12/05/2014

STEP-UP Workshop: Trajectory 4
Market model heating networks

V. Gómez Oñate

Overview

- Introduction to District Heating
- Summary Deliverable 1: Policy Framework & Business Models
  - Sweden
  - Denmark
  - Belgium
- Summary Deliverable 2: Business Models for District Heating
  - Costs
  - Revenues
  - Organizational models

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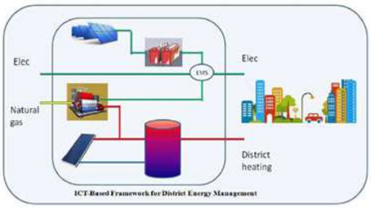
Introduction to District Heating

» **District heating** is a system for distributing heat generated in a centralized location for space heating and water heating. The heat is often obtained from a cogeneration plant. Renewable sources such as biomass, geothermal and solar thermal are also used.

» The fundamental idea behind modern district heating is to recycle the **surplus heat** which otherwise would be wasted- from electricity production, from fuel and biofuel-refining, and from different industrial processes.

» District heating plants can provide **higher efficiencies** and better pollution control than localized boilers.



Resilient project

Introduction to District Heating (II)

» There is no established definition
» **Transmission network** are the pipes that transport the heat between the producer until the heat exchanger.
» Transmission pipes are usually larger and they often contain security loops to ensure reliability.

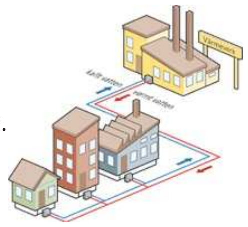


Diagram from cleanenergy.org

» **Distribution grid** starts after the heat exchanger station.
» 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.

Introduction to District Heating (III)

» 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.

» Networks are costly: long term investment

» Advantages:
  » Cost-effective: reduce use of primary energy
  » Higher efficiency with low emissions
  » Offers flexibility

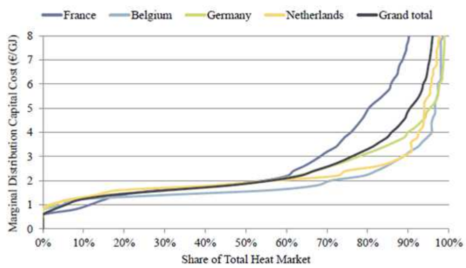
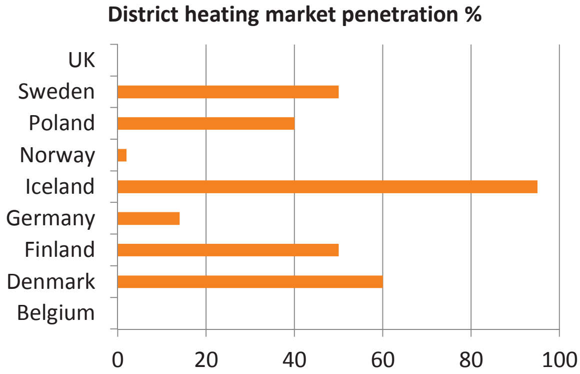


Figure 1: Marginal distribution capital cost levels for different urban DH market shares in 2008

Introduction to District Heating (IV)

» Uneven penetration of District Heating per country



Various sources

District Heating in Belgium – Case study

» Municipality of Herenthout, Belgium

» Aim: to reduce the primary energy consumption for room heating and hot sanitary water

» 19 dwellings are divided into 2 building blocks with 12 and 7 dwellings

» The owner is the social housing company Zonnige Kempen in Westerlo

» The company helps people with a low income by offering them a proper and affordable house, as owners or tenants

» Advantages:

  » social housing with low energy bills

  » Environmental benefit due

  to the lower consumption and emissions


Building Block 1

District Heating in Belgium – Case study

- **System components**
  - micro CHP system with an electrical power of 5.5 kWe integrated in a heating system existing of a condensing boiler and a solar collector
- **Performance**
  - The micro CHP delivered about 44% of the total heat demand of the dwellings
  - The primary energy consumption related to the micro CHP was reduced by 65.9 GJ/y compared to the reference situation
  - The CO_2-emission was reduced by 6.9 tons/y
  - The investment cost amounts to 12,169 € and the net energy saving is 1,773 €/y
  - The payback period of the investment was 7.9 years. If the funding of the project is included in the economic evaluation the payback time of the project is 3.1 years.

