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Third party access to district heating systems - Challenges for the practical implementation

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ABSTRACT

District heating (DH) can become a key infrastructure for achieving climate targets in the heating sector. In order to support the uptake of renewables in the DH sector, the European Commission proposed to open DH infrastructures to third parties. This will allow independent heat producers to supply heat produced from renewable energy sources and from waste heat to consumers connected to the grid.

This paper develops a better understanding of the complexity associated with the introduction of third party grid access (TPA). We will analyse the heterogeneous institutional set-up of DH markets in the EU and discuss competition and market boundaries in the heat market. Based on this, the paper investigates the technical, regulatory and economic challenges that arise from the practical implementation of TPA. We conclude that TPA alone will not be sufficient to support the expansion of renewables in the DH sector. Complementary policy measures will be necessary to transform the DH sector towards 4th generation DH systems that will become an integrated element of a smart energy system.

1. Introduction

District heating (DH) can become one of the key infrastructures for achieving ambitious climate targets in the European heating sector (Connolly et al., 2014). The European Commission's heating and cooling strategy has recognized the potential for decarbonising DH through increased energy efficiency and renewable energy deployment (European Commission, 2016a). In order to support the uptake of renewables in the DH sector, the Commission proposed to open DH infrastructures to third parties (European Commission, 2016b). This will allow heat producers others than the incumbent DH suppliers to use the infrastructure and to supply heat produced from renewable energy sources and from waste heat to consumers connected to the grid.

There is a large body of literature on DH. Research covers the broad spectrum of technical, socioeconomic, institutional, legal and political characteristics of the DH sector. Literature highlights the important role of DH in the future energy system. For that reason, it is becoming increasingly important to develop strategies how to best transform existing DH systems towards the functionalities required by a sustainable, smart and integrated energy system (4th generation DH systems, e.g. Lund et al., 2014; Averfalk and Werner, 2017).

However, there is only limited research specifically addressing third party grid access (TPA) from a conceptual perspective. Specific investigations on TPA have been carried out for specific market conditions (e.g. for Sweden (Energimyndigheten, 2011), Germany (BKartA, 2012) and Finland (Pöyry, 2018)) and on rather generic TPA concepts (Korhonen, 2014, Söderholm and Wårell, 2011). However, TPA offers a much broader diversity of design options than described in the existing literature. Moreover, literature is lacking detailed investigations on the specific regulatory challenges that would result from opening DH systems for third parties. Finally, the definition of the heating market as well as the associated market boundaries need to be thoroughly assessed in order to evaluate whether and/or to which extent TPA would be beneficial with a view to a specific context of market framework conditions.

Our contribution is to better understand the complexity associated with the introduction of TPA in the DH sector. We will start with elaborating on the role of DH in the European heating sector, the diverse ownership structure in the main heating markets as well as TPA concepts in existing DH systems. Section 3 gives an overview of the methodology of our analysis. Since TPA in a grid-bound sector is generally justified by the fact that grid operation constitutes a natural

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monopoly, we will analyse competition and market boundaries in the heat market (section 4). This is necessary in order to identify under which market conditions TPA might be beneficial and to which extent TPA requires regulation. In discussing market boundaries we challenge the frequently held opinion that DH competes with other heat supply systems in a largely homogeneous heat market. In section 5, we will discuss different concepts how TPA in the DH sector could be introduced in practical terms. We highlight the fact that there are several design features which can be combined, leading to a much larger variety of different TPA design options than currently described in literature. This will be followed by an elaboration of the regulatory challenges (section 6) that are associated to TPA in the DH sector and that result from the specific characteristics of this infrastructure. This applies both to regulation itself and to its institutional set-up, i.e. the extent to which regulatory responsibility is transferred to a (independent) regulatory authority. We will finally discuss how TPA should be designed or combined with other measures in order to maximise its contribution to gradually transforming the DH sector towards 4th generation DH systems (section 7).

2. Background

2.1. State of DH in the European heat sector

The European DH sector has a very heterogeneous structure. Fig. 1 illustrates that the highest population rates served by DH can be found in Northern and Eastern Europe. By contrast, the DH penetration rate in Southern Europe is rather low, most likely due to climatic reasons. The relatively low importance of DH in countries like the UK, Ireland and France can be explained by traditions (focus on individual space heating solutions), but also incumbency. In former communist countries, DH played a significant role, but – in some regions – DH is losing market share due to a bad image and lacking investments in outdated systems (see e.g. Büchele, 2017). However, some Eastern European countries managed to maintain a dominant role of DH in their heating markets (e.g. Poland and the Baltic countries).

The share of renewables in the DH sector is varying substantially among Member States (Fig. 2). Only few countries have a share of directly used renewables (geothermal, biomass and waste) of more than 20% (Austria, Denmark, France, Iceland, Norway, Sweden and Switzerland).

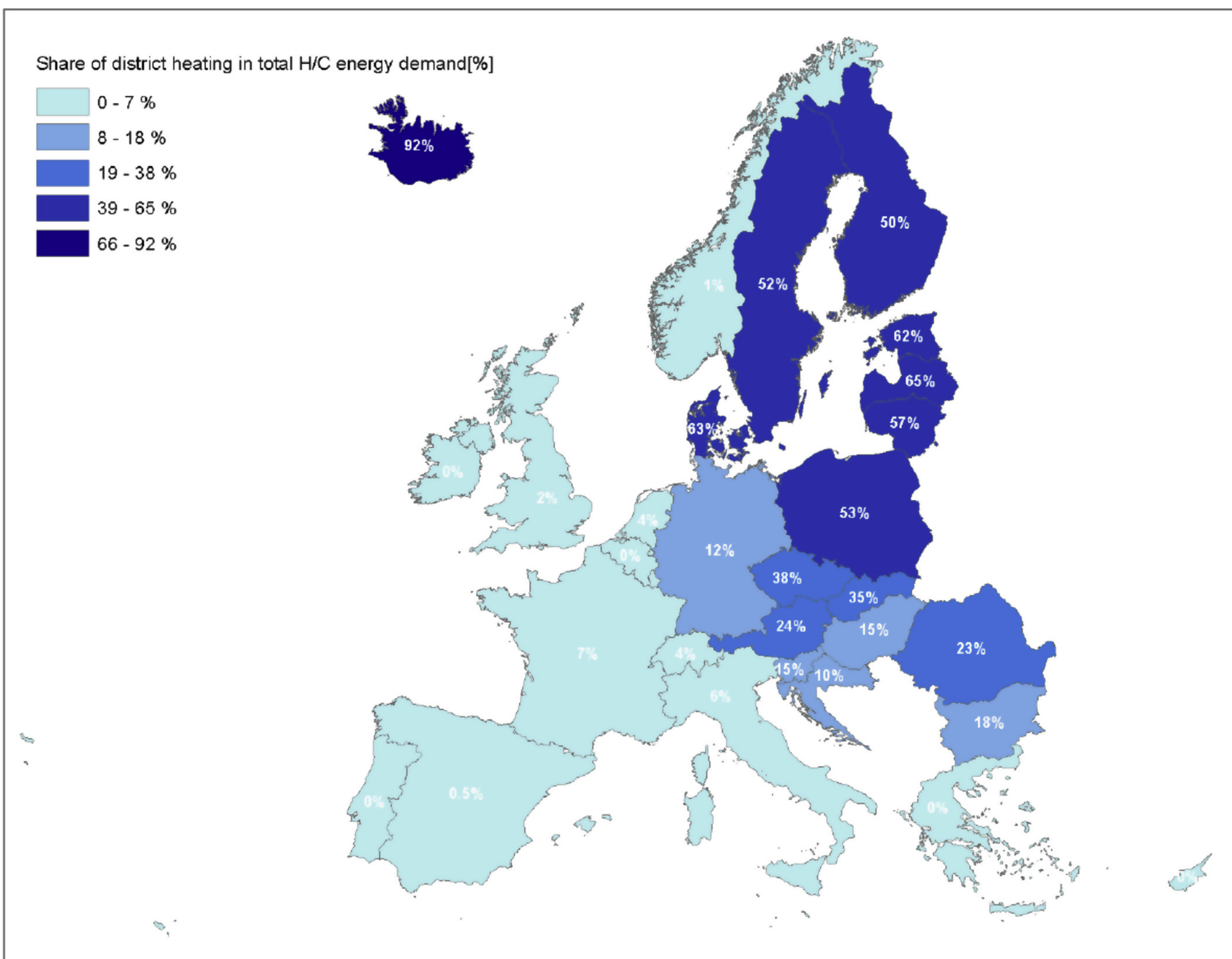

Fig. 1. Percentage of the population served by DH in 2013.
Source: Fleiter et al. (2016).

