the district heating system operations, such as heat production, sales and distribution, are currently integrated, any regulated third-party access would require significant changes to the current systems and regulation.

This study aims to analyse the potential models for third-party access to district heating in Finland and to identify the resulting impacts on heat customers, potential heat producers, current district heat companies and on society. The analysis is based on the current market design in Finland, some experiences from other countries and analysis of the potential models for TPA. The impacts are quantified with simulation examples of different size heat networks (Small 50 GWh, Medium 500 GWh and Large 5,000 GWh annual heat sales) and potential third-party production types utilising various technologies. Based on the examples and analysis of the current situation, the report pursues to identify whether there would be competition in the district heating networks, which could benefit the customer and/or society, what kind of regulation could be required, and what kind of additional costs could be borne by the district heating companies implementing the new model for TPA.

Based on the analysis and simulation, opening of the district heating networks is not likely to result in a high level of competition arising from various renewable technologies. The analysis is based on comparing the total costs of renewable technologies with the operating costs of the defined virtual example networks of different sizes. The only technology that is competitive in all of the analysed three networks is waste heat from either industry or from data centres. In the large fossil fuel based network, waste heat from the service sector, industrial-size biomass boilers and deep geothermal heat were also considered competitive. The potential of many of the larger scale industrial waste heat sources located close to the heat networks is largely utilised, which means that the techno-economic potential would have to be found from smaller scale waste heat sources. However, the waste heat potential is very network specific, which makes the drawing of general level conclusions on the potential impossible. In addition to price-competitiveness, high level of competition would require sufficient amount of suitable locations for production units, availability of investors and risk-adjusted financing as well as consideration of support schemes and rules for equal treatment.

TPA can be implemented with a variety of market models and levels of regulation. It is possible to introduce competition only to the production of heat, or to open the networks for direct supply of third-party produced heat to customers. Based on this difference, the potential models can be classified as single-buyer models or network-access models. Three different models are analysed in more detail in this report from the perspective of the Finnish heat market. Those models serve as

examples to concretise some of the required changes to the current market model and they are used as basis for the presented quantitative analysis.

TPA can be realised without regulation based on voluntary agreements, auctions for production and capacity and other measures for setting transparent market places. On the other hand, many TPA models can result in requirements for increased regulation for the district heating distribution and/or production. Especially from transparency point of view, many TPA models can require unbundling of network operations from heat production and/or sales. Unbundling can be realized with different levels, but according to full ownership unbundling, the costs are high for the district heating sector taking into account the small size of the companies.

Based on the analysis, if production is unbundled from the distribution as in model 2, the administrative cost burden for the district heating company is approximately 10 times higher than in simpler TPA model 1 that resembles the current TPA model. With network access model (model 3) where producers can utilise the network to sell their heat production directly to customers, the costs rise about 20 % more.

These costs are substantial compared to other costs of the networks. For Medium network, the administration costs of a TPA model with unbundling requirement (models 2 and 3) increase the aggregate production costs by about 10-20 % and for Small network about 50 %. Only for the analysed Large network (5 000 GWh annual heat sales), the cost increase resulting from these TPA models may be considered moderate, in the range of 1-3 % of other costs. However, it should be noted that there is only one district heating network in this size range in Finland.

Based on the additional administrative costs incurred by district heating companies under TPA models requiring unbundling (models 2 and 3) and the fact that most of the Finnish DH networks are of small size (median size ~50 GWh), it is clear that applying such TPA models for the whole district heating sector in Finland does not make sense. Therefore, of the analysed TPA models, the model 1, which requires the least regulation, is the only one whose additional costs do not clearly outweigh the potential efficiency gains resulting from increased competition that implementing the TPA could even theoretically provoke.

The question remains, does the current TPA model based on voluntary bilateral agreements need to be changed? Setting up a market place for heat and having more transparent prices according to analysed TPA model 1 can be argued to stimulate more competition in the district heating market than today with only moderate additional costs and regulation. If the market place would be based on hourly pricing that would be passed on to customer level, there could be additional benefits achievable in the demand response and in the developed new services. However, already at present, district heating companies have started to implement demand response solutions based on normal market terms.

In some cases investments in production by third-parties would still need to be realised with long-term contracts to reduce the investment risks. In that sense the situation would resemble the model of today. Nevertheless, having more transparency in the market could in the long run induce new kind of services and technology development to the district heating market that could benefit all parties. The likelihood of such development is, however, not clear and it could be further discussed.

1. INTRODUCTION

1.1 Background and aim of the study

In 2016, district heating (DH) accounted for 46 % of total heat demand in residential and commercial buildings in Finland (Finnish Energy, 2016), the share being even higher in more densely inhabited urban areas. District heating competes with property-level heating technologies, such as biomass or oil-fired boilers, electric heating and heat pumps. District heating has gained the high market share due to its competitive cost, reliability and easiness.

There are over 150 district heating networks in Finland, typically owned by local energy companies[1]. In district heating, the heat network and the production plants are mostly owned by the same company. On the other hand, there are also many networks, where a significant share of district heat comes from third-party producers, typically from industrial CHP plants or waste heat sources.

Currently the utilisation of the heat produced by third parties is based on bilateral agreements. District heating companies have been interested in utilising any heat sources that would potentially decrease the cost of heat sourcing to keep the price of district heating competitive compared to other heat sources and increase the profitability. However, there are no harmonised conditions with which the third-party producers can sell their heat to the network. From the third-party producers' point of view, this approach can sometimes lack the transparency, which can be argued to result in less new investments or agreements with the DH companies.

Third-party access to district heating has been also a discussion point with the proposed revised Renewable Energy Directive. The Article 24 of the initial proposed directive provides that Member States need to adopt measures to ensure non-discriminatory access to District Heating and Cooling (DHC) systems from renewable energy sources and for waste heat or cold (European Commission, 2016a).These kind of third-party producers would be entitled to use the DHC system for direct supply of heating or cooling to customers. There are some conditions under which the DH system operators could refuse the access, but in general this would mean some kind of third-party access (TPA) regulation. The implications of this has not been analysed any further in the directive proposal. One of the targets of this report is to analyse how this proposal could be implemented in Finland and what would be the implications.

In addition to EU level regulation, there is an ongoing discussion also on national level that existing infrastructure (such as railways and transportation sector) could be opened for competition and act as platforms for new kinds of services to decrease the cost or improve the level of service for customers. In energy sector, the electricity production and sales has been opened for competition. In similar vein, it has been argued that opening the DHC systems for competition could decrease the cost of energy for customers due to price competition within the networks, and allow the customers to select the heat supplier or service level according to their personal preferences.

Sometimes, when talking about price competition in the district heating system, reference is made to electricity markets, where increased competition has resulted in clear decrease in consumer prices. District heating has, however, some fundamental differences compared to electricity. The main differentiating factor is that heat cannot be transferred similarly to electricity and the heat networks are always local and small in size. This limits the number of potential market participants and the level of competition. If TPA succeeds in encouraging only a low number of new entrants to the markets, the prevailing new market condition may be considered rather an oligopoly than free competition. In addition, the end-product is not as homogenous as in electricity markets; the needed temperature level varies throughout the year and also between the networks or location in the network. Also, unlike electricity and gas, the district heating water is circulated back to the producers and there are requirements for the return water temperatures.

[1] The figure 150 is based on the database of Finnish Energy. If smaller networks operated by local entrepreneurs were included, the number would be in the range of 400

Even though the existing DH[2] systems already actively search and utilise potential heat streams, the district heating sector is interested in further increasing the utilisation of waste heat and improving energy efficiency to decrease the cost of district heating and environmental impacts. There is also a need to develop new services and encourage innovations in district heating and cooling sector. One option could be to develop common conditions for more open district heating and cooling systems.

Third party access can be implemented in various ways. This report aims to describe different models and the possible requirements for regulation in the models. Three models for TPA are presented in more detail to concretise the potential impacts of third party access.

The aim of this study is to analyse the benefits and disadvantages of applying a different TPA model than is in use today (i.e. voluntary agreements). The main question to be answered is: Could a mandatory and more regulated TPA model result in a high level of competition so that the efficiency gains outweigh the additional costs? This is studied as follows:

- It is first analysed what kind of waste heat streams or renewable heat production there could be available for DH networks of three different sizes and whether it is feasible from techno-economic perspective to invest in those.
- Additional costs resulting from TPA models that could encourage these investments, are estimated
- Finally, it is quantitatively and qualitatively assessed whether adding more renewable production to the DH system through various TPA models could bring any benefits compared to current TPA model.

An important factor to be considered is whether TPA is able to encourage sufficient competition in the capital intensive DH markets to create the desired cost savings for heat customers. In addition, it should be assessed whether TPA would impact the profitability of investments and the investors' willingness and incentives for long-term investment decisions. The factors to be considered in ensuring a fair and effective competition are for example reducing the barriers to enter the heat production market, incentives for investments and system efficiency and ensuring non-discriminatory treatment of all heat suppliers and network operators in the DH markets.

District heating and cooling systems have been considered energy efficient enabling low emission energy systems in cities. Therefore, TPA should be implemented in a way that would not increase the total cost of district heating and make district heating uncompetitive against other heating methods. Furthermore, it should be assessed whether TPA is an optimal policy to promote the use of renewables and waste heat sources or could they be promoted more efficiently with some other policies.

1.2 Current status of district heating and third-party access in Finland

District heating has been supplied in Finland for more than 50 years and it has grown to be the most significant heating method in the country. Furthermore, Finland has the 4th highest total annual district heating demand of all EU countries (Finnish Energy, 2016). The DH growth in Finland has been highly market-based with a very low level of regulation.

In Finland, district heating has been assumed to be in strong or dominant market position among existing customers. However, a number of clients have switched from district heating to other heating methods, which proves that there is competition in the market. Currently this competition is affected by various energy policies that impact customer preferences of the selected heating method. Such policies include fossil fuel taxation, emissions trading, energy labelling of buildings and building codes that are in place to promote the use of renewables and energy efficiency. Numerous studies have shown that alternative heating methods are competitive against district

[2] In this report, we mainly refer to district heating (DH) but third-party access can also apply to district cooling systems.

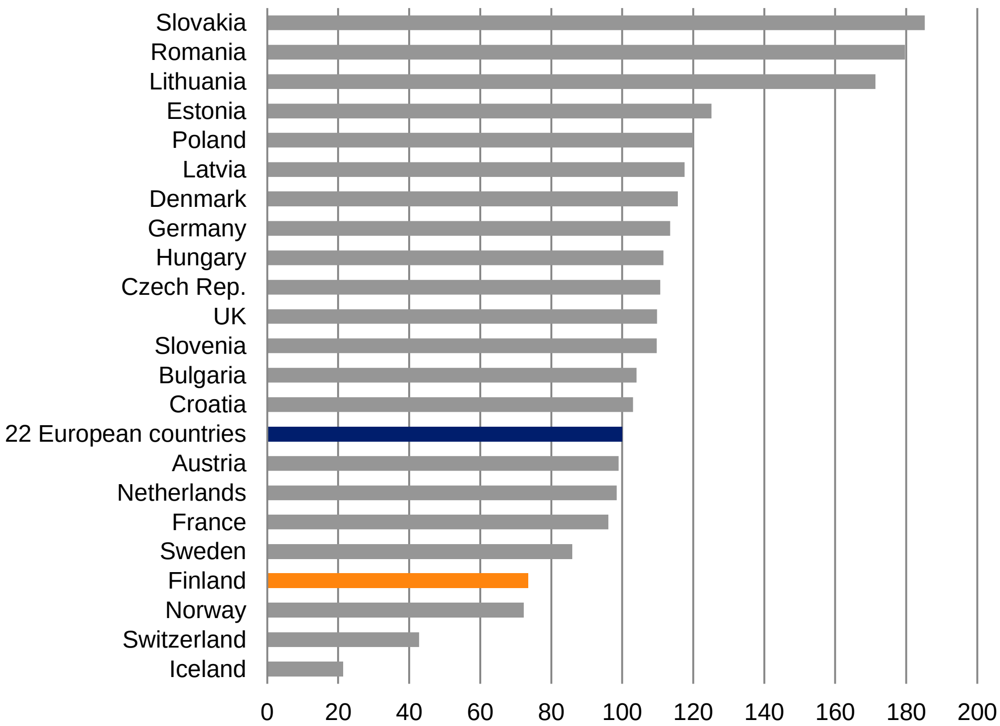
heating. There is in general no obligation to connect to district heating and the customers can disconnect from it in short notice, which means that sellers of district heat have the incentive to keep the price of DH on competitive level.

There is no DH price regulation in Finland. Based on the Competition Law, the Finnish Competition and Consumer Authority can investigate the potentially unreasonable pricing of district heating in cases when DH is in the dominant market position, as it can investigate the pricing of any other business as well.

A fundamental feature of the current market logic is that the price for the connected customers may not exceed the prices offered to new customers (Krogerus, 2014). As especially new customers are subject to competition from other heating methods, it can be argued that the price level for all customers is ultimately set in the market for new customers.

Competition has resulted in low DH prices as depicted in Figure 1-1, where Finland has one of the lowest DH price levels in Europe.

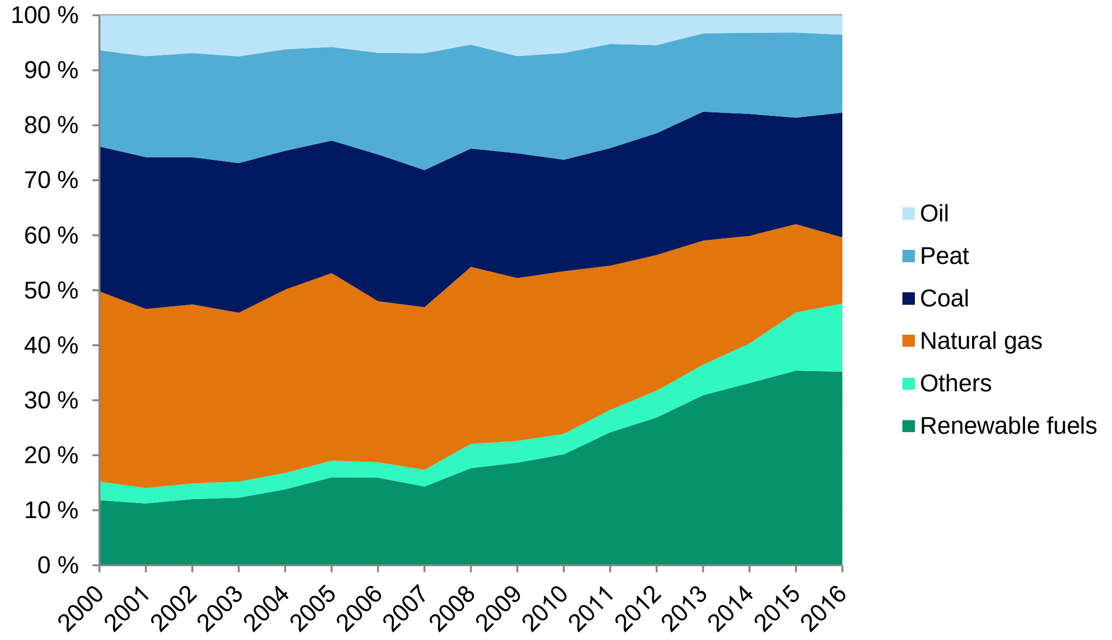
Figure 1-1 District heat price index calculated using purchasing power parities in the European countries in 2013 (excl. VAT)



Source: Energiforsk: 2016:316, corrected with Eurostat comparative price levels, 100 = 22 European countris

The share of district heat produced with renewable fuels has increased rapidly, which is depicted in Figure 1-2. In the period of 2000-2016, the share of renewable fuels utilised in DH production has increased from 10 % to over 30 %. The utilisation of renewable energy sources has allowed replacing the fossil fuels and peat in the production mix and the replacement has been especially notable in the 2010's.

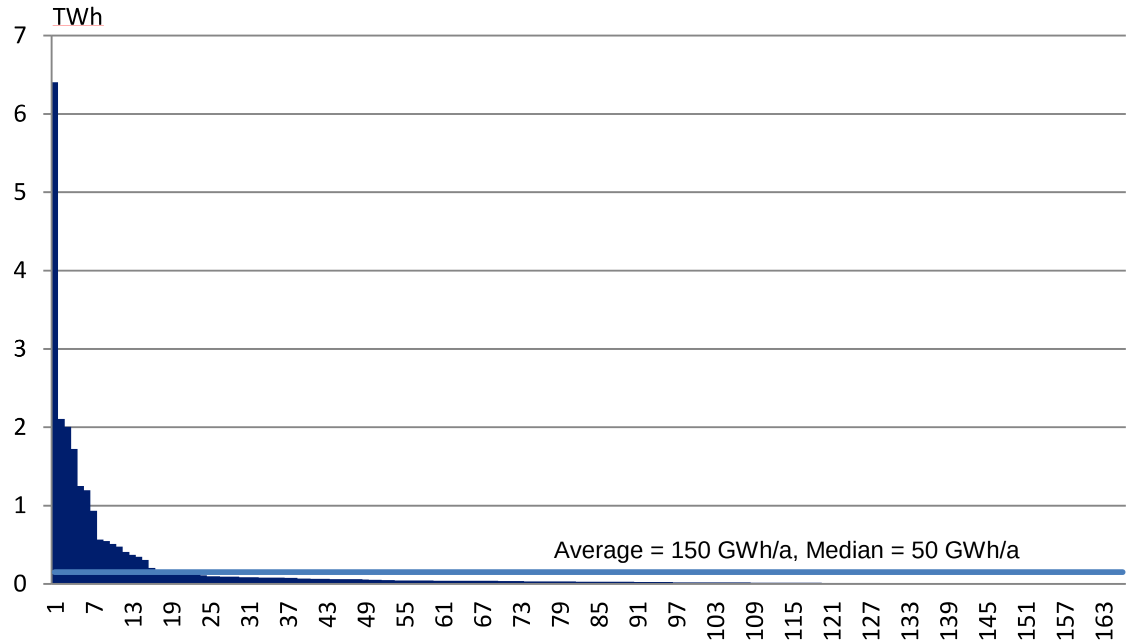
Figure 1-2 – Fuel consumption in district heating production in the period of 2000–2016



Source: Statistics Finland
'Others' include mainly secondary heat sources and heat pumps

Due to the nature of district heating, the production and networks are local and heat cannot be transferred long distances. As a result of local networks, individual heat networks are on average very small in Finland, which is shown in Figure 1-3.

Figure 1-3 District heating networks in Finland by annual heat demand*



Source: Finnish Energy, 2016
* Includes only the networks that are members of Finnish Energy

The figure indicates that the average demand in district heating networks is 150 GWh/a. In only 10 of the networks the annual heat demand is more than 1,000 GWh/a and in 115 networks the annual demand is below 50 GWh/a. According to Finnish Energy statistics, district heating is provided for more than 146,000 customers in Finland. Most of the customers are from the residential sector, which accounts for approximately 80 % of the total annual demand.

Finnish Energy statistics include all the largest Finnish DH networks and the networks that are not included in the statistics are considered to be more small-scale. As most of the networks that are excluded from the statistics are considered to be smaller than 50 GWh/a, the average network capacity may be assumed even lower than 150 GWh, the number of networks below 50 GWh even higher and the total number of DH customers higher.

A significant amount of third-party produced heat is already utilised in Finland. According to Finnish Energy statistics, approximately 8,700 GWh of third-party produced heat is utilised for district heating purposes accounting for a bit less than a third of total annual district heating sales. Most of the third-party heat sources in the Finnish Energy statistics are either industrial waste heat or heat from industrial CHP plants. In addition, an increasing amount of waste heat from data centres has been supplied for district heating.

Thus, TPA is already happening in Finland on voluntary, market-based basis. The companies actively search for available heat sources within their networks that can be utilised in district heating cost-efficiently. If the heat produced by a third-party is available with competitive price compared to own production, it will be utilised. The cost-efficiency of the heat source depends for example on the amount of available heat and potential network expansion and strengthening costs. Furthermore, the heat source must meet the technical quality requirements of the network.

In the existing voluntary TPA, the district heating company buys the heat from the third-party producer. The heat may be distributed to either supply or return (lower temperature) line depending on the temperatures of the heat source and the needs of the network.

The bilateral conditions include for example the length of purchase agreement, division of network expansion (and strengthening) costs between the TP producer and the energy company and the temperature demands for the third-party heat. Obviously, as the value and the temperature levels of the return water are lower than in the supply side, the prices for the heat distributed to the supply side are notably higher. In many cases, supply to return water is not possible and could have negative impacts on network and other production capacity. The price paid by the energy company may differ during different seasons of the month as the demand for heat is higher during heating season compared to summer time, or the TP heat is not purchased at all during summer time.

