

1. Introduction

The ensuring of third party access (TPA) to the existing infrastructure and the establishing of working competition in previously monopolistic sectors have been at focus for academic, policy and public administration practice for a number of years. Particularly in the energy infrastructures, these efforts have been rewarded with significant market changes in electricity and gas sectors all over Europe, and beyond. The infrastructure of district heating (DH), which belongs to the family of energy infrastructures, has been addressed with challenges of TPA and competitive forces to a far lesser extent.

The academic literature keeps discussion over TPA, the potential of competition, the expected benefits and challenges of introducing competition into the DH systems. Nevertheless, the allegation that DH systems are not a subject to competition is still prevailing in energy policy and practice (Poputoaia & Bouzarovski, 2010).

In Eastern Europe, and in particular in Lithuania, the DH is of essential importance as a source of thermal energy supply to households. During the heating season the bills for DH are among the most significant items of average household spending, if not the most significant. In the aftermath of several major energetic and policy circumstances that fell in Lithuania back in 2010-2012, an essential regulatory and market structure change was introduced in Lithuania – the opening of the existing DH infrastructure for TPA and the introduction of competition principles for thermal energy generation and supply at the wholesale level with monthly price and quantity formation auctions under a single buyer model.

The essentially reformed regulatory and market structure has been working for 6 years by now, and the reform has brought major changes in the sector regarding the number of active market participants, the structure of fuels used, the thermal energy price, and the ownership concentration.

The objective of this paper is to analyze the regulatory framework and assess the impact of regulatory reform conducted in the DH sector in Lithuania. The regulatory reform of 2010-2012 aimed to implement third party access to the existing infrastructure so that the DH sector was more efficient and better responding to the economic and social circumstances. The regulatory reform focused on establishing a market model based on competitive principles, thereby employing a private initiative to respond to the challenges rather than improving the administrative processes dominated by municipalities. Taking into consideration the fact that the reform is not yet completed, the authors of the paper suggest further regulatory steps to complete the regulatory reform.

The academic and practical novelty of the work – the recent regulatory reform of the DH generation market is analyzed and the impacts of the fresh reform are assessed. In Lithuania the regulatory reform itself was designed to open up third party access to infrastructure and make the competitive forces challenge the previously secured municipal entities, albeit without duplicating the pipe system.

The main question of this paper is whether the competition is viable in district heating systems, having in mind all the technical and organizational constraints. Does the transition to competition yield any benefits to the consumers in the form of lower heat tariff? How does the abandoning of the monopolistic approach reflect in the energy planning possibilities and duration for an investment decision? As the paper presents the results of the actually implemented reform, it concentrates on pros and cons of the processes by comparing the real-life experience both in the monopolistic and competitive markets.

The practical applicability of this paper may be considered in terms of further reforming the Eastern European markets of countries under transition as well as reforming other municipal sectors which introduce market-based principles.

2. Literature Review of the Market Organization Scenarios

The DH sectors in Northern, Central and Eastern Europe function as very different models. A recent overview of 23 countries in the report “Development of concept for introducing competition in centralized heat supply in Ukraine“ (USAID, 2016) provides that within the existing diversity of the DH models there are some commonalities with regard to their openness-to competition. The currently observed practical DH models may

be systematized into 4 groups based on the criteria of openness-to-competition and the regulatory measures applied in the sector:

- Inter-sectoral non-intervened competition group – the DH companies make independent decisions regarding business models to be followed in their activities, including price set up. No intervention by regulatory institution. The competition authority monitors activities from the general standpoint of preventing anticompetitive behavior in the market. The DH service is competing against other available multiple heat sources. Under market pressure rule, the DH entities are forced to look for the most efficient ways to supply the DH service and remain competitive for the consumer, who is free to choose any other type of heating (e.g. gas or heat pumps). Sweden, Finland, Denmark, Germany, Austria, Belgium, France, and the United Kingdom may be allocated to the first group of the DH markets which are open for inter-sectoral competition and are not ex-ante intervened in terms of regulation.
- Inter-sectoral intervened competition group – the DH companies under this model may independently engage in their business in many aspects, under the competition with all other available modes to supply thermal energy, however, the pricing is predetermined by the rule of the major alternative. Namely it means that the domestic law over the DH activities provides that the price for DH service shall not be higher than the alternative price for the same amount of energy, if provided over electric heating (Norway) or natural gas based individual heating (the Netherlands). This rule of alternative makes pressure for the DH businesses to operate more efficiently than the major available alternative. This rule also gives some flavor of ex-ante efforts to protect consumer interest.
- Intra-sectoral intervened competition group – a regulatory ex-ante price control based on the established methodology and obligation for the DH entities not to surpass the approved maximum prices for thermal energy. A DH entity may deviate towards lower prices. The regulatory control of other aspects of the DH entity's operations differs from country to country. A DH entity may be engaged in competition with other DH entities either directly (through third party access system) or indirectly (through peer efficiency control regulatory mechanisms). Estonia, Latvia, Lithuania, Poland, the Czech Republic, Slovakia, Hungary, Bulgaria, and Macedonia.
- No-competition group – a full regulatory control over all the aspects of the DH entities' operations. The guaranteed monopoly position of a DH entity is complemented with full ex-ante price control according to the established methodology for tariff setting by the regulating institution. The regulating institution is intervening into investment decisions, personnel costs' setting, and other managerial areas of a DH entity; sometimes the regulatory institution is even involved in possessing cash in bank account of a DH entity (Ukrainian case). Romania, Belarus, Russia - may also be provided for this group.

The presented business models presume that DH companies are run as monopolies. Following the most recent literature reviews, it could be traced that the majority of research is positioning DH as monopoly also in the future (Sandoff & Williamsson, 2016, Ziemele, Cilinskis, & Blumberga, 2018; Sernhed, Lygnerud & Werner, 2018). The most obvious monopoly directions are sensed while debating 4th generation of DH or the concept of smart districts (Good, Cesena & Mancarella, 2017). For example, when describing the liberalization of DH in Sweden, the authors had in mind the privatization and transition from public to private ownership but not allowing broader degree of competition in the DH market (Magnusson 2016). Although the monopoly concept gives comfort in the controllable implementation of the energy planning process, the authors agree, that in this market setup the consumers have the most vulnerable positions. The consumers are forced to cover all the cost of inefficiencies that could accumulate in the DH companies over the period (inefficient processes, willingness to fully cover sink cost by delaying new investment, tendency for fuel (applicable for local fuels like biomass, peat supply chain monopolization). One of the main weaknesses of the monopoly which is rather overlooked in the DH research papers is the delay of investment decision made by the DH company. This behavior in monopoly markets is usually caused by the inefficient tariffing framework (or too long regulatory lag) that tends to penalize instead of incentivizing efficient management of the companies. Taking into consideration the situation of consumers and some inherited flaws of monopoly (tendency to stock inefficiencies under poor regulatory regime), the discussions have been started at the level of the European Commission Services on further development perspectives of district heating and cooling (Lund, Werner, Wiltshire, Svendsen, Thorsen, Hvelplund & Mathiesen, 2014; Volpi, 2018). Following the debate, the TPA to the DH infrastructure shall become an important regulatory policy development milestone in the DH sector.

From the increasing amount of publications over the practical experience, it becomes obvious that the issue of competition in district heating sector is gaining more attention (Gatautis, 2004; Söderholm & Wårell, 2011; Grohnheit & Mortensen, 2013). The broad discussions were carried out in Sweden whether the competition in district heating would lead to the higher efficiency and lower cost for the consumers. The investigation findings were presented in a number of reports (Åberg, Fälting, & Forssell, 2016; Broberg, Backlund, Karlsson & Thollander, 2012). The market liberalization discussions were complemented with debating on various options for the DH prices' regulation (Difs & Trygg, 2009; Li, Sun, Zhang, & Wallin, 2015; Sarma, & Bazbauers, 2016; Wissner, 2014).