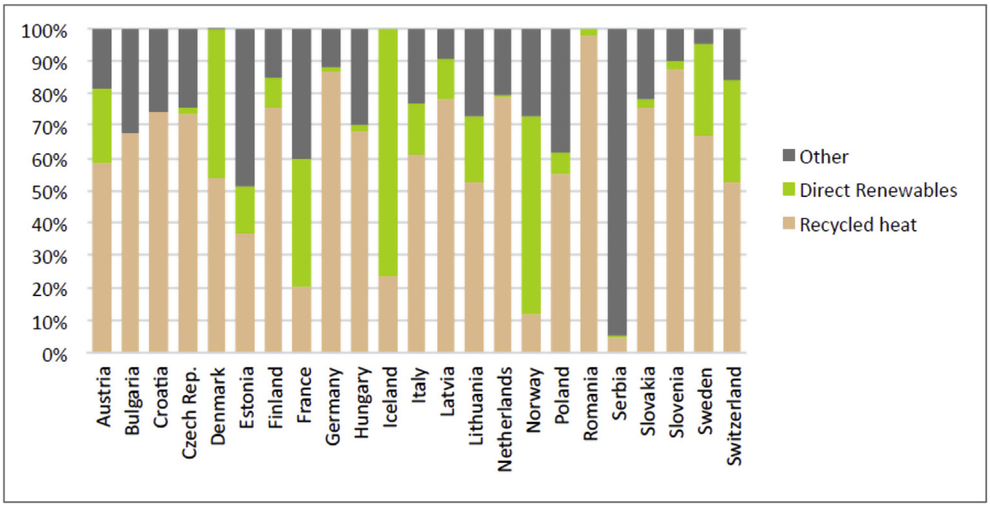

Fig. 2. Energy supply composition for DH in Europe.
Recycled heat includes surplus heat from electricity production (CHP), waste-to-energy cogeneration plants and industrial processes independently of the fuel used for the primary processes. Two thirds of the heat delivered by heat pumps is also considered as recycled heat.
Source: Own depiction based on EuroHeat and Power (2015).

2.2. Ownership structure in main district heating markets

The relevance of TPA as a measure to reduce costs for the consumer as well as to increase the share of renewables to a large extent depends on the framework conditions of the DH market in a Member State including the respective ownership structure. This section analyses and compares the ownership structures in Germany, Poland, Sweden, and Denmark (Fig. 3). Together, all four countries account for about 52% of all DH customers in Europe.

In Denmark, the Heat Supply Act has imposed a non-profit rule for the public heating market, which has largely affected the ownership structures of network operations (DEA, 2017). Grid operation and DH supply are either performed by consumer owned cooperatives or municipal owned companies (Fig. 4). The Danish Heat supply Act de facto has led to an unbundling of heat generation (mainly large generation units) and heat supply to the customers. Furthermore, for new investments, DH operators are required to conduct a comprehensive socio-economic assessment including the effect on heat prices and CO_2 savings.

With regard to the number of customers, Poland has the largest DH market in Europe. In 2016, about 430 producers and suppliers were operating on the DH market while the majority of companies are vertically integrated enterprises (URE, 2018). As regards installed capacity and ownership of network length, the majority of companies are from the private sector (URE, 2018). In Germany, the majority of DH companies are owned by the private sector, whereas in Sweden, 72% of the

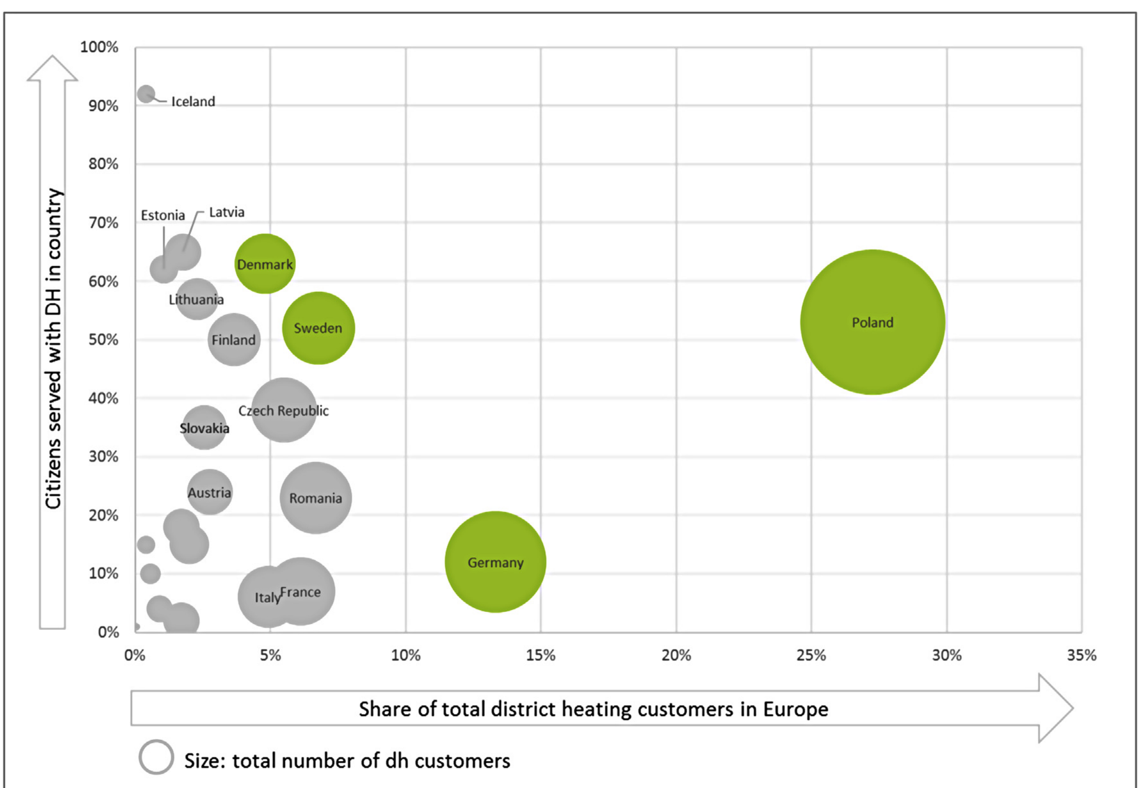

Fig. 3. DH customers by European countries.
Source: Own depiction based on EuroHeat and Power (2015).

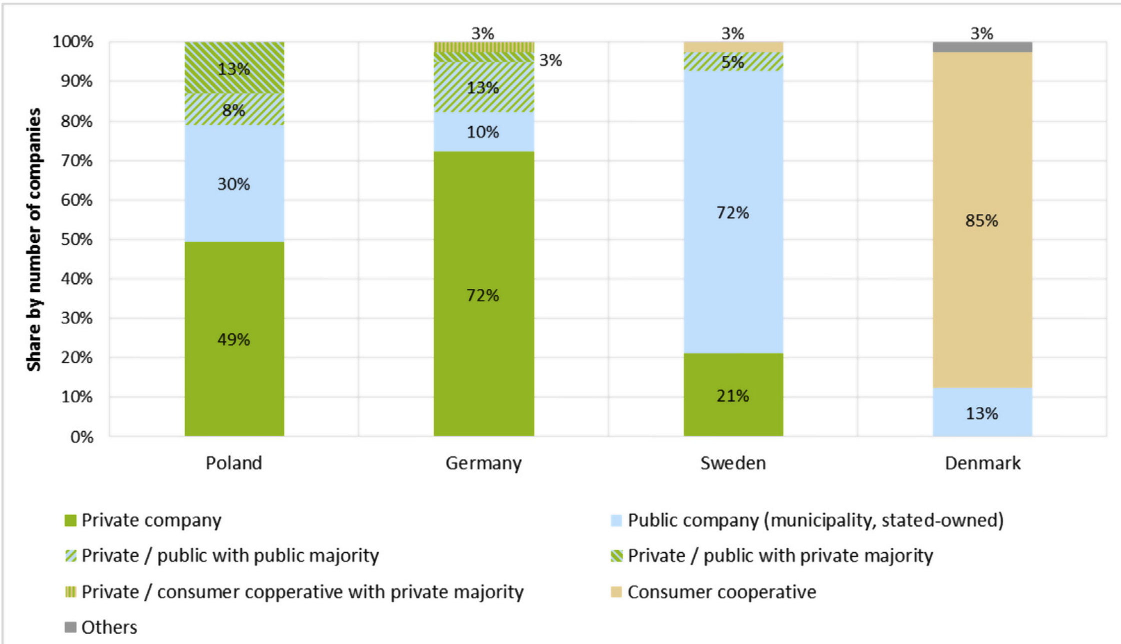

Fig. 4. Ownership structure in main district heating markets in Europe by number of companies (different base years, 2008–2016).
Source: own depiction, URE (2017), BKartA (2012); Magnusson (2016).

companies are municipal or state-owned (Magnusson, 2016; BKartA, 2012).

