Distribution: General

STEP-UP : Trajectory 4
Market model heating networks: Market models for District Heating

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SUMMARY

In the previous deliverable, 2013/ETE/R/278, the introduction strategy of District Heating (DH) in Sweden and Denmark was summarized. A long-term energy planning and an initial regulation of the heat markets were common factors of a smooth market penetration of DH.

At present, long term planning does not exist in Belgium at national level. Some cities are taking the initiative of evaluating the implementation of DH although they do not have long term targets.

In the absence of national guidelines, the cities still have some room to manoeuvre that should be taken into account, such as:

- obligation to connect in new buildings;
- require minimum consumption;
- requirements on production e.g., biomass or CHP.

Likewise, supporting measures can be implemented such as subsidies, extra taxes or alleviating fiscal advantages when possible.

After the discussion with the project partners based on the previously mentioned document, it was agreed that the organizational models would focus on a bundled structure with a third party company investing on the whole project. Due to the heat nature, its market will most probably evolve in the same way as the electricity market. The latter was unbundled when it was economically viable.

To promote the penetration of DH within consumers, the heat price will be initially calculated by the alternative cost pricing method. This means that the consumer will not be charged more than his current heating solution in case he adheres to the DH system.

Since the heat transport (and distribution) is a natural monopoly, the role of the regulatory body becomes important to protect the consumer and to ensure the reliability of supply.

In this document, some generic formulas are presented to calculate the costs of a DH system. In general, the total costs can be split into:

- Heat generation costs: including capacity investment, operation and maintenance as well as fuel costs
- Transmission costs
- Distribution costs
- Other costs e.g., taxes

The costs are very project-specific, however as a general conclusion, transmission and distribution costs are usually the dominant costs.

In a separate chapter, all the possible revenues are summarized. Within this chapter, the alternative cost heat pricing methodology is presented in detail. In the Netherlands, the Autoriteit Consument & Markt published in January 2014 a way of calculating the maximum price that can be charged to consumers by the heat provider. This calculation is presented here.

In the final chapter, different organizational models are analysed including a quantitative comparison. Concretely, the following organization options are studied:

- Fully integrated heat company where the production, transport and supply are integrated
- All the steps in the value chain are separated
- The retailer is the company in charge of distributing the heat
- The producer is the distributor of heat
- The producer is the retailer of heat to the consumer

In a nutshell, each DH project has different distribution and production costs. These costs are determining the viability of the project when compared to other heating options e.g., heat pumps or gas boilers. Therefore, the possible organizational structures should be analysed case per case.

Nevertheless, in small DH projects, when the market is barely existing in the country, the bundled structure is the most appropriate. In this case, the heat company runs all the risks while receiving all the revenues of the system. The main advantage of this configuration is the limited administrative burden since the management of the system is rather simple. The consumer should be protected against abuse from the heat company since competition is inexistent. In this line, the role of the regulatory body is relevant to watch over the natural monopole.

It could also be that the consumers are the owner of the heat company as well creating the so-called cooperatives. This configuration encourages the consumers/owners to work towards a more efficient system. This structure is strongly linked to the culture of the area. It is a common configuration in Denmark but it does not mean that it can be easily transferred to other countries.

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CHAPTER 1 INTRODUCTION

In the previous deliverable of this project 2013/ETE/R/278, the initial situation that allowed the extensive development of District Heating (DH) in Denmark and Sweden was analysed. A long term energy planning was found to be essential for an extensive DH implementation.

The planning should include the identification of the areas where DH stands out as the most adequate technology. DH is beneficial on dense areas where production is close to loads and loads are close to one another. Access to cheap fuels is also an important factor to take into consideration.

In 2013, (Connolly, et al., 2013) published the "Heat Roadmap Europe 2050 - Second pre-study for the EU27". They compared for four different countries the marginal distribution capital cost with respect to the heat market share of DH. See Figure 1. Belgian marginal distribution capital costs resulted as one of the lowest when compared to prices of France, Germany and the Netherlands. The optimal market share fulfilled by DH varies between 20% and 60% approximately. With lower market shares the market is not sufficiently mature while with higher market shares the areas covered are remote which is not ideal for a DH project.

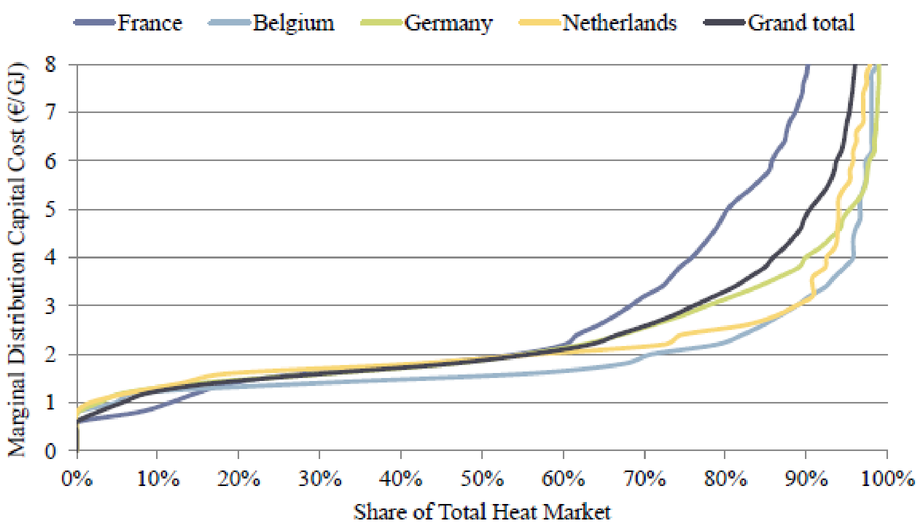

Figure 1:Marginal distribution capital cost levels for different urban DH market shares in 2008

To assess the economic feasibility of a project the total cost and revenues of the project must be analysed. The costs should include the purchase cost of the system components, the construction cost and installation cost as well as the operation and maintenance cost. The total revenues are the fees charged to the customer as well as other incomes from e.g. selling electricity or subsidies (Ajah, Patil, Herder, & Grievink, 2007).

The competitiveness of district heating against local solutions is determined by the generation costs and the distribution costs. At the same amount of revenues, the total cost of district heating (including transmission and distribution[1]) must be lower than the cost of any local heat generation alternative (Persson & Werner, 2011). Thus, high distribution costs can jeopardize the DH competitiveness.

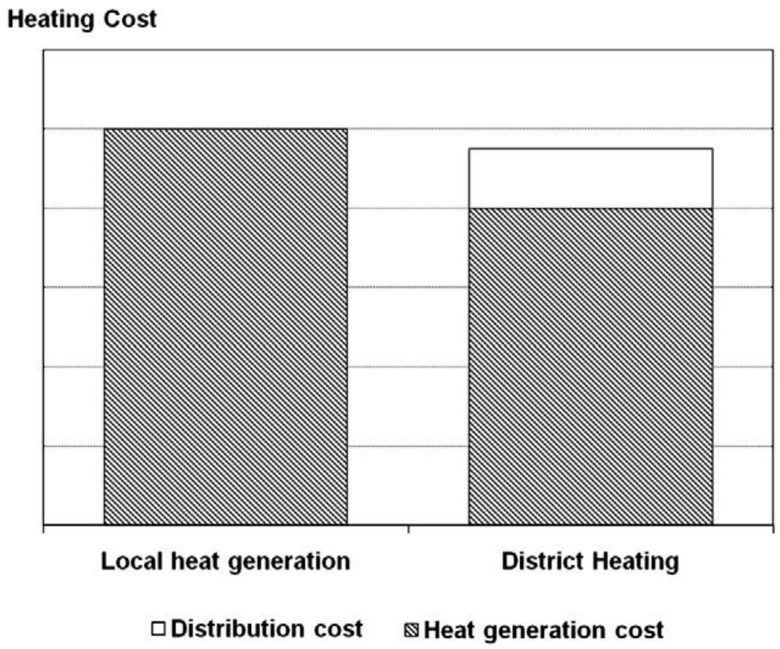

Figure 2: General cost structure comparison between local heat generation and district heating, with respect to the heat generation cost and the distribution cost (Persson & Werner, 2011).