The Danish model for integration of large-scale combined heat and power plants (CHP) and utilization of surplus heat in district heating systems on competitive grounds presents possible symbiosis of energy planning and some elements of competition. Each country emerged with different solutions for the DH competition that incorporated specific national conditions. As a result, the most successful one could be multiplied along the EU scale.

P. Soderholm and L. Warell in their paper (2011) have summarized and presented their view on the possible market organization scenarios regarding access to the existing DH infrastructure. Their focus was on introducing TPA to the DH network and applying the correspondent market organizational schemes. The regulated and negotiated TPA, single buyer and extended producer market models were discussed. Authors' systematic approach can be updated by adding holistic view on the DH market organizational possibilities. The figure below is drawn by the authors to visualize all the major DH organizational schemes identified by Soderholm and Warell (2011).

[insert Figure 1.]

The vertically integrated DH company owns generation capacity and transmission (distribution) system, it also performs the supply (billing) function. The consumers' connection to the grid is usually governed by the municipality level planning regulations.

The negotiated Third Party Access (nTPA) under Single buyer model is the second organizational DH system scheme, within which the DH company is still viewed as a monopoly with a right to buy thermal energy from the external producers. Usually those are surplus heat providers from industries located near the DH networks. Each time it is up to the DH company to decide and to negotiate the contract, but in any case, it is not mandatory for the company to connect the external heat producers to the grid. In typical cases, the contracts are settled if the price for the procured thermal energy is lower than the variable cost of own production.

The regulated Third Party Access (rTPA) under Single buyer model presumes that the DH company is obliged to connect the external heat producers. This DH organizational scheme requests full opening of heat generation market and a mechanism for all the connected heat producers to compete with each other in place. The effective unbundling of the DH company's functions - generation and transportation – are of key importance.

The full Third-Party Access (fTPA) is the last scheme for the DH market arrangement and it reflects the highest degree of market liberalization. The idea is that the DH network operator is seen as a “blind” heat transportation provider, and the full market opening is applicable to the generation part as well as to the retail (supply) part of operations. With analogy to natural gas or electricity markets, in this case a consumer would choose his heat supplier from the variety of market players. For this the most liberal setup to be implemented, a number of technical uncertainties must be clarified and settled up, such as the system capacity reserves, heat transportation inertia, balancing responsibilities, sufficient market scale, and other.

Summarizing the literature review, it could be stated that currently there are no cases describing the application of full TPA in real district heating systems. There is only theoretical discussion considering the possible TPA (or partial) introduction and the discussions considering forecasted effects on the technical and economic efficiency of the system. The purpose of this paper is to present the actual Lithuanian experience in the district heating liberalization under the rTPA model and to discuss further target models for heat generation market.

3. Preconditions for Competition in the Lithuanian District Heating Sector

The district heating infrastructure is well developed in Lithuania. The centralized DH systems deliver up to 70% of total heat for space heating and hot water preparation. Due to the historical level of penetration of the

centralized DH systems, the DH sector has become of high importance in technological, environmental and social terms. The discussions and decisions of how to enhance this sector have been on the political spotlight since many years.

In Lithuania, before 2010 DH was considered as a non-questionable monopoly. Essentially this infrastructure was managed by the municipalities as they were the owners of the DH companies after the first wave of reforms in 1996. A limited number of the DH entities were a subject to multi-year concession contracts concluded round 2000. In all cases, the municipalities retained their significant say in the DH infrastructure management through the procedure of granting Council approvals to the long-term DH infrastructure investment programs. It is important to note, that according to the Lithuanian legal framework, the approval by municipal council for a long-term investment program of a DH entity is the prerequisite for that entity to enter a long-term base price establishment procedure with the Regulator at the national level. A DH entity must present to the Regulator the long-term investment program approved by a municipal council, however, the municipal bodies are not effectively restrained with time limits for issuing an approval nor for the essential amendment to the proposed investment program. On the other hand, the Regulator is not mandated to revise the already approved investment program, and it further considers only those investment projects that have survived the municipal procedure. The dispersed administrative responsibility among three main players (municipal council, national Regulator, DH entity) over investment decisions could not provide a proper answer to the sharply rising energy source prices, as well as the consequently rising DH bills.

The decision to switch the DH sector to the competitive market model was taken by the relevant amendment of Law on Heat Supply back in 2010 (Law). It was expected that a private initiative would act more quickly and efficiently with investment decisions in the given circumstances than the efforts to improve the administrative inefficiencies; the private newcomers were not obliged to enter the municipal procedures over long-term investment programs. The context for the Lithuanian decision to establish the competitive market structure in the DH generation included economic, social, and global market development considerations. The authors of this paper identify the following developments as the most important to reform the DH sector (the list is not exhaustive):

- Municipalities were locked in indecisiveness and demonstrated reluctance to approve investments into infrastructure in general, and into generating capacities over renewable energy sources (RES) in particular. The projected changes in the DH price was the reason of this reluctance to approve new projects. Therefore, the introduction of independent heat producers (IHP), which could decide by themselves on investment projects, meant that municipalities, as the owners of the historical DH companies (incumbents), would start feeling competitive pressure and would be forced to move forward timely investment decisions;
- DH companies postponed investment decisions due to the lack of motivation or willingness to secure the EU support. The delay in using the EU support for partial financing of investment projects resulted in lost opportunities for the consumers to receive heating services under lower cost;
- Global trend of rising prices for natural gas and the DH sector's overall dependency on natural gas requested changes in fuels' structure and quick investment decisions;
- Significantly lower prices for biomass and high potential availability of local biomass suggested a way-forward with investment into generating capacities to make the switch from gas to RES, in parallel creating new jobs locally in the context of economic downturn (the global crisis of 2008);
- Lithuanian strong "anti-Gazprom" policy campaign, started back in 2009, seemed to encourage all the diversity of actions to reduce consumption of natural gas, including massive DH switch to RES;
- General concept of competitive energy environment was "flavoring in the air" at that time, imported with the EU 3rd energy package and supported by the recent successive competitive reform experiences from other infrastructure sectors of the state (electricity and gas).

In 2010 Lithuania made a daring step towards the DH development via introducing the concept of competitive market in district heating, i.e. market liberalization. The introduction of competition in the DH market in Lithuania was a political move to shift the behavior of the stagnating management of the DH companies and mitigate sector's severe demands on gas as merely the only fuel option.

The introduced amendment of the Law on Heat Supply (Law) has enabled the implementation of rTPA under Single buyer model. The DH companies were obliged to connect alternative heat producers to the existing grid and to buy heat from those IHPs. The development and supervision of the entirely new market setting was dedicated to the National Regulatory Authority (NRA). The rules on connection of heat producers to the grid, the non-discriminatory procedures of sharing the grid by all parties, the mechanism of purchasing thermal energy under competitive basis, as well as the price-ceiling setting mechanism were established.

4. Design of Regulatory Framework

The amendment to the Law on Heat Supply (Law) was adopted to introduce the regulated TPA and to open up the sector for competition in the DH generation segment. In particular, the amendment of 2010 to the Heat Supply Law provided: “District heating suppliers purchase heat from independent heat producers, when the heat is generated using renewable energy sources, incinerating waste, using fossil fuels, if the heat meets requirements of quality, reliability of supply and environment. The National Commission for Prices and Energy Control establishes terms and procedure to purchase heat from independent heat producers. The National Commission for Prices and Energy Control, while establishing the terms and procedure to purchase heat from independent heat producers, shall take duly into account the principle of ensuring working competition in heat generation, the principle of stimulating utilization of renewable sources and residual (waste) sources, and the right of consumers to receive heat at the lowest cost. In all cases, the heat, purchased from independent heat producers, cannot be more expensive than the comparative production costs of the heat supplier.”