2.3. TPA in existing DH systems

Most Member States consider DH as an integrated infrastructure. The DH market is thereby considered as a natural monopoly requiring a vertically integrated supplier that is responsible for production and delivering heat to the customer (see section 4). With the exception of Poland, no Member State has introduced full TPA, which would allow independent heat companies (third parties) to access a heating grid in order to supply own customers. In Poland, however, the possibility of grid access is not used because regulations are too complicated and restrictive (Korhonen, 2014). Some Member States allow grid access on the production side (Producer TPA), whereby grid access is regulated. This applies, for example, to Estonia: When new heat production capacities are necessary, the grid operator is obligated to launch a public call for heat producers in order to determine the most cost-efficient offer (RES-Legal, 2019). In Latvia, grid operators are obliged to purchase thermal energy from all heat producers, including independent producers, provided the price is below a threshold, and technical conditions are met. The agreements between a heat producer and the grid operator have to be in line with the requirements set by the Latvian Energy Law. A similar system can be found in Lithuania (RES-Legal, 2019). There are some countries, in contrast, without any regulation for TPA, e.g. Sweden, Austria, and Germany. Here, grid access is negotiated between the parties involved on a completely voluntary basis.

As outlined in the previous section, Denmark pursues a different strategy. Here, the DH market is dominated by non-profit ownership structures, and legislation has a strong customer orientation. For that reason, policy makers do not see any necessity for an enforcement of TPA. Still, day-ahead heat plans are compiled based on bids submitted by different heat producers in the DH network of the greater Copenhagen region (DEA et al., 2015; Galindo Fernandez et al., 2016). Yet, the Danish case is not representative for the majority of DH markets in Europe where such legislation (driven by socio-economic goals) does not exist.

3. Methodology

The European Commission proposes to introduce TPA in order to support the uptake of renewables in the DH sector. Apart from this TPA would strengthen competition in the DH market. The level of required regulation is depending on the market boundary that is relevant for DH supply. We will discuss different options how the market boundary could be defined. We will analyse to which extent market functions (including competition, consumer choice, switching costs etc.) are working properly in view of different market boundaries, and whether different market concepts justify the necessity of TPA enforcement.

In order to classify different TPA concepts, we will start with a systematic review of concepts as described in literature. Following the typical structure of grid-bound utility markets (production, distribution/grid, and supply/retail) we will identify and discuss various TPA designs. Since the number of possible combinations of these design features is very large (thus the number of possible TPA concepts), this approach provides a significant contribution to a more systematic discussion about options to realize TPA in the DH sector and implications associated to it.

Grid-bound utility markets require a certain level of regulation, while opening such markets for third parties adds additional regulatory requirements. In our analysis, we will identify the areas that need to be regulated under different TPA regimes. Here, the focus is laid on the grid, mainly regulating the access to and use of the DH infrastructure. For different areas (e.g. allocation of costs to maintain and upgrade the infrastructure and for balancing and providing back-up capacities) we will discuss regulatory challenges and different options how these areas could be regulated.

As regards the implications of opening DH markets for third parties, we will focus on the question whether TPA seems to be an appropriate concept for transforming the DH sector towards more renewables (as well as waste heat). In this context, we will identify additional and/or alternative policy interventions that also aim at strengthening the role of renewables and waste heat. Here, we will extend the discussion on instruments that more broadly aim at transforming existing DH systems towards smart 4th generation DH systems.

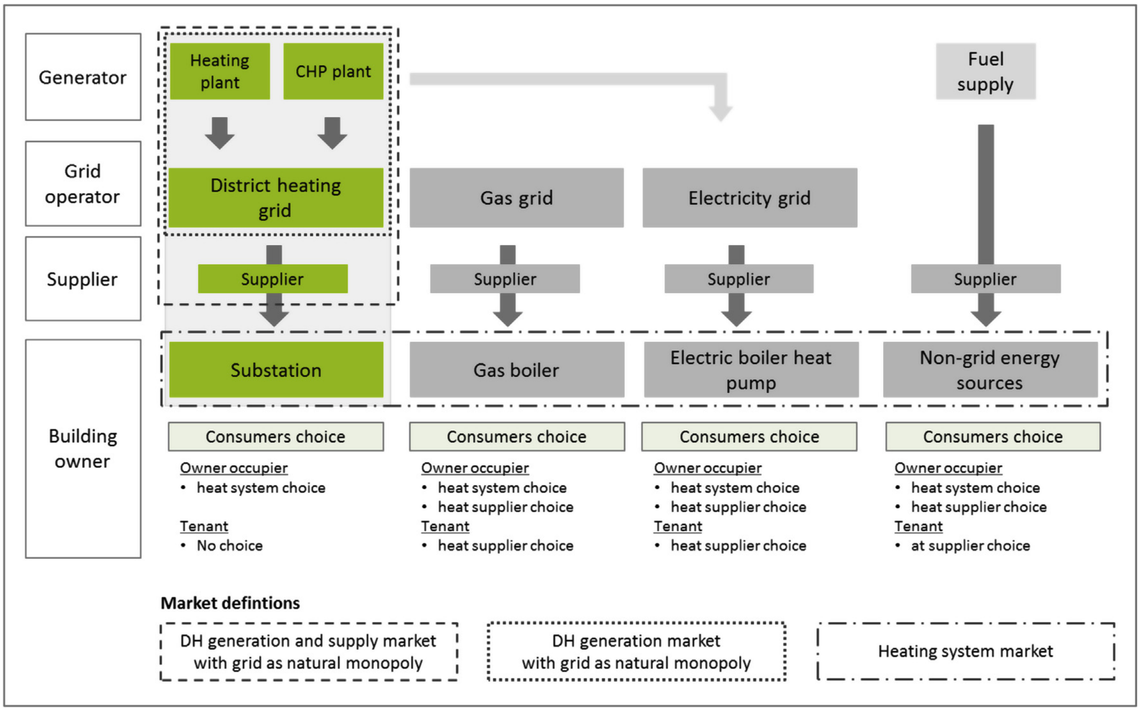

Fig. 5. District heating market definition.
Source: Own depiction.

4. Competition and market boundaries of the heat market

With its proposal for the new Renewable Energy Directive the European Commission aims at opening the DH sector for third parties (European Commission, 2016b). Although this is mainly motivated by supporting renewables and waste heat, TPA is also linked to competition policy and regulation. This is rather similar to other grid-bound sectors such as electricity, gas, and telecommunication. Elements and interventions with regard to competition policy apply to sectors whose structural conditions generally allow for competition but market functions are not working. Regulations, on the other hand, are required for sectors in which structural conditions are not compatible with competitive markets and only natural monopolies can operate (Motta, 2004). If DH as a whole or parts of the DH supply chain are considered as a natural monopoly, regulations, for instance on end consumer prices, are required in order to reduce welfare losses, whereas TPA is an element of competition policy.

Fig. 5 depicts different concepts of DH markets from a regulatory point of view. The grey shaded area defines DH production, grid operation, and supply as integrated infrastructure operated by vertically integrated suppliers.

- The dashed rectangle defines a market where only the grid is regarded as natural monopoly with potential competition on the market for heat generation and supply to the customer (as principally introduced in Poland).
- The dotted rectangle defines a market where grid operation and supply are held by the same company, while there is competition on the market for heat generation (as implemented in the Baltic States).
- The dot-dashed rectangle reflects the concept of a heating system market in which DH supply is competing with other heat supply technologies.