The typical local heat generation usually consists of a gas boiler for urban areas and a fuel oil based heating source for more rural areas. In Flanders, 66% of the heating source is based on gas boilers (VREG, 2014).

In order to estimate the heating costs for the reference case of a gas boiler, the capacity needs to be dimensioned to cover the peak demand of a standard year. The price can be estimated as 70 €/kWth with a depreciation time of 15 years. The efficiency of the gas boilers can be considered as 90% with maintenance cost of 150 €/year.

(Commission, 2008) reported per heating technology, the conversion efficiency, capital investment, life-time and O&M costs. A summary is shown in Figure 3.

[1] Even though there is no established definition to distinguish transmission and distribution, it is understood that the transmission network are the pipes that transport the heat between the producer until the heat exchanger. After the heat exchanger station, the distribution grid starts. Transmission pipes are usually larger and they often contain security loops to ensure reliability. Usually, the transmission grid is owned by a different party than the distribution grid. In the case of small DH systems, the production is directly connected to the distribution grid.

Technology	Description	Capacity	Efficiency		Capital costs, 2007 [€$_{2005}$/kW], VAT excl.			Annual O&M costs (VOM+FOM) [€$_{2005}$/kW], VAT excl.			Life-time	Lifecycle GHG emissions	
		[kW]	[%]	*References*	REF	Range	*References*	REF	Range	*References*	[year]	t_{CO2}/toe	*References*
Natural gas boiler	Natural gas fuelled boiler, large size, combi, floorstanding	75	89%	[112], [117], [116]	110	95 ÷ 135	[112], [118]	9	9 ÷ 10	[112], [118]	17	3.3	[95]
	Natural gas fuelled boiler, medium/small size, combi, wall-hung	20	86%	[112], [117], [116]	125	100 ÷ 130	[112]	13	11 ÷ 14	[112]	17	3.4	[95]
	Natural gas fuelled condensing boiler, medium size, combi, wall-hung	20	104%	[112], [117], [116]	145	115 ÷ 155	[112]	11	10 ÷ 12	[112]	17	2.9	[95]
Heating oil boiler	Heating oil fuelled boiler, large size, combi, floor standing, with oil reservoir	75	86%	[112], [117], [116]	190	160 ÷ 240	[112], [110], [118]	12	11 ÷ 14	[112], [118]	17	4.2	[95]
	Heating oil fuelled boiler, medium/small size, combi, floorstanding, with oil reservoir	20	80%	[112], [117], [116]	325	265 ÷ 355	[112]	18	15 ÷ 19	[112]	17	4.5	[95]
	Heating oil fuelled condensing boiler, medium size, combi, floorstanding, with oil reservoir	20	99%	[112], [117], [116]	390	310 ÷ 425	[112]	13	11 ÷ 14	[112]	17	3.6	[95]
Coal boiler	Solid fuel fuelled boiler, large size, with heat buffer	50	75%	JRC	340	310 ÷ 410	JRC	13	12 ÷ 15	JRC	17	6.1	[95],[103]
Wood chips boiler	Wood chips fired boiler, large size, with hot water reservoir and heat buffer	50	79%	[110]	385	325 ÷ 440	[109], [110], [111]	16	14 ÷ 18	[110]	17	0.3	[59], [95]
	Wood chips fired boiler, medium size, with hot water reservoir and heat buffer	35	79%	[110]	575	490 ÷ 665	[109], [110], [111]	22	20 ÷ 25	[110]	17	0.3	[59], [95]
Pellets boiler	Pellets fired boiler, large size, with hot water reservoir and heat buffer, inc. pellets silo	50	84%	[110]	355	300 ÷ 410	[109], [110], [111]	15	13 ÷ 17	[110]	17	0.7	[95]
	Pellets fired boiler, medium size, with hot water reservoir and heat buffer, inc. pellets silo	35	84%	[110]	505	430 ÷ 585	[109], [110], [111]	19	17 ÷ 22	[110]	17	0.7	[95]
	Pellets fired boiler, small size, with hot water reservoir and heat buffer, inc. pellets silo	15	84%	[110]	940	800 ÷ 1080	[109], [110], [111]	34	29 ÷ 38	[110]	17	0.8	[95]
Solar heat	Water heating system	3.5	98%	[135]	980	340 ÷ 2800	[92]	16	-	[92]	20	0.3	[95]
Geothermal heat pump	Large size electrical operated heat pump with geothermal heat source	100	100%	[116]	500	200 ÷ 1150	[92]	39	34 ÷ 60	[92]	25	0.2 ÷ 3.7	[95]
	Medium size electrical operated heat pump with horizontal or water ground heat source	15	100%	[116]	640	550 ÷ 720	[115]	55	54 ÷ 69	[112]	17	0.3 ÷ 5.9	[95]
Electrical heating	Electric combi heating/water boiler, medium/small size, wall-hung	20	100%	JRC	75	65 ÷ 90	JRC	5	-	JRC	17	0.7÷14.8	[95]
	Resistance heaters with fan assisted air circulation	2	97%	[123]	140	30 ÷ 300	JRC	n/a	-	[123]	10	0.7÷15.2	[95]

Figure 3: Heating technology, conversion efficiency, capital investment, life-time and O&M costs (Commission, 2008).

(Persson, 2011) identified feasibility thresholds for DH projects expressed by the quantities of specific heat demand, plot ratio (fraction of total building space area in a given land area) and heat density (sum of total heat demand in a given land divided by the land area). He identified that threshold for a feasible project is at a specific heat demand of 0.50 GJ/m^{2}a, for heat densities between 75 TJ/km^2 (plot ratios of 0.15) and 100 TJ/km^2 (plot ratios of 0.20).

In his thesis, he focused on the potential to recover excess heat and its use in future European DH systems. He identified that three main concepts are of critical importance: recovery efficiency, heat recovery rate, and heat utilization rate. He compared several European countries by using those parameters (Persson, 2011).

(Persson, 2011) also studied the total customer DH costs in different Member States. The prices vary significantly between 13-17 €/GJ excluding VAT although Euroheat & Power 2011 country by country survey reports total costs above 20 €/GJ in some Member States. Back in 2011, the natural gas household prices including taxes were around 16 €/GJ [2]. For 2013, the household gas natural prices varying between the 33 €/GJ of Sweden and the 8 €/GJ of Rumania [3].

An example of the municipalities involvement is the largest DH system in Copenhagen[4]. The transmission pipes are built across five municipalities. The board of directors of the company represents the five municipalities. The management team is advised by two committees for economic and technical matters.

2

http://epp.eurostat.ec.europa.eu/statistics_explained/index.php?title=File:Natural_gas_prices_for_household_consumers,_second_half_2011_(1)_(EUR_per_kWh).png&filetimestamp=20130116115252

3

http://epp.eurostat.ec.europa.eu/statistics_explained/index.php?title=File:Natural_gas_prices_for_household_consumers_2013s1.png&filetimestamp=20131106145433

4 http://freshaireva.us/wp-content/uploads/2012/04/Copenhagen-District-Heating.pdf

The Metropolitan Copenhagen heating Transmission Company purchases heat from refuse incineration plants and CHPs in the metropolitan area and transport it. The delivery of heat to the consumers is done by local organizations (distribution companies) different from the company owning the transmission pipes.

The heat price calculation follows a particular principle in this case: the operations budget should balance in the year 2009. After the year 2009 – or if the investments in construction have been repaid in full before that – the heat price charged by the company will be set according to the principle that the operations budget should balance from year to year.

In this case, the heat tariff is composed of a fixed part and a variable energy charge. The fixed part covers fixed costs such as the producers' fixed charges, wages, administration costs and loan repayments. The energy charge covers the actual cost of fuel, the cost of running pumps and other variable operational costs. The size of the fixed charge is paid regardless of the actual level of heat consumption. On the other hand, the variable charge is paid in accordance with the number of heat units that have actually been used.