1.3 Potential for third-party heat production

Even though the amount of third-party heat utilised in district heating sector on voluntary basis is already notable, according to a study by YIT (YIT Teollisuus- ja verkkopalvelut Oy, 2010), there is still some unused potential in industrial waste heat sources. According to the study, the unutilised industrial waste heat potential is estimated to be 1,4 TWh/a for heat that could be utilised with heat exchangers and additional 2,8 TWh/a for heat that could be utilised with heat pumps. There are many reasons for the relatively high amount of unused potential, mostly the cost of the industrial heat and its effect on the security of supply.

The main reasons for the high cost are for example equipment and distribution system investment costs, variable costs due to heat priming energy needs and long distance from the heat customers. In some cases, the availability and the technical quality of the waste heat may be irregular or unpredictable, which may affect negatively on the security of supply and thus, reduce the DH companies' willingness to implement these energy sources. Last, the benefits of the utilisation of industrial waste heat sources may not be identified or supported properly by the Finnish energy policies (YIT Teollisuus- ja verkkopalvelut Oy, 2010).

Even though not all of the industrial waste heat may be cost-efficiently utilised for district heating purposes, the relatively high amount of waste heat indicates that there is still some unused potential in industrial waste heat. Furthermore, the amount of data centres has increased during the latest years in Finland indicating more potential in waste heat utilisation.

On the other hand, fossil fuels still account for 46 % of the total district heat production in Finland. Thus, implementing TPA could potentially improve the decarbonisation process of Finnish district heating. However, the energy companies are already implementing the renewable technologies as part of their normal operation.

The life-cycle of energy production plants is typically relatively long, up to 30-50 years and the implementation of new, low-carbon technologies is typically made once the existing plant reaches the end of its technological lifetime. In this sense, TPA could sometimes accelerate the implementation of low-carbon alternatives as the third-party investments are not dependent on the dynamics of the existing production plants. However, from utilities point of view the entering of TP producer to the system may be considered an unforeseen event that would leave their existing asset as stranded.

From the TP producers' perspective, the major expectations in TPA are easier access to the district heating networks as well as more transparent heat supply contracts. Many of the existing and the most potential TP producers are waste heat sources (such as industries or data centers), whose core competence and business is neither in heat production nor in heat sales. Therefore, it may be that the existing model where the district heating company buys the heat from the third-party producer to be utilized in its network and is responsible for the overall optimisation of the district heating system, is the most suitable for TP producers as well.

However, it could also be possible that new producers with the production as their core business could emerge in the district heating market. These could be e.g. companies developing new technologies or having access to fuel sources. In some cases, the TP producers could be interested in network access models where they can do sales contracts directly with the clients and utilise the heat network as a platform for heat supply and services. Potential production technologies are analysed in chapter 3.3 in more detail.

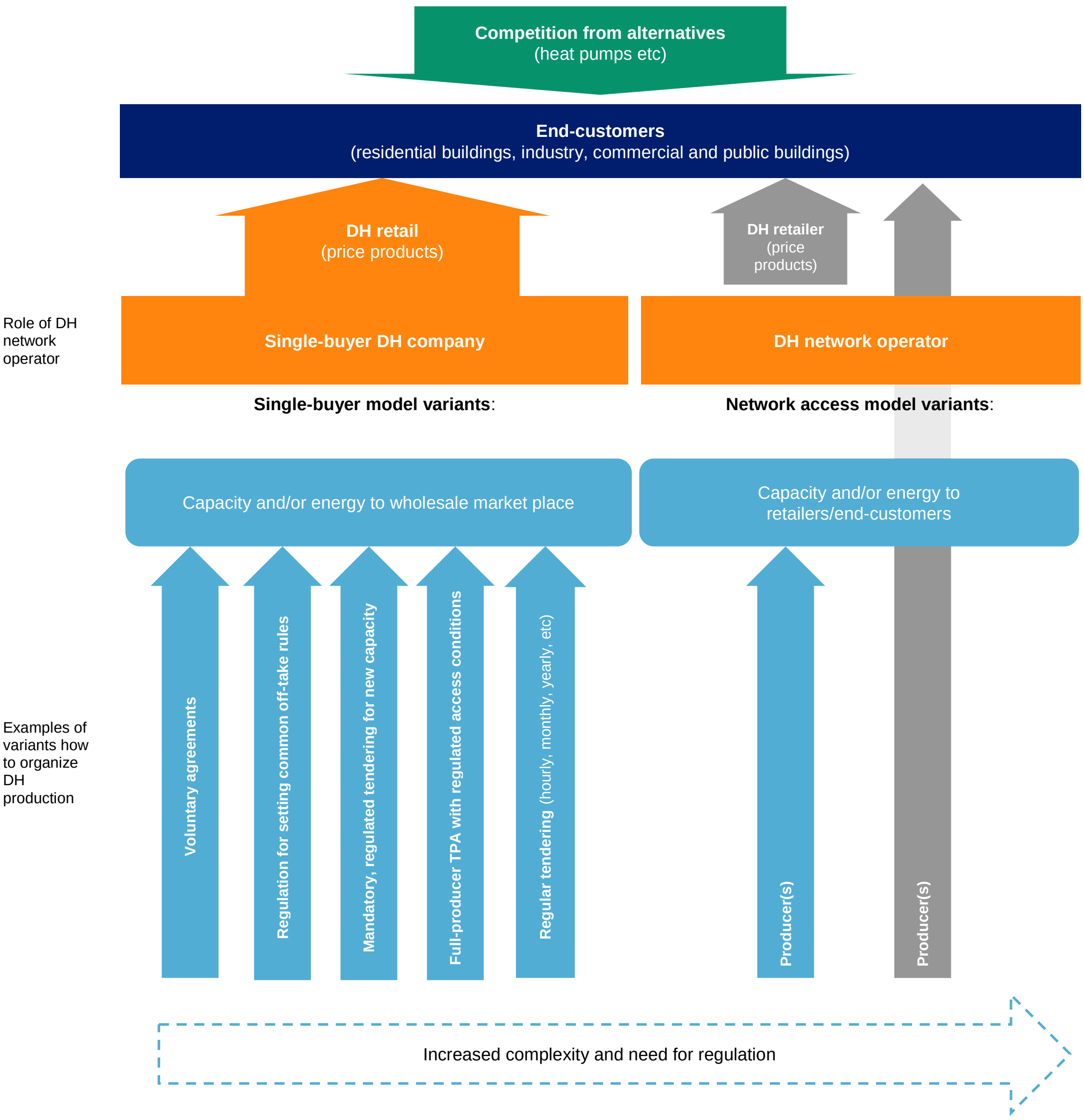
2. THIRD PARTY ACCESS MODELS IN DISTRICT HEATING

2.1 Alternative single-buyer and network access models

Third-party access to district heating can be realised with a variety of models. As described earlier, third-party produced heat is already widely utilised also in Finland without any regulation or specific conditions. In this chapter, models to implement TPA are described on theoretical level.

Generally the TPA models can be divided into single-buyer and network access models (NAM), as described in Figure 2-1. In single-buyer models, the customers are served by the district heating company responsible for the network and retail. The access to district heating network can be organised with a variety of options. In the figure below, 5 different single-buyer models are presented. The other main option is the network access model, where the producers can utilise the network to sell heat directly to end-customers. Two different NAM-models are described in the figure. The current heat market design can be considered to be based on single-buyer model with voluntary agreements for TPA.

Figure 2-1 Main TPA model options



Source: Fortum

The TP producers' network access in both the single-buyer and in network access models may be based either on voluntary basis, negotiated mandatory basis or fully regulated basis. In voluntary network access, the DH company and TP producer negotiate the conditions for network access bilaterally.

In negotiated mandatory network access, the legislation may set requirements for the network operators to provide the third-party producers the access to the network, but the specific terms for the access are ultimately negotiated between the two parties. Furthermore, there may be specific mandatory heat off-take rules for preferred heat sources, such as renewables or mandatory tendering for new capacity.

In the negotiated mandatory models, mandatory access can increase the transparency and the amount of third-party producers in the networks, but the bilateral agreements allow taking the individual characteristics of the heat network and the specific third-party producer into account. However, the amount of regulation and the transaction costs are higher than in the voluntary network access.

In fully regulated network access, the preconditions for third-party producer to join the network are determined by regulation. If the third-party producer meets these conditions, the heat network owner is required to provide the producer the access to the network. In this market model, typically some sort of unbundling is required for the existing DH company.

2.1.1 Single-buyer models

In the single-buyer models, the network operator supplies heat to customers on equal conditions. (In this report the wording "equal conditions" means both equal pricing and conditions of contract) The network operator is responsible for system optimisation and provides the network access to the third-party producers on equivalent terms. The theoretical level of competition in production and regulation depend on the selected single-buyer model.

The simplest one of the single-buyer models is the negotiated voluntary network access, which is currently applied in Finland, Sweden and Germany for example. In this model, the network operator and the third-party operator agree on the terms of the network access on voluntary, bilateral terms, which means that the model works with very low level of regulation. As the network operator has economic incentives to actively search for cost-efficient heat streams to be utilised in the network in order to minimise the total production costs, this model has resulted in significant amounts of third-party produced heat. In addition, as most of the heat production, network operation and overall system optimisation are all done by the district heating company, the company may be in best position to deliver heat cost-efficiently in comparison to unbundled distribution and production companies.

On the other hand, the bilateral agreements may lack the transparency from the third-party producers' perspective and may not attract new investments. Furthermore, due to the nature of district heating networks, third-party producers mostly have only one available network operator to sell their heat to. Thus, it could be argued that the network operator has superior bargaining power compared to third-party producer. However, according to decisions of Finnish Competition and Consumer Authority, the stipulations related to dominant market position are valid for both heat sales and purchase and such abuse of market power should not be possible even today (Krogerus, 2014). In addition, vertically integrated district heating company is not allowed to prevent competition from other producers by offering distribution services at exaggerated price.

Current low level of disputes indicates that the issues mentioned in the previous paragraph are not a big problem. However, regulated take-off rules can be developed to address these concerns. In regulated take-off, the third-party access for the new entrant is mandatory given that the producer meets the specific technical and/or economic conditions. However, due to the large variation in heat networks requirements and on the other hand, variation of the characteristics of the potential heat sources, it can be challenging to develop general off-take rules which would incentivise more third-party heat production and decrease the total cost of heat production.

Other options within single-buyer models include mandatory tendering for new capacity in heat production, regular auctions for energy and/or capacity, and full producer TPA. In full producer TPA model, the TP producers are granted an access to the heat network and they may enter the markets if they consider the investment attractive enough. In the auction systems, the potential producers bid their production or capacity and the system operator can acquire all heat from these producers. For the markets to function effectively there should be enough participants in the auctions, which could be difficult to achieve especially in any smaller heat network. On the other hand, the limitations related to available space in the cities pose another challenge and may severely limit the level of competition. This is a common bottleneck for both Single-buyer and Networks access models. One solution for this problem would be that city might offer readily available spaces for the new production. In addition, the length of the tendering process and purchase agreements significantly affect both the short-term cost optimisation of the district heating network and the risk levels of new entrants and their willingness to invest, which needs to be considered in the regulation if such a TPA model is applied.

2.1.2 Network access models

In the network access models, the producers have access to the heat networks and they provide heat to customers through open heat networks. The producers can compete in retail market as well, and equal treatment of similar customers is more difficult to ensure or may not be applicable any more.

From customers' perspective, network access models allow them to choose heat supplier according to their personal preferences.

Different network access models differ from each other in the way the retail competition is organised – more specifically whether the market consists only of independent retailers and independent producers, only of DH producers as retailers or a combination of these. Assessing the specific benefits of different network access models and the specific differences between them on empirical basis is highly challenging as there currently are no well-functioning examples of TPA models of this kind.

However, the assumed benefits of network access models are increased transparency and high theoretical level of competition, which would allow utilising the existing infrastructure as a platform for competition. Also, in theory the customer-specific characteristics and individual requirements could be more thoroughly acknowledged and the customers can have increased incentives for demand response resulting in savings for both the producers and customers. However, in comparison to single-buyer models, NAM models result in increasing complexity. Both the technological challenges and amount of regulation required increase with more complex TPA models.

2.2 TPA in the proposal for Renewable Energy Directive

In November 2016 the European Commission published “Clean Energy for all Europeans” package (European Commission, 2016b) with the aim of putting energy efficiency first, taking a global leadership role in renewable energies, and improving the role of consumers. The package aims to improve the role of consumers as active players in the energy market. The target is to increase the possibilities for consumers to produce energy themselves and also sell the energy. Although electricity is discussed more, the package addresses district heating, too.

As a part of the package, the renewable energy directive proposal (COM (2016) 767 final) was published. The article 24 of the directive proposal contains provisions for the third-party access to district heating network. The aim is to increase the utilization of waste heat and renewable energy in heating.

The proposal on the third-party access to the district heating system provides for producers of renewable heating and cooling, and waste heat from industry to have an open access right to local district heating and cooling systems. This would enable direct supply of heating or cooling to customers connected to the district heating or cooling system by suppliers other than the operator of the system. It is thus proposed that the third party producer could sell heat directly to consumers utilizing the existing heating system. Therefore, the proposed model can be considered a network access model with the district heat producers as the retailers.

The article mentions some possibilities for exemptions. The operator of a district heating or cooling system may refuse access to suppliers where the system lacks the necessary capacity due to other supplies of waste heat or cold, of heat or cold from renewable energy sources or of heat or cold produced by high-efficiency cogeneration. If such a refusal takes place, the operator of the district heating or cooling system should provide information to the authority on measures that would reinforce the system. In addition, new district heating or cooling systems may, upon request, be exempted from ensuring open access for a defined period of time.

However, Council of the European Union and European Parliament have declared that the proposal of the Commission should not be deployed. Instead, they suggest that for inefficient DHC systems, the TPA should be based on single-buyer model, or the renewable share of production can be increased by other means.

2.3 TPA experiences from other countries

2.3.1 TPA studies conducted in Sweden

District heating is widely used also in Sweden, and the market models have been widely discussed there. The Swedish government decided in 2009 to analyse the possibility for introducing regulatory third-party access to district heating networks to create competition in district heating markets. In 2011, the so called TPA-investigation assigned by the Government (SOU, 2011) proposed that that production, distribution, optimization and retail of DH would be unbundled, and third-party access to district heating networks would be introduced. Furthermore, the TPA investigation (SOU, 2011) suggested that the customers should be able to choose heat suppliers freely in a competitive market.

However, in 2012, the Ministry of Industry concluded in its follow-up memorandum (Sweden Ministry of Industry, 2012) that the conditions for such competition in the district heating market as suggested in the TPA-investigation (SOU, 2011) are limited and that the cost would in many cases exceed the potential benefit for the customers. According to the Ministry of Industry´s memorandum (Sweden Ministry of Industry, 2012), the cost increases of 10-15 percent could be possible if distribution was unbundled from other DH operations. The costs would arise from increased requirements for DH measurement and administration, as well as from sub-optimal production of heat. In addition, the degree of concentration in the production chain would become very high - higher than the EU Commission's threshold benchmark for mergers between companies. In the memorandum, the Ministry of Industry highlights that environmentally friendly waste heat should be used for heating in the places where it is economically reasonable.

Based on the Ministry of Industry´s memorandum (Sweden Ministry of Industry, 2012) and the previous process, the Government instructed the Energy Market Inspectorate to further investigate and propose a market model for regulated access to district heating networks for heat producers. The results of this investigation (Energimarknadsinspektionen, 2013) and Ministry of Industry´s proposal for changes in the District Heating Act (Lagrådsremiss, 2014) lead to District Heating Act (Swedish District Heating Law, 2008) being updated in 2014. According to the current District Heating Act (37 §), if a district heating operator receives a request for access to the DH network from a party wishing to sell heat to the district heating operation or use the DH network for the distribution of heat, the district heating operator shall conduct negotiations regarding access with the party making the request. If no agreement can be reached for this access, the district heating company shall state the reasons for not allowing the access.

As a summary, after several years of official discussion on third-party access to district heating networks, there were no major changes made to the TPA regulation.

2.3.2 District heating competition studies in Germany

District heating is used to heat about 14 % of housing stock in Germany. The German federal competition authority, Bundeskartellamt, published in 2012 a study on district heating market and its competitive situation (Bundeskartellamt, 2012). The study was conducted to find out what impact monopolistic supplier structure of district heating sector and hence lack of competition between district heating suppliers within a network has on competitive behaviour and market in Germany.

District heating suppliers generally have a right under the German competition law to use the network of the incumbent district heating network operator and supplier to supply heat to their own customers. However, the right of access to the incumbent's network remains within the bounds of what is technically feasible and can be reasonably expected from the network operator.

Bundeskartellamt concluded in its study (Bundeskartellamt, 2012) that it is not advisable to unbundle and regulate district heating networks as heat cannot be transported from one regional network to another like gas and electricity. In addition, district heating networks are designed as closed circuits with demand-specific heat generation. The access of third parties to existing district heating networks for the transmission of heat to their own customers will therefore at best remain an exception in future, according to Bundeskartellamt (2012).

Unbundling of network operation, heat generation and distribution would involve considerable administrative costs and possibly synergy losses, and only marginally improve competitive conditions in the sector according to Bundeskartellamt. Instead of unbundling the district heating operations, an intensification of competition between different heating systems would be desirable action to increase competition in the market, since that would exert pressure on pricing in the district heating sector. To achieve this, greater transparency in district heating prices should be aimed at by providing prices publicly, and by shortening the contract periods with private end consumers. Bundeskartellamt (2012) also emphasizes creating a level playing field for competition between heating systems - compulsory connection to the district heating system should remain as an exception rather than a rule.

2.4 Selection of TPA models for quantitative assessment

As described earlier, there are several options for third-party access models in district heating networks. In this chapter, three different models are described in more detail and the possible requirements and impacts are analysed later in the report. The three models have been selected with an attempt to demonstrate the variety of options and the scale of impacts. Due to the variety of potential models and the specific details in each model, the analysis cannot comprehensively capture all options and impacts. Third-party access can be implemented also in other ways, with different requirements and implications.

The analysed models in this study are:

1) Single-buyer with open and transparent access conditions
2) Single-buyer with regulated wholesale competition
3) Network access (full-scale)

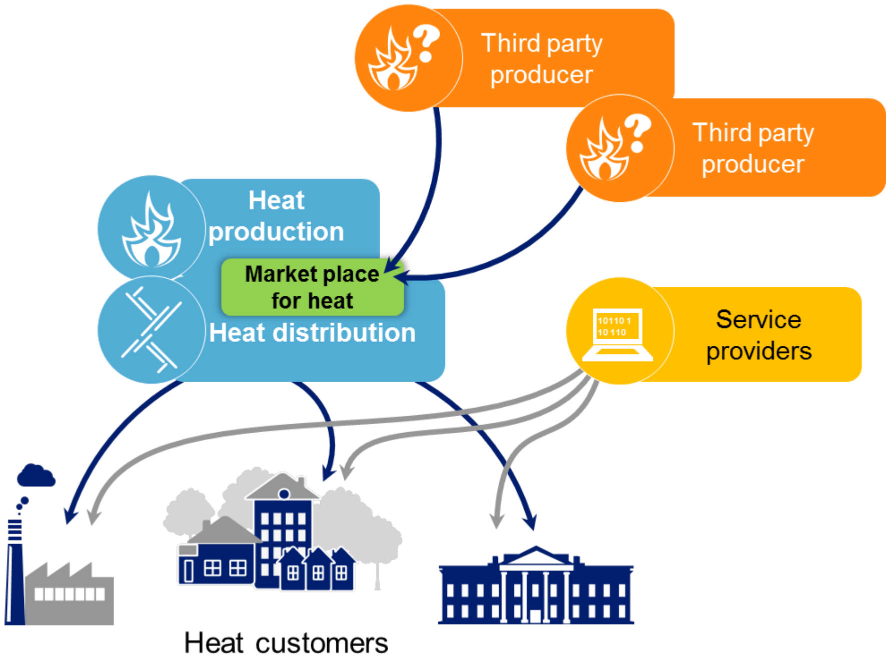
It should be noted that the market models are analysed based on the current Finnish heat market set-up, where district heating competes with other heat sources and there is typically no obligation for consumers to connect to the district heating system and disconnection is allowed for all heat consumers.