Following the new amendment of the Law on Heat Supply, NRA was mandated to develop a conceptual regulatory model and a relevant regulatory framework to implement the strategic concept of competitive market in district heating and to spin-up the working of this competitive DH market in Lithuania. The conceptual regulatory model of competitive market was based on the following pillars:

- the ensured technical abilities for newcomers to enter the market and to stay in; as regards the technical side, NRA developed and approved the Network Access Rules (Grid-Code), which provided terms and conditions of connection to the grid and operating connected under the non-discriminatory rTPA scheme. The Grid-Code was adopted in 2013, and as a result, all the IHP were granted with the right to be connected to the existing DH network. The rTPA on technical part was established;
- the economic model of competitive market functioning. While developing the economic model, it was essential to design an instrument of thermal energy purchases by the single buyer, and to construct it in such a way, that the final result, at least would not increase the system price of thermal energy (as if it was generated by a single monopoly entity), and at the same time would make significant pressure over the incumbent generator, in case they were not efficient enough. The core item of the model was the wholesale price setting algorithm. The economic model however had to ensure the technical reliability of the entire system and the security of supply to end-users. The economic model is discussed in detail below;
- the effective working mechanism of *ex-ante* supervising the competitive processes, market powers exercised by individual entities and anticompetitive practices in the market, if any. In 2010 NRA adopted the Rules on market analysis, which were to be followed to assess the exercised market power by participants of the given market. In 2010 NRA adopted the Dispute resolution procedure, to be used when investigating complaints of market participants on each other’s behavior. The Rules and procedures of purchasing thermal energy from IHPs, adopted by NRA in 2010, provided clear requirements on transparency, i.e. the keeping and the public access to information over all bids, organized by a network operator, in terms of participants, prices, quantities, contracts concluded, etc. The mechanism of supervising and *ex-ante* intervention, if reasonably needed, was established to ensure a non-discriminatory access of all market participants to the opportunities offered by the competitive market model.

The price setting algorithm and heat procurement procedures have a great number of possible scenarios of implementation. Few could be named: competition in the market (usually there is an auction for providing the service or product for a defined period of time, day, month or year) and competition for a share of the market (usually competition takes place for installing and operating equipment at the initial moment when the most competitive proposals are ranked). In Lithuania the monthly auctions were chosen for the DH market by NRA, and it was approved by the relevant resolution of the National Commission (Resolution, 2011). The main reason to choose this monthly-auctions’ approach was the need to create a dynamic system, which is able to

adjust to the required changes and to correct the potential deficiencies in the shortest possible timeframe. The consideration, supporting the expectation that monthly auctions would enable dynamic improvements in the shortest timeframe, was as follows:

- A monthly auction ensures the highest pressure towards price reduction to actual production cost;
- The monthly auctions could better reflect the changes of fuels' market, which is important when it has a high rate of dynamics;
- One month period causes rather adequate period for the auction losers to review their bidding strategies and enter the market next month. In case of half a year, one year or longer periods, losing the auction would most probably mean exiting the market permanently;
- Fixing long periods for private investors' operations in the DH systems had limited political support, if any.

It is to be underlined that in Lithuania the opening and liberalization of the DH market were implemented under the two-phased approach. The approach was designed recognizing the major need to ensure the reform to move without temporary negative effect to status quo on consumer-price and reliability of service supply. The phases of implementation of the reform were the following:

- The first phase (transitional) – a gradual transformation from monopoly to the liberalized market using the single buyer model for generated heat procurement, and safeguarding cost-coverage for the incumbent;
- The second phase (target model) – a fully liberalized market structure with market players competing on full price offers, including the incumbent.

The decision on the approach of the two-phased market opening was taken by the National Commission, based on a number of regulatory considerations, some of which are provided below:

- The security considerations: the security of supply to consumers, non-interruptability and resilient functioning of the entire technical DH system were the prevailing warranties while designing the change;
- The consumer concern: the experimental DH sector transformation process could not negatively affect consumers from the financial point of view, otherwise the process could be stopped externally – the rise of prices, even temporary, was to be avoided at any effort;
- The limited or no competition to start with: merely no competitors or new entrants were on board at the beginning, and time was needed to build capacities and start operating. Until the working competition developed, the market design had to support the security consideration and consumer economic interest;
- Trusting a new framework by investors: time was needed for potential investors to “buy-in” the new system, and start trusting the regulatory system's separation from the political cycles as well as its predictability and credibility.

It must be noted, that the communication of the National Commission with the market players and other stakeholders on the two-phase approach was provided from the very beginning of the discussions on the forthcoming market reform. However, there was no determined date or timeframe when the first (transitional) phase was to be ended and the second (target model) phase was to be implemented. The non-clarity over the term was due to the prevailing understanding that the technics of market mechanism of the transitional phase needed continuation until the working competition enabled a seamless switch to the target model phase (Biekša, 2015).

The technics of the market mechanism under the transitional phase worked as follows. The price signal in the market was formed as a freely established price from the bids of IHPs. The monthly auctioning procedure was organized by an incumbent (a DH network operator). The announcement of next month's forecasted amount of heat to be produced and supplied to the consumers was obligatory before the auction was announced. The incumbent calculated how much one MWh would cost if the entire amount was produced using the incumbent's own generation capacities, and the average variable cost for producing 1 kWh of heat was established. This variable cost was used as a ceiling price for the auctioning procedure. The IHPs could not bid for a price higher than the average variable cost of the incumbent for the next month. This mechanism safeguarded the economic interests of consumers.

After the projected amount of heat was identified and the variable cost as the ceiling price was announced, the IHPs presented their bidding offers. In a bid the IHP provided the amount of heat and the price for the amount. All the bidding offers were collected and ranked from the lowest to the highest price. The offers with the lowest price, while not exceeding heat demand, would be accepted. If several bids had the same price and could not be accumulated into the projected demand, the further ranking established priority according to the origin of energy generation – biomass/waste CHP, biomass boilers, waste heat suppliers, efficient CHP and finally fossil fuel boilers. The incumbent was granted with opportunity to bid its own thermal energy by individual capacity units at the same terms (i.e. below reference price); if the incumbent made a bid with his unit, the constant cost was remunerated via tariff.

At the beginning of the market opening, only few IHPs were operational. Thus, the production capacity of the incumbent remained in heat tariff and the cost covering was guaranteed. The incumbents had obligation to produce heat in the amounts that were necessary to cover full heat demand if the heat produced from IHPs were not enough. The capacity reservation and balancing functions were left with the incumbent and were reimbursed as monopoly services due to the security of supply reasoning.

The model of transitional phase had the following advantages:

- The security of supply was ensured to full extent;
- The consumers' economic interest was safeguarded, and the price during the transition was not higher than without the market opening process;
- The IHPs were granted with real opportunity to enter the market and access the network;
- The composition of fuels used for the thermal energy generation had changed significantly towards the usage of biomass and alternative fuels;
- The concentrating focus on the DH companies' managerial decisions and the active involvement of a municipality.

The model of transitional phase had the following drawbacks:

- The unequal competition conditions for the incumbent and newcomers resulted in partial pressure for efficiency for the incumbent and the delayed growth of market share of IHPs;
- The existence of the transition phase implied additional risk that investors might behave cautiously and might not enter the market (doubts considering the introduction of phase two).

The first market opening phase had the specific context of the Lithuanian fuels' market back in 2010-2012. The DH market opening started at the time when the conventional DH fuel prices were sky-rocketing. Figure 2 presents data on the dynamics of prices for natural gas, biomass and heat since 2010.

[insert Figure 2.]