In this report, the costs of a DH system are analysed in a CHAPTER 2, while CHAPTER 3 is dedicated to the revenues of the project and the alternative cost heat pricing mechanism. CHAPTER 4, is dedicated to methodologies to evaluate a long term investment. CHAPTER 5 presents an analysis of different organizational models including a qualitative comparison. Finally, conclusions are drawn in CHAPTER 6.

CHAPTER 2 COSTS

In this section, all the costs of a DH system are split in different components from the heat generation to the transmission and distribution costs. In general, the total costs can be split into:

- Heat generation costs: including capacity investment, operation and maintenance as well as fuel costs
- Transmission costs
- Distribution costs
- Other costs e.g., taxes

(Nielsen & Möller, 2013) did an analysis of the parameters influencing the costs of the future district heating potential in Denmark. This work is used as a guideline below.

2.1. HEAT GENERATION COSTS

The heat generation model mainly consists of the investment in the production capacity, the fuel costs and the operation and maintenance (O&M) costs (Nielsen & Möller, 2013):

2.1.1. INVESTMENT IN PRODUCTION CAPACITY AND OPERATION AND MAINTENANCE COSTS

There exist a variety of technologies that can be applied in a district heating system. The Danish Energy Agency yearly publishes a technology catalogue where information about different present and future technologies is gathered. This information includes a description of the technology, technical data regarding efficiencies, expected lifetime of the plant, and information on the economics, such as investment costs and O&M costs. The investment costs include the cost for all physical equipment and infrastructure or connection costs to electricity, fuel, and water. It does not include the cost of land, development costs of the owner, or decommissioning costs (Nielsen & Möller, 2013). The O&M costs do not include fuel expenses (The Danish Energy Agency, 2012), (Nielsen & Möller, 2013). See Table 1 below:

Table 1: Investment, O&M cost and lifetime of the technologies (The Danish Energy Agency, 2012).

Category name	Specific investment MEUR/MW	Total O&M %	Total O&M EUR/MWh	Fixed O&M EUR/MW/a	Variable O&M EUR/MWh	Lifetime a
Coal power plant	1.45		7			40
Wood pellet power plant	1.45		7			40
Natural gas power plant	0.93			36,000	0.78	30
Gas turbine single cycle (40–125 MW)	0.57			8550	3	25
Gas turbine single cycle (5–40 MW)	0.84			9300	3.8	25
Gas turbine single cycle (0.1–5 MW)	1.65		8			10
Gas turbine combined cycle (100–400 MW)	0.575			14,000	1.8	25
Gas turbine combined cycle (10–100 MW)	0.835			12,000	3.2	25
Gas engines (1–10 MW)	1.15		9			25
Waste-to-energy CHP plant	8.5			155,000	22	20
CHP Wood chips (10–100 MW)	1.5			29,000	3.2	30
CHP Straw (10–100 MW)	2.7			38,000	6.1	25
CHP Wood chips (8–10 MW)	4.85	3.5			8.3	20
CHP Straw (0.6–4.3 MW)	4.8	4				20
Gasifiers, biomass, staged gasification	3.4			78,000	18	20
Biomass gasifier, updraft	3.6			180,000	18	20
Stirling engines, gasified biomass	5.8			30,000	30	15
Biogas plant (1.5 MW)	5.9		33			20
Biogas plant (2.4 MW)	4.2		30			20
Biogas plant (3 MW)	3.4		30			20
Heat pumps (compression)	0.65			5250		20
Heat pumps (absorption)	0.45			15,000		20
Electric boilers (1–3 MW)	0.135			1000	0.5	20
Electric boilers (3–10 MW)	0.075			1000	0.5	20
Electric boilers (10–20 MW)	0.06			1000	0.5	20
Waste-to-energy	1.1			51,000	5.3	20
Wood Chip boiler	0.21			23,500		20
Straw boiler	0.26		2.8			20
Wood pellet boiler	0.17		3.1			20
Gas boiler	0.09	3.5	0.54			20
Geothermal	1.8			46,000		25
Solar DH				440		20

In general, the costs can be split into two categories: the fixed costs and the variable costs. The fixed costs consist of annual investment costs and O&M costs which are not determined by the operation of the plant. The variable costs, however, are mainly fuel expenses and O&M costs which are associated with the utilization of the plant (Nielsen & Möller, 2013).

2.1.2. Fuel costs

The fuel costs include handling and transportation to the production units. The fuel cost for each DH area is found by multiplying the annual fuel consumption for each production unit by the fuel costs. Eventually, the costs are then allocated between produced heat and electricity. The prices for Denmark can be seen in Table 2 below:

Fuel type	EUR/MWh
Coal	9.7
Fuel oil	32.6
Gas oil	49.0
LPG	28.5
Natural gas	28.6
Biogas	45.9
Straw	17.0
Wood chips	21.5
Wood pellets	34.1
Bio oil	36.2
Electricity	60.3

Table 2: Fuel costs based on the Danish Energy Agency

The total annual fuel cost for each DH area is divided by the total annual heat delivery, including a 20% heat loss, giving a EUR/GJ price for each area (Nielsen & Möller, 2013).

Table 3 below shows a summary of fuel prices for Belgium.

Fuel type	Price for Belgium	Reference
Unleaded (Superbleifrei, Euro sans plomb, Euro95)	Retail price: 1.610 €/l. Excl. VAT: 1.331 €/l.	http://www.energy.eu/
Diesel (Gazole, Gasóleo)	Retail price: 1.465 €/l. Excl. VAT: 1.211 €/l.	http://www.energy.eu/
Natural gas for industrial consumers (ref. May 2013, Consumption: 10 GWh/year, or approx. 0.93 million m^3)	0.03783 €/kWh	http://www.energy.eu/
Electricity for industrial consumers (ref. May 2013, Consumption: 2 GWh/year)	0.09714 €/kWh	http://www.energy.eu/
LPG (GPL, Autogas)	Retail price: 0.726 €/l.	http://www.energy.eu/
Home heating oil	Retail price: 0.889 €/l.	http://www.energy.eu/
Steam coal (2008)	130.54 $/metric ton	http://www.eia.gov/countries/prices/coalprice_elecgen.cfm

Table 3: Fuel prices for Belgium.

In general, the production costs can be summarised in the following equation:

$$C_{prod} = C_{invest} + C_{O\&M} + C_{fuel}$$

2.2. Transmission costs

There exist various methods to design the heat pipes path such as (Fazlollahi, Becker, Guichard, & Maréchal, 2013) and (Craus, Leon, & Arotaritei, 2010). Details on this design process fall out of the scope of this deliverable.

Ideally, the pipes should follow the designed path. However in practice, it will not always occur meaning that the model is a conservative estimate (Nielsen & Möller, 2013).

To find the total cost of each transmission line, the length and cost per meter is multiplied for each transmission line. The calculated cost is annualized by using a discount rate of 5% for socio-economic calculations in Belgium.

In the Table 4 the total transmission pipes cost (EUR/m) are shown including projecting, field work, pipe work, materials, and digging for Denmark (Nielsen & Möller, 2013):

Dimension DN	Water flow m/s	Capacity MW	Cost EUR/m
32	0.9	0.2	195
40	1	0.3	206
50	1.2	0.6	220
65	1.4	1.2	240
80	1.6	1.9	261
100	1.8	3.6	288
125	2	6.1	323
150	2.2	9.8	357
200	2.5	20	426
300	2.7	45	564
400	2.8	75	701
500	2.9	125	839
600	3	190	976

Table 4: Total transmission pipes cost including projecting, field work, pipe work, materials, and digging for Denmark.

Here below the formula to calculate the transmission costs being t the number of transmission lines is presented:

$$C_{tran} = \sum_{1}^{t} Length_t * cost_t$$

2.3. Distribution costs

As mentioned before, high distribution costs can vanish the competitiveness of district heating.