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Summary Deliverable 1:
Policy Framework & Business Models

- Policy Framework
  - Planning
  - Support
  - Burden
- Business Models:
  - Market structures: Unbundling level
  - Heat price:
    - Alternative pricing: Not more than others
    - Cost plus
    - For the consumer: variable and fixed part

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Summary Deliverable 1:
Denmark: Policy Framework

Planning	Support	Burden
General heat planning	Subsidies	Energy taxation
Waste planning	Heat price regulation	
Ban on electrical heating and obligation to connect	CHP requirement	
Law on district cooling		

Implemented in the 90's

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Summary Deliverable 1: Denmark: Business Models

- Organizational structure: bundled
- Cooperatives: consumer or municipality owned
- Heat pricing:
  - cost plus: calculation of real costs including investment and financial costs
  - To facilitate the transition of natural gas consumers to DH: guarantees a maximum of 90 % of the equivalent annual cost of heating based on natural gas.

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STEP UP 13

Summary Deliverable 1: Sweden: Policy Framework

- Competition based approach: deregulated except for transmission/distribution

Planning	Support	Burden
Long term planning introduction of DH	Subsidies	Tax on electricity consumption
Climate change program	Green electricity certificates	

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Summary Deliverable 1:
Sweden: Business Models

- Organizational structure: bundled
- Owners: private companies or municipalities
- Heat pricing:
  - Varies: mainly alternative pricing or cost plus
  - Flow cost component: based on volumetric flow
- Third Party Access discussion

Summary Deliverable 1:
Belgium: Policy Framework

- **Regulatory framework**
  - Not ensuring the deployment of DH systems
  - No subsidies for DH implementation
  - Heat is not regulated
  - CHP incentives are in place in the three regions of the country
- **European Directives**
  - The Renewable Energy Sources directive, article 22 (3): Member States to indicate geographical locations suitable for exploitation of energy from renewable sources in land-use planning and for the establishment of district heating and cooling
  - Energy Efficiency Directive 2012/27/EU (§ 1.2.3.6): a map with demand and supply points of warmth and coolness shall be drawn by 31 December 2015

Summary Deliverable 1: Belgium: Policy Framework

- **The Flemish region**
  - Assessment of the potential for qualitative development of cogeneration and efficient district heating and cooling by analysing current and future supply and demand
  - Demand and supply heating map is planned for the end of 2014
  - Together with the map, a strategy and instruments needed for the achievement of the potential will be drafted (Vlaams mitigatie plan 2013).

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Summary Deliverable 1: Belgium: Policy Framework

- No heat legal framework – increasing interest

Planning	Support	Burden
Unclear	CHP certificates	-
	Green heat	

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18

Summary Deliverable 1: Belgium: Business Models

- Organizational model: specific cases
- Owners: private companies or municipalities
- Heat pricing:
  - Mainly alternative pricing to encourage acceptance

Summary Deliverable 1: Conclusions

- Targets on DH implementation: No clear target on implementation of DH.
- Unbundling level: bundled. Start of the market.
- Some legal aspects to implement DH:
  - obligation to connect in new buildings;
  - require minimum consumption;
  - requirements on production e.g., biomass or CHP
- Consideration should be given to consumer protection & reliability assurance by implementing restringing KPIs.
- Cities are not at the position to implement subsidies or impose extra taxes.
- Heat price mechanism: alternative pricing to promote acceptance.

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Summary Deliverable 2: Assessing Economic Feasibility

» Total **cost and revenues** of the project must be analysed.

» The total cost of district heating (including transmission and distribution) must be **lower than** the cost of any local heat generation alternative (Persson & Werner, 2011).

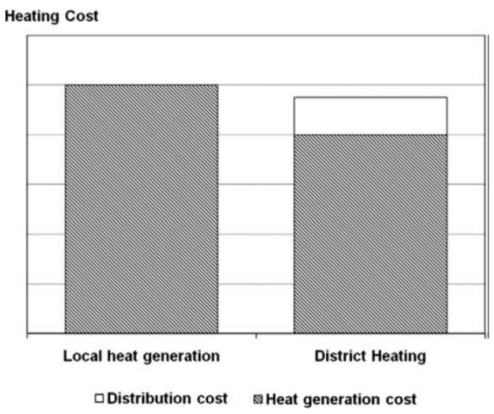

Figure 2: General cost structure comparison between local heat generation and district heating, with respect to the heat generation cost and the distribution cost (Persson & Werner, 2011).

Summary Deliverable 2: Assessing Economic Feasibility

- Net Present Value: gives an indication of the value the investment

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

- Internal Rate of Return: compares the profitability of investments

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

- Payback time: period of time needed to recuperate the funds of an investment or to reach the break-even point.