In 2012, when the development of the regulatory framework took place, the natural gas price was at all times' top. At that time the competitive fuel biomass price levels were times lower (biomass was 2.8 times cheaper than gas). This significant price difference was convincing that a regulatory setting of variable cost, as the price capping limit for the monthly auctions, would still generate positive financial results for biomass generators and present sufficient attractiveness for new investments to enter the market.

The reference price at the level of variable costs of the incumbent creates the unequal competitive conditions in the market with the incumbent at a better-off situation. The logic behind this setting was that this inequality might be tolerated until there were still sufficient market drivers for the new independent heat suppliers to enter the market, namely the substantial fuel price differences and low concentration of IHPs in a particular DH system. As soon as the fuel price differences diminished and IHPs took over a significant market share in the particular DH system, the competitive conditions needed to be made equal for all the market participants and the phase two of market opening needed to be started.

To summarize, in Lithuania the regulatory framework of the DH market opening was designed as a two-phased process. The first transitional phase incurred the heat procurement model under the condition of IHPs generated heat price to be lower than the reference price for heat produced by incumbent at the level of its variable costs. The second - the target model - phase was to be started when the sufficient market liquidity levels were reached, and the phase implied competition at full cost for all the market participants. In Lithuania the first phase has

continued since 2010, and the second phase is forecasted to commence on January 1st, 2019. The concept of the second phase is presented further in this paper.

5. Implementation of Transition from Monopoly to Competitive Market

The implementation of the designed market opening during the transitional phase and the practical implications caused by the process are presented over two examples, i.e. the market openings in Kaunas city DH system and Klaipėda city DH system. Kaunas city DH system is analyzed in sub-section 5.1. and Klaipėda city DH system is analyzed in sub-section 5.2. below. The key findings of the DH market opening practice are provided in section 5.3.

5.1. Kaunas City DH System's Transition to Competitive Market

Figure 3 presents the basic information on the market opening in Kaunas city DH system. Kaunas DH system is the second largest DH system in Lithuania. The peak load capacity accounts for 442 MW (in 2016), the total pipe line length is 400 km, the annual heat consumption is 1097 MWh (2016), the average annual heat losses in the DH network equals to 16 % (2016 data). Back in 2012 the municipal DH entity in Kaunas city owned 398 MW of heat generation capacity and it was complemented by IHP KTE (CHP power plant) capacity for covering the peak loads and securing the reservation. Historically, the DH system in Kaunas city was fully vertically integrated and included CHP as an integral unit; after 2003 the privatization of CHP until the market opening in 2011, the functioning of Kaunas DH system and CHP was very alike as it was before the privatization, with CHP supplying to the DH system about 93% of all the thermal energy annually.

The opening for competition was a turbulent process. Due to the high natural gas price and relatively cheap biomass fuel, the investments in heat production units yielded considerable returns in a short period of time. However, there were doubts among investors regarding the market organization stability in the future in terms of the existing competition conditions and the regulatory policy readiness or willingness to enter the second phase of market liberalization. The first investors that managed to construct their plants and start operations were able to enjoy rather fast paybacks of their investments due to high price ceiling and the lack of competitive pressure in the market. Much more new investors flushed in immediately afterwards.

[insert Figure 3.]

Figure 3 was developed by the authors of the paper to demonstrate the development of prices in the context of the intensifying competition in Kaunas DH system. Authors used the data publicly available at the website of the Kaunas DH entity "Kauno energija" (Kauno energija, 2018) and at the website of NRA (VKEKK, 2018^p). Looking at the process chronologically, in 2012 in Kaunas DH system only one IHS KTE was operational. Starting from 2013 two new IHSs entered the market adding total 33.3 MW of heat generation capacity. In 2014 three new IHSs built their capacities adding 75 MW. In 2015 only one IHS entered the market with 20 MW. And the last entry to the DH market was observed in 2016 when 3 new IHSs become operational and provided additional 73.7 MW. Currently in Kaunas DH operates 10 IHSs. The accumulative capacity increase during the period of 2013-2017 was equal to 202 MW when the peak demand of the system reached 442 MW.

In Figure 3 scale x is a time line as axis Y corresponds to the amount of heat produced in MWh (primary axis) and heat price in ct/kWh (secondary axis). The columns on the diagram represent the amounts of heat that was produced during a particular month. The dark shaded column indicates heat that was produced and sold by the IHPs as a lighter colored column shows heat produced by the municipal DH entity. The upper punctual line shows monthly DH price for end users (final tariff). The continuous line represents the reference price (variable cost of DH entity). The dotted line indicates monthly weighted average price set by the IHPs via monthly bidding. In other words, the continuous line presents the cost level for heat production in the municipal DH entity generation units and the dotted line provides the cost level that is transferred to the consumer by buying heat from IHPs rather than producing it by the municipal entity itself. To summarize, the accumulated difference between those two lines indicates the benefits that the liberalized market brings to the final consumer if compared to the monopoly situation. During the 2013-2017 period the difference between the heat procurement price and the municipal DH entity's own generation cost accumulated total benefits of 25.3 mill. € to final consumers served by Kaunas municipal DH system.

At the very beginning of the market liberalization, true competition was observed among IHPs, as the incumbent's fixed costs were remunerated by a regulated tariff. Under this model, during the non-heating season IHPs were forced to struggle for the market share as the total generation capacities exceeded monthly heat demand. However, during the heating season the competition pressure was weaker due to heat demand being greater than the sum of the overall IHPs production capabilities; as a consequence, the bidding prices might follow the reference price and the final outcome for consumers might be insignificant.

This concern was true for Kaunas case only for the first two years. In 2014 the continuous and dotted lines started to diverge (Fig. 3). Even during the high demand months, the average bidding price from IHPs was lower than the reference price. This could be explained by the fact that a sufficient number of IHPs had already operated in the system and IHPs started to compete against each other for a share of market by reducing their bidding offers. The fierce competition continued until now. Numerically the impact of competition could be traced when total 25.3 mill. € of benefits is broken down into separate periods: in 2013 the savings to the consumers were equal to 1.2 mill. €, in 2014 – 4.3 mill. €, in 2015 – 7.1 mill. €, in 2016 – 5.2 mill. €, and in 2017 – 7.5 mill. €. The interim conclusion followed that in 2014 the savings were stabilized and since then they continued to deliver economic welfare to the final consumers served by Kaunas DH system.

An additional remark should be placed to explain the non-heating season and the bidding offers that follow closely the reference price in Kaunas. This is triggered by the fact that the reference price in Kaunas during the summer time is calculated merely on the generation capacities over biomass, thus the reference price corresponds mainly to variable costs over cheap biomass fuel. Due to the comparably low bidding price threshold, IHPs started to postpone the generation during summer, and the DH entity supplied the heat from its own generation units in 2015 and 2016. Nevertheless, in 2017 two new biomass CHP units entered the market in Kaunas and offered a price for heat which was lower than the variable cost (over biomass) of DH entity. This recent entrance could result in even larger savings for final consumers.

5.2. Klaipėda City DH System Transition to Competitive Market

A different situation is in Klaipėda city DH system. Prior to the start of the unified market opening process, the municipal DH entity had experience of buying heat from IHPs for several years. Under the not regulated third party access rule, the DH company purchased heat from geothermal power plant and the residual heat – from some industrial units. The non-regulated TPA rule meant that Klaipėda DH entity had the right to decide on the connection specifics and price settlements; the costs for the purchased heat were a type of pass-through costs into final tariff. The regulated third party access framework changed the situation in Klaipėda DH system, and Figure 4 below presents the heat market development over the last five years.

Klaipėda DH system is the third largest DH system in Lithuania. The maximum peak demand equals to 218 MW (2016). The annual heat consumption – 696 MWh (2016). The heat losses in the network – 14.4%. DH entity “Klaipėdos energija” owns 606 MW of heat generation units.