The total distribution costs consist of four different categories (Frederiksen & Werner, 2013):
1. Distribution capital cost: it represents the yearly investment capital payment for the construction of the network;
2. Distribution heat losses: they depend on the distribution temperature used, the average pipe diameter, and the heat resistance of the pipe insulation;
3. Distribution pressure losses: they are proportional to the product of the volume flow and the pressure increase in all distribution pumps;
4. Service and maintenance costs: they are considered to be proportional to the specific investment costs for placing the pipes underground. Experience showed a level of 1%.

Most of the components of the total distribution costs are inversely proportional to the linear heat density, thus the total distribution cost is also usually inversely proportional to the linear heat density[5].

The specific distribution capital cost dominates the distribution cost (Frederiksen & Werner, 2013). The general cost level is determined by the annuity and the two constants for the construction costs. However, for each individual system, the annual distribution capital cost will depend only on the average pipe diameter and the average linear heat density. The distribution capital cost is defined as below (Frederiksen & Werner, 1993):

[5] The linear heat density is defined as the ratio of the annual heat delivered to the total length of the DH piping and network. High linear densities increase the cost effectiveness of the DH system.

$$C_{dist} = \frac{a \cdot I}{Qs} = \frac{a \cdot (C_1 + C_2 \cdot d_a)}{\frac{Qs}{L}} \qquad \text{in [EUR/GJ]}$$

Where

I = total investment cost for the distribution network [EUR]
a = annuity, from the chosen hurdle rate[6] and the investment lifetime
Qs = district heat sold per annum [GJ/a]

C_1 = construction cost constant [EUR/m]
C_2 = construction cost coefficient [EUR/m^2]
d_a = average pipe diameter [m]
L = total trench length [m]
Q_s/L = linear heat density [GJ/m]

It is possible to create a bridging between the linear heat density parameter and demographic quantities such as population density (*p*), specific building space (α), and specific heat demand (*q*). To complete this bridging, the concept of effective width (*w*) is introduced (Persson & Werner, 2011). The formula can then be rewritten as below:

$$C_{dist} = \frac{a \cdot I}{Qs} = \frac{a \cdot (C_1 + C_2 \cdot d_a)}{p \cdot \alpha \cdot q \cdot \omega} \qquad \text{[EUR/GJ]}$$

The population density is a measure of the population living in the land area to be analysed. The specific building space is the area measure of the amount of building space available in the area. The specific heat demand contains information about the amount of heat needed in order to provide space heating and domestic hot water in these buildings. The effective width provides information about the length of district heat pipes required to heat the buildings in the area.

2.4. Other costs

There are other costs to be taken into account when calculating the feasibility of the district heating system. These comprise:

1. The operation and administration salaries
2. Insurances
3. Taxes, if applicable: such as the CO_2 tax, energy and sulphur tax, as well as national taxes

In summary, local costs should also be included. In Table 5, the fuel taxes for Belgium and Denmark are shown[7]. The price components that make up the retail price for one litre of fuel.

Crude - Purchase price of one litre of crude.
Margin - Refining, transportation, insurance, stockpiling, distribution and sale to consumers.
Excise duties and VAT - Taxes levied by local governments. May include environment related taxes.

[6] Minimum acceptable rate of return

Table 5: Fuel taxes for Belgium and Denmark[7].

Dec. 9, 2013	Unleaded (Superbleifrei, Euro sans plomb, Euro95) (€)						Diesel (Gazole, Gasóleo) (€)				
Country	**Crude**	**Margin**	**Excise duties**	**VAT**	**Retail price**		**Crude**	**Margin**	**Excise duties**	**VAT**	**Retail price**
Belgium	0.496	0.221	0.614	0.279	1.610		0.496	0.287	0.428	0.254	1.465
Denmark	0.496	0.270	0.593	0.340	1.698		0.496	0.316	0.444	0.314	1.570

In a nutshell, the total DH costs are the sum of the production, transport, distribution and other costs described above.

$$C_{DH} = C_{prod} + C_{tran} + C_{dist} + C_{other} \quad \text{[EUR/GJ]}$$

For reference on more Belgian costs, please consult: I. Moorkens, K. Briffaerts, 'Onrendabele toppen groene warmte', Studie uitgevoerd in opdracht van VEA 2009/TEM/R/116, 2009. http://www2.vlaanderen.be/economie/energiesparen/milieuvriendelijke/Cijfers&statistieken/Rapport_OT_groenewarmte_2009.pdf

[7] http://www.energy.eu/

CHAPTER 3 REVENUES

The revenues for the entity operating the district heating system come from the heat fees such as supply, connection, and other fees. The heat price was already studied in the previous deliverable of this same project 2013/ETE/R/278.

In Table 6, a summary of the different billing concepts for the consumed heat at end-user side is presented.

Concept	Granularity	Units
Connecting fee	One off	€
Transport and distribution cost (depending on network size)	Annual	€/kWh
Heat price – Energy	Annual	€/kWh
Heat price – Fixed costs	Annual	€/year
Heat price - Capacity costs	Annual	€/kWh usually
Other charges: e.g., O&M costs	Annual	Depending on the supply company

Table 6: Summary of the concepts and billing parameters of heat at the heat consumer side.

One of the main advantages of district heating is the environmental benefits involved. However, they are not so simple to quantify since the owner of DH does not have to pay emissions rights. Environmental benefits account for the country targets which should take them into account for their long term strategy and policy. That will determine the measures to implement in order to attain their emissions targets. As DH is one technology with low emissions, the correct installation of DH in a country can be one of the appropriate tools.

Other possible sources of income are subsidies. Flanders is setting a supporting system for green heat generation for installations of more than 1MW thermal power. More details can be found in (The Flemish Energy Agency, 2013)

In the case of plants that are also producing electricity, the selling electricity price should also be taken into account.

The revenues per year can be calculated multiplying the estimated demand by the heat price and adding the fixed, capacity, connection fee, and other charges as appropriate.

A revenue model was developed by (Ajah, Patil, Herder, & Grievink, 2007) where the operational availability (λ) of the production plant is taken into account. They defined the operational availability as follows:

$$\lambda = \frac{(1 - FDR)(365 - T_s)}{365}$$

where T_s is the planned downtime (d/y) and FDR is the Forced Down Ratio and given as (Ajah, Patil, Herder, & Grievink, 2007):

$$FDR = \frac{T_u}{T_o + T_u}$$

T_u is the unplanned downtime (d/y), and T_o is the operational time.

3.1. Heat price calculation: Alternative cost

3.1.1. Calculating the Heat Price by the Alternative Cost Method

The heat tariff can be divided between fixed costs and variable costs. The variable costs are depending on the heat consumed while the fixed costs are independent of the consumption and are to be paid annually. As mentioned before, usually a one-off fee is charged when connecting to the DH network.

In the alternative cost calculation method, the different parts of the fee can be estimated as follows:

One-off fee: connection fee, can include investment costs. It can relate to the heat exchanger investment. This one-off fee can cover 100% of the heat exchanger and pumps or a fraction of these costs. Alternatively, it can be calculated as the connection costs to the gas grid and the investment in a heating individual system.

Fixed costs: This annual fee can be calculated as the sum of the average fixed costs of the gas supplier plus the average fixed costs of the gas distributor for a specific type of consumer plus the average maintenance costs of a gas boiler. All excluding VAT.

Variable costs: Can be calculated by multiplying the average of the variable costs of the gas tariff for the specific consumer by the efficiency factor of that type of consumer.

3.1.2. The Dutch Alternative Cost Calculation

The Netherlands exercise the alternative cost calculation, named Niet Meer Dan Anders model in Dutch. The Autoriteit Consument & Markt published in January 2014 a way of calculating the maximum price that can be charged to consumers by the heat provider (Autoriteit Consument & Markt, 2014).