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Summary Deliverable 2: Future trends

- Heat Demand: expected to **decrease** due to better building isolation
- Energy Prices*: expected to **increase** for the following years.
  - Electricity price forecasted to increase at a rate of 6% per year
  - 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)

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Summary Deliverable 2: Costs in a DH system

- Total costs can be split into:
  - Heat production costs
  - Transmission costs
  - Distribution costs
  - Other costs e.g., taxes

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

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25

Summary Deliverable 2: Heat production costs

- Heat production costs:
  - Capacity investment
  - Operation and maintenance
  - Fuel costs
- Various technologies, e.g.:
  - Waste heat
  - CHP
  - Heat pumps
- Two categories:
  - the **fixed** costs: annual investment costs and O&M costs which are not determined by the operation of the plant.
  - the **variable** costs: fuel expenses and O&M costs which are associated with the utilization of the plant (Nielsen & Möller, 2013).

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

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26

Summary Deliverable 2: Heat production costs

» *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

Summary Deliverable 2: Heat production costs - Fuel costs

» Include **handling and transportation** to the production units.

» Calculated by **multiplying** the annual fuel consumption for each production unit by the fuel costs.

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

Summary Deliverable 2: Transmission costs

- In practice, pipes do not always follow the design: **conservative estimate** (Nielsen & Möller, 2013).
- Calculated by **multiplying**, for each transmission line, the length and cost per meter
- The calculated cost is **annualized** by using a discount rate of 5% for socio-economic calculations in Belgium

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

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

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

Summary Deliverable 2: Distribution costs

- Four different **categories** (Frederiksen & Werner, 2013):
  - Distribution **capital cost**: it represents the yearly investment capital payment for the construction of the network;
  - Distribution **heat losses**: they depend on the distribution temperature used, the average pipe diameter, and the heat resistance of the pipe insulation;
  - Distribution **pressure losses**: they are proportional to the product of the volume flow and the pressure increase in all distribution pumps;
  - **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%.

Summary Deliverable 2: Distribution costs

- Total distribution cost is usually **inversely proportional** to the linear heat density*.
- The specific distribution **capital cost dominates** the distribution cost (Frederiksen & Werner, 2013). The

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

- I = total investment cost for the distribution network [EUR]
- a = annuity, from the chosen hurdle rate 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/m²]
- d_a = average pipe diameter [m]
- L = total trench length [m]
- Q_s/L = linear heat density [GJ/m]

p = population density
α = building space
q = heat demand
ω = effective width

*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.

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Summary Deliverable 2: Other costs

- These comprise:
  - The operation and administration salaries
  - Insurances
  - Taxes, if applicable: such as the CO_2 tax, energy and sulphur tax, as well as national taxes

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SEVENTH FRAMEWORK PROGRAMME

32

Summary Deliverable 2: Revenues in a DH system

» Heat fees:
  » connection
  » supply
  » other fees

» Selling electricity

» Subsidies:
  » E.g., green heat generation for installations of more than 1MW thermal power.

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.

Summary Deliverable 2: Heat pricing - Alternative costs calculation

» Fee can consist of different fees:
  » **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 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.
  » **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.

Summary Deliverable 2:
Heat pricing - The Dutch alternative cost calculation

- 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

- The maximum heat price that can be charged to the consumer can be calculated as follows:

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

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

Summary Deliverable 2:
Organizational models

- Possible stakeholders are:
  - Consumer
  - Heat producer / transporter/ distributor / retailer
  - Investor
  - Regulatory body

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

Summary Deliverable 2: Organizational models

- Production
- Transmission
- Distribution
- Retail

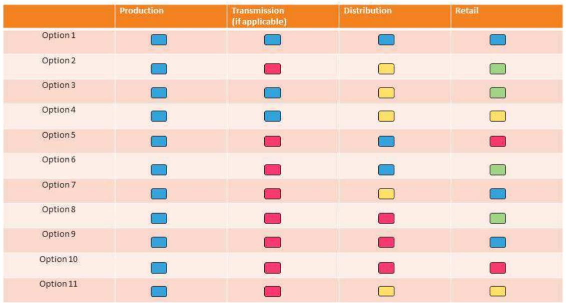

Figure 4: Organizational options in a DH system including production, transmission, distribution, and retail.

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37

Summary Deliverable 2: Organizational models

- **Option 1:** Fully integrated heat company where the production, transport and supply are integrated
- **Option 2:** All the steps in the value chain are separated
- **Option 3:** The retailer is the company in charge of distributing the heat
- **Option 4:** The producer is the distributor of heat
- **Option 5:** The producer is the retailer of heat to the consumer

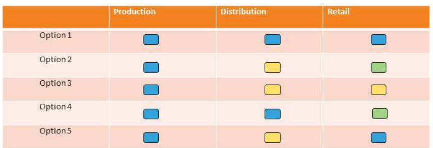

Figure 5: Organizational configurations for DH systems with Production, distribution, and retail activities.