A waste CHP IHP has been operating in Klaipėda DH system since 2013; since the end of 2014 the waste CHP has been regulated (due to holding the significant market power). Being regulated, currently the waste CHP has two limitations for participating in monthly auctions - first, the waste CHP cannot exceed the reference price (variable cost Klaipėda DH entity), and second, the waste CHP cannot exceed the regulated price ceiling that is set by the NCC.

In 2013 in Klaipėda DH market 7 IHPs were operational with accumulative 134 MW heat generation power. In 2017 9 IHPs were on the market with total of 141 MW of heat generation capacity. Figure 4 was developed by the authors of the paper to demonstrate the development of prices in the context of the intensifying competition in Klaipėda DH system. Authors used the data publicly available at the website of the Klaipėda DH entity “Klaipėdos energija” (Klaipėdos energija, 2018) and at the website of NRA (VKEKK, 2018^p).

[insert Figure 4.]

Klaipėda DH system under the opened market framework gained some specific features for non-heating seasons. As it was presented in Kaunas case, during the summer time when the heat load is decreased and the reference price reflects heat over biomass variable costs, IHPs can hardly cover their costs. In Kaunas case some IHPs decided to pause the production during the low ceiling price periods; although new CHPs over

biomass still continue bidding as they receive feed in tariff for electricity over biomass and this way they are able to balance their financial flows. In Klaipėda just the opposite situation is observed. During the summer period the bidding price is decreased considerably, and the decrease is related to the fact that WCHP is the “must run” unit and the option of waste storage or accumulation is not feasible. This way the company operating WCHP is forced to maximally decrease the bid price in order to continue selling heat on the competitive market.

The second conclusion from Figure 4 is the following: Klaipėda generation market is not yet sufficiently saturated. The existing convergence between the reference price and the bidding price during the heating season evidences that there is not enough of competing capacities on the market, and thus the current market players can enjoy setting bidding prices that nearly correspond to the reference price without risking losing an auction. More IHPs’ entering shall change the situation towards a stronger competition and lower bidding prices during the heating season.

Similarly to Kaunas DH case, in Klaipėda DH the competition over the period of 2013-2017 brought overall benefits to the consumers for 17.8 mill. €.

5.3. Key Findings

The practical cases of opening third party access to the existing centralized district heating infrastructure in two Lithuanian cities evidence that the centralized district heating systems may practically be reformed into competitive systems, in particular at the segment of generation. In two Lithuanian cities – Kaunas and Klaipėda, the centralized DH systems function with more than 50% of thermal energy produced by a number of IHPs. The centralized district heating is not a natural monopoly, as the practical evidence demonstrates, contrary to the still prevailing misbeliefs.

The prices for the generated thermal energy can result from the competitive mechanism. As a result of the operational monthly auctions, the prices for the generated thermal energy to be supplied to the centralized system are established every month under competitive pressure. The five-year trend in both analyzed cities demonstrated a continuous decrease of prices for thermal energy. In Kaunas case in 2017 the average price was 36.9% lower than the average price in 2013. In Klaipėda case in 2017 the average price was 37.4 % lower than the average price in 2013 (VKEKK, 2018).

The third party access to the existing infrastructure model is viable and attractive to investors in thermal energy generation. During the period of 2012-2017, there were 18 new IHPs established in both cities, and approx. 240 million € were invested into the generating capacities by IHPs in Klaipėda and Kaunas (VKEKK, 2018). It must be underlined, that the investment of IHPs was conducted fully at their own risks, there were no legal or regulatory obligations to secure investment return.

The third party access and market opening conducted pressure onto the incumbent operators to invest, which was also beneficial for the upgrade of the existing system of the centralized district heating system, the keeping or increase of the competitive potential and moving forward with implementing preconditions to supply the best value for consumers. Kaunas city alone incumbent “Kauno energija” invested 29.3 million € into generating capacities in 2013-2017 (VKEKK, 2018).

The design of market to be expected heavily depends on the initial conditions in the centralized district heating system. For example, in Kaunas case there was already one large incumbent producer which supplied thermal energy to the system. That particular incumbent IHP, “Kauno Termofikacinė Elektrinė”, gas-fueled CHP, was established after the political decision to separate the generating unit from the entire system and to privatize that unit back in 2008. Nominally, the entity was IHP, however, practically, the DH system was operated by “Kauno energija” with nearly a single thermal energy supplier available. The reform in Kaunas therefore resulted in the establishment of numerous new IHPs and in commissioning new generation capacities by DH system operator “Kauno energija”. In Klaipėda case, historically, there were several IHPs already which supplied to the DH system residual (industrial) energy, geothermal energy (experimental entity); the considerably cheaper residual (industrial) energy blended well the thermal energy produced by gas-fueled capacities of “Klaipėdos energija”. The reform in Klaipėda case resulted in even a larger number of IHPs established, which could supply thermal energy at the competitive price (industrial and renewable/incineration

based), the extinction of those IHPs which could not compete (geothermal), and the reduced generating capacities of “Klaipėdos energija” (gas-based).

The first phase of the reform resulted in a drastic change on the fuel structure in the cities. In Kaunas the annual share of RES/AES increased from 11.05% in 2013 to 81.31% in 2017 (VKEKK, 2018). In Klaipėda the annual share of RES/AES reached 80.0% in 2017 (VKEKK, 2018). The switch was made mostly by private investors having no legal/regulatory guarantee to return the invested capital in terms of the secured tariff or guaranteed contacts for thermal energy. The economic/market forces had rather a prevailing impact – the investors opted for RES/AES installments due to the attractive biofuel price compared to natural gas and therefore the ability of new installments to be competitive against the incumbent’s natural gas based installments. The market opening and auction mechanism enabled to realize the potential to generate and sell cheaper thermal energy to the DH operator.

The presented cases reflected the current situation and the actual DH market development direction. It must be noted, that the market mechanism, enacted for the first market opening phase, worked well with “low hanging fruits”. With the growing number of IHPs and the increasing market share taken by IHPs, the need for the next regulatory major solution to complete the market reform aroused. Next chapter will present phase-two for the DH market development that will come into effect from 1st January 2019.

6. Finalizing the Competitive Market Design and Moving Forward

According to the initial plan, the DH market liberalization process should be finalized by introducing the second phase under which all the generation units of IHPs and the DH entity participate in monthly auctions on equal terms and conditions (Biekša, 2015). From the regulatory point of view, competing in auctions under equal terms and conditions means that bidding offers are meant to include full cost coverage to all parties. If the generation unit of the DH entity lost its bid on a respective monthly auction, this unit would not receive any cost remuneration from the regulated tariff in any form. This regulatory setting seems to be implementable for the operational capacities of the relevant DH system.

While assessing the processes during the transition phase, it becomes obvious that specific market components still have weak chances, if any, to be transitioned from monopoly to the competitive market conditions. Namely, we speak of a peak load generation capacities that account for up to 1/3 of the operational capacity (the size is subject to a separate technical regulation) and balancing. The peak load capacity is activated for less than 1000 hours per year. A short time of operation implicates the following peculiarities:

- Investors may not see feasibility to invest in peak capacities because the utilization ratio of those capacities varies drastically due to the fluctuation of climate conditions and due to the growing energy efficiency at the consumer side;
- Due to the low utilization ratio of peak capacities, the price for the heat during the peak load could be unacceptably high (if it is to be auctioned on monthly bids). And those costs would emerge during the coldest period of the year, thus resulting in even more fluctuating final tariff. It is recognized to attribute these cost as monopoly cost and distribute them equally on yearly basis.
- Balancing as a function is attributed to the system security of supply and is recognized as sole responsibility of the DH entity that operates the DH network and bears responsibility for the quality of heat supply to the final users.