According to the above mentioned policy, article 2, the maximum heat price that can be charged to the consumer can be calculated as follows:

$$P_{maxw} = VK_w + P_w * W_w$$

where

P_{maxw}: maximum heat price [€]
VK_w: fixed costs per year [€]
P_w: variable costs per year [€/GJ]
W_w: consumption per year [GJ]

In article 3 of the policy, the calculation of the fixed costs is the following

$$VK_w = VK_g + \nabla GK \text{ in [€]}$$

where

$$\nabla GK = GK_g - GK_w - K_e$$

VK_g: is the yearly fixed costs of transport, delivery and gas connection. It consists of:

a. The average of the three largest gas suppliers' fix tariff for gas supply for consumers with a one year contract with a fixed price based on the G1[8] tariff in the year t.
b. The weighted average of the transport-independent consumer tariffs for G6[9] connections of the distribution network operators in the year t.
c. The weighted average of the transport-dependent consumer tariffs for G6 connections of the distribution network operators in the year t.
d. The weighted average of the periodic connection tariffs for G6 connection types of the distribution network operators in the year t.

∇GK : it is the cost difference between the use of gas as source or the use of heat.

where:
GK_g: is the costs of using gas. It consists of:

a. The capital costs of the gas boiler;
    - the annual depreciation costs based on a linear depreciation scheme
    - cost of capital based on the average residual lifetime and the real discount rate.
b. The maintenance costs based on an annual maintenance contract
e. The measurement costs based on the weighted average measuring costs of the gas meter for G6 connections of the distribution network operators in the year t.

GK_w = is the heat use cost. It consists of:

a. The capital costs of the heat exchanger;
    - the annual depreciation costs based on a linear depreciation scheme
    - cost of capital based on the average residual lifetime and the real discount rate.
b. The maintenance costs based on an annual maintenance contract
c. The measurement costs based on the weighted average measuring costs of the gas meter for G6 connections of the distribution network operators in the year t.

K_e: is the extra costs for cooking on electricity

In article 4 of the policy, the variable part is calculated with the formula:

$$P_w = \frac{P_g}{(\eta * CV_g)} \qquad \text{in [EUR/GJ]}$$

[8] G1 is defined as a connection that can consume up to 5.000 m^3 per year.
[9] G6 is defined as a connection that can consume up to 500 m^3 per year.

P_g: Average of the three largest Dutch suppliers of the usage dependant gas price based on yearly contracts with fixed price based on the G1 tariff including energy taxes in EUR/m^3.

CV_g: upper caloric value of natural gas: 0.03517 GJ/Nm^3

η: fuel efficiency of the heat production. Can be calculated from the following formula

η = 1/(energy g)

energy g = energetic value of natural gas consumption in the household, which can be calculated as

$$energy\ g = \frac{VR * (1 + LVR)}{\eta\ ruimte} + \frac{VT * (1 + LVT)}{\eta\ tap}$$

VR: heat demand for room heating as percentage of the total heat demand
VT: heat demand for tap water as percentage of the total heat demand
LVR: Percentage line losses for room heating
LVT: Percentage line losses for tap water
η ruimte: average room heating efficiency
η tap: average tap water heating efficiency

CHAPTER 4 LONG TERM INVESTMENT EVALUATION

4.1. ECONOMIC ASSESSMENT

There exist several methods to perform an assessment of a long term investment. Each of them gives different insights and information, so a combined assessment is usually recommended to not get biased decisions.

The most common ones are: the net present value, internal return of investment and payback time. The three methods are described more in detailed in the next paragraphs. A brief description of different evaluating methods can be found in the following link: http://pmbook.ce.cmu.edu/06_Economic_Evaluation_of_Facility_Investments.html

4.1.1. THE NET PRESENT VALUE

The net present value (NPV) of the system can be estimated using the relation (Ajah, Patil, Herder, & Grievink, 2007):

$$NPV = \sum_{i=1}^{N} \frac{CF_i^{Ri}}{(1+r)^i}$$

where CF_i^{Ri} is the cash flow in year *i*, *r* is the discount rate (which captures the time value of money), *i* is the particular year under consideration, *N* is the total number of time periods. In the case of Belgium, a discount rate of 5% can be used for long term investments.

$$CF_i^{Ri} = R_i - C_i$$

where R_i is the total revenue in year i, Ci are the year costs, including the investment (capital) costs.

In a nutshell, NPV compares the current value of the difference between cash in and out now with the value of the same difference in the future taking inflation into account. It gives an indication of the value the investment has.

If the results of the calculated NPV is a positive value, it means that the project brings in positive cash inflow in the time of N. If NPV is negative, then the project results in a cash outflow in the time of N. In the case that NPV equals 0, it means that the operation does not either gain or lose value. In the latter case, decision should be based on other criteria.

Operations with a positive NPV should not be undertaken by default. The project should be appropriately risked and compared with other available investments.

4.1.2. THE INTERNAL RATE OF RETURN

The internal rate of return (IRR) compares the profitability of investments. It is the discount rate that makes the NPV equal to zero. At that particular discount rate the present value of the future cash flow beaks even. The higher a investment's IRR, the more desirable it is to undertake the project.

To calculate it, the NPV formula should be equal to 0. The IRR is given by r.

$$NPV = \sum_{i=1}^{N} \frac{CF_i^{Ri}}{(1+r)^i} = 0$$

4.1.3. THE PAYBACK TIME

The payback time or period of time needed to recuperate the funds of an investment or to reach the break-even point. It is an easy calculation to apply and to understand. It should be carefully used. On the other hand, it can be useful when comparing similar investments. Payback time also reveals the risk level: the longer the payback time, the higher the risk. Usually, investment on DH systems are long term, thus having a long payback time. In this sense, risk management becomes of critical importance.

The payback time is usually expressed in years. It can be calculated by adding the net cash flow per year until a positive number: that year is the payback year. It can also be calculated by dividing the amount to be invested by the estimated annual net cash flow.

4.2. FUTURE TRENDS

As mentioned before, a DH project is a long term investment. Therefore, the future trends of the heat demand and energy prices should be taken into account to hedge the risk. If these parameters are not properly considered, they can jeopardize the feasibility of the project in the long term.

4.2.1. HEAT DEMAND

It is very well possible that in the future, the heat density lowers in an area. This relates to the heat demand of that specific area. As seen before, when heat density decreases, it is the specific distribution cost that decreases. Therefore, the total cost decrease is not directly proportional to the heat demand reduction (Persson & Werner, 2011).

4.2.2. ENERGY PRICES

The Belgian Commission for the Regulation of Electricity and Gas forecasted that energy prices will increase for the following years. It analyses the price evolution of the past years and extrapolates the observed tendency. The electricity is expected to increase at a rate of 6% per year while the gas price is expected to increase at a rate of 7,68% per year (Commissie voor de Regulering van de Elektriciteit en het Gas, 2012)

CHAPTER 5 ORGANIZATIONAL MODELS

As mentioned before, the generated heat has to be transported to the load location to be consumed. The main steps in this chain are: production, transport and supply or retail. Moreover, the investor in the heat production, distribution or transport network does not necessarily have to be the same market player as the one exploiting the DH system. Therefore, another stakeholder could be involved in the project.

In large DH projects, where the transport network is needed, a regulatory body should be involved in order to avoid any abuse to consumers. The transport of heat is a natural monopole and thus a regulatory body should be in place.

In a nutshell, the possible stakeholders are:
- Consumer
- Heat producer / transporter/ distributor / retailer
- Investor
- Regulatory body

Consumer
The heat consumer seeks to cover his/her heat demand by the most affordable and safe mean. Depending on certain social factors, the consumer could be actively participating to the environment by implementing low carbon emission technologies for heat supply. In the latter case, the consumer will actively take part of the incipient implementation of the technology in the country. This can be a refurbishing project by exchanging the previous heat source by district heating for example, or a new building construction.

A group of consumers in an area or district could get actively involved in the implementation of DH by investing themselves in the DH project instead of only contracting the supply what is so-called cooperatives. Since the benefits of the DH system revert to himself, the consumer cares for the efficiency and maintenance of the installation.

A different case is when the policy maker of the region decides to implement DH in that area. In this case, the DH is sort of imposed to the consumer. This is more common in new building areas. The level of active involvement of the consumer is lower in this case.