The respective market definition determines whether there is a justification or even a need for enforcing TPA or market regulations. In any case, the relationship between different market definitions and TPA concepts (as described in section 5) should be subject to further research.

Wissner (2014) concludes that a DH grid must be regarded as a non-contestable natural monopoly. A second grid operator in the same area would not lead to a reduction of distribution costs due to the fixed costs of the grid infrastructure and the minimum connection density that is required to achieve an economic operation. In addition, the costs for constructing a grid are sunk costs, thus, an essential barrier to the market entry of new competitors. As a consequence, price regulation is necessary.

While the grid can be regarded as natural monopoly, this does not automatically apply to the other elements of the supply chain, e.g. the production side. A second competitor does not face high sunk costs. While technical restrictions, especially for smaller grids, might inhibit an economic operation of more than one production unit, a competitive heat production market is generally possible in larger networks.

Considering that DH production and supply is not a natural monopoly, the main question is whether market functions are working properly to ensure competition. If DH supply is considered to be the relevant product market (dashed rectangle in Fig. 5), competition between different DH producers and suppliers needs to be enforced by the development of sound framework conditions for TPA.

The main argument against the need for more competition within a DH sector is that DH belongs to a heating system market (dot-dashed rectangle in Fig. 5) in which it competes against other decentralised heat supply options such as gas and oil boilers or heat pumps (Wissner, 2014; Lukosevicius and Werring, 2011). However, this argument can be thoroughly challenged for several reasons, which include financial constraints, constraints in the rental sector, and in the case of joint ownership, as well as multiple infrastructure ownership.

4.1. High upfront costs as financial constraint

The existence of a heating system market is only feasible if all consumers have the possibility to switch their heat supplier without major financial constraints and other market barriers. In theory this leads to competitive pricing of the heat delivery. Contrary to gas markets, where consumers can easily switch between different suppliers, switching from DH requires a replacement of the heat generation system, e.g. by replacing the DH substation with a gas boiler. Thus, the required investment for the new heating system might represent a significant financial constraint. In a functioning heating system market these financial barriers would be addressed by other market actors such as energy supply contractors that offer the installation and operation of decentralised heating technologies (Wissner, 2014). Other possibilities are leasing contracts for heating systems. However, energy supply contracting is not available in every European region and/or for each customer.

With regard to this question, one must bear in mind that building owners and consumers are a very heterogeneous group. This heterogeneity also has a large influence on the dynamics in the heating market and in particular on which heating systems are preferred. However, this aspect is not in the scope of this paper and is left for further research.

4.2. Constraints in the rental sector and in the case of joint ownership

Moreover, the definition of a heating system market as the relevant market boundary is not convincing since DH consumers are often not entitled to take decisions about the heating system. Only in owner-occupied single family buildings heat customers have full control over the decision about their heating system, whereas heat customers in rented buildings cannot replace their heat generation system since it is owned by their landlord. In such cases, the heat consumer is depending on the decision of the landlord. In multi-family buildings with joint ownership, often even a three quarter majority decision among all owners is required to change the heating system (Heiskanen et al., 2012). Moreover, in many buildings, especially in the case of self-contained central heating, a supply contract is usually concluded between a supplier and the resident of the apartment. While tenants are allowed to switch their gas, electricity or heating oil supplier, switching from DH to another energy source is not possible.

All these constraints are even more relevant since DH networks are usually built in areas with high heat demand density. High heat demand density is often given in areas dominated by multi-story residential buildings with either tenants or joint owners as heat customers which are, as shown above, heavily constrained in switching between different heating systems. For instance, in Germany about 81% of all residential DH customers live in rented dwellings, in which they may not decide about the change to another heating system (Destatis, 2014).

4.3. Multiple infrastructure ownership

Covering over 50% of the total final energy demand for space heating and hot water, decentralised gas boilers are the most common heat generation technology in the EU-28 (Fleiter et al., 2016). Very often, the installation of a gas boiler turns out to be the most cost-effective alternative to DH. In many regions municipal utilities operate both infrastructures – DH and local gas networks. In such cases competition between gas and DH markets is rather limited since the DH network operator decides whether access to a competing technology is granted.

Similar limitations can be expected if electricity for heating (e.g. by using heat pumps) is considered to be part of a heating system market. In a given city or region, utilities operating DH networks are often the same companies that operate the electricity distribution system. Thus, they can place a ban on the installation of a heat pump (e.g. on the grounds of constrained electrical networks). And they can influence a heat pump's profitability by limiting the availability of a low heat pump electricity tariff to regions where DH is not available. This limitation could be implemented by claiming regular (instead of lower) network charges for all power-to-heat applications in those areas where DH competes with these options.

If one considers the limitations on consumer choices, switching costs, as well as the multiple infrastructure ownership, a heating system market is not an appropriate market boundary for DH. Apart from the markets for different energy sources (DH, gas, electricity, non-grid based energy sources), other markets also have a relevant impact on the heating system choice. This includes the technology market for heating systems, the buildings' retrofit market, as well as the housing market. They all determine the availability of different heat supply options for consumers and their economic efficiency. Consequently, the heat sector can be described by multiple supply markets including the DH market instead of a pure heating system market.

Our analysis shows that a heat market concept that is defined by competition between different heating systems (heating system market) is not a valid argument against the necessity of TPA enforcement. The level of competition and market boundaries in the heat markets rather suggest that DH needs to be considered as a heat market by itself. Therefore, consumer rights need to be addressed by either enforcing competition (e.g. through the introduction of TPA) or by other means, e.g. legislations regulating the ownership structure and profit margins. In any case and besides the correct market definition, the complexity of the heat market makes a case for a minimum regulation standard which includes DH as well as other energy types.

5. Design features for third party access (TPA)

Up to now, there has only been limited scientific literature on third party access to DH grids. Two main sources are Korhonen (2014) and Söderholm and Wårell (2011). Both introduce certain terminologies and generic definitions of TPA concepts.

Korhonen (2014) describes the following concepts:

(1) **Network Access Model**: Producers have access to heat networks provided that they supply heat to their own end-customers, which could be new customers or existing customers of the – previously – vertically integrated grid operator. Although Korhonen (2014) indicates that this is currently possible under Polish law, "*it is otherwise practically never implemented due to its complexity*".
(2) For the **Single Buyer Model**, Korhonen (2014) distinguishes between three different approaches. These are:
  a) negotiated voluntary network access under which "*the DH operator and supplier*" (requesting grid access) "*determine, on a voluntary basis, how to set up the heat dispatch order to the DH network*". Thus, this is typically applied in DH systems that integrate excess heat from industry or from CHP, in case that the access heat is not owned by the DH incumbent company.
  b) negotiated mandatory network access with a clear obligation to grid operators to enable grid access. However, the (technical and economic) conditions for grid access still need to be negotiated between the grid operator and the third party requesting grid access. According to Korhonen (2014), typical examples for negotiated "mandatory" network access include mandatory rules for establishing regular competition (tendering), e.g. monthly auctioning in Lithuania or mandatory rules for network access for preferred heat sources (e.g. tendering for new capacity in Estonia).
  c) fully regulated network access, where the regulator determines ex ante access provisions for grid access. Here, the network operator is obliged to provide access to the network if these conditions are met by the heat producer requesting grid access. Regarding unbundling, Korhonen (2014) argues that "*in this model, it is usually important, or necessary, to unbundle the DH networks and production.*"

While for the single buyer model Korhonen (2014) distinguishes between different approaches as to how grid access of a third party (producer) is regulated he does not say anything about how supply to customers is organised. The distinction between the Network Access Model and the Single Buyer Model, however, implies that under the Single Buyer approach it is the single buyer who is finally supplying DH to customers regardless of whether third party DH production is involved or not.

Söderholm and Wårell (2011) distinguish between systems called "regulated TPA" and "negotiated TPA". Whereas "*negotiated TPA implies that the district heating network owners are required to negotiate about access to the network with the producers of heat*", regulated TPA refers to a regime "*where the network owner has a legal obligation to allow access to the network*" while the conditions for access to the network are negotiated between the network operator and the third party in advance (Söderholm and Wårell, 2011). In both cases, customers have the right to choose their own supplier. In the terminology of Korhonen (2014), both systems could be classified as Network Access Models. Moreover, Söderholm and Wårell (2011) describe single buyer models and a system called "extended producer market". The latter is a certain form of a single buyer model, extended by high transparency rules for all market actors. The idea of this model is that due to clear unbundling rules and high transparency requirements regulation efforts can be reduced.