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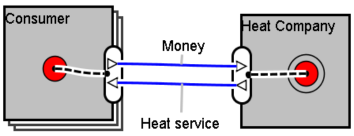
38

Summary Deliverable 2:
Option 1: Fully integrated

- 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.
- 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.
- **Administration costs** are kept to a minimum.
- The heat company undertakes all the risks and investment.



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Summary Deliverable 2:
Option 1: Fully integrated

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.

	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)

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40

Summary Deliverable 2: Option 2: Fully integrated

- 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.
- **Risks are distributed** amongst different market players. At the same time this creates some interdependencies in between the roles.
- 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.

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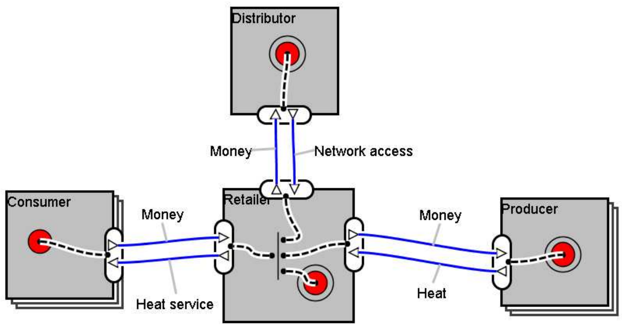
41

Summary Deliverable 2: Option 2: Fully integrated

- The three roles are distributed amongst different companies.



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42

Summary Deliverable 2:
Option 2: Fully integrated

	Consumer	Retailer	Producer	Distributor
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.

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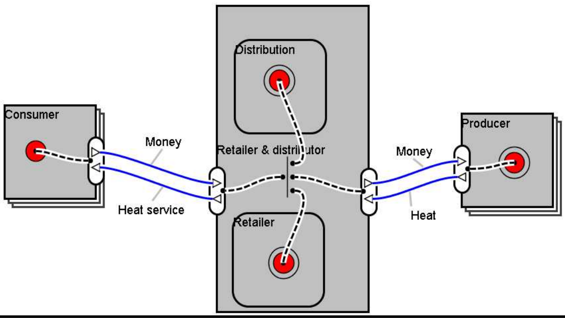
Summary Deliverable 2:
Option 3: Retailer is the distributor

- The distributor and the retailer are the same company.
- This market player buys the heat from an **external producer**
- The retailer and distributor is 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.
- The **consumer is bounded** to use as retailer the distributor company operating in his area.



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Summary Deliverable 2:
Option 3: Retailer is the distributor

	Consumer	Producer	Retailer & distributor
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.

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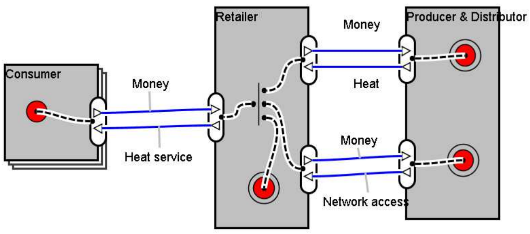
Summary Deliverable 2:
Option 4: Producer is the distributor

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



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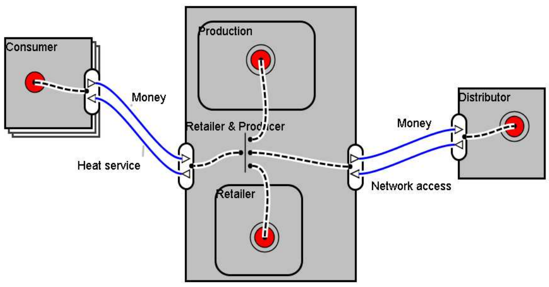
Summary Deliverable 2:
Option 4: Producer is the distributor

	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

Summary Deliverable 2:
Option 5: Producer is the retailer

- 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 to protect the consumer and to watch over the natural monopole on the distribution task.



Summary Deliverable 2:
Option 5: Producer is the retailer

	Consumer	Producer & retailer	Distributor
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.

Conclusions

- Regulatory framework is key: long-term planning, support…
- Secure long-term investments: distribution networks
- Incipient markets:
  - Bundled structure
  - Heat regulation: alternative pricing
  - Ensure reliability to consumers (KPIs)
- Distribution and production costs are case-specific
- City level initiative: tenders

Questions?

Thank you for your attention