2.4.1 (1) Single-buyer with open and transparent access conditions

The simplest market model presented in this study is close to the current practices in district heating networks in Finland. However, currently there are generally no publicly available prices and conditions for connecting third-party production to heat networks. These would be introduced in this model, where the district heating company acts as a single-buyer in the wholesale heat markets. Producers can make voluntary agreements for the supply of heat to the network with the district heating company.

The model is presented in Figure 2-2 below. In addition to district heating companies, the heat customers can have a direct relationship with service providers, offering a variety of heating related and possibly also other services. The actual heat delivery is in the hands of the district heating company.

Figure 2-2 Model 1 – Single-buyer with open and transparent access conditions



Source: Pöyry

In the first model, unbundling of heat production, distribution and sales is not required, and also the level of required regulation is low. A prerequisite for the model is a heat market place, where the third party producers can sell their heat. Market place is established for each network separately, which will cause some additional costs. However, it would be possible to develop general principles for pricing and connection conditions for all networks. Market place services can be provided by external company serving several district heating companies, which could reduce the cost of creating the market place. Connection of new production to the network is based on general terms and there is a separate connection fee for production.

Publishing prices in the heat market place ensures non-discriminatory treatment of all producers. However, due to the specific features of the heat networks compared to the electricity networks for example, it is likely that more complicated pricing options might be needed to take into account for example the location, availability of production, heat levels etc. Therefore, instead of one simple price in €/MWh unit, there might be several products and pricing options.

It is also possible to set a separate market price for heat supply to the return-side of the network, if the heat supply to return-side is beneficial. This depends on the current production capacity of the district heating company. This option is not analysed separately in this report.

Due to the network constraints, there can be requirements for the location of third-party heat supply within the network. Alternatively, there may be several price areas within the heat networks. In this TPA model, the district heating company is responsible for the network investments. Without long-term heat supply contracts it is unlikely that there is enough incentive for network investments. Another option is to include all network strengthening costs in the connection fee of new production.

In addition to several price zones and other variation, it would be possible to set up at least two separate markets in the market place for heat: one for energy, and the other for capacity. The two products would have different pricing approaches and frequency of auctions. Separating these two products can serve the needs of different producer types, but do not necessarily result in lowest cost of heat production. More complex products combining requirements for capacity with energy supply could capture the third-party producer potential in a more optimal way, but each potential producer can have different needs and possibilities to commit to contracts. Therefore, it can be necessary to design the products based on the potential third-party producer's capacity, taking into account the current district heat company heat production capacity and requirements at the same time. As a result, it is likely that each network would need to have some tailor-made products for third-party heat supply. However, these tailor-made products can be seen to compromise the non-discriminatory treatment of all potential producers. In this report, the capacity contracts are not analysed in detail but this model is assumed to be based on energy-only trading similarly to the electricity markets in the Nordic countries.

With energy-only contracts, the pricing of heat in the market place can be based on short-run marginal cost (SRMC) of heat. As long as the energy offered to the market place by third-party producers is not significant compared to the production of the heat company, the price can be set by the marginal cost of the district heating company's production. District heating company publishes the prices e.g. day-ahead on hourly level, or for a longer period. Alternatively, certain rules can be developed for the pricing, such as outdoor temperature dependent pricing to avoid the need to calculate the prices for each hour. The third party producers can choose to produce energy and receives this price for the heat supplied, but there is no obligation to supply heat. From the district heating company's perspective this means that there is a need to maintain excess capacity at all times, to replace this third-party heat supply if needed. To be able to decrease the energy cost for customers, the TP producers should be offered a price below the marginal cost of current district heating production. Therefore, the price offered for third-party producers could be set as the marginal production cost of the district heating company's production minus a fixed or relative (percentage) component.

From the potential third-party producers point of view SRMC-based approach is unlikely to be attractive for any producer requiring notable investments to supply the heat. The producer can try to estimate the SRMC of district heating production, but has no certainty over long-term development of prices. The district heating company, or another TP producer, can also make investments to new production capacity decreasing the SRMC, which could make the third-party producer's production uncompetitive. However, short-term contracts could suit the producers having waste heat sources and no need for significant investments.

From the district heating customers' point of view this approach might not bring immediate benefits in the form of heat price. Instead, the model could bring benefits to some TP producers, if they would receive a higher price compared to their production costs. However, if this model attracts more producers to the market, the benefits for customers may arise later in the form of increased utilisation of low-cost waste heat and potentially competition in production.

When there is more third-party production in the network, the market place for heat could be organised as auctions, where the price is set by marginal producer (either third-party producer or district heating company). When there is enough district heating capacity supplied to the system by third-party producers, also the district heating company can avoid using more expensive capacity and the marginal cost of production decreases.

Impacts of the model 1

The potential impacts of this kind of model are analysed later in this report quantitatively based on three example networks. Below, the impacts are described qualitatively from different perspectives.

Although this model is the simplest one of the analysed models, there are some **additional system costs for current district heating systems** also in this model. These include the cost of setting up the market place for heat, the process (automated) for the calculation of market price for energy based on marginal production cost, and the need to communicate the dispatch order and production plans to third-party producers. This needs to be developed for each network separately and adapted to the current organisation and operations. In a simple version, the prices can be published on company website but there needs to be a system in place to receive the production plans of the TP producers.

From the customer perspective, this model is unlikely to have any significant impact on the heat price due to increased competition in the market, or impacts on security of supply. In general, there is no possibility for the customers to select their district heat provider, but the district heating company is responsible for the retail and delivery of heat. However, it would be possible for the district heating company to launch new heat products based on TP production. This model is easy for customers as heat is purchased always directly from the district heating company.

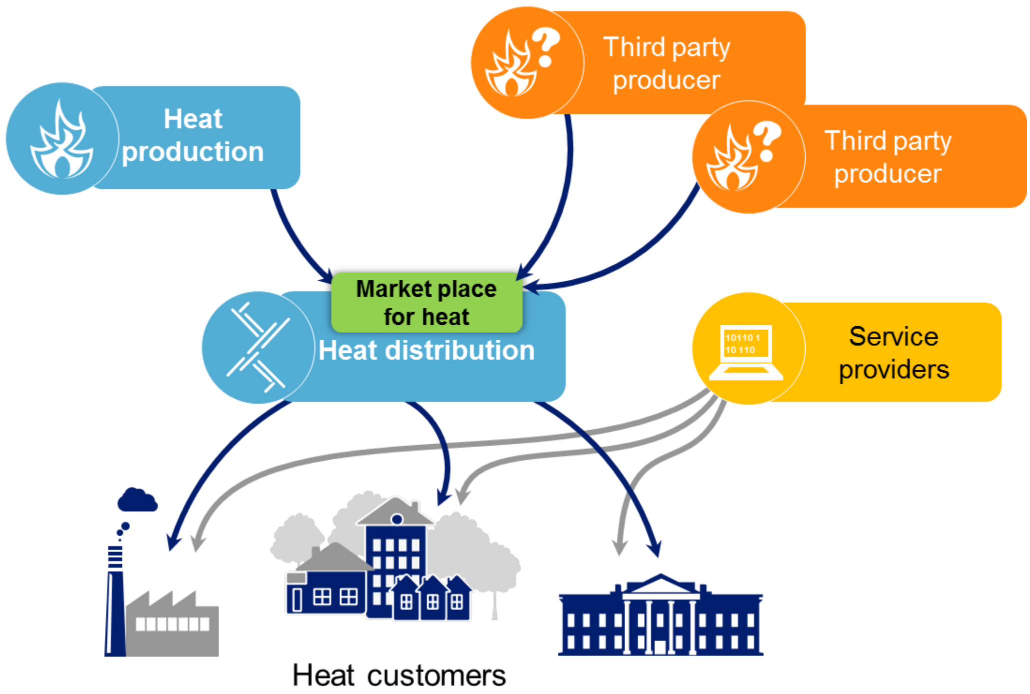
Regulation needs in this model are related only to requirements to publish conditions and pricing principles for heat supply by third party producers and/or daily/hourly prices. Similarly to the Swedish model, which requires parties to negotiate, the regulation could be light and more based on voluntarily setting favourable pricing for TP producers. Requirement to publish the prices would make it possible to compare the pricing principles of TP heat of different district heating companies, putting pressure on fair pricing. If this voluntary approach would be deemed unsatisfactory, a proper authority could confirm the pricing principles for each company.

2.4.2 (2) Single-buyer with regulated wholesale competition

In the second model, the district heating company is responsible for the network and retail operations, and buys the heat from producers. Unbiased competition in production can be secured with ownership unbundling of the production. Another option could be financial unbundling, which would be easier to realise. With this model, the attempt is to create free competition in the production market of heat. Therefore, model 2 in this report is based on full ownership unbundling of production from the network and retail operations. This has an impact on the organisational and system costs described in more detail in chapter 3.6.

In model 2, the heat distribution company is also responsible for the optimal dispatch of the production plants and maintaining the balance of demand and supply. Heat customers are not able to directly choose the heat producer in this model. However, the distribution company can offer different products for clients, e.g. heat produced by a certain producer with different pricing structure. The model is described in Figure 2-3. In addition to district heating company, also service providers can have direct connection to customers, or their services can be offered through the heat distribution company.

Figure 2-3 Model 2 – Single-buyer with regulated wholesale competition



Source: Pöyry

In this model, all producers are treated on non-discriminatory basis and can offer heat to the market place with their marginal production cost. The price setting in the market place can function similarly to the electricity market, where the price is set based on marginal bid. Outside peak times, the bidding price is likely to be based on SRMC only. When new production is connected to the heat network, connection fee is charged to cover the cost of connection.

In this model, the heat distribution company operating the heat network acts as a production market operator, who is responsible for optimising the heat production. The market operator buys heat with the lowest cost and communicates the production plan to the potential producers.

Without any long-term contracts, there could be a high risk for the heat distribution company not being able to serve all the heat customers at all times. The producers competing in the market would not have the incentive to maintain any back-up capacity. The peak-load prices should be high enough to compensate the requirement to maintain the capacity, which is used only during coldest winter days. At peak times, this margin above SRMC (scarcity rent) is present in the electricity markets, too. High peak prices could incentivise demand response effectively, if the prices are passed on to customers or customers are compensated for demand reductions based on separate contracts.

To guarantee the availability of heat at all times, the ownership and operation of backup and peak-load capacity need to be considered. It is possible to set up separate market for the capacity with long-term contracts. It could also be possible that back-up capacity is owned by the distribution company.

As with the simplest model, in this model, the location of heat production has to be taken into account, too. Bottlenecks in network may appear, resulting in different area prices within a heat network. The distribution company operating the market place would need to take this into account when setting the dispatch order. If additional investments to the network are required, the distribution company should make the investments to strengthen the network. These investments are only profitable if lower cost heat will be available in large enough quantities to decrease the marginal cost, and there is certainty of the availability of the heat. Due to these requirements, these kinds of investments are unlikely unless there would be a large scale production connecting to the network. Another option is to include the network strengthening cost to the connection fee for the producer.

Impacts of the model 2

The potential impacts of this kind of model are analysed later in this report quantitatively based on three example networks. Below, the impacts are described qualitatively from different perspectives.

Additional system costs for current district heating systems are likely to be involved with model 2 especially due to the ownership unbundling of production from network operations. Currently in many companies, production operators are also responsible for operating the heat network, and unbundling would set a requirement to separate network operators from production, have separate IT systems and separate maintenance (possibility to outsource). In smallest companies, this could mean that the organisation could be doubled compared to the current system. There is also a need to set up a market place and the need to communicate the dispatch order and production plans to third-party producers, as in the model 1. For the heat production company, a process (automated) for the calculation of market price for energy needs to be established.

Impacts on customers in this model are in principle similar to the model 1. Customers have no possibility to select their district heat provider, but the distribution company is responsible for the heat sourcing from different producers. The district heating price can decrease only if a substantial amount of new, lower cost production would be available due to this model. On the contrary, if the peak capacity question is not organised optimally and unbundling of production requires additional resources, the cost of heat is likely to increase. This is very likely to happen especially in smaller networks. In model 2, the customers are served by the heat distribution company, which keeps the model simple for customers.

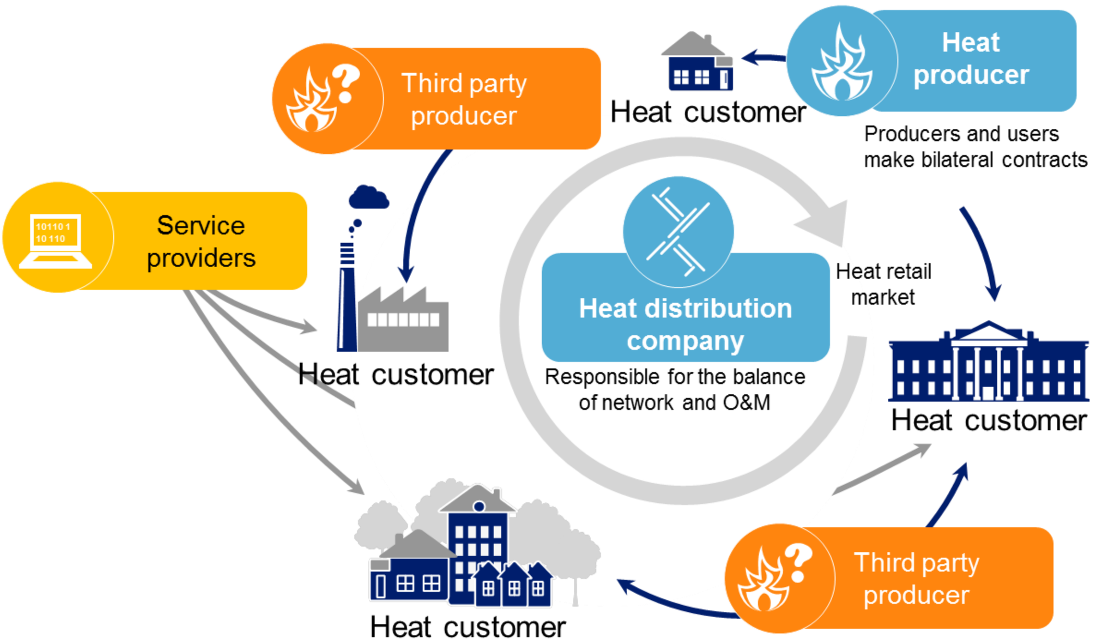
Regulations needs in this model are more complex than in model 1. The production market in this model would be open for competition, but as there are currently only a few large production units in each network, the market is likely to be dominated by a few producers. New, competing large production units (such as CHP plants or large heat-only boilers) are unlikely to emerge in most of the networks due to large investment needs but also due to town planning issues, fuel procurement and other challenges. In city areas, it is very difficult to find a suitable location for a new large heat plant. The dominant producers are therefore likely to have a significant market power, which could mean that there is a need for regulation to prevent the abuse of dominant position in production.

Regulation of the heat distribution and retail company is likely to be similar to the current system, as the customers would continue to have the possibility to switch away from district heating.

2.4.3 (3) Network access (full scale)

The third model is a network access model (see chapter 2.1.2), where all heat producers can access the network on non-discriminatory basis and customers make contracts directly with heat producers or separate retailers. The heat network operations are unbundled from any production. The model can be compared to electricity market model and the open gas market model Finland is going to introduce. The heat network services can be bought directly by the customers or the heat supplier can take care of the distribution costs and ensure availability of network capacity similarly to the open gas market model. In both cases, there is a need to establish transparent transmission prices and conditions in the heat network. The model is described in Figure 2-4.

Figure 2-4 Model 3 – Network access (full scale)



Source: Pöyry

In model 3, the distribution company is responsible for the operation and maintenance of the network, but also for the balancing of supply and demand, and balance settlement. The distribution company can have own balancing capacity, or it is also possible to organise a balancing market within a heat network. However, due to the small size of heat networks, it is unlikely there would be a lot of competition in the balancing market. The cost of the balancing heat must be passed on to the heat consumers as part of their heat (energy) bills. The consumers can choose demand response instead of using balancing heat, provided they have agreed that beforehand and there are devices in place to restrict the heat use in certain situations. The distribution company also operates all pumps in the network.

In this model, heat customers are responsible for contracting all the heat as well as the capacity they need, but it is possible to buy heat from several producers. This can be organised through service providers or retailers as in electricity markets. The producers can act as the retailers, but it also separate retail companies can emerge.

If the network cost is allocated to the customers similarly to the new gas market model in Finland, the retailers (or producers) can take care of the network cost for the clients and include it in the heat bill. To take into account the possible bottlenecks in the system, there should be capacity and congestions charges.

As the current heat networks have been designed based on the locations of current production, connecting new production in other locations can be challenging and might require investments to reinforce the heat network. This cost has to be taken into account in the connection fee of new production. Therefore, each producer is likely to have a specific connection and network fee.

As in electricity markets, it might be necessary to nominate one producer as responsible for delivering heat for existing small customers, such as households etc. (obligation to retail). However, the customers have the option to switch to other heat sources instead of district heating, if they do not find competitive offers for district heating. New customers can only connect to heat network, if they find a heat supplier and make a contract. The producers and/or retailers would be the main parties responsible for acquiring new clients. However, the distribution company is also likely to be interested in connecting new clients for the network to increase their business volumes.

Impacts of the model 3

The potential impacts of this kind of model are analysed later in this report quantitatively based on three example networks. Below, the impacts are described qualitatively from different perspectives.

Additional system costs for current district heating systems are likely to be born especially from the ownership unbundling of production and retail from network operations. If also the retail function is unbundled from production, there might be additional costs for the retail company organisations and systems.

Additional balancing responsible body is needed, or the network company can take this role. Cost of this balancing responsibility depend on how efficiently it can be organised compared to the current system. The heat supply contracts need to be registered and need for balancing heat needs to be calculated for balance settlement. Especially in this model, a datahub for heat similarly to electricity datahub could be necessary for information exchange and contract registering.

Compared to the current system, there might be excess investments to production capacity as the competing producers are making their investment decisions independently and the investments might not be optimised from system perspective.

Impacts on customers differ compared to other models, because the customers have freedom of choice of DH supplier and there can be separate retailers. However, the system is likely to be more complicated from customer perspective with a variety of different contract types available.

Fundamental difference impacting the customers' position in this model is that not all clients are equally treated. Producers are likely to compete for the most profitable clients, but the less attractive clients, such as small houses, are likely to suffer from the lack of competition and could face increase in heat prices. Large customers are more likely to benefit from the competition.

Another change to the current situation and to other models is that there could be different types of customer contracts, and the heat supplier and the customer could mutually agree e.g. on the level of security of supply. In practise it could mean that with a lower price, the customer agrees the heat supply to be cut in certain situations. In practise this would require some automated system in the customer end. Some general terms are however needed in any case, e.g. in relation to the return water temperatures, for the network to operate optimally.

It could be argued that **regulation** is required similarly to the electricity and gas markets. However, in the district heating, there is more competition because the customers have also possibility to switch to different heating sources, although that requires some investments. Therefore it has been assumed that the role of consumer is not as strictly regulated as in the electricity markets.

With a separate heat distribution operations, it is necessary to develop heat network codes to address capacity allocation and congestion management questions etc. In addition, balancing responsibility party has to be defined and the balance settlements need to be made. This is assumed to be the distribution company's responsibility, but it is possible to also name some other party to take care of these duties. All this has to be addressed by regulation. In addition, it can be necessary to regulate the transmission prices and possibly peak-capacity and reserve capacity, too.

2.4.4 Summary for the selected TPA models

Key aspects and assumptions made for the selected three TPA models are described in the following table.

Table 2-1 Summary for the three TPA models

Item	Model 1 "Single-buyer with open and transparent access conditions"	Model 2 "Single-buyer with regulated wholesale competition"	Model 3 "Network access (full scale)"
Description	Voluntary market place for wholesale heat	Regulated market place for wholesale heat	DH producers have direct access to end-customers (separate retail markets)
Menu of choices for the customers	DH against alternative other heating solutions, no DH supplier choice (DH company can have different products though)	Same as for model 1	Various DH retailers/producers and alternative other heating solutions
Rationale and form of unbundling	Not required	Heat production is unbundled from distribution and retail (mandatory, ranging from financial to ownership). This study assumes ownership unbundling.	Heat distribution is unbundled from production and retail. Mandatory ownership unbundling.
Responsibility for balancing	District heating company	Distribution company	Distribution company that may have own capacity or it may organise a balancing market within a heat network
Market for capacity and demand response	Market for capacity is possible but not modelled in this study (demand response in general is also possible in this model)	Same as for model 1	Variety of contract types based on customer preferences
Retailing	By district heating company	By distribution company	Separate retail market, but the producers can sell directly to customers.
Pricing towards customers	Equal treatment, i.e. same as today	Same as for model 1	Based on bilateral agreements between producers and customers. The prices between customers may vary.
Method of competition in production	Transparent prices and supply conditions	Regulated regular tendering	Competition for the end-customers
Network fee	No separate fee (part of heat energy price)	Same as for model 1	Producer-specific network fee
Network connection fee	Connection fee depends on the location, i.e. need for network strengthening	Same as for model 1	Same as for model 1

Source: Pöyry

3. DISTRICT HEATING SIMULATIONS

3.1 Main simulation principles and assumptions

The purpose of this section is first to study the potential waste heat and renewable energy streams that could be added to district heating networks to determine the potential level of competition and secondly, to quantify the additional administration costs resulting from applying other TPA than is in use today. The potential is studied with economic network simulations. It should be noted that this potential can be well realised also in the current TPA environment based on voluntary agreements and the investments can be made by the district heating companies as well. These potential production options are however assumed to be available for the third-party producers also. In this section of the study the abbreviation “New RES” stands for renewable energy production added to current networks (that already may contain renewable energy production) including waste heat.