At first glance, it seems logical to associate negotiated TPA with DH systems that operate under free market conditions while state intervention is minimal (e.g. Sweden, Finland, Austria and Germany). Regulated TPA appears to be suitable for DH regimes that are subject to tight regulation and state control (e.g. Denmark, Eastern European Member States). However, whether such assignment really makes sense, needs to be analysed in depth.

While we find the discussion of the concepts in above mentioned sources extremely valuable, we also see a risk for misunderstanding the chosen terminologies and classifications. In particular, we would like to draw attention to the fact that there are several design features which can be chosen and combined in multiple ways, opening up a large variety of options how TPA could be designed. Fig. 6 shows the different design features which we consider most relevant. They are structured along the supply chain from heat generation to the DH grid to the retail market. Whereas the design features listed in the second column can be clearly assigned to certain parts of the supply chain, the cross-cutting aspects listed in the third column have implications on all steps of the supply chain.

On the retail market, the first design option is whether consumers should have the possibility to choose between different DH suppliers, i.e. whether there is an open retail market with competing heat suppliers or not. Although this may be considered as a crucial design option, we would like to emphasize that TPA is also possible if it is implemented on the production side only, without opening the retail market. Thus, one of the fundamental questions is to which extent consumers' freedom of choice should be put at the core of a TPA approach, or whether the intention lies more on the heat production side to ensure economic (and renewable) supply of heat to the grid. The question whether the retail market should be opened also needs to be discussed in view of the wide range of system sizes in the DH sector. While competition on the retail level might be an option for rather large DH systems, it should be thoroughly evaluated above which minimum regional system scale opening of the retail level might be beneficial. We are not aware of any previous scientific work to identify such thresholds. One of the crucial criteria is the attractiveness of the number and/or size of customers to be supplied by an alternative DH supplier (or even several alternative DH suppliers). However, a detailed analysis of this question is not within the scope of this paper.

The second design option refers to the question of end-user price regulation. The neo-classical argument is that under a properly working retail market no price regulation is required. However, the question is to what extent there is really sufficient competition – even in an open retail market and taking into account the market boundaries and constraints as discussed in section 4. And of course, the question also depends on whether the heating policy in a municipality foresees zoning of DH priority areas. In such a case, as e.g. implemented in some Scandinavian and Baltic regions, competition might be restricted since building owners do not have the right to disconnect from the DH system.

On the production side, a crucial design feature is whether there is an open producer market or whether producers supply their own customers. The latter case is covered by an open retail market on the supply side as described above. However, if there is no open retail market, the producer market can still be opened (Producer TPA). In such a case, rules are required to determine the conditions under which the grid operator or single supplier has to purchase heat produced by third parties.

The next TPA design feature is whether there should be mandatory

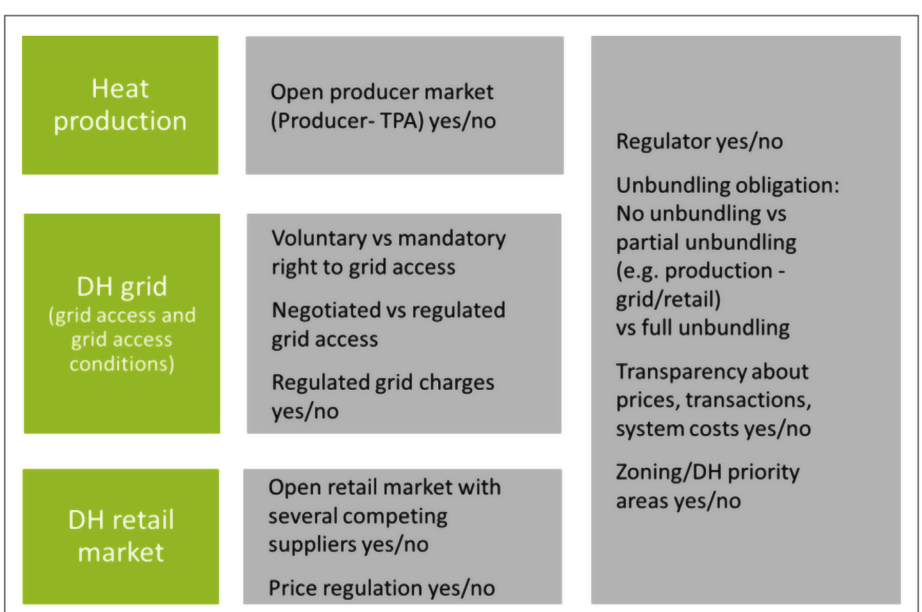

Fig. 6. Design features of third party access to DH.
Source: Own depiction.

or voluntary grid access. Voluntary grid access is occurring in many DH grids by integrating industrial excess heat. However, if TPA is aimed at opening DH systems beyond the limitations of voluntary agreements, introducing mandatory grid access is needed. Under mandatory grid access, grid operators would be obliged to grant grid access if certain minimum requirements are met. In the case of mandatory grid access, it could be left to the market actors involved to negotiate the specific grid access conditions (negotiated grid access), or grid access could be regulated (regulated grid access). In the case of negotiated grid access, unbundling is required to a certain extent in order to avoid a vertically integrated DH company misusing its predominant role and negotiation power. If regulated grid access is applied, the regulatory authority defines ex-ante grid conditions. If these conditions are met by a heat producer, grid access must be granted.

Regulating grid access also involves the question of how to determine the level of grid fees in a fair and non-discriminatory way. Here, different aspects need to be taken into account. This includes the contribution of a heat producer or consumer in stabilizing or destabilizing the DH grid as well as in increasing or decreasing supply and return temperature. Both can have a positive or negative impact on the overall efficiency of a DH grid. It is obvious that the effectiveness of this policy design feature also depends on the unbundling obligations within the whole DH system.

Four design features can be regarded as cross-cutting issues, which can have an impact on all levels of the DH supply chain and thus the effectiveness of TPA regulations:

- Firstly, the extent to which the DH system is regulated and whether or which of the regulatory tasks have been transferred to an (independent) regulatory authority.
- Second, the question to which extent unbundling of the different levels of the supply chain is required (no unbundling obligation vs. partial unbundling, e.g. unbundling of production and grid operation/retail vs. full unbundling of all three levels of the supply chain). As described above (e.g. in the case of negotiated vs. regulated grid access), the depth of unbundling can have a considerable impact on the effectiveness of a TPA regime.
- Third, mandatory transparency regarding prices, heat generation costs, number and amount of transactions etc. might be an essential instrument to implement a properly working TPA. The key issue is that a vertically integrated DH operator may have a substantial information advantage making it more difficult for new market entrants to join the market. Transparency rules are expected to improve this situation.
- Fourth, the design feature of zoning and identifying DH priority areas in which consumers are obliged to connect to DH under certain conditions (forced connection) is crucial for setting other design features. DH priority areas may strongly contribute to lower heat supply costs due to higher connection rates and thus higher utilization of the infrastructure. This is the reason why some countries, in particular in Scandinavia, have been implementing this idea successfully in the past decades. However, it is obvious that zoning is conflicting with consumers' free choice of a heating system. And in several cases it turned out to be politically rather difficult to restrict consumers' free choice. In any case, zoning or defining preferential areas might have an impact on other design features. In particular, price regulation might be required as competition on the retail level might be fundamentally limited.

Fig. 7 illustrates some of the key relationships and interdependencies between the different TPA design features. However, in reality the process of designing a regulatory scheme will never follow such a linear logic. The numerous interdependencies have to be assessed in an iterative process. The box at the bottom of the figure also highlights that there are several aspects to be considered in different types of regulatory regimes. This is the close link between price regulation and zoning as well as the close interlinkage of transparency rules, regulation efforts, and potential unbundling obligations. One of the conclusions that can be drawn from Fig. 7 is that some combinations of TPA design features are not recommendable. For example, mandatory negotiated grid access without unbundling will not work properly due to the market power of vertically integrated companies.