Heat producer / transporter/ distributor / retailer
The number of companies involved in the physical production, transport and supply depend on the specific heat market structure of the country. In new markets, all the steps are usually bundled. It is very likely, that the heat market will follow the same path as the electricity market: the market was unbundled by regulation once it was economically viable.

Investor
At this point in time it is unclear which party will take the investor role for DH in Belgium. It seems very likely that the investor will be a combination of the company doing the later exploitation of the project and a participation of the administration.

Regulatory body

The regulatory body is in charge of watching the good overall and ethics performance of DH systems. They can decide on the bundling level of the market as well as the regulation level. As an example, heat prices could be totally or partially regulated or an obligation to connect could be imposed to new consumers' buildings.

The regulatory body also has the possibility to implement financial alleviating measures such as taxes reductions or subsidies.

5.1. STRUCTURES: QUALITATIVE ASSESSMENT

In the most general case, large DH systems are built including the transmission network. In that case, depending on the number of companies performing the different tasks (production, transmission, distribution, and retail) up to eleven organizational options are possible. See Figure 4 where each colour represents a legally independent company.

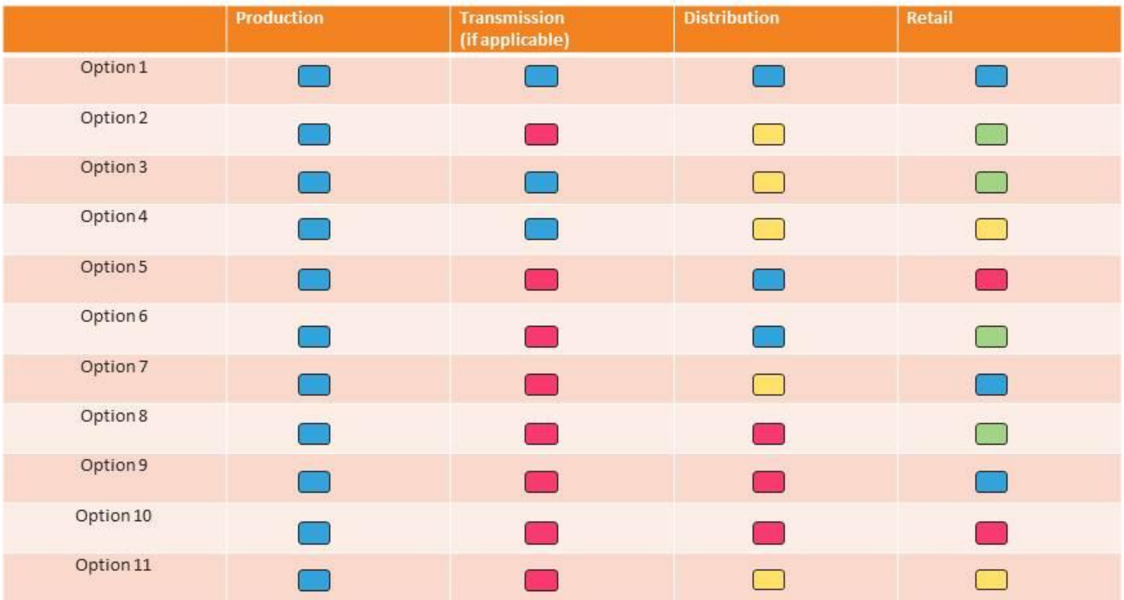

Figure 4: Organizational options in a DH system including production, transmission, distribution, and retail.

Within those options there also exist the possibility that each company is a privately-owned company, owned by one or more municipalities or by a consumer's cooperative. The main differences between the eleven configurations are the level of competitiveness and the administrative burden; the higher the number of companies involved in the value chain, the higher the administrative burden.

For simplification purposes, we assume that DH systems we will be looking at are of smaller scale and thus, counting only with the distribution network and not what was considered transmission previously. One of the aforementioned reasons for a viable DH system is that the heat source is found close to the loads, and thus, avoiding the transmission part. Moreover, since DH is barely being implemented in Belgium, the majority of the projects would be of small scale.

In that case the organizational models are reduced to five options. See Figure 5 below where each colour represents a legally independent company:

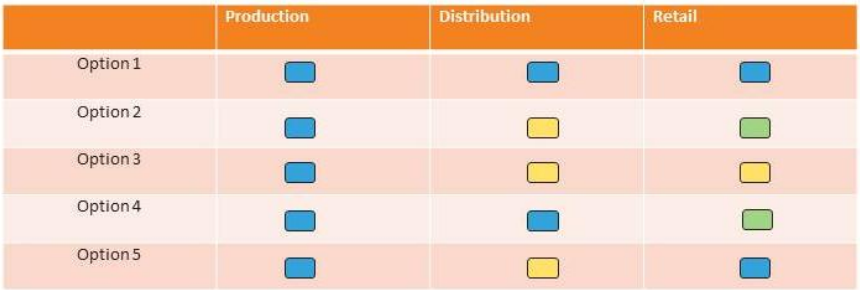

Figure 5: Organizational configurations for DH systems with production, distribution, and retail activities.

In the next sections, the five options will be analysed more in detail:

Option 1: Fully integrated heat company where the production, transport and supply are integrated

In this option, there are two actors on the heat market: the consumer and the heat company that perform the role of producer, distributor and retailer. Within this option 1, there are two main possibilities, when the heat company is privately owned or when the company is owned by the consumers and structured in a cooperative way. This structure is typical in incipient markets and small-sized projects. Figure 6 represents the market actors and the value exchange in e3value ontology[10].

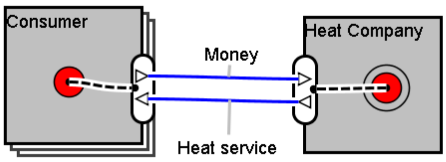

Figure 6:e3value representation of fully integrated heat company market model

The competition in this market configuration is rather limited, thus an important risk for the consumer is a high price or abuse from the heat company. This risk can be limited by partially regulating the heat price either the amount or the calculation method.

Due to the simplicity of this market structure, the administration costs are kept to a minimum. On the other hand, the heat company undertakes all the risks and investment. The risks and advantages for both parties are summarized in Table 7.

[10] http://e3value.few.vu.nl/

Privately owned company	Consumer	Heat company
Risk	High heat price if not regulated or capped. No competitive structure.	Investment in production and network. Runs all the risks.
Advantages	If regulation is in place, it limits the risks.	Not administrative intensive. Receives all the money. No competition.

Table 7: Risks and advantages of a fully integrated heat company market model

Previously, it was assumed that the heat company was a third legally independent party. In Table 8, the risks and advantages of the cooperative case are summarized. In this case, the consumer is also owner of the heat company which encourages his/her to work towards a more efficient system. This structure is strongly linked to the culture of the area. It is a common configuration in Denmark but it does not mean that it can be easily transferred to other countries.

	Consumer as owner: cooperative structure
Risk	Undertakes all investments and risks
Advantages	Benefits for the consumer. Involved in the management. Incentive to keep the system efficient. Limited administrative costs (few roles on the market)

Table 8: Risks and advantages of a cooperative market model

Option 2: All the steps in the value chain are separated

At the other extreme, the completely unbundled market is found. In this case, the three roles are distributed amongst different companies. This is the most administrative intensive configuration. The consumer has one single point of contact, the retailer, who afterwards distributes part of the fees paid by the consumer to the distributor and the heat producer.

The main advantage of the configuration is the fact that the risks are distributed amongst different market players. At the same time this creates some interdependencies in between the roles. Still the role of the regulatory body is important for the heat pricing control. This structure is more competitive than the previous one although distribution is a natural monopole and as such needs to be surveyed.

Figure 7 and Table 9 present the schematic of the business organization and the risks and advantages per market player.