Following the peculiarities provided above, the second phase regulatory market design was constructed to the separate three sub-markets:

- Sub-market for operational generation capacities, to function as full-cost entirely competitive monthly auctions; the terms and conditions are equal for all participants;
- Sub-market for peak load generation capacities, to remain as a monopoly market. The peak load generation capacities are considered as the monopoly services for the second phase of the market liberalization, and these services are to be provided by the DH entity;
- Sub-market for heat generation balancing function and reserve (or back up) capacities, to remain as monopoly market allocated for serving by the DH entity. Although balancing and reserve function at least partially in theory could be seen as competitive services due to their provision mechanism, the cost efficiency and security of supply considerations were defined as prevailing in deciding to attribute this sub-market to the DH entity.

It cannot be excluded, though, that after several years when the second phase is implemented fully and results are assessed, also taking into consideration the technical and economic developments of the sector, the regulatory approach to monopoly sub-markets may be changed. The structure of the DH generation market under the second phase is presented in Figure 5 below.

In Figure 5 a structure of the fully liberalized DH generation market is presented. The model is developed by the authors, as the target model for the Lithuanian fully liberalized DH market. The model was developed assuming the liberalized power market as the working example and taking into account specifics of DH market for seasonality and the list of system services. The concept model has been discussed with DH market stakeholders in Lithuania.

The accumulated heat demand diagram offers a good visualization possibility of the main market components. On the Y axis the heat generation capacity of the standard DH system is presented. The accumulated number of hours is marked on axis X. As it may be seen from the chart, the heating season in Lithuania amounts for approximately 4600 hours. During the non-heating season the heat generation capacities are used for hot supply for hot water perpetration, and heat losses' compensation in the network.

The dark segments are marked as monopoly services' sub-markets and the light-colored area is dedicated to the full competition. Peak load capacity generators as the monopoly services account for 30 % of the system's maximum capacity. Those capacities usually are gas fueled flexible boilers.

The system reserve (or back up) capacities cannot exceed 50 % of the system's maximum capacity. These reserves are used to ensure the security of supply and to back up IHPs in the case of planned maintenance or unplanned breakdowns. That means that combining peak load boilers and backup reserves capacities DH company owns 80 % of generation capacity that is attributed to the monopoly services.

Even though in second phase of DH market liberalization competition will take place on full cost basis the additional regulatory decision is made to leave the "artificial" reference price (a price formation ceiling). It was designed as a safeguard for the price volatility risk management in auctions. The reference price is designed to be reasonably high but still being able to eliminate price spikes in the case of market failures. The level of reference price is established based on biomass HoB alternative, assuming that it would work at its full capacity for 4000 hours/year.

[insert Figure 5.]

The competitive heat generation sub-market is operational the whole year round. The market model states that during the periods when DH demand does not exceed 70 % of maximum load, all the heat demand is the subject for auctioning on a monthly basis. If the maximum load exceeds 70 % then the part that exceeds 70 % is covered from peak load capacities (monopoly service) and the rest of load is auctioned. The eligible participants for the auctions are IHPs and the incumbent DH generation units. The bidding for projected monthly amount of heat is performed by offering bid prices that should include all the costs of a producer. After the bids are issued, the queue from the lowest to the highest price bidders is compound and publicly presented to all the auction participant and other interested parties through electronic means. A participant cannot recall its bid, however, if it cannot deliver the bided amount of heat, a mechanism of ensuring heat generation at the requested demand is applied, and the failing participant would cover the cost difference.

7. Results and Discussion

The DH market opening is a complex process that must be guided having in mind not only the technological and regulatory, but also the political environment. Section 4 provides analysis of market opening model, which was designed for Lithuanian DH sector's environment, including political environment. The competition in the DH generation market can be feasible if the systems are large and can accommodate a sufficient number of market players without delivering the decisive market power to any of them.

The necessity to have a sufficient number of market players suggests two conclusions: the DH systems, where the competition in heat generation market is feasible, should be considerable in size; if competing is started in a small system, some installations could automatically gain significant market power positions and thus influence and manipulate price formation. Further, a small market would not offer the sufficiently wide limits for cash flows' balancing during winter-summer season on the level of an individual producer.

In Lithuania a lot of discussions were dedicated to the fact that new market players install rather small generation capacities across the system, which on its turn creates extra burden for the network operator to balance the hydraulics of the network. Furthermore, small installations are usually a bit less efficient as compared to the large installations. However, one must underline, that during the market opening process the investors are cautious considering the future of the market, its policy, and regulatory predictability, thus the minimization of units (and investments) is to be regarding as the measure of risk mitigation. The real experience has evidenced already that the second and the latest market entries are constructing the increasing capacities, they also have turned for more complex and expensive technologies as waste to energy CHP plants construction.

The market opening is a very complex process judging from the political as well as policy perspective. First of all, the regulating institution must be able to withstand direct pressure during the initial market opening period when new competitive generation capacities start to show fast payback time. The political governance naturally would act to address the regulator with multiple suggestions to regulate new market players at full extent, arguing this suggested inconsistency as serving consumer interest. The incumbent DH entity would be on the side of these arguments, as incumbent is threatened to lose the market (partially) or to move towards greater efficiency. If the regulating institution follows the pressure, the generation market opening will be suspended as the incentive for investors to enter the market will be diminished significantly. If the regulating institution withstands the political pressure and proves in action to the market participants that liberalization direction is chosen permanently by the regulator, the investments will continue to enter the market and the fruits of the competitive market framework will be sustainable. In the political debate it is worth mentioning that fast pay back of the investments in biomass burning capacities indicates nothing else than the inefficiencies that are accumulated in the DH entities due to the investment decision postponements or the overall unwillingness to invest to fuel conversion (e.g., paying dividends to the municipal owner granted with the higher priority than the DH system upgrade and development).

The most common observation against the market opening in DH is that the **fierce** competition takes place only during the non-heating season, **as demonstrated in Figure 3 and Figure 4**. The answer to this position will be twofold. First, it is obviously true for the non-heating season situation, and the competition during this period reduces prices, thus delivering direct benefit to the final heat consumer. Second, the heating season situation at two phases of reform must be addressed separately. **As evidenced in Section 5**, on the initial market opening phase, when only few new IHPs are on the market, the auction price would usually follow the reference price signal. But when the market accommodates more participants bidding offers, the reference price stays at a distance from the bid prices. **For eg.**, in Kaunas case it took only 1,5 years to observe this particular effect. As it may be seen from Figure 3, during the last years the difference between the average ceiling price and the average weighted bidding price fluctuated in the range (0.5; 1.5) ct/kWh. Numerically, this corresponds to the situation that heat from IHPs was bought at proximately 12-37% lower price than the DH entity could produce with its own generation units, and this was accounting only the variable cost of the DH entity.

In Lithuania the regulatory reform was successful and, on final counts, it assisted in rapid switch from natural gas to biomass usage in the DH generation (2009 – 19.3 % biomass, 2017 – 66.5 % biomass) during the worst times of state economy. The strong neighboring market – biomass market – emerged and grew up in Lithuania. More complex technologies started entering the Lithuanian DH sector. The consumers benefit annually at the level of 12.3 mill € (VKEKK, 2018) all over the country. The private capital and competitive mode of functioning made the municipal entities stronger and more dynamic, in the context of gradual shift in political thinking on municipal level regarding the functioning of the municipal DH entity.