6. Regulatory requirements

The original Commission's proposal to introduce TPA provided that Member States should lay down necessary measures to ensure non-discriminatory access to DH for renewables and waste heat. This implies a mandatory approach to be taken, backed by appropriate regulation. Many of the aspects around TPA discussed in the previous sections translate into the question of how to best regulate the respective issue. The adaptation of the regulatory framework is challenging since opening DH systems for TPA will increase the complexity of the regulatory regime. If, by TPA, more parties get involved additional regulation is required to ensure fair and non-discriminatory market conditions for all system participants. But how much regulation is needed, and which system functionalities need further rules when opening a DH system?

The different areas that need to be regulated and the respective regulation depth depend on the specific TPA concept that is introduced (see above) and, of course, the design of the existing system. To a certain extent, regulation might be required on all three levels, production, distribution/grid, and supply/retail. For instance, if unbundling is not foreseen, rules need to be implemented that hinder an incumbent integrated grid operator to be too restrictive when independent heat producers apply for grid access. If the retail market is not opened, a certain level of price control (ex-ante or ex-post) should be in place to protect connected consumers against unjustified price increases. In addition to the regulatory rules, it must be discussed how best to enforce these rules. This is about the institutional set-up of regulation. In countries that do not yet have a regulatory authority, the introduction of TPA could call for a regulator. In countries that have a regulatory authority for the heating market, but which has little competences only, the role of the regulator might need to be strengthened.

While the production as well as the retail level need regulatory oversight, the regulatory focus lies on the access to and use of the DH infrastructure. Third party use of a DH infrastructure faces the overarching challenge of determining fair and non-discriminatory grid charges. This topic, however, goes beyond the scope of this article. Specifically related to TPA, as a minimum, the following areas need to be regulated:

- defining technical parameters to ensure the reliable operation of the infrastructure (grid code)
- allocation of costs to maintain and upgrade the infrastructure
- allocation of balancing costs, costs for back-up capacities including allocation of benefits such as flexibility/inertia benefits of the grid
- allocation of grid losses
- allocation of sunk costs

6.1. *Defining technical parameters to ensure the reliable operation of the infrastructure*

For TPA systems specific technical requirements for grid access and usage of the grid need to be defined. While general pre-qualification criteria might apply to all DH systems – these criteria could be set by the regulator – the specific technical requirements are specific for each DH system (e.g. depending on the layout of the infrastructure, temperature level etc.) and also depend on the specific location of the heat producer requesting grid access etc. Usually the technical requirements are defined by the grid operator. However, integrated grid operators might have an incentive to set up rather restrictive requirements in

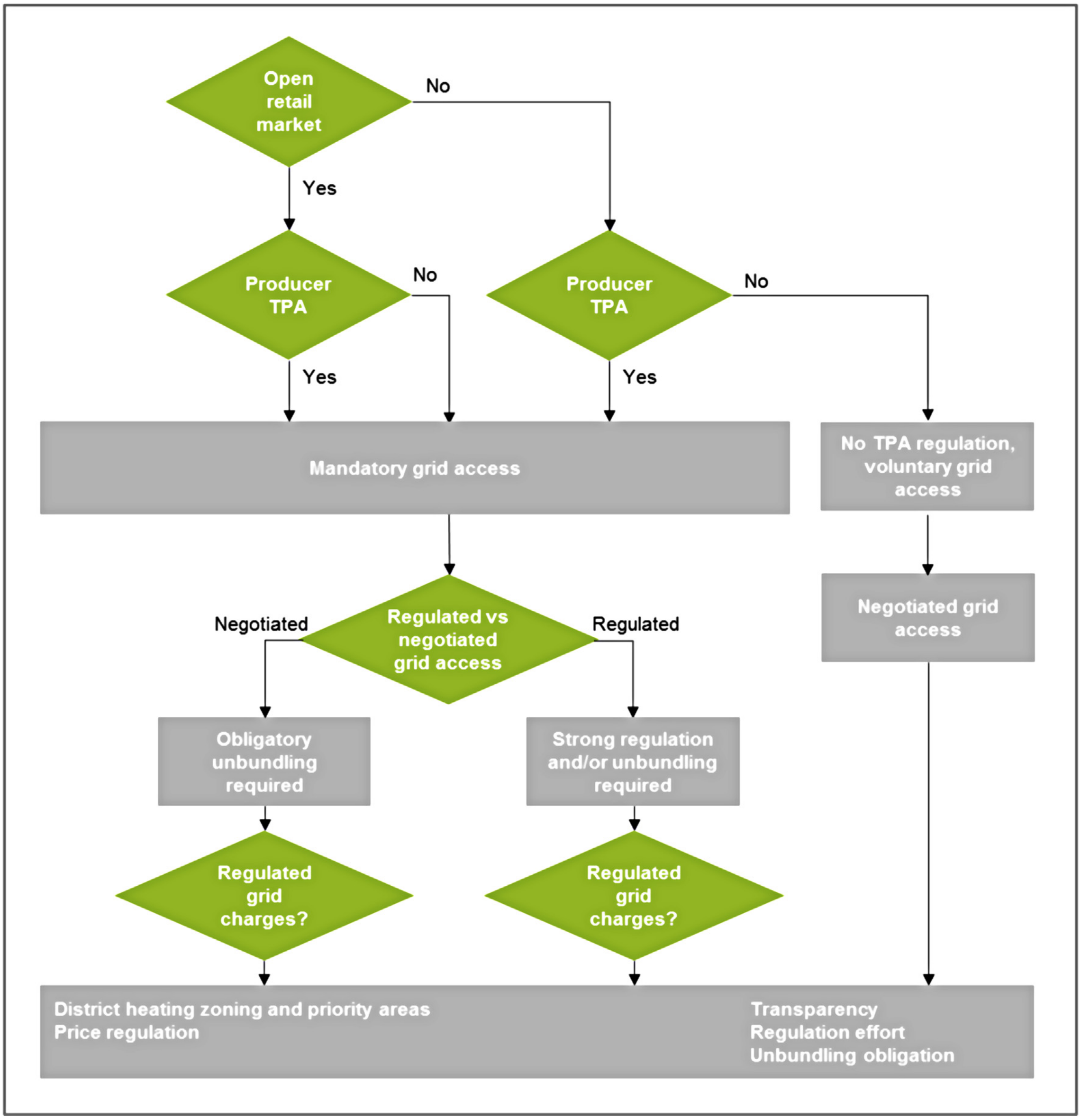

Fig. 7. Key relationships and interdependencies between different TPA design features.
Source: Own depiction.

order to increase the hurdle to get connected to the grid. TPA regulation needs to ensure that the technical requirements for grid access are fair and non-discriminatory (comparable to the technical connection conditions for the connection of a consumer to a DH system). Independent heat producers need to gain grid access on equivalent terms compared to the production plants of the integrated grid operator.

6.2. *Allocation of costs to maintain and upgrade the infrastructure*

TPA might gradually transform the topology of a DH system, which is rather centralised today, to a decentralised system with a variety of different heating sources with different characteristics of being connected to the grid. This change in the topology might require technical adaptations to ensure the technical performance of the grid. If for example a large waste heat producer, a large heat pump, or a large solar collector field apply for grid access, the layout of the grid needs to be adjusted to the new topology. It needs to be regulated which party will be required to establish the grid connection, to make the respective investment, and how to allocate these costs, e.g. whether such investments in the infrastructure have to be borne by the system participant who caused these costs (option 1). For instance, in Estonia, the operator of the plant applying for grid access is charged with the costs of grid connection (RES-Legal, 2019). As an alternative (option 2), these costs could be equally distributed among all system participants via the grid charges (Wissner, 2014). Option 1 can be justified by the cause-and-effect relationship if one argues that the party has to cover the costs that can be assigned to his activity. However, the existing infrastructure might already be stretched to the limit by production plants that were connected to the grid earlier. In such a case it would be the marginal plant (applying for grid access) to cover all costs that also other parties have caused. So it can be concluded that option 1 introduces a potentially severe barrier to new market entrants.

6.3. *Allocation of costs for balancing and backup capacities*

Despite the fact that DH systems offer a certain storage capability, and through that, flexibility between the load curves of supply and demand, it needs to be ensured that production meets demand on the required time scale. On the demand side for the load standard, load profiles will be used for small scale consumption in private households and small businesses (similar to the electricity and gas sector). For large consumers online load measurements will deliver the required data. The aggregation of all load profiles on the consumption side including the anticipated grid losses and the inertia/storage capability of the grid determine the required load curve of all production units feeding the DH system.