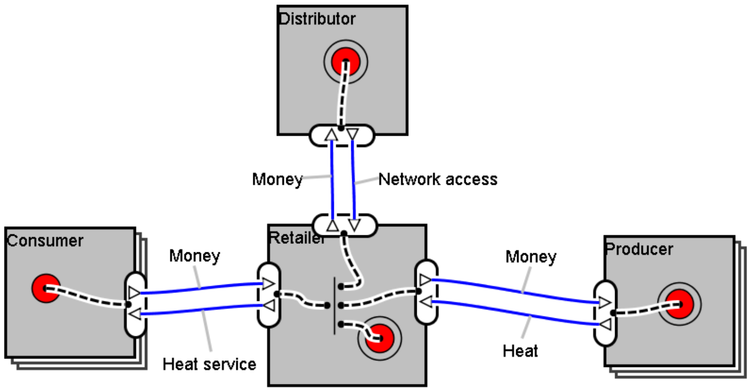

Figure 7: e3value representation of a fully unbundled market model

	Consumer	Retailer	Producer	Distribution
Risk	High heat price if not regulated or capped Can result more expensive due to the administrative costs.	Depends on the network owner. It is a monopole, no incentive to be efficient. Depends on the producer.	Investment in production capacity. May have competition from other producers	Investment in network. Natural monopole, should be watched over.
Advantages	If regulation is in place, it limits the risks. More competitive structure.	Has the contract with the consumer. He can stimulate competition at the production side by releasing tenders	Limited investment.	Limited investment.

Table 9: Risks and advantages of a fully unbundled market model.

Option 3: The retailer is the company in charge of distributing the heat
In between configuration 1 and 2, there are several options where two activities could be bundled within the same market player. Option 3 presents the structure when the distributor and the retailer are the same company. This market player buys the heat from an external producer. A possibility is to release a tender on that option to encourage competition. The retailer and distributor is also the single point of contact to the consumer.

The regulatory body roles are to protect the consumer and to watch over the natural monopole on the distribution task. In this structure, the consumer is bounded to use as retailer the distributor company operating in his area. Therefore, competition is limited in that role.

The management of this structure is easier than in the complete unbundled case represented in option 2.

Figure 8 and Table 10 show the organizational model and the risks and advantages per market player.

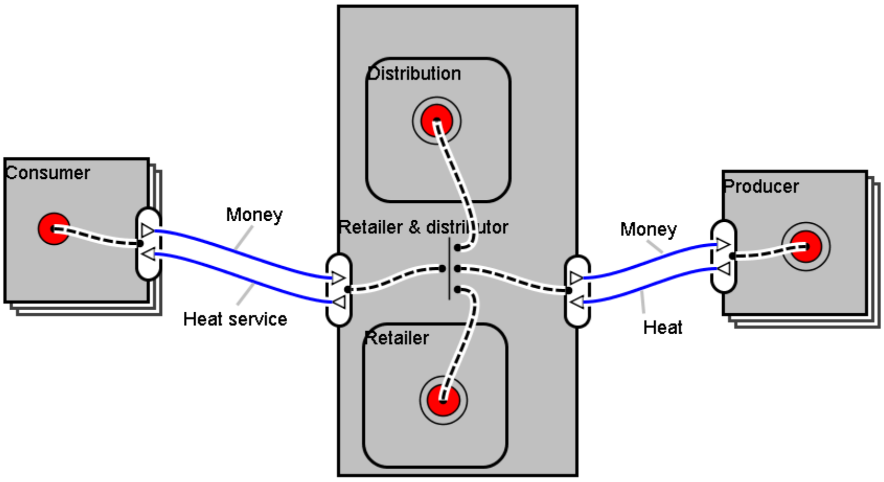

Figure 8:e3value representation of bundled retailer and distribution activities market model.

	Consumer	Producer	Retailer & distribution
Risk	High heat price if not regulated or capped. No competition to choose the retailer.	Investment risk in production capacity. May have competition from other producers.	Investment in network. Natural monopole, should be watched over. Depends on the heat producer. Higher administration costs than an-only distributor.
Advantages	If regulation is in place, it limits the risks	Limited investment.	Has the contract with the consumer. He can encourage competition by releasing tenders.

Table 10: Risks and advantages of a bundled retailer and distribution activities market model

Option 4: The producer is the distributor of heat

In this case, the producer and distributor's role are performed by the same market player. The point of contact with the consumer is done via de retailer, who signs the contract with. The retailer does not invest in any heat production facility or distribution network. He outsources it to an external company. This makes him also dependant on this third party company. Moreover, the consumer may have a broad option to choose his heat retailers. Competition is larger than in the Option 1 and 3 previously analysed.

The regulatory body roles are to protect the consumer and to watch over the natural monopole on the distribution task.

Figure 9 and Table 11 show the schematic representation of the organizational model and a summary of the risks and advantages for the different actors.

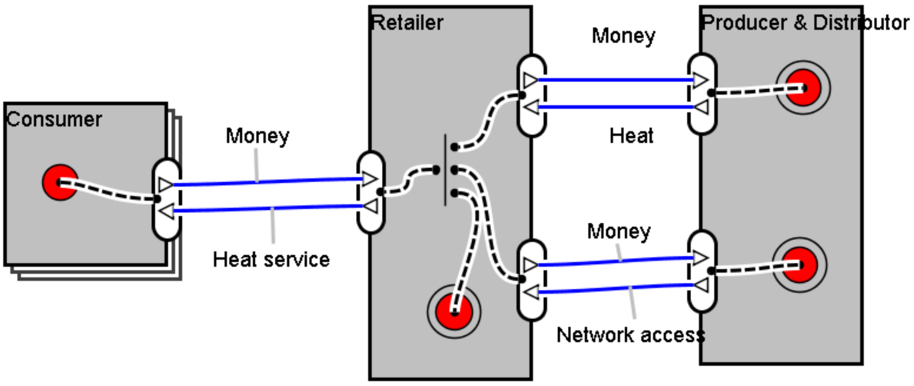

Figure 9:e3value representation of bundled producer and distribution activities market model

	Consumer	Producer & Distributor	Retailer
Risk	High heat price if not regulated or capped.	Investment risk in production capacity and network. Depends on the retailer for commercialization.	Depends on the producer & distributor. In this structure there is no competition at the production side. If prices are not correctly regulated he might incur into losses.
Advantages	If regulation is in place, it limits the risks. Might be a competitive market at the retailer side.	There is no competition.	Has the contract with the consumer.

Table 11: Risks and advantages of a bundled producer and distribution activities market model.

Option 5: The producer is the retailer of heat to the consumer
Option 5 represents the organizational model when the retailer is as well the heat producer. The heat distribution network is owned and exploited by a separate company. The retailer and producer is the company in contact with the consumer and pays the distributor for the network access.

The regulatory body roles are, as in the previous cases, to protect the consumer and to watch over the natural monopole on the distribution task.

Figure 10 and Table 12 present the schematic of the business organization and the risks and advantages per market player.

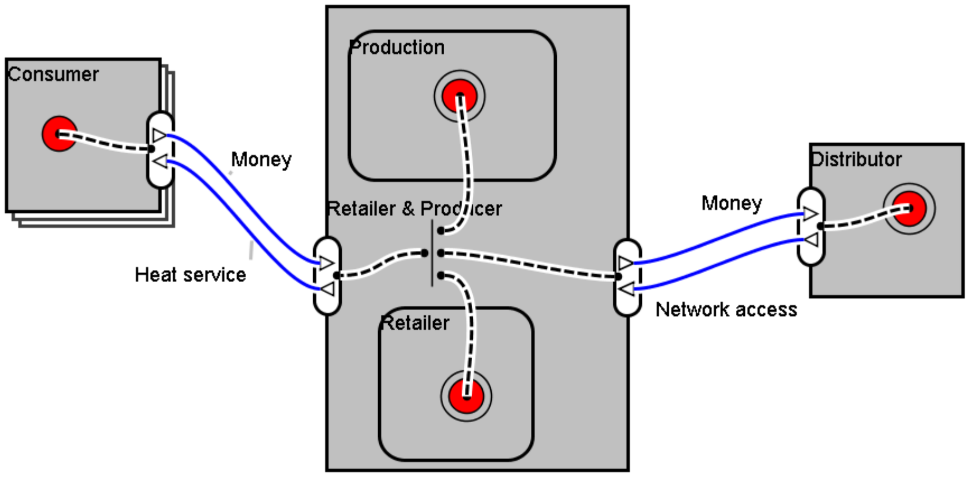

Figure 10: e3value representation of bundled retailer and production activities market model

	Consumer	Producer & retailer	Distribution
Risk	High heat price if not regulated or capped.	Investment risk in production capacity. Depends on the network owner. Competition from other producers. Higher administrative costs than an only-producer.	Investment in network. Natural monopole, should be watched over.
Advantages	If regulation is in place, it limits the risks. It can be a competitive market.	Has the contract with the consumer.	Limited marketing efforts.