The success of this regulatory reform was depended, *inter alia*, on the following preconditions in place:

- the problem was real - the expensiveness of DH was a big, painful and real problem, the regulatory solution was at a high stake;
- the significant positive impacts were expected – the designed market liberalization reform and the developed regulatory framework suggested a long-lasting increase of the sector sustainability, resilience, and economic benefits;
- the political support was ensured at the highest level to the very concept of reforming the DH sector on competitive principles – this enabled the regulatory institution to keep negative pressure of middle-level political subjects at a distance;

- the alternative solutions were already available – the primary energy resource (biomass), which was underutilized and which could provide with the economic and competitive advantage, was at high potential and available, and just a push was needed to employ this primary resource under the competitive model;
- the technical readiness - the system was ready to accommodate new capacities; the DH networks (pipe systems) were largely available in the cities and settlements in Lithuania, no need to install new systems or re-install once dismantled systems, which is costly; the DH networks were integrated and looped, working on circle mode, and no need to perform network looping, which would again be costly and time-consuming; the centralized DH was the prevailing source of thermal energy for consumers, and inter-sectoral competition was merely not available;
- the regulatory readiness – the regulating institution was eager to implement major reforms quickly and was pro-competitively minded.

The experience of Lithuania in reforming the DH market and transiting it towards a competitive one may be considered for adaptation in those countries which meet the criteria mentioned above, and first of all - for those countries with the developed centralized DH systems, albeit lacking investment. The market opening under the proper regulatory framework may ensure investment flow from private sources, this way providing opportunities to allocate the limited public resources where they are needed, but not attractive for private capital.

Summarizing the result from the case studies and a real regulatory experience from the market opening process, it need to be stated that the DH generation segment can successfully operate as competitive market. Due to the technical limitations as market specificities, some of market share should be allocated to the reserves and necessary maintenance capacities in order to endure the security of heat supply to the consumes, as provided in Section 6.

From the economical point of view, the competition in the DH generation segment has shown economic viability. The monthly auctions help to pinch efficient production cost levels that could be transferred to the regulatory benchmarking system. Moreover, the monthly auctions helped more rapid transfer of fuel price fluctuation benefits to the consumers. Generally, the competition brought direct savings to the consumers if compared to the monopoly situation.

8. Conclusions

The literature review has shown that most of the researches still consider DH as a natural monopoly with no or weak possibilities for competition within the DH system. The main arguments speak in favor of the controllable energy planning process (monopoly approach) and the sufficient competitive pressure from the alternative technologies (such as individual electricity or gas heating). The final consumers in this context have minimum possibilities to choose heat supply but they have the direct duty to pay the tariff. This market setup has some weakness considering the postponed investments that are followed by the consumers overpaying for the heating services. That aspect of consumers covering the cost of the inefficient performance of monopoly is not investigated in any literature and it directly relates to the poor openness to the competition pressure (or failed regulatory regime).

The statement that DH as a monopoly has sufficient competitive pressure from the alternative heating technologies, like heat pumps or natural gas, is inaccurate. Usually the gap between heat price production via alternative heating technology and DH differs considerably. Thus, this potential should be harvested by introducing competition in the DH generation segment. Executed regulatory reform in Lithuania has showed that partial liberalization in DH generation segment is possible and feasible.

The initiation of the DH liberalization process in Lithuania was triggered by three major conditions. First, there were artificially high prices for the major fuel used (natural gas), which was provided from the single source. The sky-rocketing major fuel prices resulted in extremely high DH prices in the context of state economy crisis. It is also worth mentioning that DH is the major energy service consumed in Lithuania by residential consumers, and therefore it is socially sensitive. Second, the generation capacities of the municipal DH entities were based mainly on natural gas and the necessity for switching to times cheaper biomass was obvious and urgent. However, back in those days there was no other effective mechanism available under the policy and regulatory framework to push the municipal entities for fuel converse investment. And last, the management

of DH monopolies and especially the role of municipalities resulted in the postponement of the investment decision or even rejection in multiple cases.

The experience of the DH generation market's liberalization has demonstrated that the process may be implemented in few phases. The main argument supporting the two-step approach is necessity to ensure the security of supply under a new market structure.

In phase one competition in DH generation segment was introduced via single buyer model for heat procurement from IHP and incumbent DH company. There were three specificities related to the first phase of the reform. First, IHP in their bids could not set the price that exceeds variable cost of DH company for the particular month. Second, DH company was granted the full cost coverage even in the case they have lost the auctions (the fixed costs were remunerated via tariff). Third, competition took place in full generation capacity spectrum – from peak load to summer time generation.

In the phase two market structure was fixed in three sub-markets: peak load capacities (30 % of maximum load that was attributed to the monopoly services), reserves and back-up capacities (50 % of maximum capacity that was attributed to the monopoly services) and full competition segment that corresponds to 70 % of maximum load. In competition segment all participants compete on the same rights via monthly auctions. In the event of losing the auction remuneration is not received.

The Lithuanian experience has demonstrated that the competition in the DH generation is possible and it delivers direct benefits to the final heat consumers. Taking Kaunas as a reference case, it could be estimated that only in this city heat consumers over the last 5 years have received benefits via lower heat production (or procurement) price that amount for 25.3 mil €. In Kaunas case the accumulated 5-year benefits for consumers equal to 17.8 mill. €. If consideration is given only to the annual benefits across the country, they correspond to 12.3 mill. €. In general, the initial phase of the reform could be evaluated as a success.

The DH generation market's liberalization ensured rapid penetration of biomass capacities in the market, thus natural gas was exchanged to biomass and the municipalities started to be more active in the supervision of their municipal DH entities.

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Figures:

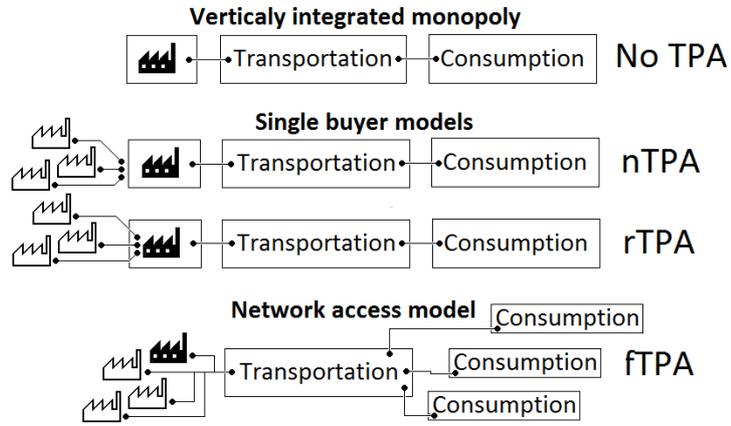


Figure 1 Possible schemes for district heating market organization

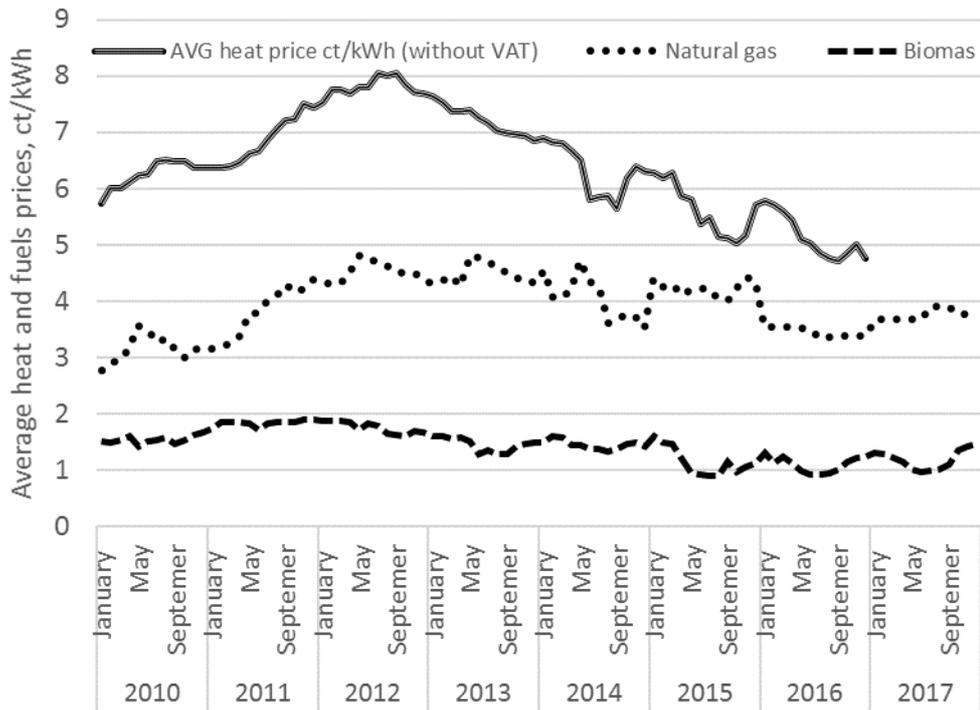


Figure 2 Natural gas, biomass and heat price dynamics in Lithuania 2010-2017

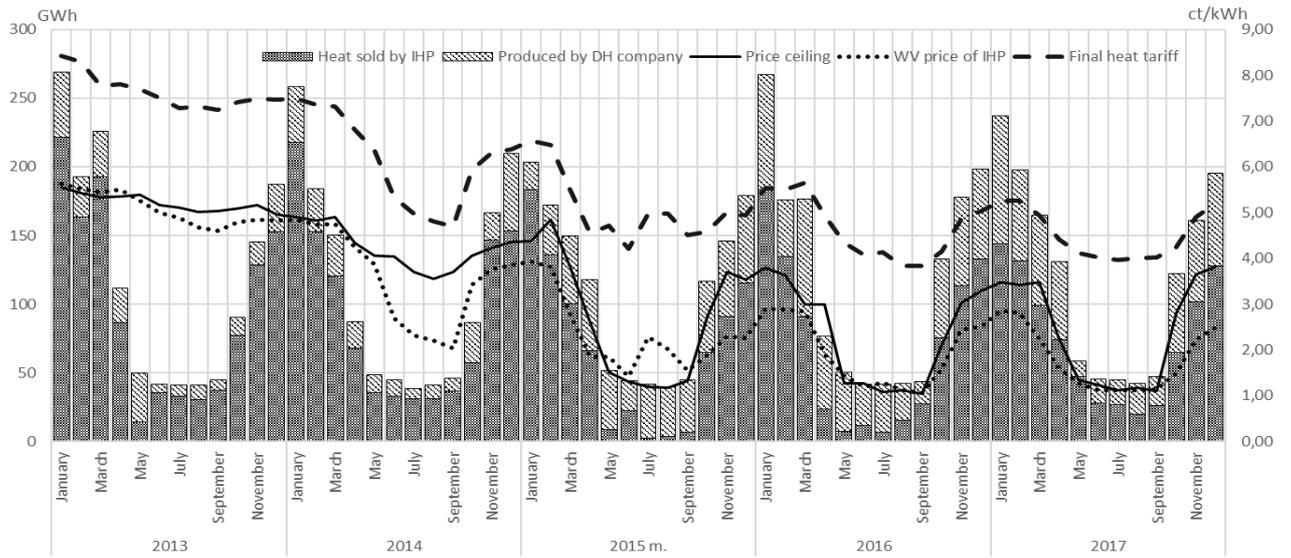


Figure 3 Market opening in Kaunas DH system 2013-2017

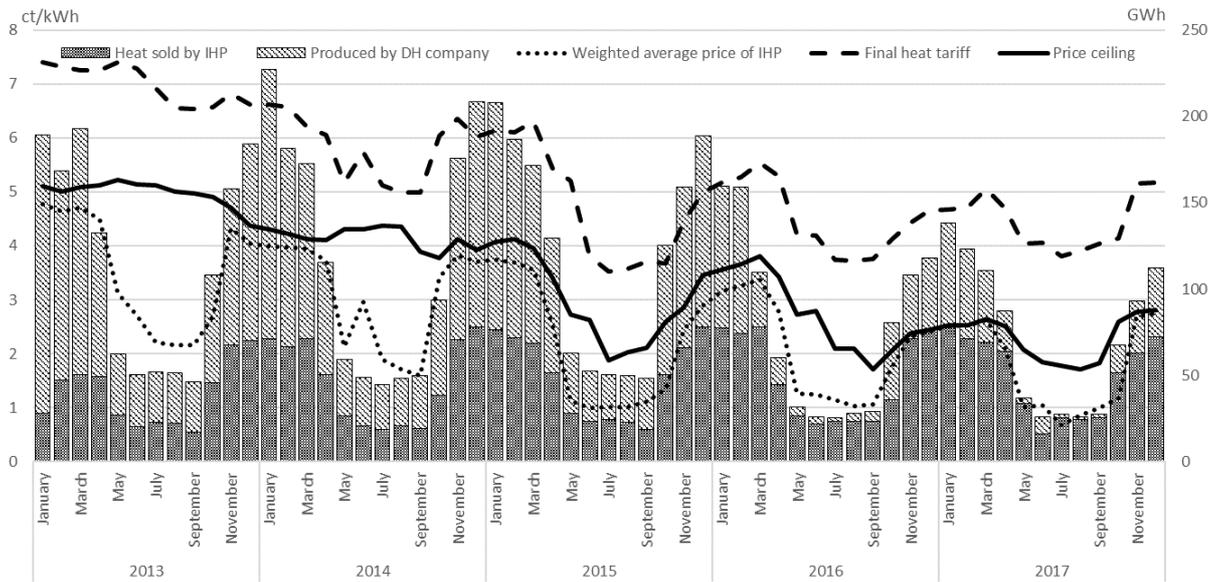


Figure 4 Market opening in Klaipeda DH system 2016-2017

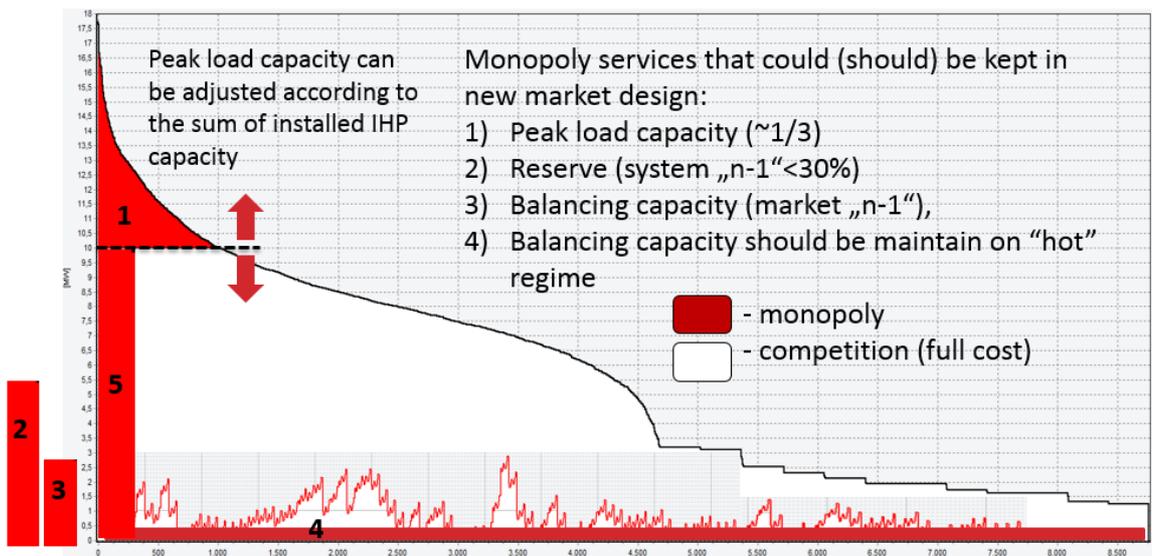


Figure 5 Design model of fully liberalized DH generation market