The calculations are done in the following main sequence:

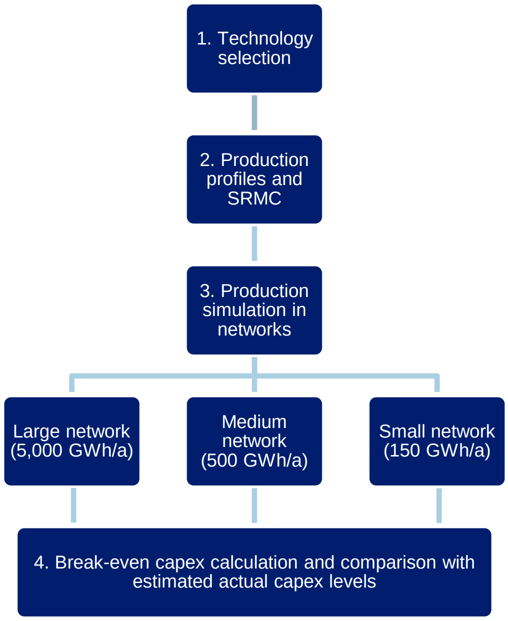
- The technologies to be used in the simulation are selected by performing an investment calculation made for the New RES technologies. As the capex for the New RES can be considered uncertain especially for some technologies or it is subject to rapid decline, the results are shown as “break-even capex”, i.e. the capex level that would allow profitable investment (see the Figure 3-1 and the related descriptions for details of this phase and chapter 3.5 for results). If the break-even capex is higher than estimated actual capex level, the technology is selected to the next phase. In this way of showing the results, the potential for the technology to become profitable in the future (with lower capex) can be assessed.
- The technologies selected in the previous phase are added to the production mix of three different example DH networks of different sizes and production structures. Calculations for each network are performed under three different scenarios with different amount of New RES exposure (see chapter 3.4 for details and chapter 3.8 for results). The results for this simulation are shown as sum of annual costs (in million EUR per year) after the New RES production is added to the DH network as follows:
  - The sum of costs includes the variable costs of the current portfolio, variable and fixed costs of New RES production as well as annualised capex of the New RES production. The capex of current portfolio is already sunk and is therefore omitted. Fixed costs related to current portfolio are assumed equal in every scenario and are left out, too.
  - If the previous RES investments are realised in TPA environment other than what is in use today, there will be additional costs (due to e.g. unbundling). Those costs are estimated separately for each TPA model described in chapter 2.4 and added on top of the cost items listed in the previous item. Only direct costs borne by the DH company are included here. In reality, there are also costs for the society resulting from e.g. regulation.

The purpose of these dispatch and cost simulations is to show the order of magnitude of different cost items under different scenarios, not to provide definitive results if applying different TPA models is beneficial or not. It should be noted that the production simulation does not take into account the specific market model, such as the pricing of heat produced by third-parties. Instead, the production costs are analysed as total system cost if New RES is added to the system, and therefore reveal if there is any potential for cost reduction if all production would be dispatched optimally.

3.2 Simulation principles for the selected RES technologies

The calculation methodology to study the cost-effectiveness of potential New RES production technologies in comparison to existing production utilities is depicted in Figure 3-1.

Figure 3-1 Calculation steps in assessing the cost-effectiveness of various new renewable heat production technologies



Source: Pöyry

The approach presented in Figure 3-1 is based on following steps:

1. **Technology selection**

   The most potential technologies for producing heat to the networks in terms of availability and cost-efficiency are selected for the study and the challenges and opportunities for each of the technologies are described.

2. **Production profiles and Short-Run Marginal Costs (SRMC)**

   For each of the selected technologies, the production profile and SRMC are determined in order to determine the availability and production costs for the New RES heat for each hour of the year. SRMC for the heat-only production contains the costs for fuel and variable O&M costs (Example: If the efficiency of the boiler is 90 %, fuel cost is 20 EUR/MWh and variable O&M 2 EUR/MWh$_F$, the SRMC is 22/0,9 = 24,4 EUR/MWh). SRMC for CHP plants is calculated by deducting the income from electricity production from total heat and electricity variable production costs.

3. **Production simulation in DH networks**

   The production potential of the New RES heat producers is simulated in three example networks of different scale in order to study the competitiveness of new renewable heat in different types of networks. The studied three example networks are Large (5,000 GWh/a), Medium (500 GWh/a) and Small (50 GWh/a).

   The demands in the networks have been chosen to represent networks of different scale and characteristics in Finland. The production units and fuels as well as production profiles of the network have been selected to correspond to a typical heat network in each category.

   Furthermore, three different New RES heat production scenarios are considered for each of the networks:

- A relatively high share of the annual total demand in the network (~30 %) is produced by only a few New RES sources with relatively high capacities.
- A relatively low share of the annual total demand in the network (~10 %) is produced by a high number of individual New RES sources with low capacities
- A very low share of the annual total demand in the network (~1 %) is produced by individual New RES sources with low capacities

In each simulation scenario, the SRMC of the available heat from the New RES producer is compared to the SRMC of the existing DH plants at each hour of the year. If the SRMC of the New RES producer is lower than the SRMC of the existing DH plants, the New RES production is dispatched. It has been assumed that the revenue for the New RES producer is equal to the SRMC of the existing DH system production capacity at the specific hour. The approach is chosen to describe the maximum economic potential and benefits if the systems are optimised, and does not take into account specific features of the analysed three different TPA models.

In addition to general cost requirements, the heat produced by the New RES producer must meet the temperature requirements of the network in order to be dispatched. Thus, the temperature of the heat source is a constraint in the simulation as the network rejects heat with not high enough temperature. If the heat source does not meet the temperature demands, it needs to be primed with electrical coil and the variable costs of priming have been included in the total SRMC of the New RES production technology at the specific hour. It is assumed that the heat produced by New RES is always fed into the supply-side of the heat network, not to the return-side.

4. **Calculation for the break-even capex and comparison with estimated actual capex levels**

According to the results of the step 3, the break-even capex level for the New RES production units are calculated in the different simulation scenarios. The calculation is based on the income from the simulated heat sales and variable costs of production. Margin between heat sales price and costs (both variable and fixed) is used as a whole for the capex recovery. The capex level calculated like this (break-even capex) is then compared to the estimated actual capex levels in order to determine whether a specific New RES production technology is cost-efficient in a specific scenario.

In the capex-estimations, WACC for domestic production technologies including ground-source heat pump, domestic biomass boiler and electric boiler, is 3.5 %. WACC of 9.0 % is applied to other technologies. This is due to the fact that professional investors require higher return for their investments, whereas domestic investors may consider the return requirement to be equal to their cost of debt (or investment decisions may not be based on economics at all). Lifetime of 15 years is used in the calculation. It should be noted that the WACC may be dependent on the TPA model and especially on the pricing principles in the DH market that impact the investment risks. Especially if the revenue for the TP producer is based on hourly pricing only, higher return may be required.

3.3 Potential renewable and waste heat sources studied in the simulations

Pöyry has identified potential production technologies or heat sources in terms of availability and cost-efficiency that could be utilised in the DH networks.

However, it is to be noted that these low-carbon technologies or their potential benefits do not require TPA as such, but the energy companies may implement these heat sources alongside their normal replacement processes whenever their implementation is cost-effective. The main opportunities and challenges for the technologies are as follows:

1. **Shallow and deep geothermal and other heat pumps**

   In conventional heat pumps, heat is constantly available and they may provide heat with high efficiency and low marginal costs in case the electricity prices are low. The technology is commonly used and technologically proven. However, the water supply temperature may be relatively low in comparison to quality demands in DH networks – especially during winter months when the network temperatures are high. The assessment only includes new heat pump investments (and not production of existing heat pumps).

   On the other hand, in deep geothermal solutions, the water supply temperature is suitable for DH networks and the efficiencies are higher than in conventional heat pumps. However, the implementation process is long, complex and expensive and there are uncertainties about the costs and technology risks as the technology is not yet in commercial use.

2. **Solar thermal**

   Solar thermal applications provide potential for emission-free heat with low variable costs. However, the availability of heat changes spatially and according to the time of the day and year and the water supply temperature is low in comparison to DH network.

3. **Industrial, data centre or service sector waste heat**

   Utilising waste heats provides an opportunity for potentially cost-efficient heat sourcing and improving the overall efficiency of the energy system.

   In case of industrial waste heat, the heat has relatively high temperature. However, the location of the industrial sites may be distant from the urban areas where the heat demand is located.

   In case of waste heat from data centres, the business potential has already been proven in many existing data centres. However, the location of the data centres may be distant from the heat demand and the temperature of the waste heat is relatively low.

   In case of waste heat from the service sector, the location and thus, availability of waste heat may be closer to the areas where the heat demand is located. However, the temperature of the waste heat is relatively low.

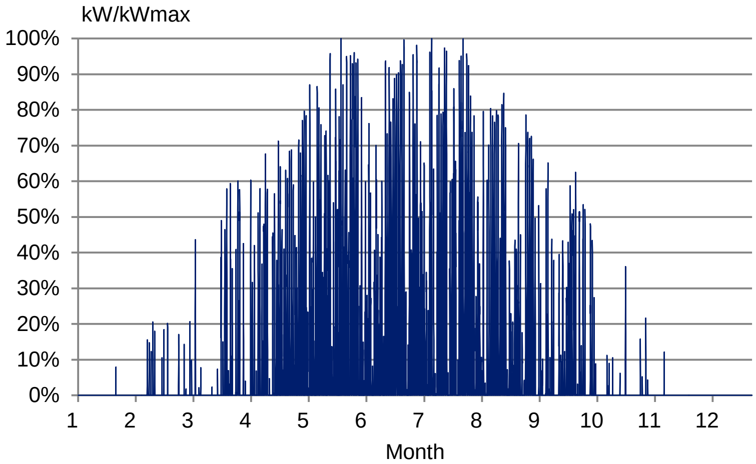
4. **Biomass boiler**

   Biomass boilers provide potential for heat from renewable energy source utilising for example woodchips, pellets or agricultural wastes. The water supply temperature is relatively high and biomass boiler applications are available in both small- and large-scale.

The above described potential technologies have different production profiles, which are presented in Figure 3-2 and in Figure 3-3. The figures indicate the amount of available heat over a year in comparison to the maximum production by the production unit. However, the water supply temperatures are not included in the figures. The water supply temperature is compared to the network temperature levels at each hour network-specifically and if the supply temperature from the New RES production unit is not sufficient in comparison to network quality demands, it needs to be primed. The priming energy is calculated separately but not included in the figures.

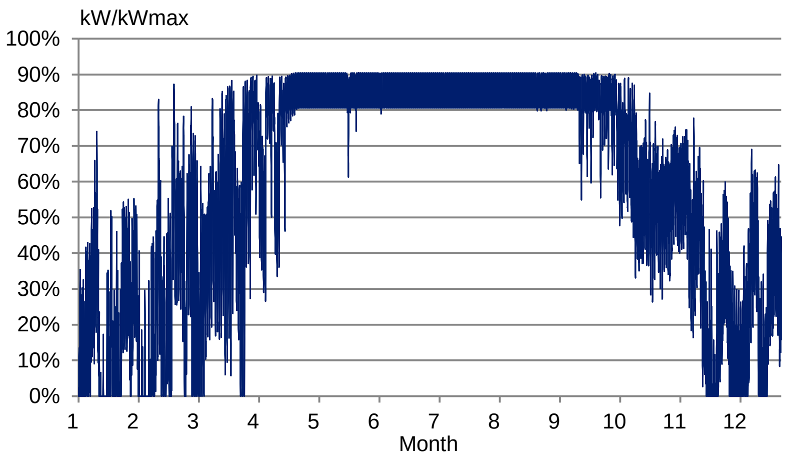
Figure 3-2 indicates the production profile for solar thermal plant. It is calculated according to average annual weather conditions in Finland (*Solar* in Table 3-1). Figure 3-3 indicates the amount of available energy with domestic-scale heat pump production technologies after the domestic consumer's own consumption (*Domestic* in Table 3-1). In addition, many waste heat sources can have a flat production profile with a constant amount of heat constantly available throughout the year (*Flat* in Table 3-1).

Figure 3-2 Solar production profile



Source: Pöyry

Figure 3-3 Production profile for domestic-scale applications



Source: Pöyry

The simulation assumptions and the assumed production profiles for each considered technology are represented in Table 3-1.

Table 3-1 Assumptions for the new RES production used in the simulations

	Variable cost (EUR/MWh)	Fuel	Efficiency / COP	Production profile	Supply temperature* (°C)	Typical capex (€/kW)	Electricity distribution and tax (€/MWh)
Shallow geothermal	Based on electricity price	Electricity	3	Domestic	80	1,800	65
Deep geothermal**	Based on electricity price	Electricity	50	Flat	150	1,500	48
Solar thermal	0	Solar	1	Solar	80	800	52 ***
Industrial waste heat	0	Waste heat	1	Flat	150	-	-
Waste heat from data centers	Based on electricity price	Electricity	4,5	Flat	80	500	32
Waste heat from the service sector	Based on electricity price	Electricity	3,5	Flat	80	550	48
Biomass boilers, domestic	50	Pellets	85 %	Domestic	150	500	-
Biomass boilers, industrial	29	Woodchips	85 %	Flat	150	800	-
Electric boilers	Electricity	Electricity	95 %	Domestic	150	150	52

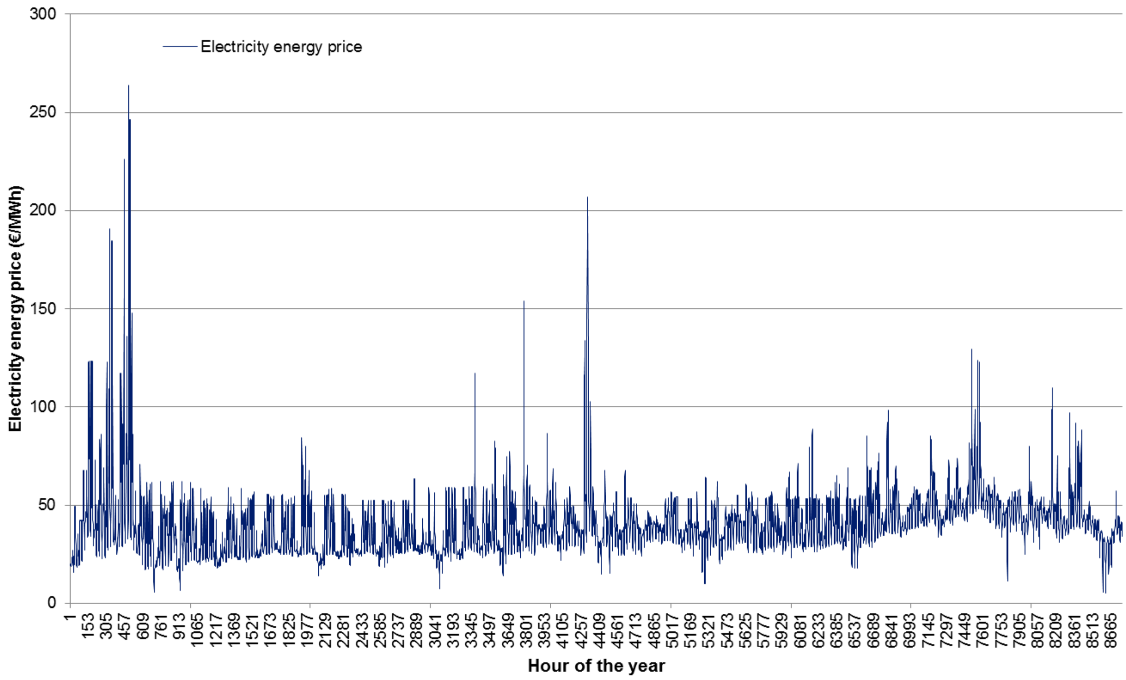
*The very high supply temperature of 150 °C is indicative to point out that the specific technology does not require priming (increasing of temperature) in order to be sold to the network. In the technologies where the temperature is lower, priming is required especially during winter

**The technological performance and costs are based on assumptions as the technology is not yet in commercial use in Finland

*** Electricity required for the priming of supplied heat

The electricity energy prices used in the simulations are presented in Figure 3-4 and the other fuel price assumptions are presented Figure 3-5. The emission allowance price is assumed at 11 €/t_{CO2}.

Figure 3-4 – Electricity energy price assumptions in the simulations



Source: Pöyry
The average electricity energy price is 40 €/MWh

Figure 3-5 – Fuel price and tax assumptions used in the simulations

Fuel	Unit	Fuel price	Fuel Tax, CHP	Fuel Tax, HOB
Coal	EUR/MWh	10	17,20	27,1
Gas	EUR/MWh	27	12,95	18,7
Peat	EUR/MWh	14	1,90	1,9
Woodchips	EUR/MWh	23	0	0
By-product	EUR/MWh	19	0	0
LFO	EUR/MWh	55	15,25	23,0

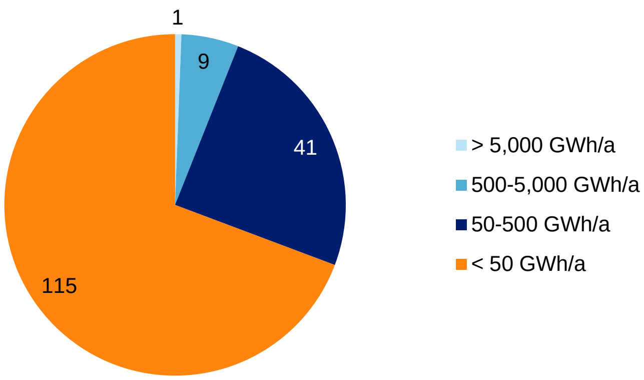
Source: Pöyry

3.4 Modelled networks and scenarios used in the assessment

The modelled networks in this study have been selected to describe the networks of different scale in Finland. The fuels, production technologies and production profiles in the networks correspond to typical networks of the specific scale.

In this study, the networks are defined according to the annual heat demand in the network: large network 5,000 GWh/a, medium network 500 GWh/a and small network 50 GWh/a. Figure 3-6 presents the amount of different size groups of district heating networks in Finland.

Figure 3-6 Number of different size district heating networks in Finland based on annual heat demand



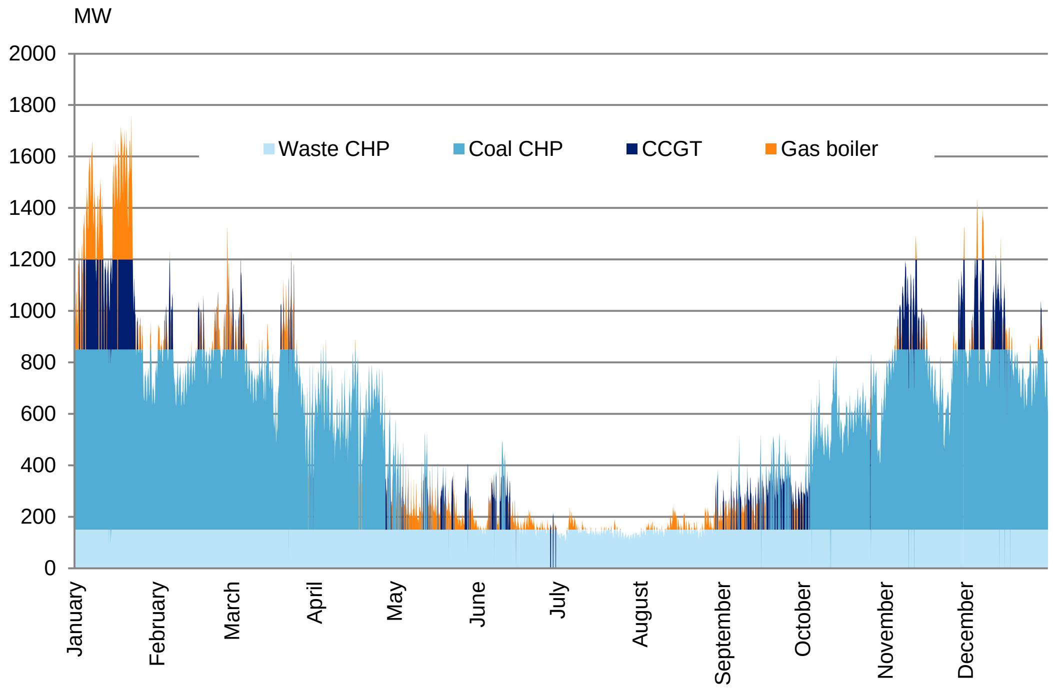
Source: Finnish Energy, 2016

As the Figure 3-6 shows, around 70 % of the networks in Finland are below the 50 GWh annual demand size, 25 % between 50 GWh and 500 GWh and 5 % over 5,000 GWh. In only one of the networks in Finland, the annual demand is more than 5,000 GWh/a. The cost structures of DH networks of different size are significantly different and this needs to be taken into consideration when the implementation model of TPA is assessed. Especially on very small networks the impacts of TPA need to be considered thoroughly as they represent majority of all DH networks in Finland.