Table 12: Risks and advantages of a bundled retailer and production activities market model.

5.2. CALCULATIONS

In this section some market calculations are presented for the fully bundled (Option 1), the fully unbundled market models (Option 2) and when the retailing activities are integrated within the producer of distributor (Option 3 and 5). Option 4 can be considered a sub-case of Option 1 by taking into account the extra benefit margin for the retailer. The calculations are done with an in-house developed tool.

For those three different configurations, the investments on heat production and distribution are assigned to the party or parties undertaking that responsibility. Equally, the heat tariff paid by the consumer is split amongst those parties. The payback time, Net Present Value and Internal Rate of Return are calculated per party active in the heat market.

The time horizon of the simulations is thirty years and the reference case is a condensing gas boiler with 90% efficiency. The heat demand is considered to decrease within the years since it is assumed that housing insulation is improved. The heat loads are very close to one another (appartment building area) reducing the size of the network needed being thus, an ideal situation to implement a DH system.

In this example, the calculation of the heat tariffs is based in alternative pricing (or not more than others) calculation.

For the heat production, two CHPs, waste heat and a gas boiler as back-up are employed. This means that the owner of the production part benefits from the green certificates of the CHP and from selling part of the generated electricity. The rest is self consumed in the district.

Option 1: Fully bundled market: One market player - heat delivery company
Taking into account all the parameters mentioned above, the financial calculations were done with the following results:

Payback time: 16.79 year[11]
NPV: 11.713.690 EUR

Equity IRR: 9.97%
Project IRR: 5.5%

The total investment costs in the network are almost double than the amount invested in the heat production just taking into account "installation" costs. When considering O&M, capital costs, and fuel costs the production costs amount to 54% against 46% of the network costs including O&M and capital costs.

Figure 11 shows the investment costs in the heat network and heat production in the thirty years timeline. In year 10 and 20 re-investments in the production facility take place (second CHP and waste heat use).

[11] As mentioned before, the example chosen is close to an ideal situation for the implementation of DH. Therefore, the payback times are rather short when compared to other cases.

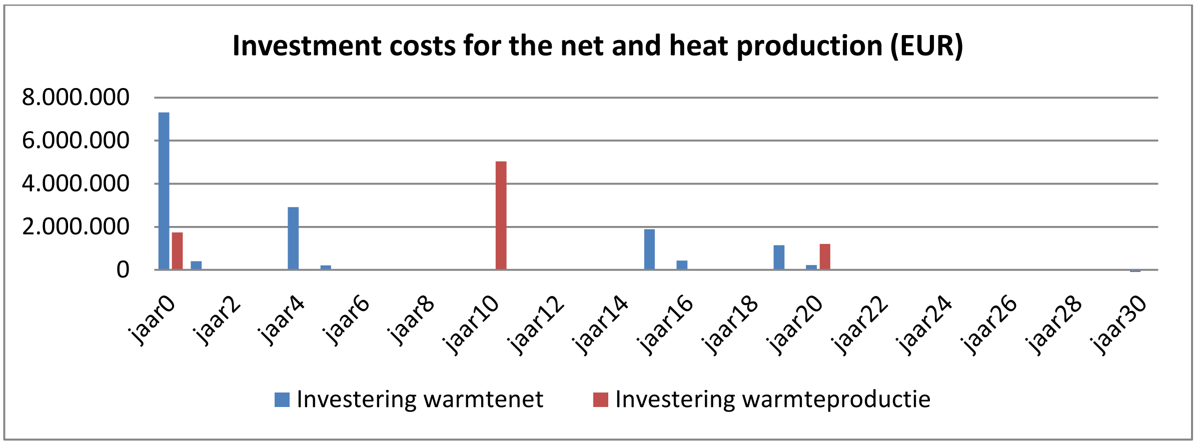

Figure 11: Investment costs in the thirty years for the heat network and heat production.

Note: to calculate Option 4, the benefit margin of the retailer should be taken into account. That will reduce the NPV and increase the payback time.

Option 2: Fully unbundled. Producer, distributor and retailer are separate entities.

- *Distributor:*

The revenues of the distributor consists of the 35% of the heat variable tariff, the connection fee and the fix heat tariff. He invests exclusively in the heat network.

Results of the calculations:
Payback time: 19.67 year
NPV: 4.141.423 EUR

Equity IRR: 4.19%
Project IRR: 0.92%

- *Producer:*

The revenues of the producer consists of the 60% of the heat variable tariff. He invests exclusively in the heat production facilities.

Results of the calculations:
Payback time: 18.39 year
NPV: 4.837.893 EUR

Equity IRR: 8.91%
Project IRR: 5.81%

- *Retailer:*

The revenues of the retailer consists of 5% of the variable fee. He does not undertake specific investments. He does not undertake any particular investment, just the administrative burden.

NPV: 2.737.182 EUR

It is possible to accommodate three parties in this specific business model. Depending on the profitability goals one or the other structure should be selected.

Option 3 or 5: Producer and distributor are separate entities.

- *Distributor:*

  The revenues of the distributor consists of the 35% of the heat variable tariff, the connection fee and the fix heat tariff. He invests exclusively in the heat network.

  Results of the calculations:
  Payback time: 19.67 year
  NPV: 4.141.423 EUR

  Equity IRR: 4.19%
  Project IRR: 0.92%

- *Producer:*

  The revenues of the producer consists of the 65% of the heat variable tariff. He invests exclusively in the heat production facilities.

  Results of the calculations:
  Payback time: 15.29 year
  NPV: 8.263.613 EUR

  Equity IRR: 18.61%
  Project IRR: 11.82%

With this heat tariff split, the investment results more beneficial for the producer. Still, another split ratio of the heat tariff amongst the different market players could be agreed and analyzed. In this case, the best option would be that the producer undertakes the retailer role as well.

In general, each DH project has different distribution and production costs. The possible organizational structure should be analyzed case per case.

CHAPTER 6 CONCLUSION

In this document, some generic formulas calculate the costs of a DH system were presented. The competitiveness of district heating against local solutions is determined by the generation costs and the distribution costs. At the same amount of revenues, the total cost of district heating must be lower than the cost of any local heat generation alternative (Persson & Werner, 2011). Thus, high distribution costs can jeopardize the DH competitiveness.

In a separate chapter, all the possible revenues were summarized and the alternative cost heat pricing methodology presented. The alternative pricing model charges to the heat load on average no more costs than when using natural gas for the individual central heating. This approach is not based on the cost of heat supply, but on a comparison with similar gas references. The alternative pricing is mainly used to persuade consumers to switch to DH or to prevent loss of consumers. This heat pricing mechanism can force the utility to invoice prices well below its real costs resulting in a non-sustainable business model. The regulatory body should carefully evaluate the calculation mechanism to avoid such a situation.

In the final chapter, different organizational models were analysed including a quantitative comparison. In small DH projects, when the market is barely existing in the country, the bundled structure seems to be the most appropriate. In this case, the heat company runs all the risks while receiving all the revenues of the system. The main advantage of this configuration is the limited administrative burden since the management of the system is rather simple. The consumer should be protected against abuse from the heat company since competition is inexistent. In this line, the role of the regulatory body is relevant to watch over the natural monopole as well.

In a nutshell, each DH project has different distribution and production costs. These costs are determining the viability of the project, therefore, the most viable organizational structure and revenues split should be analysed case per case.

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