If parties other than a vertical integrated DH company use the grid, matching load profiles becomes more challenging since additional players need to be involved. Firstly, it is necessary to regulate who is responsible for load matching. Usually, this will be the grid operator, who needs to have access to balancing heat capacities (e.g. via own or contracted heat generators). Secondly, it is necessary to regulate who is responsible for providing backup capacity. Backup capacity is required for managing the risk that a production plant suddenly fails, for instance due to technical problems. Moreover, backup or reserve capacity might be required if weather conditions do not ensure sufficient heat generation by renewables (e.g. in the case of solar thermal heat). So far, in all DH systems with an open production market (Producer TPA) both system services are provided by the system operator.

For both system services it is necessary to regulate how the corresponding costs are distributed among the system participants. Costs that unambiguously can be assigned to one participant will need to be borne by this party. All other cost items, e.g. for providing balancing heat that cannot be clearly assigned to any actor, might be integrated in the grid charges. Under such a concept all system participants benefit from the flexibility/inertia benefits of the grid (mainly the heat storage capability of the grid).

6.4. Allocation of grid losses

Swedish DH systems are reported to have average grid losses as high as 12% (Vesterlund et al., 2013). The larger Austrian DH systems analysed by Böhmer and Gössl (2009) have distribution losses in the range of 7%–20%. According to Larsen (2002), heat losses in a DH network should be in the range of 10%. Regarding network losses, the position of the feed-in point within the DH grid topology can have a considerable impact. Costs associated to grid losses must be allocated among all system participants in a fair and transparent way, preferably via the network charges.

6.5. Allocation of sunk costs

If TPA stimulates many new heat producers (e.g. renewable heat producers) to access a DH system and if increasing demand within the DH scheme does not compensate for the additional production, existing (e.g. non-renewable) heat producers (e.g. operated by the integrated DH system operator) will be replaced by the new entrants. In extreme cases, this can lead to the bankruptcy of the DH company, whose generation unit is affected. This raises the question of whether there will still be sufficient generation capacity at all. In any event, capacity that is forced out of the market might lead to stranded investments if the replaced capacities was not fully amortised by then. Accordingly, the question arises of how to allocate the respective costs. Should the sunk costs solely be borne by the heat producer that was driven out of the market? Or should the sunk costs at least partly be allocated to the heat producer that caused these costs? The latter case leads to the question how to determine these costs in a transparent and fair way.

Most of the cost components described in the previous sections are generally integrated into the grid charges. This also applies to the costs resulting from grid losses that have to be distributed among the DH participants. TPA regulation must ensure that grid charges are fixed in a transparent, fair, and non-discriminatory way.

6.6. Impact on the uptake of renewable energy, waste heat and other climate mitigation contributions

Opening the DH sector for third parties increases the level of required regulation, especially, if unbundling was not implemented. This provokes the question whether the introduction of more complexity is justified by the anticipated benefits associated with TPA. In other words, TPA is not a value per se. Pros and cons, potential benefits and disadvantages need to be thoroughly evaluated. In theory, TPA can have an impact on many areas, including competition (production and retail), costs as well as the technology, and fuel mix of a DH system. In the following section, we will discuss TPA with regard to its potential impact on transforming the DH sector towards the 4th generation concept.

Isolated TPA, e.g. as foreseen in the original Commission's proposal of the new RED, mainly addresses a competition issue. If grids are opened to third parties without specific rules supporting renewables or waste heat, this mainly aims at strengthening competition on the production and supply side of the DH sector. However, there is no evidence that the lack of competition is one of the key barriers against the uptake of renewables or waste heat in the DH sector. So, TPA alone might not be sufficient for boosting renewables or waste heat, especially given the local scale of DH systems. Using the measure to support competition and trigger the uptake of renewables and waste heat at the same time would also go against the so-called Tinbergen rule, which is one of the key rules in policy science. Simply stated, the rule lays down that for every independent policy target there must be at least one complementary independent enabling policy instrument. If there are fewer instruments than targets, then some policy goals will not be achieved (Tinbergen, 1952; Turner, 1993). As the main purpose of TPA is to strengthen competition, additional/alternative policy instruments are required to boost renewables. Such policy instruments include

- an obligation for (integrated) DH suppliers to gradually increase the share of renewables or waste heat in their supply portfolio (quota, e.g. Seefeldt et al., 2011), and to ensure a minimum renewables share if a certain trigger is met, such as falling below a certain minimum efficiency level or exceeding a certain primary energy factor (Paar et al., 2013),
- an obligation to gradually reduce the primary energy factor or the GHG emission factor of a DH system,
- preferential TPA for renewables or waste heat combined with an obligation for (integrated) DH suppliers to purchase this "preferential" heat fed into the system at a fixed minimum price (similar to a feed in system), e.g. Veum et al. (2016),
- the introduction of mandatory tendering rules for renewables and/or waste heat when new capacity is required (e.g. to meet demand from new customers, to replace existing heat generation capacities),
- specific financial programmes to support renewables installations and/or industrial waste heat to be connected to a DH system (e.g. solar collector fields, large heat pumps), and to support the installation of new DH systems mainly fed by renewables.

It becomes quite obvious that TPA is not a key prerequisite when implementing most of these instruments. An alternative to directly supporting renewables or waste heat are measures that have an impact on the use of fossil fuels. Typical candidates of this type of measure are energy and carbon taxes, which are imposed on coal, natural gas, and oil. Energy and carbon taxes on fossil fuels increase the price of fossil fuel input and thus incentivise the use of renewables and waste heat, which are not subject to the tax.

The main purpose of integrating renewables and waste heat into DH systems is to decrease the CO_2 emissions of the heat supply. However, apart from the share of renewable or waste heat, there are a couple of other measures that contribute to the same target to gradually decarbonize the whole heating sector. On the one hand, this includes measures that are necessary to facilitate the integration of renewables and waste heat in the infrastructure. On the other hand there are measures that aim at the transformation of existing DH systems towards so-called 4th generation DH systems which become an integrated part of a smart integrated energy system (Lund et al., 2014). Measures to support both targets include activities to

- gradually reduce the temperature level in existing DH systems (transformation to LowEx grids), e.g. by implementing thermal energy cascades such as connecting low temperature customers to the return flow of a high-temperature DH system (e.g. Köfinger et al., 2017), and by reducing the temperature requirements at the demand side (see next point). Lowering the system's temperature increases the efficiency of low temperature heat sources from e.g. solar thermal or heat pumps (for heat pumps see e.g. DECC, 2016) and improves the potential for excess heat recovery of e.g. CHP plants (Rämä and Sipilä, 2017),
- lower the temperature level of the heating distribution systems in existing buildings, e.g. by replacing critical radiators (e.g. Østergaard and Svendsen, 2016), by installing floor and wall heating systems and by installing ventilation based heating, as well as the temperature level of the domestic hot water system,
- decoupling high temperature customers (e.g. industrial high temperature heat demand) from the system,
- lower grid losses by e.g. reducing grid temperatures, enhancing pipe insulation, improving control and introducing continuous monitoring of the system performance,
- strengthen the connection of the DH sector to the overarching energy system (mainly the electricity sector) by installing (seasonal) heat storage capacity, electric heat generation, DSM measures at the consumption side etc.

7. Conclusions and policy implications

The analysis of four key countries, covering more than 50% of the European DH sector, shows that today a considerable share of the sector is hold by vertically integrated, profit-oriented companies. While DH grids can be regarded as natural monopolies, competition could be introduced at the production and supply end of the DH sector. Given the different regional scales of existing DH systems, introducing competition on the production and retail level might be worth consideration at least for large scale systems (e.g. systems with a thermal capacity larger than 100 MW, a minimum network length of 50 km supplying more than 25 000 customers), and if customer rights are not guaranteed by other means, e.g. the institutional settings and ownership structure. A precondition for opening the DH market to competition is allowing third parties to use the grid infrastructure. Introducing TPA could be designed by a large variety of different options including voluntary and/or mandatory elements (e.g. voluntary or mandatory, negotiated or regulated grid access).

Pros and cons of different TPA concepts respectively certain design features strongly depend on the specific policy targets. If the policy target is to increase consumers' freedom of choice, the opening of the retail market would be essential. If policy is aiming at ensuring low consumer prices, producer TPA might be an appropriate measure. Finally, the degree of regulation (and associated costs) that policy-makers are willing to accept is also crucial for the decision whether mandatory and negotiated vs. regulated grid access should be implemented. While we discuss different TPA design features, further research should be dedicated to analysing the specific impact of these concepts in the context of different DH regimes, and in light of different policy targets.