3.4.1 Large network

The annual heat demand profile in large network is represented in Figure 3-7. The heat production in the network is mostly based on CHP accounting for 95 % of the total annual production with gas boilers for peak and reserve capacity. The base load is produced with waste-firing CHP throughout the year supported by coal and biomass CHP during winter. The share of coal and biomass is 80 % and 20 %, respectively. Combined cycle gas turbine (CCGT) is mostly operated during high demand periods in winter and individual periods at the beginning of the summer. The annual total demand is 5,000 GWh/a and the annual peak demand is 1,700 MW.

Figure 3-7 Production in large network used in simulations

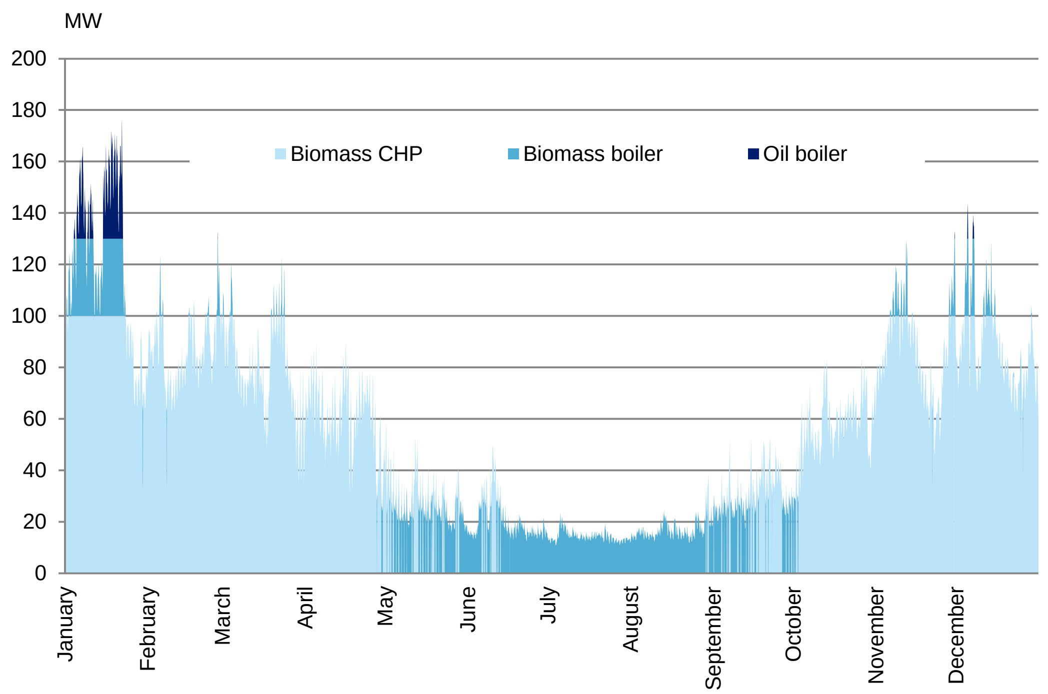


Source: Pöyry

3.4.2 Medium network

The annual heat demand profile in medium network is represented in Figure 3-8. The heat production in the network is mostly based on biomass-fired production units accounting for 98 % of the annual total demand with oil boilers for peak and reserve capacity. The base load is produced with biomass CHP during winter and biomass heat-only boiler during summer. Oil boilers are only required on individual peak demand periods. The annual total demand is 500 GWh/a and the annual peak demand is 170 MW.

Figure 3-8 Production in medium network used in simulations

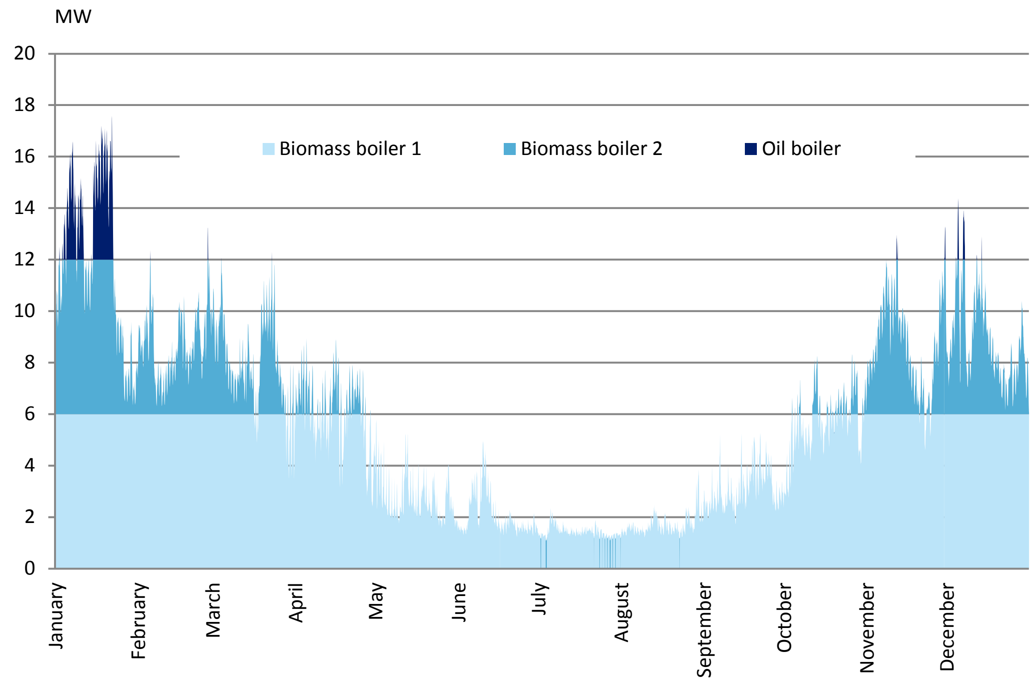


Source: Pöyry

3.4.3 *Small network*

The annual heat demand profile in small network is represented in Figure 3-9. The heat production in the network is mostly based on biomass boilers accounting for 98 % of the annual total demand with oil boilers for peak and reserve capacity. The base load is produced with biomass boilers throughout the year with oil boilers required only on individual peak demand periods during winter. The annual total demand is 50 GWh/a and the peak demand is 17 MW.

Figure 3-9 Production profile in small networks used in simulations



Source: Pöyry

3.4.4 *Modelled scenarios*

For each of the networks, three New RES production scenarios are analysed. The aim of this analysis is to study the effects of different amount of New RES heat by different types of producers are introduced to the system.

1. **High scenario**

   In this scenario, a relatively high share of the annual total demand in the network (15-30 %) is produced by a low number of New RES sources with relatively high capacities. The technologies considered in this scenario are deep geothermal, industrial and data centre waste heat and industrial-scale biomass boilers.

   High scenario could be considered an optimistic scenario, where a notable, cost-efficient waste heat source is available in close proximity to the network. This is the case for example in Mäntsälä where approximately half of the total annual production is TP waste heat from Yandex data center (Talouselämä, 2016). This scenario can also be compared to Fortum network in Espoo, where approximately 10 % of the total annual production could be produced by deep geothermal plant if the project is successful (St1).

2. **Medium scenario**

   In this scenario, a relatively low share of the annual total demand in the network (~10 %) is produced by a high number of individual New RES sources with low capacities.

   Medium scenario could be considered a scenario where market conditions have enabled the entrance of many New RES sources to the market but not as significant heat sources in relation to the total annual production in the network are available as in the High scenario.

3. **Low scenario**

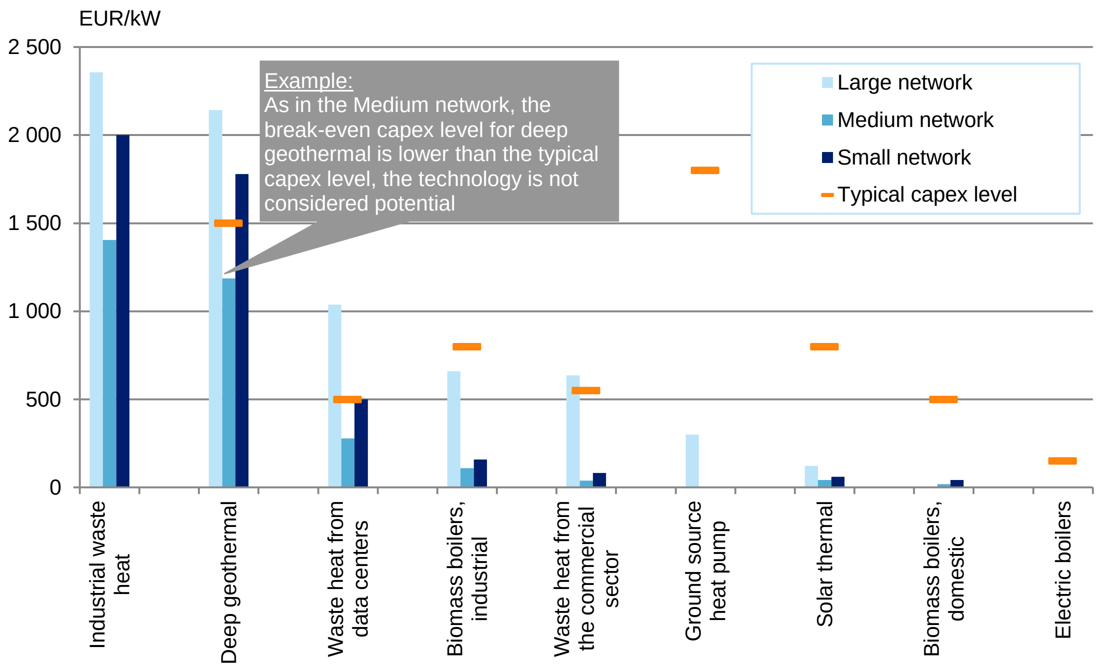
   In this scenario, a very low share of the annual total demand in the network (~1 %) is produced by individual New RES sources with low capacities.

   Low scenario could be considered a scenario equal to Stockholm, where TPA has been applied since 2013 and approximately 1 % of the total annual production comes from the TP producers (Pöyry, 2016)

3.5 Production potential of renewable energy sources in the modelled networks

The calculated break-even capex of each New RES technology per example network and their typical capex level are shown in the Figure 3-10.

Figure 3-10 Break-even capex level for New RES production for each example network compared to estimated typical capex level*



* WACC of 3.5 % applied to ground source heat pumps, domestic biomass and electric boilers. WACC of 9.0 % applied to other technologies. Lifetime of 15 years assumed for all technologies.

The competitiveness of New RES production is limited (the orange lines are higher than the columns in the previous figure) in Medium and Small networks where biomass is used as main fuel, and especially in Medium network that has CHP production. The variable cost of existing production in Medium network is low and therefore only industrial waste heat is competitive New RES production technology in this network. In addition to industrial waste heat, deep geothermal and waste heat from data centers are potential technologies in small network.

The industrial waste heat is the most potential New RES production technology in all networks. However, industrial waste heat costs, both variable and investments costs are case specific. The analysis shows that with an assumed flat production over a year, the capex would need to be in the range of 1,400-2,400 €/kW. Investment costs related to the heat exchanger and connection pipeline are typically relatively minor.

In large networks, supplying waste heat from commercial sector or data centers could also be profitable. However, this assumption is based on flat production of waste heat through-out the year, which might not be realistic for many commercial sector heat sources. If the waste heat is available e.g. only for half of the hours of the year, the profitability is not achieved.

With applied assumptions, the break-even capex level of industrial-scale biomass boiler is only slightly below the typical investment cost. The industrial-scale biomass boiler is considered as a potential technology only in large network. In other networks the break-even level is lower than industry-scale heat only biomass boiler and the income is not sufficient to make investment profitable. Other technologies are not competitive in any of the networks.

Potential and selected New RES technologies per network are listed in Table 3-2. Although the profitability assessment indicated deep geothermal to be potential technology in small network, it has not been included in the modelling as a potential production technology. This is due to the fact that deep geothermal is not yet in commercial use and is being piloted only at large scale.

Table 3-2 Potential technologies selected for modelling

	Large network (5,000 GWh/a)	Medium network (500 GWh/a)	Small network (50 GWh/a)
Industrial waste heat	✓	✓	✓
Deep geothermal	✓	✗	✗
Waste heat from data centers	✓	✗	✓
Biomass boilers, industrial	✓	✗	✗
Waste heat from the commercial sector	✓	✗	✗
Ground source heat pump	✗	✗	✗
Solar thermal	✗	✗	✗
Biomass boilers, domestic	✗	✗	✗
Electric boilers	✗	✗	✗

Source: Pöyry

3.6 Additional system costs in the existing organisations due to TPA

In this section, the additional system costs in the existing organisations due to the implementation of TPA are discussed. The aim is to identify and quantitatively analyse the potential impacts the potential additional implementation costs as well as administrative tasks and other workload the three different example TPA models presented in chapter 2.4 would cause in the existing DH organisations. With different market models and characteristics of the models, the impacts can differ significantly from the presented. The views presented in this section are mostly based on interviews with Finnish DH companies.

3.6.1 Model 1

In the first market model, the changes in the existing DH companies may be considered relatively small as the proposed market model is highly similar to the TPA model currently applied in Finland. In this model, the DH companies would still be responsible for the overall system optimisation and balance, as well as for the sales of heat to customers.

The difference to the existing market model is that some common conditions and price for TPA would be implemented. This would require the district heating companies to set up a market place for heat, develop their IT systems accordingly and calculate and validate the purchase prices for the third-party heat.

In case the company already buys heat from third-party producers, it may be enough if the existing IT systems are optimized for the open market place. However, also additional IT system and server purchases may be required if the existing IT systems are not suitable for creating the market place. In addition, the market place and server administration and maintenance costs may increase annual costs in the district heating companies.

The additional costs depend on the scale of the network. In small networks, the total cost for IT system optimisation/purchase is estimated somewhere between some tens of thousands and a hundred thousand euros. The third-party heat purchase price calculation and validation and other administrative tasks are estimated to require extra work of 0.5-1 man years. In addition, if the amount of TP producers is high, the company requires additional personnel to control the contracts and cooperation between the producers. In medium and large network, the requirement for additional work and costs are higher. The cost assumptions used in the calculations in small, medium and large networks are represented in the following table.

Table 3-3 Additional administrative costs due to TPA in market model 1

	Small network	Medium network	Large network
IT system purchases /optimisation	12 k€/a	24 k€/a	35 k€/a
Market place administration, heat balance calculations and data validation	38 k€/a	75 k€/a	75 k€/a
Increase in production and distribution personnel (due to unbundling of distribution and production)	0 k€/a	0 k€/a	0 k€/a
Increase in administrative procedures (due to unbundling of distribution and production)	0 k€/a	0 k€/a	0 k€/a
Increase in management costs (due to unbundling of distribution and production)	0 k€/a	0 k€/a	0 k€/a
Total additional costs per annum	**50 k€/a**	**100 k€/a**	**110 k€/a**

Source: Interviews with Finnish DH companies, Pöyry

3.6.2 Model 2

In this market model, the changes in comparison to existing TPA model and in the expected regulation are more extensive than in the market model 1. The most significant difference is the ownership unbundling of the heat production from other functions in existing companies.

In ownership unbundling, the two companies require their own management and administration. Therefore, the management and administration costs could be doubled in comparison to the existing model. Also, maintenance and some other IT systems may need to be separated creating additional costs. From operational perspective, the unbundling of the companies may result in some additional work.

Currently, production and network operation work in close cooperation or both of them may even be operated by the same employees. Thus, if the companies are unbundled, the tasks and the cooperation between network and production personnel need to be reviewed.

There may be requirement for double personnel in the operation of production and network even though the workload does not significantly change in comparison to the current system. In case the production plant is manned for 24 hours a day, the additional requirement is ~5 man years per a network. This is highly significant additional cost in small (50 GWh/a) and very small (<50 GWh/a) networks as the typical size of the existing organisations is 0-10 full-time employees.

In terms of additional costs and work caused by TPA model, a market place for heat also needs to be set up and administrated with similar additional costs as in the market model 1.

Other costs of unbundling depend on the size of the DH network and the company. However, the minimum administrative cost of unbundling is estimated at minimum ~50 EURk/a in small networks which may result in relatively high increase in annual costs in small and very small netwoks (<50 GWh/a). Also in larger companies the annual costs may increase due to separate administrations, but the relative impact on the total annual costs is not estimated to be as significant as in the smaller networks. The estimated additional costs caused by TPA model 2 utilised in calculations are represented in Table 3-4.

Table 3-4 Additional administrative costs due to TPA in market model 2

	Small network	Medium network	Large network
IT system purchases /optimisation	16 k€/a	32 k€/a	47 k€/a
Market place administration, heat balance calculations and data validation	38 k€/a	75 k€/a	75 k€/a
Increase in production and distribution personnel* (due to unbundling of distribution and production)	375 k€/a	375 k€/a	750 k€/a
Increase in administrative procedures (due to unbundling of distribution and production)	50 k€/a	50 k€/a	50 k€/a
Increase in management costs (due to unbundling of distribution and production)	100 k€/a	250 k€/a	350 k€/a
Total additional costs per annum	**580 k€/a**	**780 k€/a**	**1,270 k€/a**

Source: Interviews with Finnish DH companies, Pöyry

* Assumed requirement for 5 additional full-time employees in small and medium networks and 10 in large network

3.6.3 Model 3

In this market model, the changes in comparison to existing district heating and TPA models in Finland are considered the most significant of the studied models as the TPA producers are allowed to make contracts directly with the customers using the heat network as a platform for the service. A proper body for the overall system optimisation must be determined separately and in this report, Pöyry has assumed this responsibility to belong to the distribution company.

Due to the significant change in market structure, the implementation of the TPA may be considered the most difficult and expensive and the expected amount of regulation the highest. The organisational changes to the existing DH companies in this model may be considered relatively similar to model 2 with small additions.

From the organisation structure perspective, similarly to model 2, also in this model distribution and production need to be unbundled with similar additional costs due to increase in administration and operation. In addition, after the unbundling of the companies, the production companies may require additional personnel on customer services and sales as customer-side competence may become an increasingly important asset for the company.

From the system administration perspective, similarly as in the other two models, additional work is required in the distribution company for distribution planning and heat balance calculations. However, the model is considered more challenging than the other models and therefore, more resources are required in the system administration in the distribution company.

From the IT systems perspective, the IT systems used for production and distribution need to be separated and/or optimised/renewed. It is estimated that the IT systems acquired in this model are very different from the existing systems and thus, the systems require higher investments than in the other TPA models due to for example more complex integration to invoicing system. The estimated additional costs caused by TPA model 3 utilised in calculations are represented in Table 3-5.

Table 3-5 Additional administrative costs due to TPA in market model 3

	Small network	Medium network	Large network
IT system purchases /optimisation	18 k€/a	35 k€/a	53 k€/a
Market place administration, heat balance calculations and data validation	38 k€/a	75 k€/a	75 k€/a
Increase in production and distribution personnel* (due to unbundling of distribution and production)	375 k€/a	375 k€/a	750 k€/a
Increase in administrative procedures (due to unbundling of distribution and production)	50 k€/a	50 k€/a	50 k€/a
Increase in management costs (due to unbundling of distribution and production)	100 k€/a	250 k€/a	350 k€/a
Increase in sales and customer service personnel due to increased complexity in the retail markets	75 k€/a	150 k€/a	225 k€/a
Total additional costs per annum**	**660 k€/a**	**940 k€/a**	**1,500 k€/a**

Source: Interviews with Finnish DH companies, Pöyry

*Assumed requirement for 5 additional full-time employees

3.7 Assessment of network constraints

The analysis performed in the previous chapters does not include any costs for strengthening of the DH network as a result of capacity additions. However, existing networks are designed to transfer the heat to consumers taking into account the locations of current main heat producing units, and in real life it might not be possible to off-take the heat from producers for the full amount suggested by economic dispatch analysis. Therefore, a physical DH network model was used to study the various impacts that the new capacity might have on the existing network.

This bottleneck problem is not relevant for the production scenarios 2 and 3. In those scenarios the New RES production units are of relatively small size and the total New RES production is under 10 % of the total annual production. In scenario 1, which is based on large individual units entering the DH system, however, the network strengthening can require significant investments.

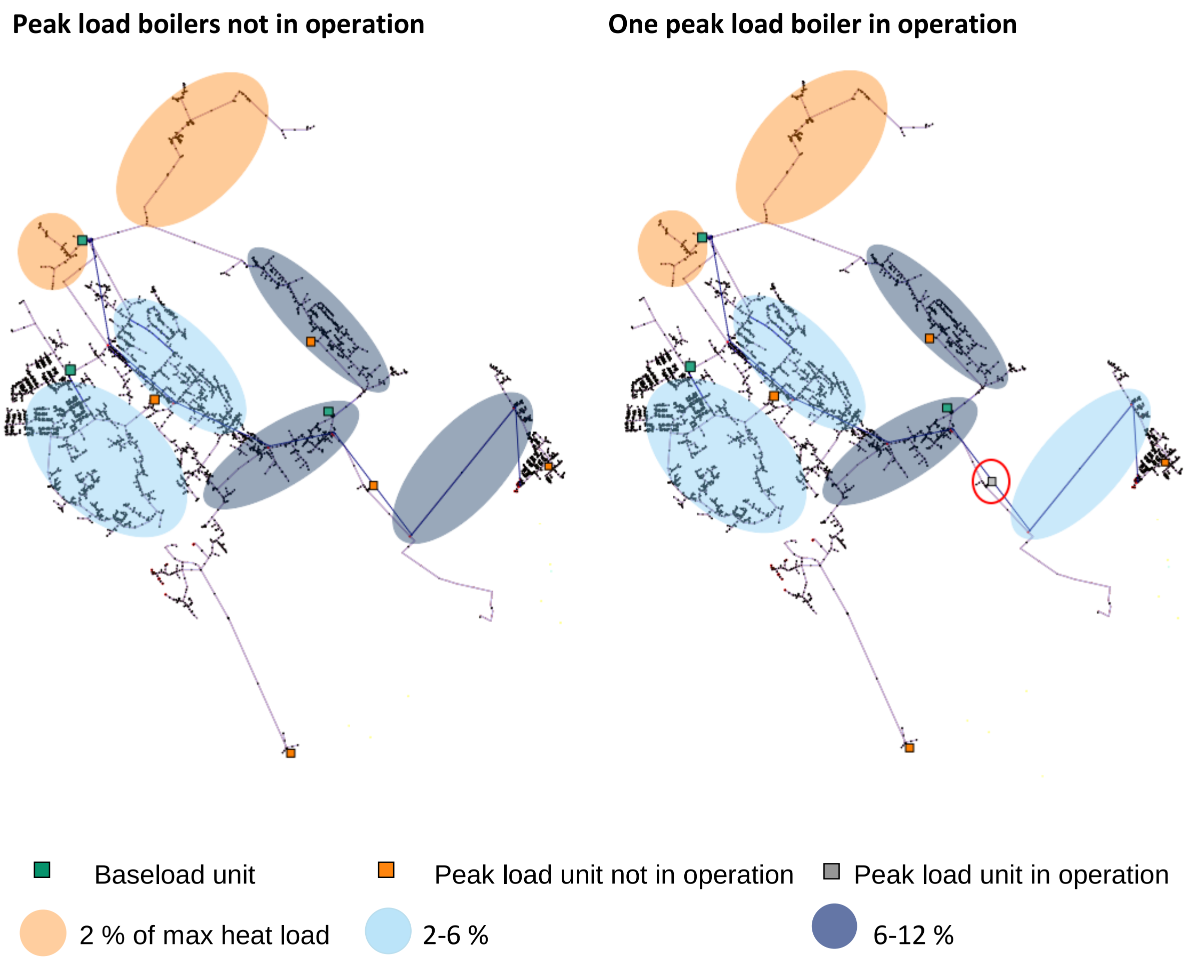
The example DH network used in the bottleneck analysis represents an average-sized network in Finland with a CHP production unit and biomass-fired heat-only boilers (HOB) for base load production and oil-fired units for peak load purposes and as spare capacity. The purpose of the simulation is to:

- Identify the optimal placing of the New RES units
- Define the potential cost for the network strengthening

Simulations are done in two operation modes; (i) the peak load boilers not in operation and (ii) one peak load boiler in operation, the latter case describing the winter situation. This approach has been selected to be able to capture the different potentials of the network to absorb New RES heat during different production situations.

The following figures (Figure 3-11) show the results of the modelling with maximum New RES capacity that can enter the DH system in different parts of the network without bottlenecks forming.

Figure 3-11 Maximum New RES capacity in the DH network without bottlenecks

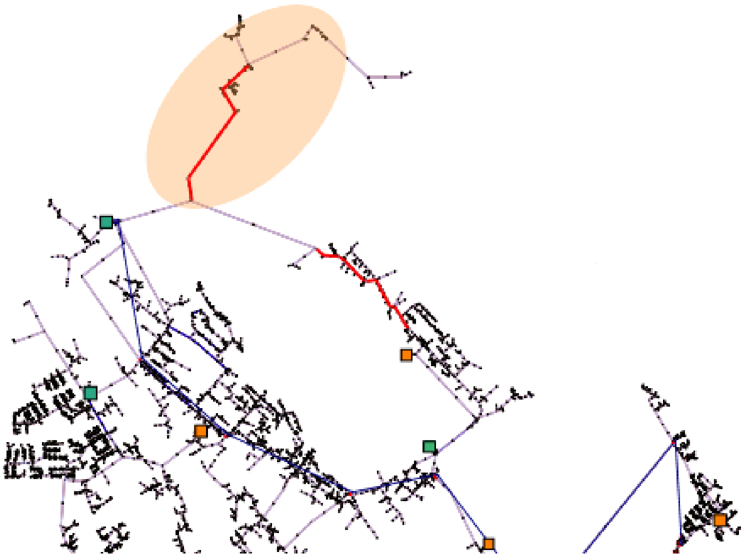


Source: Pöyry

It can be seen from the previous figure that the most suitable locations for New RES production units are in the proximity of existing peak load boilers. When the peak load boiler is turned on (the figure on the right, red circle), the network cannot, in theory, absorb as much heat from the New RES unit as when the peak load unit is not in operation. In practise this may not a problem, because New RES production unit will most likely supersede the peak load unit in the merit order. The next best location for New RES units is close to biggest production units (CHP in this case, described with green box). Here the New RES capacity is limited by the continuous flow from the main units to the network.

The maximum size of New RES units used in the scenario 1 of the dispatch analysis of section 3.8 is in the range of 6 % of the maximum heat load for each network. It is thus likely that investments in network strengthening are needed only if single large production units are placed at the network ends. The following figure (Figure 3-12) shows the areas where the network strengthening is needed in that case. In this calculation, a New RES capacity addition of 10 % is assumed.

Figure 3-12 Areas in the DH network that need to be strengthened if large New RES unit is placed at the network end



Baseload unit   Peak load unit not in operation   Peak load unit in operation

Location of the large New RES unit

Pipelines that need to be strengthened

Source: Pöyry

In this example, investments to the network consist of new pipeline of about three kilometres and a new booster pump station. The investment cost for the network total to 130 EUR per kilowatt of added New RES capacity. Even if the needed network investment depends strongly on the location of the connection point, it can be concluded that compared to the investment of New RES capacity itself (in the range of 1 000 EUR/kW), the maximum investment need for DH network strengthening is moderate. In theory, the other alternative for network strengthening is to allow New RES unit to operate in the network only locally and allow different pricing in different parts of the network (as in electricity markets).

3.8 Impacts on network dispatch and production costs

The impact of New RES production on network dispatch and total production costs is analysed separately for each of the three example network and scenario. The most potential New RES production technologies have been selected for each scenario and network based on the assessment presented in chapter 3.5 .

Since the capacities of various New RES production technologies are known at this stage (unlike in the potential analysis described in chapter 3.3), a detailed dispatch analysis can be carried out. Used model optimizes the production of existing DH plants and New RES so as to satisfy the network heat demand at specific hour with minimum (variable) costs. This methodology follows the way production is dispatched in DH networks today. The total annual production costs for the DH network is calculated as a sum of variable costs of the whole DH network, fixed costs of New RES and annualised capex of New RES. The theoretical cost of stranded assets (for existing production) is omitted from the calculation.

If the investments in New RES are carried out by DH company or by third-party in another TPA environment than today, there are additional costs for DH companies. In this chapter, those costs (estimated in chapter 3.6) are added to the production costs described in the previous paragraph.

3.8.1 Large network

The large network production assets consist of several CHPs and heat-only boilers, which use mainly fossil fuels, coal and natural gas. The large network has also one waste-to-energy CHP. Due to a high share of fossil fuels, SRMC of current production units is on higher level compared to SRMC in Medium and Small networks. Higher SRMC mean that several technologies are competitive compared to other networks. In Large network, the most potential technologies are deep geothermal, industrial waste heat, waste heat from data centres and commercial sector and industrial scale biomass boilers. Solar thermal is also included as in large scale it may be competitive against the current production.

Capacities used in the modelling are presented in Table 3-6. In High scenario New RES production is produced from two large heat sources, à 50 MW. In Medium scenario all above mentioned potential technologies are used in New RES production, totalling 140 MW. In Low scenario New RES production capacity is 17 MW.

Table 3-6 New RES production capacities in different scenarios, Large network

Technology	Unit	High scenario	Medium scenario	Low scenario
Deep geothermal	MW	50	20	0
Solar thermal	MW	0	10	2
Industrial waste heat	MW	50	0	0
Waste heat from data centres	MW	0	20	0
Waste heat from the commercial sector	MW	0	40	10
Biomass boilers, industrial	MW	0	50	5
Total capacity	**MW**	**100**	**140**	**17**

Source: Pöyry

The share of the New RES production of the total heat production in the network is 17 %, 10 % and 1 % in High, Medium and Low scenario, respectively. Although the total New RES capacity is lower in the High scenario compared to the Medium scenario, the amount of New RES production is the highest. This is due to the fact that the production technologies in the High scenario have the lowest variable costs and therefore they operate as base load. The energy production and emissions in Large network are presented in Table 3-7.

Table 3-7 Energy production and emissions, Large network

	Unit	High scenario	Medium scenario	Low scenario
Heat production				
Current CHPs	GWh/a	3 960	4 360	4 710
Current HOBs	GWh/a	190	130	250
New RES production	GWh/a	880	530	60
Share of New RES production	% - of production	17 %	10 %	1 %
Electricity				
CHP production	GWh_e/a	2 080	2 270	2 510
New RES consumption	GWh_e/a	10	70	10
Emissions				
Emissions	MtCO2/a	1.39	1.48	1.66

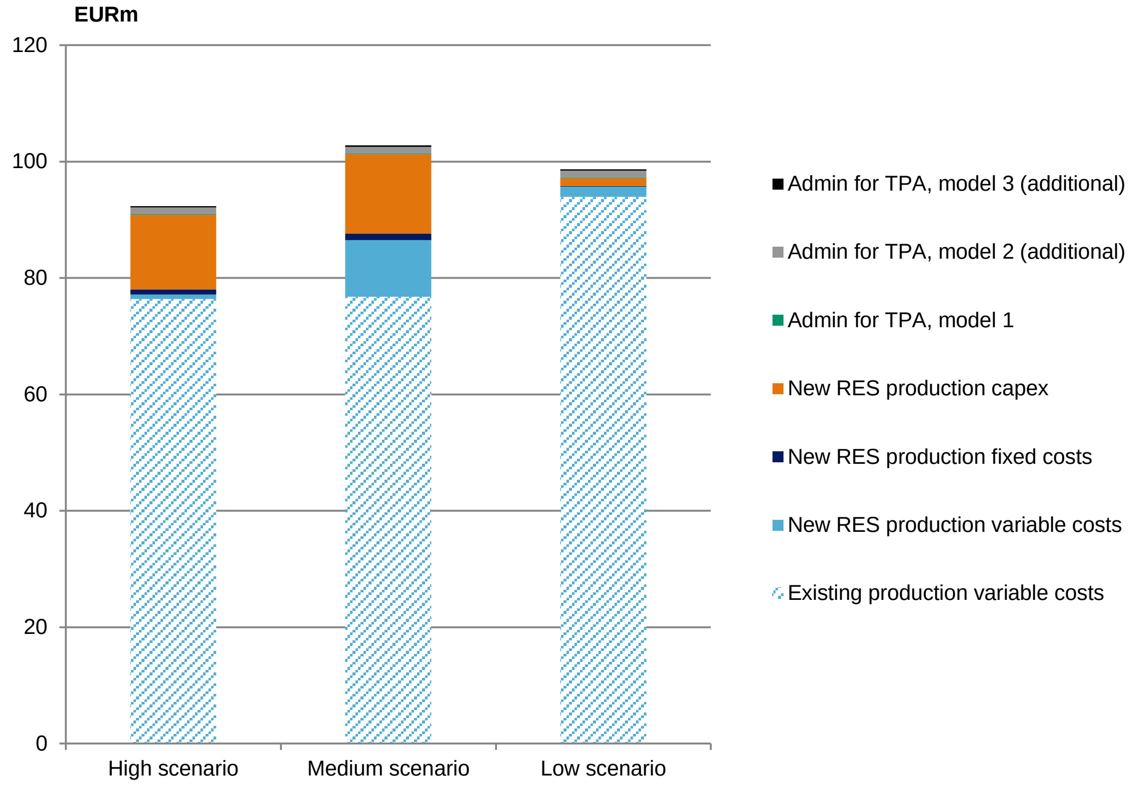
Source: Pöyry

Current heat-only production has higher variable costs than current CHP plants and therefore the New RES production substitute more the production of heat-only boilers. However, also CHP production decreases, which results in reduction in electricity production. At the same time, electricity consumption increases due to heat pump electricity use. Since the current fuel mix is heavily based on fossil fuels, the New RES production decreases emissions. However, in the emission calculation, the impact of decreasing electricity production from CHP and the increasing electricity demand for the heat pumps is not taken into account.

In theory, when analysing emissions on European level, the emissions from production that replaces Finnish CHP production should be added to this calculation. For scenario High, the additional emissions as a result of this replacing production will be in the range of 0-0.17 MtCO2/a. In short term, the replacing technology is likely to be CCGT (in Continental Europe), but in the longer term, it can be argued that the emissions will correspond to emissions of new investments that are likely to be realised, mostly wind. It can be further argued that since the district heating is part of the EU Emissions Trading System (ETS), whose emissions are limited by annually declining emissions cap, the emission allowances not used by the Finnish DH sector will be used by some other producer in the ETS and a decline in local (Finnish) emissions has no impact on the total EU-wide emissions.

Variable costs of existing production and total costs related to New RES production and TPA admin costs are presented in the Figure 3-13. Capex of New RES production are based on the estimated typical capex level presented in chapter 3.3 and include costs related to strengthening the network in High scenario (130 €/kW) as assessed in chapter 3.7. Administration costs for TPA are relatively minor in all market models in comparison to total costs of the large network.

Figure 3-13 Variable costs of existing production and total costs of New RES production in comparison to TPA admin costs, Large network

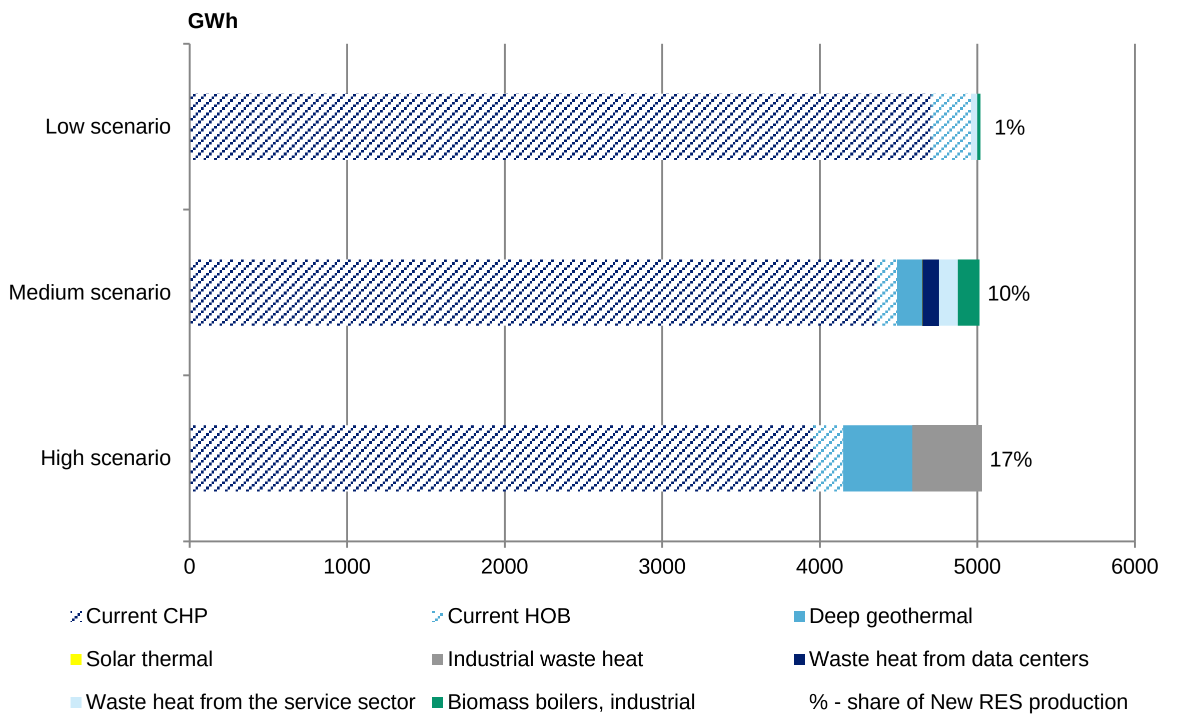


Source: Pöyry

It should be noted that in the above figure, the High scenario is based on the assumption that there would be significant amount of waste heat and deep geothermal heat available. Concerning waste heat, this kind of potential is typically already well utilised, and geothermal heat technology is still under development and the potential is uncertain. Therefore, the figure does not describe the potential cost impact of New RES in general but rather a specific situation if there were low-cost heat sources available.

Annual production of current plants and New RES producers in different scenarios are shown in the Figure 3-14.

Figure 3-14 Production of current DH plants and of new RES, Large network



Source: Pöyry

3.8.2 Medium network

The medium size network production assets consist of CHP plant and several heat-only boilers, which use mainly biomass but also peat. Due to a high share of biomass and CHP production, SRMC of current production units is the lowest compared to other networks. Since the current production is already very cost-efficient, there is only little potential for New RES producers. In Medium network, the only cost efficient New RES technology is industrial waste heat.

Capacities used in the modelling are presented in the Table 3-8. In all scenarios, New RES production is based on industrial waste heat source.

Table 3-8 New RES production capacities in different scenarios, Medium network

Technology	Unit	High scenario	Medium scenario	Low scenario
Industrial waste heat	MW	12	6	0.6
Total capacity	**MW**	**12**	**6**	**0.6**

Source: Pöyry

The share of the New RES production of the total heat production in the network is 21 %, 10 % and 1 % in High, Medium and Low scenario, respectively. The New RES production substitutes more heat-only boilers than CHP plants. However, also CHP production decreases, which results in reduction in electricity production. At the same time, electricity consumption increases slightly in High and Medium scenario due to heat pump electricity use. Since the current fuel mix is mainly based on biomass, the New RES production does not have significant impact to emissions. This analysis does not take into account the emissions from electricity production. Taking into account the need to replace renewable CHP electricity and the electricity consumption of the heat pumps, the impacts on CO_2 emissions may even be negative. The energy production and emissions in Medium network are presented in Table 3-9 below.