In order to ensure fair and non-discriminatory market conditions, opening a natural monopoly needs to be adequately regulated. Given the physical and technical specifications of DH, TPA will add complexity to the regulatory regime, especially if unbundling is not implemented. For that reason TPA is only justified if there is an indication that the expected benefits will outweigh the impact of a growing level of complexity.

What are the expected benefits of TPA? In theory TPA could have a positive impact in many policy fields including competition, energy prices, greenhouse gas mitigation. The European Commission proposed the introduction of TPA in order to provide incentives for an enhanced use of renewables and waste heat in DH systems. However, while strengthening competition seems to be the primary impact of TPA, the impact on renewables and waste heat penetration might be rather limited. This particularly holds true if TPA is not combined with effective additional measures specifically supporting renewables and/or waste heat. Further research should be dedicated to the question how the policy mix should be designed as to effectively incentivise the transformation of existing DH regimes towards 4th generation, taking into account the heterogeneous framework conditions for DH in the different Member States.

Our paper contributes to the current discussion and scientific literature by putting the different concepts of TPA in the context of the European DH sector. Various questions remain for further research, in particular regarding the effectiveness and economic efficiency of TPA in view of different framework conditions. There is also a need for further research with regard to the question of how the heating market should appropriately be defined and to the relationship between different market definitions and TPA concepts. We also believe that a better understanding of the socioeconomic, institutional, legal, and political characteristics – in other words, the non-technical factors – of DH contributes to an improved regulatory policy framework for a future-proof, decarbonised, and smart DH sector.

References

Averfalk, H., Werner, S., 2017. Essential improvements in future district heating systems. Energy Procedia 116, 217–225.

Böhmer, S., Gössl, M., 2009. Optimierung und Ausbaumöglichkeiten von Fernwärmesystemen. Austrian Environmental Agency, Vienna Report REP-0074.

Büchele, R., 2017. Results of the quantitative assessment of selected policy packages for Brasov. Report in the Frame of the Project progRESsHEAT.

BKartA (Bundeskartellamt), 2012. Sektoruntersuchung Fernwärme. Bonn.

Connolly, D., Lund, H., Mathiesen, B.V., Werner, S., Möller, B., Persson, U., Boermans, T., Trier, T., Østergaard, P.A., Nielsen, S., 2014. Heat Roadmap Europe: combining district heating with heat savings to decarbonise the EU energy system. Energy Policy (65), 475–489.

DEA (Danish Energy Agency), 2017. Regulation and Planning of District Heating in Denmark. Copenhagen.

DEA, et al., 2015. District Heating - Danish Experiences. Copenhagen.

DECC (Department of Energy and Climate Change), 2016. Heat Pumps in District Heating. London.

Destatis (Federal Statistical Office and the statistical Offices of the Länder), 2014. Dwellings on Type of Heating and Type of Use of Dwelling for Germany. Zensus 2011 Available at: https://ergebnisse.zensus2011.de.

Energimyndigheten, 2011. Yttrande angående Fjärrvärme i konkurrens (SOU 201144).

EuroHeat and Power, 2015. Country-by Country Survey in 2015. Brussels.

European Commission, 2016a. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions (2016): an EU Strategy on Heating and Cooling (COM (2016) 51 Final). Brussels.

European Commission, 2016b. Proposal for a Directive of the European Parliament and of the Council on the Promotion of the Use of Energy from Renewable Sources (Recast). COM (2016) 767 final).

Fleiter, T., Steinbach, J., Ragwitz, M., Herbst, A., Hirzel, S., Krail, M., Naegeli, C., 2016. Mapping and Analyses of the Current and Future (2020 - 2030) Heating/cooling Fuel Deployment (Fossil/renewables) - Work Package 1: Final Energy Consumption for the Year 2012.

Galindo Fernández, M., Roger-Lacan, C., Gährs, U., Aumaitre, V., 2016. Efficient District Heating and Cooling Systems in the EU – Case Studies Analysis, Replicable Key Success Factors and Potential Policy Implications.

Heiskanen, E., Matschoss, K., Kuusi, H., 2012. Working paper: literature review of key stakeholders, users and investors. D2.4. Of WP2 of the Entranze Project. National Consumer Research Centre.

Köfinger, M., Basciotti, D., Schmidt, R., 2017. Reduction of return temperatures in urban district heating systems by the implementation of energy-cascades. Energy Procedia 116, 438–451.

Korhonen, H., 2014. Regulated Third-Party Access in Heat Markets: How to Organise Access Conditions.

Larsen, H., 2002. Aggregated dynamic simulation model of district heating networks.

Energy Convers. Manag. 2002 (43), 995–1019.
Lukosevicius, V., Werring, L., 2011. Regulatory Implications of District Heating; Textbook Developed for the INOGATE Programme "Capacity Building for Sustainable Energy Regulation in Eastern Europe and Central Asia".
Lund, H., Werner, S., Wiltshire, R., Svendsen, S., Thorsen, J.E., Hvelplund, F., Mathiesen, B.V., 2014. 4th Generation District Heating (4GDH). Integrating smart thermal grids into future sustainable energy systems. Energy 68, 1–11.
Magnusson, D., 2016. Who brings the heat? – from municipal to diversified ownership in the Swedish district heating market post-liberalization. Energy Research and Social Science (22), 198–209.
Motta, M., 2004. Competition Policy : Theory and Practice. Cambridge University Press.
Østergaard, D.S., Svendsen, S., 2016. Replacing critical radiators to increase the potential to use low-temperature district heating: a case study of 4 Danish single-family houses from the 1930s. Energy 110, 75–84.
Paar, A., Herbert, F., Pehnt, M., Ochse, S., Richter, S., Maier, S., et al., 2013. Transformationsstrategien von fossiler zentraler Fernwärmeversorgung zu Netzen mit höheren Anteilen erneuerbarer Energien.
Pöyry, 2018. Third-party Access to District Heating Networks. Vantaa.
Rämä, M., Sipilä, K., 2017. Transition to low temperature distribution in existing systems. Energy Procedia 116, 58–68.
RES-Legal, 2019. RES-legal Europe Database. available at: http://www.res-legal.eu/about-res-legal-europe/.
Seefeldt, F., Brandt, E., Bürger, V., Jacobshagen, U., Kachel, M., Nast, M., Ragwitz, M., Simon, S., Steinbach, J., Struwe, J., 2011. Fachliche und juristische Konzeption eines haushaltsunabhängigen Instruments für erneuerbare Wärme. Berlin.
Söderholm, P., Wårell, L., 2011. Market opening and third party access in district heating networks. Energy Policy 39, 742–752.
Tinbergen, J., 1952. On the Theory of Economic Policy. North-Holland Publishing Company, Amsterdam Books (Jan Tinbergen).
Turner, R.K., 1993. Sustainable Environmental Economics and Management: Principles and Practice, second ed. Belhaven Press.
URE, 2017. Energetyka Cieplna W Liczbach – 2016. https://www.ure.gov.pl/pl/rynki-energii/cieplo/energetyka-cieplna-w-l/7171,2016.html.
URE (Urząd Regulacji Energetyki, Energy Regulatory Office, Poland), 2018. Heat – Energy in Poland. (last access 2018-03-11). https://www.ure.gov.pl/en/energy-in-poland/25,Heat.html.
Vesterlund, M., Sandberg, J., Lindblom, B., Dahl, J., 2013. Evaluation of losses in district heating systems, a case study. In: Proceedings of the ECOS 2013 - the 26th International Conference on Efficiency, Costs, Optimization, Simulation and Environmental Impact of Energy Systems, July 16-19, 2013, Guilin, China.
Veum, K., Bauknecht, D., Brückmann, R., Bürger, V., Fouquet, D., Jansen, J., Pause, F., Uslu, A., van Elburg, J.C., et al., 2016. Study on the Impact Assessment for a New Directive Mainstreaming Deployment of Renewable Energy and Ensuring that the EU Meets its 2030 Renewable Energy Target. ("Mainstreaming RES"), Brussels.
Wissner, M., 2014. Regulation of District-Heating Systems. Utilities policy, pp. 63–73 31.