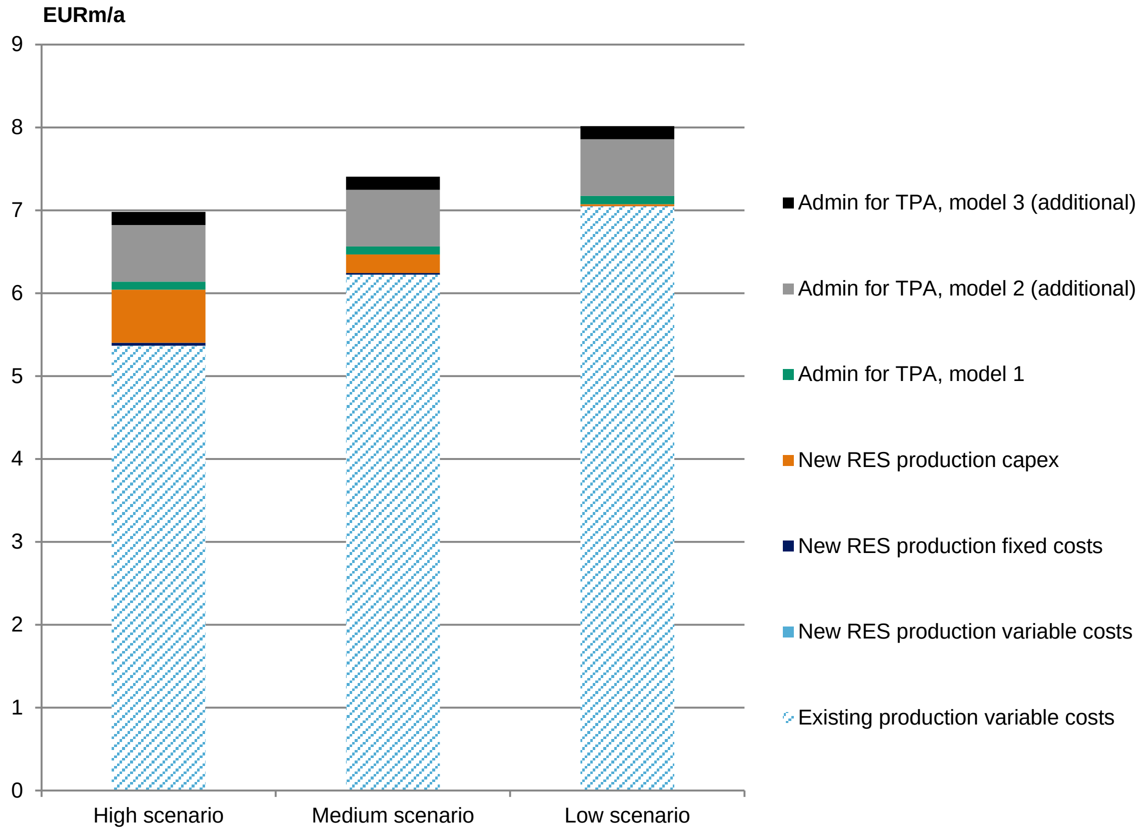
Table 3-9 Energy production and emissions, Medium network

	Unit	High scenario	Medium scenario	Low scenario
Heat production				
Current CHPs	GWh/a	348	381	416
Current HOBs	GWh/a	50	69	81
New RES production	GWh/a	104	52	5
Share of New RES production	% - of production	21 %	10 %	1 %
Electricity				
CHP production	GWh_e/a	157	172	188
New RES consumption	GWh_e/a	0	0	0
Emissions				
Emissions	MtCO2/a	0.06	0.07	0.08

Source: Pöyry

Variable costs of existing production and total costs related to New RES production and TPA administration costs are presented in Figure 3-15. Capex of New RES production includes investment costs for the New RES production and costs related to strengthening the network in High scenario (130 €/kW). Network constraints and additional investment requirements are assessed in chapter 3.7. Administration costs for TPA are relatively minor in market model 1 but in models 2 and 3 administration costs form a significant share.

Figure 3-15 Variable costs of existing production and total costs of New RES production in relation to TPA admin costs, Medium network

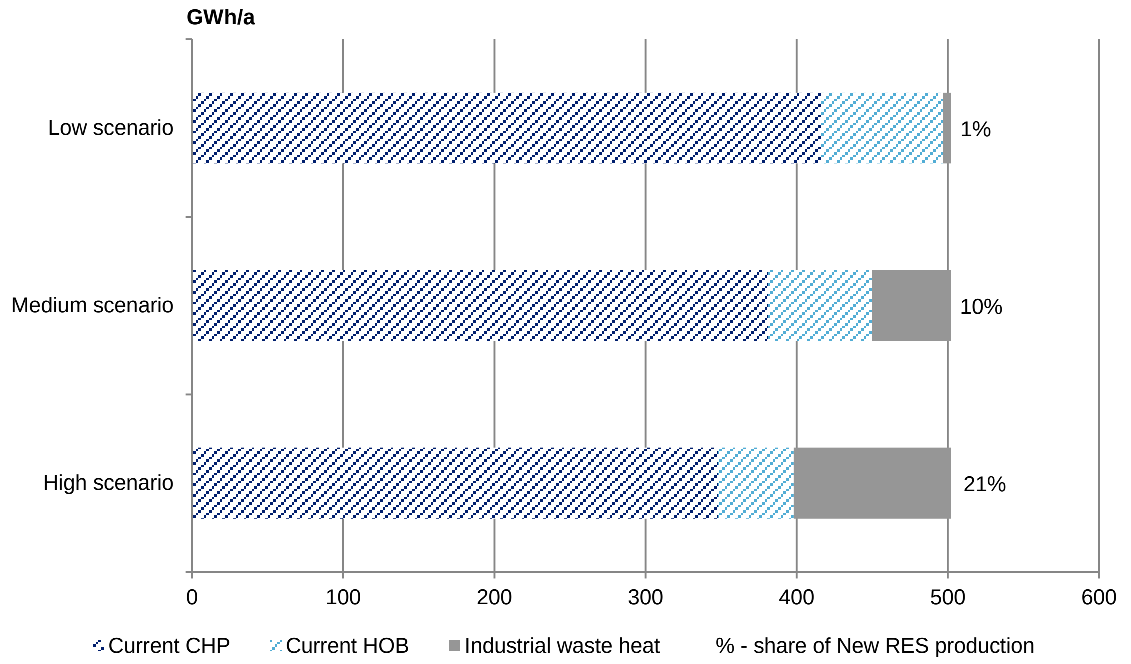


Source: Pöyry

In the modelled Medium network example, only industrial waste heat is competitive with the existing production. The availability of this type of waste heat sources is very limited as the potential is typically already utilised. Therefore, based on the modelling there seems to be very little potential competition in this type of heat networks, where biomass and peat are utilised in CHP production. This production composition reflects the majority of the district heating networks of this size.

Annual production of current plants and New RES producers in different scenarios are shown in Figure 3-16.

Figure 3-16 Production of current DH plants and of New RES, Medium network



Source: Pöyry

3.8.3 Small network

In the Small network, production assets consist of two heat-only boilers, which use mainly biomass but also peat. As there is no electricity production, the variable cost is dependent on the fuel cost only and it is considered to be constant throughout the year. Current production is already relatively cost-efficient and therefore there are only limited amount of potential New RES technologies. In Small network, the most potential technologies are industrial waste heat and waste heat from data centres

Capacities used in the modelling are presented in the Table 3-10. In High scenario, New RES production comes from one industrial waste heat source. In Medium scenario, waste heat from data centres are used in New RES production, totalling 0.6 MW. In Low scenario, New RES production capacity is only 70 kW.

Table 3-10 New RES production capacities in different scenarios, Small network

Technology	Unit	High scenario	Medium scenario	Low scenario
Industrial waste heat	MW	2.00	0.20	0.00
Waste heat from data centers	MW	0.00	0.40	0.07
Total capacity	**MW**	**2.00**	**0.60**	**0.07**

Source: Pöyry

The share of the New RES production of total district heat production is 33 %, 10 % and 1 % in High, Medium and Low scenario, respectively. The New RES production substitutes heat-only boilers using biomass and oil during the peak demand. When New RES production substitutes oil consumption, it decreases CO_2 emissions. The energy production and emissions in Small network are presented in Table 3-11 below.

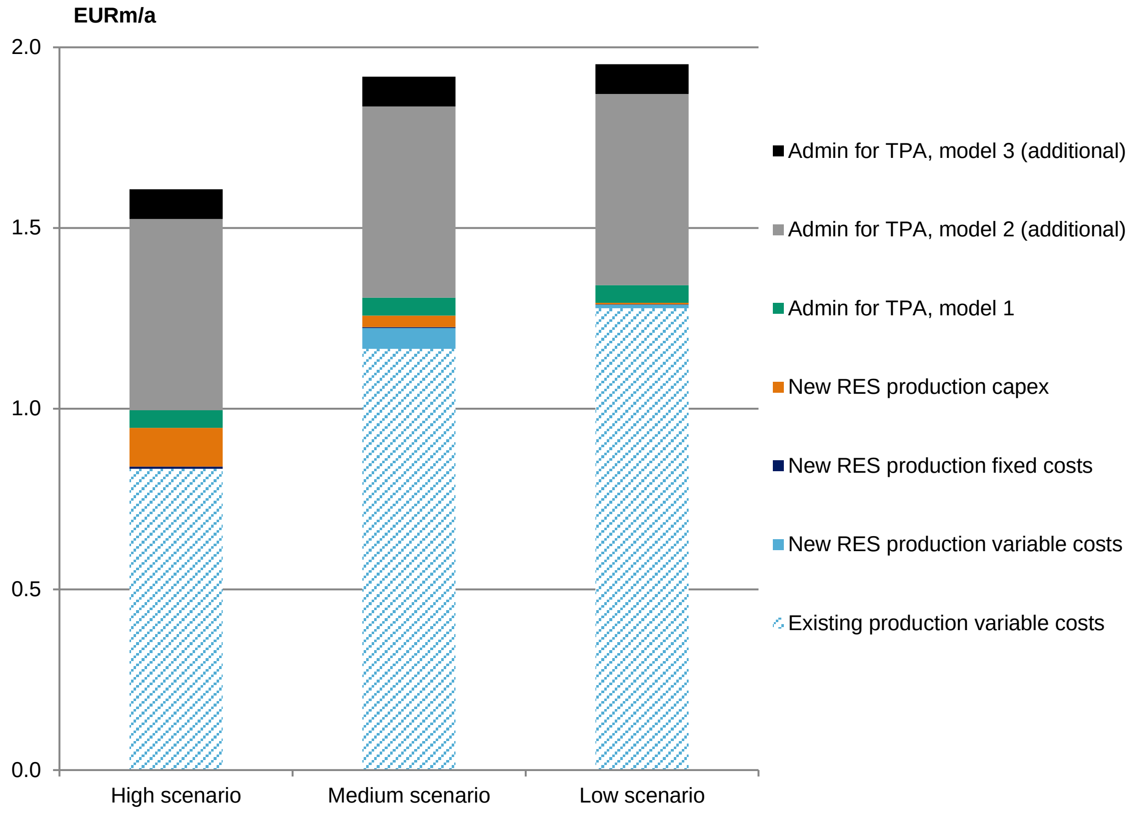
Table 3-11 Energy production and emissions, Small network

	Unit	High scenario	Medium scenario	Low scenario
Heat production				
Current CHPs	GWh/a	0	0	0
Current HOBs	GWh/a	34	46	50
New RES production	GWh/a	17	5	1
Share of New RES production	% - of production	33 %	10 %	1 %
Electricity				
CHP production	GWh_e/a	0	0	0
New RES consumption	GWh_e/a	0	1	0
Emissions				
Emissions	tCO2/a	3 420	5 160	5 530

Source: Pöyry

Variable costs of existing production and total costs related to New RES production and TPA admin costs are presented in the Figure 3-17. Capex of New RES production includes costs related to strengthening the network in High scenario (130 €/kW). Network constraints and additional investment requirements are assessed in chapter 3.7. As the figure indicates, admin costs for TPA are significant in relation to the size of the network.

Figure 3-17 Variable costs of existing production and total costs of New RES production in relation to TPA admin costs, Small network

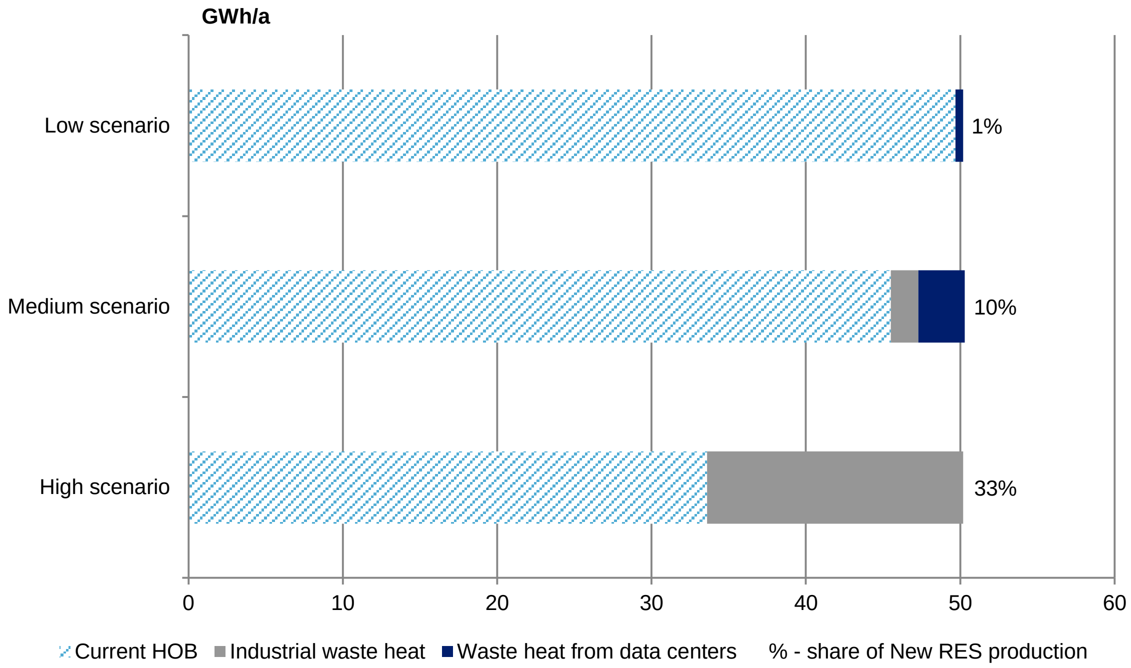


Source: Pöyry

In the above example, the New TPA production is assumed to be industrial waste heat and waste heat from data centers. All other New TPA production has been estimated not to be competitive compared to current production. Therefore, any cost savings in variable production cost can only be achieved, if there is unutilised waste heat sources available. Without this available capacity, any mandatory TPA would only result in the price increase due to increased costs for TPA administration.

Annual production of current plants and New RES producers in different scenarios are shown in Figure 3-18.

Figure 3-18 Production of current DH plants and of New RES, Small network



Source: Pöyry

3.9 Discussion on sensitivities

The modelled networks represent typical district heating networks in Finland in different size categories. However, each district heating company has a unique production asset portfolio and fuel mix. Especially fuel costs may vary between the companies depending on the fuel types but also on the availability of the fuel. The variable costs of RES production technologies are mostly not location dependent. The other key assumption (besides fuel price) is the electricity price, which impacts the heat production variable cost of the CHP plants. The lower the electricity price is the higher the share of total costs assigned to the heat production. Simultaneously, the lower electricity price is beneficial to heat pump based production technologies. The price of electricity cannot, however, be analysed in isolation. Main long-term drivers of electricity price in the Nordics are the fuel (gas and coal) price and cost of CO_2. So, for a fossil fuel burning CHP plant the lower electricity price is likely to be at least partly offset by lower fuel prices.

Different RES production technologies' marginal costs and profitability are sensitive to different assumptions. Industrial waste heat is considered to be always profitable unless the heat source is located far from the distribution network, which would lead to significant investment costs. Deep geothermal has very low variable costs due to the high COP factor and is only slightly dependent on the electricity costs. As deep geothermal technology is still on the development stage, its feasibility and investment costs are uncertain. The profitability of the other heat pump technologies (waste heat solutions) is most sensitive to COP factor, which is dependent on the heat source temperature. COPs listed in the Table 3-1 are based on the heat source temperature in the range of 25-45 °C. The energy component of the electricity bill has smaller impact as it accounts only for 30-50 % of the total electricity costs. The competitiveness of biomass boilers against the existing production assets is dependent on the fuel costs to large extent. Should the New RES producer have e.g. low cost forest industry by-products available, the variable cost could be lower and profitability higher compared to the existing production. In the simulations of this study it has been assumed that New RES producer and the district heating company pay the same price for the fuel.

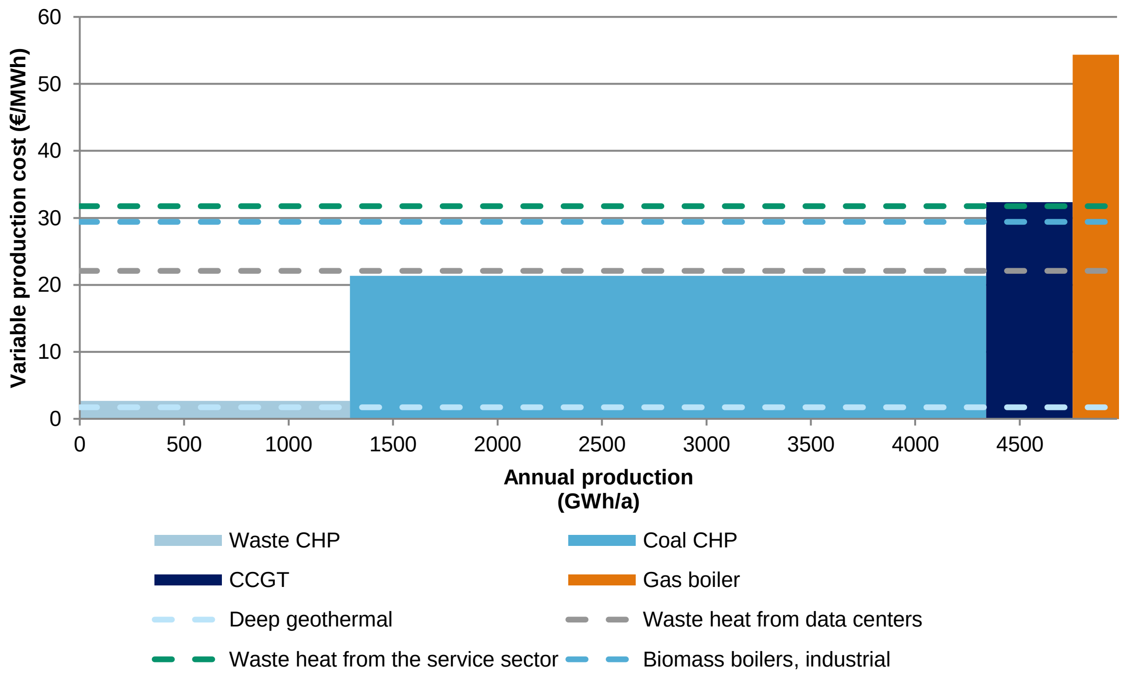
4. POTENTIAL IMPACTS OF TPA

4.1 Level of competition

The impact of TPA, such as potential customer price impact, is strongly dependent on the level of competition in production. As described in section 3, the level of competition is most likely low. Compared to the electricity networks for example, the district heating networks are very small. As a result, there are only a very limited number of production units in each network and it is likely that the DH prices are still set by the production capacity of the DH company for the most of the year. Even if from the production cost perspective there would be more room for competition, the market environment in DH production may not be considered attractive for many investors; it is capital intensive, subject to declining technology costs (future investors can make more profitable investments) as well as ever changing regulations (taxes, EU legislation, etc.). In addition, municipal investors competing in the market may have substantially lower return requirement for their capital.

The following figure shows the merit order of existing DH production units in the Large network and the amount of production that the various RES technologies could replace calculated with average annual SRMCs. In reality, the SRMC varies on hourly basis based on changing electricity price. As the heat amount from data centers can be considered limited and the technology for deep geothermal production is not yet proven, waste heat from the service sector as well as industrial biomass boilers are the only RES technologies that could theoretically gain some operation hours in the Large network. It should be noted that the coal-fired CHP plants that those technologies would replace are to be replaced with large-scale biomass boilers. Those boilers are likely to have smaller production costs than industrial biomass boilers depicted in the below figure and the merit order is thus likely to remain the same.

Figure 4-1 Merit order and SRMC of existing DH plants and SRMC of new RES in Large network



Source: Pöyry

Generally, there is potential for cost savings with TPA mainly if the existing network has high variable costs, applied TPA model attracts low-cost production and the production from the third-party producers is extensive enough to impact the dispatch of existing DH production. Even if that is the case the benefits of increased competition are not likely to benefit customers much, unless there is substantial amount of competition.

In market model 2, the major benefit for the customers in comparison to the market model 1 is the increased theoretical level of competition, which would improve the third-party producers' position in entering the markets and could potentially stimulate the price competition and service development in the DH markets. However, as the model 1, also this market model is a single-buyer market model where the eventual customer price would be determined by the local district heating company (alternative to switch off from district heating would of course remain).

It can be argued that especially in the short term, the number of new entrants would be relatively low and therefore the resulting market scenario would be considered rather as oligopoly than competition. On the other hand, it is challenging to assess the level of competition or the amount of new entrants in more long-term and to study whether the competitive situation would evolve in the future. Due to the high capital-intensity of district heating sector, it could be argued that the number of new entrants could remain low in the future, too.

4.2 Customers

The customers can have a variety of expectations for third-party access to district heating. These expectations may include lower DH prices, new kinds of heat services, increased transparency and freedom of choice for the heat supplier. The strengths of district heating have traditionally been very high security of supply, reliability, ease of use and competitive price. As described in chapter 1.2, the district heating price levels in Finland have been among the lowest in Europe. These positive characteristics should be maintained, if the TPA is implemented in new ways. Maintaining competitive price is especially important as DH is in heavy competition against other heating methods and any additional cost burden for DH would ultimately lead to switching to property level, often electricity based heating methods.

Even though the district heating prices are published by the DH companies, the costs for heat generation are not publically available. Introduction of more complicated TPA models than is in use today might not change this, especially for Network access type of models. However, setting up a market place for heat and services with open pricing for heat procurement (for example market model 1 as described in chapter 2.4) would put pressure on the pricing, and that could ultimately benefit the customers, too.

Even if TPA was able to encourage a high number of low-cost newcomers to enter the markets and decrease the production cost of heat, the potential cost savings should compensate the additional system costs caused by the implementation of TP. As demonstrated with the examples in chapter 3.8, the relative organisational and regulation cost of TPA are likely to be higher with smaller heat networks, but also in large networks the cost can be high depending on the selected model for TPA.

In market model 1, the major benefit for the customers is the simplicity of the arrangement. As the proposed market model is close to the TPA model already applied in Finland, the expected changes to the existing DH system are the smallest of the studied potential TPA models. As a result, the risks of decreasing security of supply and the potential changes required in the regulation are considered the smallest. Due to the smallest changes, the risk of cost increase is smallest and there could be some potential for savings due to increased transparency and competition. However, if the model would not create enough competition to production market, it is unlikely to bring any positive price impacts. However, from whole society's point of view, there may be benefits, if more low-cost and low-emission heat sources were used.

In market model 2, the competition would rather concern the production companies than the customer prices. The district heating retail and distribution company would try to minimise the heat purchase cost through competition in production. Obviously, if cost savings are achieved due to competition in production side, these savings may be allocated to the customers to reduce their prices. However, significant system costs of this TPA market model are more likely to increase heat prices.

In market model 3, the major benefits from the customers' perspective are the greatest theoretical level of competition and transparency and freedom of choice for the heat supplier. In theory, the high level of theoretical competition should have high potential to reduce the customers' heat prices – especially as in contrast to the single-buyer models, in network access models the heat producers would be allowed to make agreements directly with the customers and compete against other producers in terms of customer prices and service. In addition, the customers could select the heat supplier according to their personal preferences, for example based on the renewability of the energy. In other analysed TPA models the issue of customer preferences would be solved by creating different products within the district heating company (as today).

Nevertheless, the network access models would enable free competition in district heating customer prices better than the single-buyer models even if the long-term effects of the network access models may not be specifically studied. The main risk is that there would be oligopoly pricing in free markets rather increasing than decreasing the prices. As the prices would also in this case be ultimately set/limited by the cost of other heating methods, the end result could – from competition point of view - resemble the situation of today added with cost burden coming from additional administration and regulation, especially in case of TPA model 3.

The network access models are considered to be clearly more complex than the single-buyer models and create more challenges for the DH companies to ensure the proper technological operation of the DH system as well as ensuring the security of supply. The system costs in the network access TPA models are considered higher than in the single-buyer models, which increase the risks of higher heat prices. In addition, in the network access models it is more difficult to ensure the equal treatment of all customers.

On the other hand, TPA could increase some synergies within the DH networks that could benefit both the heat producers and the customers. If TPA encourages customers for demand response, the production costs in the production company could decrease. Or if for example industrial reserve boilers owned by a TP producer may be utilised as reserve capacity in the DH network, the maintenance and investment costs to reserve capacity in the DH company may be decreased. The cost savings caused by these factors could be allocated to customers reducing the heat prices. Synergies related to demand response are most likely to materialise in model 3 as in that model there is a separate balancing market (as in electricity markets) that the demand response can participate in. Industrial reserve boilers have also the easiest access to peak market in model 3, but it is questionable, whether capacity management as a whole leads to savings compared to current TPA model where one party optimizes to whole system.

Even though district heating companies already try to improve the level of their customer experience and develop new services, it could be possible that the implementation of TPA may stimulate the development process, potentially resulting in wider variety of alternative new services. If TPA succeeds in attracting new service providers to district heating networks, this could improve the customer experience and create additional savings through optimised energy efficiency for example.

4.3 Producers

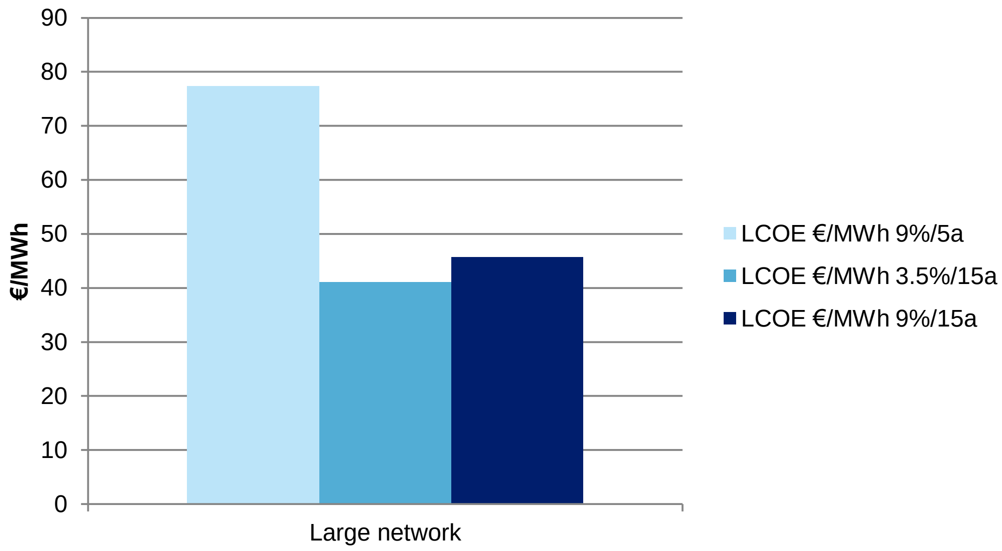
The third-party producers can be divided into two groups based on their characteristics and expectations. The groups could be defined as new entrants who need to make significant investments in order to participate in the market and the TP producers who only sell excess or waste heat. The TP producers who need to invest could be considered to have heat sales as their core business and thus, they would be more interested in actively competing against the existing DH companies.

TP producers who only sell excess/waste heat and whose core business may not be heat sales, are likely to value ease of operation and potential for increased transparency and higher profitability (more efficient price formation). They would thus most likely be interested in maximising the cooperation with the DH company and minimising the utilisation of their own resources in the heat sales. In model 3, this problem is addressed by introducing a separate retail layer to the model. However, the use of retail services of others would incur additional costs for their product and result to lower profitability. It can be argued that waste heat producers as non-professional operators would favour as simple market model as possible (model 1), but on the other hand, the relative competitiveness of their production against other players would be more highlighted in more competitive SRMC-based environment of models 2 and 3.

From contract length perspective, it could be argued that short-term contracts based on marginal costs could suit best the producers having waste heat sources and no need for significant investments. However, when the existing DH company still controls the majority of the production capacity, the TP producers are dependent on the cost development of DH company's production. Other producers (DH company or other TP producers) can also make investments to new production capacity decreasing the operating costs, which could make the third-party producers production uncompetitive. The third-party producers who have investment needs when entering the markets are more exposed to risks of volatile short-term markets. They may do stress tests in analysing their market entry with very low calculation periods compared to the 15 years used in the analysis done in section 3.

The following Figure 4-2 illustrates the Levelized Cost of Energy (LCOE) of TP production based on industrial biomass boilers with different combinations of calculation period and Weighted Average Cost of Capital (WACC) values. The dark blue column (on the right) represents the assumptions used in section 3 and the lightest blue (on the left) the same WACC assumption but only 5 years as calculation period. As the new investment competes against existing production with sunk investment cost, the LCOE of TP production should be lower than Short-Run Marginal Cost (SRMC) of existing production. Comparing the LCOE calculated with 5 years' calculation period and the SRMCs presented in Figure 4-1, it can be concluded that investments to TP production based on industrial biomass boilers will only materialize, if the investors have decent view of the markets going at least 10 years forward. Impact of smaller WACC (column in the middle in Figure 4-2), and thus lower risks, can be considered smaller in this case.

Figure 4-2 Impact of calculation time and WACC to LCOE of industrial biomass boiler in the modelled Large network



Source: Pöyry

The DH companies seek for additional cost savings for DH customers and further developing the sustainability of district heating through even higher utilisation of renewable/waste heat sources. In addition, if the DH companies voluntarily open their district heating networks for competition, the companies as well as the DH sector may be expected to reach considerable image benefits. In order to achieve the expected cost savings, the implementation of TPA should be easy with low investment costs as well as low additional resource needs and system costs due to administrative tasks.

The additional workload, investments, administrative tasks and other system costs for the existing organisations were discussed in section 3.6, where some quantitative assumptions of the annual expenses caused by the implementation of TPA were represented. The system costs were categorised into IT system and market place investments, market place administration tasks, increase in production and distribution personnel and increase in management costs. In addition, in the network access model, additional requirement for personnel in customer service and sales tasks may be expected due to competition in the retail sector.

The impacts of TPA on the existing DH organisations and the resulting relative costs depend notably on the implemented TPA model and the size of the heat network. In short, the relative impact and increase in relative costs are the greater, the smaller the company in question is.

In the market model 1, the changes in comparison to the existing model in terms of system optimisation and additional costs are relatively low. In addition, the implementation process should be relatively simple and fast as no major organisational changes are required and the conditions within the DH markets do not change significantly.

In the market models 2 and 3, the changes in existing organisations and the resulting costs are significantly higher as unbundling is required for the companies, as presented in section 3.5. Furthermore, the unbundled production and distribution companies may not have similar, common incentives or the possibility to keep the price levels low in comparison to the current competitive situation, where the production and distribution companies may cooperate better in order to minimise production costs. Unbundling implementation process may be long and expensive.

Therefore, it is questionable whether any potential (but not definite) cost savings caused by the increasing price competition in the networks is enough to compensate for the additional administrative costs. The analysis in section 3 shows that the potential to achieve any cost savings is especially questionable in small (50 GWh/a) or very small (<50 GWh/a) networks as the additional system costs are very high in comparison to the scale of the networks. Also in medium and large networks, the annual system costs caused TPA are significant but the relative costs are not as high as in the smaller networks.

4.4 Society and regulation

TPA for district heating can be seen in the framework of opening various activities for competition, such as electricity and gas markets, railways, taxi services, pharmacies or gambling. The opening of the market will - in addition to increased theoretical efficiency - result in additional costs for the society. This study focuses on analysing the costs that are clearly borne by the actual players in the district heating markets. In addition to these costs, there are costs for the society arising from increased regulation.

In addition to additional costs for the society, there are also expectations. The choice of heating method and energy sources is currently steered with building codes, energy taxation and emissions trading. High fossil fuel taxes combined with emissions trading has already directed to the use of renewable energy in district heat production when renewables are available. (see Chapter 1.2 for the development of the use of renewable sources and secondary heat from third parties in district heating). Customers' preferences are also an important steering vehicle.

Analysis done in Chapter 3.6 aimed at quantifying some of the costs attributable to regulation borne by the district heating companies. In addition to regulation related to those cost items, there are various aspects that need to be taken into account and possibly regulated, if the current market model will be changed. The following table summarises the most important regulation needs for the analysed three TPA models.

Table 4-1 Regulation needs for the analysed TPA models

Regulation need related to:	**Model 1** "Single-buyer with open and transparent access conditions"	**Model 2** "Single-buyer with regulated wholesale competition"	**Model 3** "Network access (full scale)"
Unbundling		X	X
Network access	(X)*	X	X
Peak and reserve capacity			X
Balancing market			X
Heat prices	(X)**	(X)**	
Heat distribution prices		X	X
Network codes			X
Equal treatment of customers	X	X	

*Only for the conditions of contract

** Monitoring in case of dominant market position

Source: Pöyry

4.5 Service providers

One potential benefit of more open TPA could be the higher level of competition in the DH service markets, which could stimulate the development and introduction of new services, such as services related to digitalisation and IoT products. The introduction of new services could improve the level of customer experience as well as improve the cost- and energy-efficiency in the DH markets. TPA has already been successful in this development for example in the telecommunications networks, where a vast range of services has been developed once the existing infrastructure has been opened for competition and service development.

In the existing competitive situation, the DH companies are rather incentivised to keep the price of DH low in comparison to alternative heating technologies than develop new services. The services could then be implemented in cooperation with the DH companies to create benefits for the existing DH companies, service providers and heat customers.

The service providers' willingness to enter the markets and the capability to develop innovative services is highly dependent on the transparency of the market and the ease of entry. Considering the selected DH TPA market models for this study, the transparency and the theoretical level of competition are the highest in market model 3. Therefore it could be argued that the market model would encourage the highest number of new service providers. However, the market model 3 increases the complexity of the DH markets also from the service providers' perspective. Depending on the service to be developed, the market model 1 could be the most suitable for a new service provider as the DH market logic and the system responsibilities are the most clear.

Naturally, the development of the new services could occur also in the existing DH markets. In addition, the higher number of new entrants and the resulting competition in the service providers' markets would more likely guarantee higher level of innovation in the DH sector and higher quality of new services. However, the question remains whether more open TPA is a requirement to encourage the service developers to more actively enter the markets or could they be similarly attracted in the existing DH markets.

4.6 Summary of expectations for different stakeholders

The expectations, opportunities and challenges for the TPA for different stakeholders are summarised in the following Table 4-2.

Table 4-2 Expectations, opportunities and challenges of TPA for different stakeholders

Stakeholder	Expectations	Opportunities	Challenges
Heat customers	Lower heat prices New services Security of supply Ease of use Freedom of choice of heat supplier Maintaining the existing level of service	In theory, the potential for lower heat prices and faster implementation of new services increase as the theoretical level of competition increases. The freedom of choice of heat supplier is achieved in network access models.	In single-buyer models, it may be argued that the cost-competition concerns mostly the production companies rather than customer heat prices High TPA system costs may cause a risk of higher customer prices – especially in more complex TPA models. Complex TPA models can decrease the security of supply or service level if these issues are not properly addressed in the market model
Existing district heating companies	Ensuring the cost-competitiveness of district heating against the substitutes Ensuring the high security of supply Improving the public image of district heating Treatment of stranded assets	In case TPA is available to incentivise more low-cost heat supply , the production costs as well as production unit investments may be reduced TPA could potentially stimulate also the implementation of demand response. Improving the cost-efficiency in operation by finding synergies with the new entrants and thus, maintaining or increasing the market share of district heating	The implementation of TPA causes additional work and costs, which can impact the customer prices – especially if unbundling of distribution and production companies is required In the case of competition in production (potentially also retail), the optimisation of heat production, maintaining the balance as well as peak and reserve capacity cannot be imposed on DH company without fair compensation Potential overcapacity would need to be addressed
Third-party producers	Easier entrance to the markets Improved competitive position when entering the markets Higher profitability, low risks Ease of operation and good cooperation with the distribution companies	Suitable TPA model could better incentivise investments to utilise new heat sources TP producers income from heat sales can increase with some models	Even though TPA may increase the bargaining power of the new entrants, there is a possibility that the TPA policy does not make entering the markets attractive enough for new investments The market conditions are likely to be rather an oligopoly than sufficient competition The length of the contracts significantly affects the risk levels of the new entrants. Short tendering may be better in optimising the variable costs in the DH networks but cause high risk levels for the new entrants and may reduce the investors' willingness to enter the markets.
Society	Improving energy efficiency Decreasing environmental impacts of heat sector Opening existing infrastructure for competition and promoting free competition	Decrease in emissions and use of fossil fuels in case TPA succeeds in the implementation of renewable and waste heat sources better than today	Determining the optimal TPA model and level of regulation which would serve the benefits of all TPA stakeholders and would achieve the aims of TPA with minimum regulation

Source: Pöyry

5. CONCLUSIONS

Potential TP producers and level of competition

The results of the simulation in section 3 show that with the cost assumptions made, there are only few technologies that could compete with existing heat production in district heating networks. The only technology that is competitive in all of the analysed three networks (Small 50 GWh, Medium 500 GWh, Large 5000 GWh annual heat sales) is waste heat from either industry or from data centres. In the large fossil fuel based network, waste heat from the service sector, industrial-size biomass boilers and deep geothermal heat were also considered competitive. Deep geothermal heat may be a disruptive technology in the future, but it cannot yet be considered as proven concept. However, for district heating sector to benefit from these technologies, a change in market setup is not necessarily needed as DH companies can add these technologies to their production portfolio also today.

As most economically beneficial waste heat potential is already likely to be utilised, and there will be only a limited amount of new data centers in Finland, the overall level of competition arising from third-party renewable energy sources is likely to be low. In the biggest cities, it could be possible that some competition might arise from players investing in biomass boilers, but it is difficult to see why they would be able to produce heat with lower costs than district heating company investing in the same technology and having, due to economies of scale, a better position in the fuel markets.

Even if there would be large amount of players entering the market with waste heat based production, it is likely, especially in the cities, that a vast share of the annual energy would come from the base load plants of the district heating company and the impact on customer prices would be limited.

Additional costs resulting from the TPA

Additional costs borne by the district heating companies resulting from the TPA were estimated for three different TPA models. If production is unbundled from the distribution (model 2), the administrative cost burden for the district heating company is approximately 10 times higher than in simpler the TPA that resembles the current TPA model. With network access model (model 3) where producers can utilise the network to sell their heat production directly to customers, the costs rise about 20 % more.

These costs are substantial compared to other costs of the networks. For Medium network, the administration costs of a TPA model with unbundling requirement (models 2 and 3) increase the aggregate production costs by about 10-20 % and for Small network about 50 %. Only for the analysed Large network (5 000 GWh annual heat sales), the cost increase resulting from these TPA models may be considered moderate, in the range of 1-3 % of other costs. However, it should be noted that there is only one district heating network in this size range in Finland.

Potential benefits of applying different TPA model than today

Based on the additional administrative costs incurred by district heating companies under TPA models requiring unbundling (models 2 and 3) and the fact that most of the Finnish DH networks are of small size (median size ~50 GWh), it is clear that applying such TPA models for whole district heating sector in Finland does not make sense. Therefore, of the analysed TPA models, the model 1, which requires the least regulation, is the only one whose additional costs do not clearly outweigh the potential efficiency gains resulting from increased competition that implementing the TPA could even theoretically provoke.

The question remains, does the current TPA model based on voluntary bilateral agreements need to be changed? Setting up a market place for heat and having more transparent prices according to analysed TPA model 1 can be argued to stimulate more competition in the district heating market than today with only moderate additional costs and regulation. If the market place would be based on hourly pricing that would be passed on to customer level, there could be additional benefits achievable in the demand response and in the developed new services. However, already at present, district heating companies have started to implement demand response solutions based on normal market terms.

In some cases investments in production by third-parties would still need to be realised with long-term contracts to reduce the investment risks. In that sense the situation would resemble the model of today. Nevertheless, having more transparency in the market could in the long run induce new kind of services and technology development to the district heating market that could benefit all parties. The likelihood of such development is, however, not clear and it could be further discussed.

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