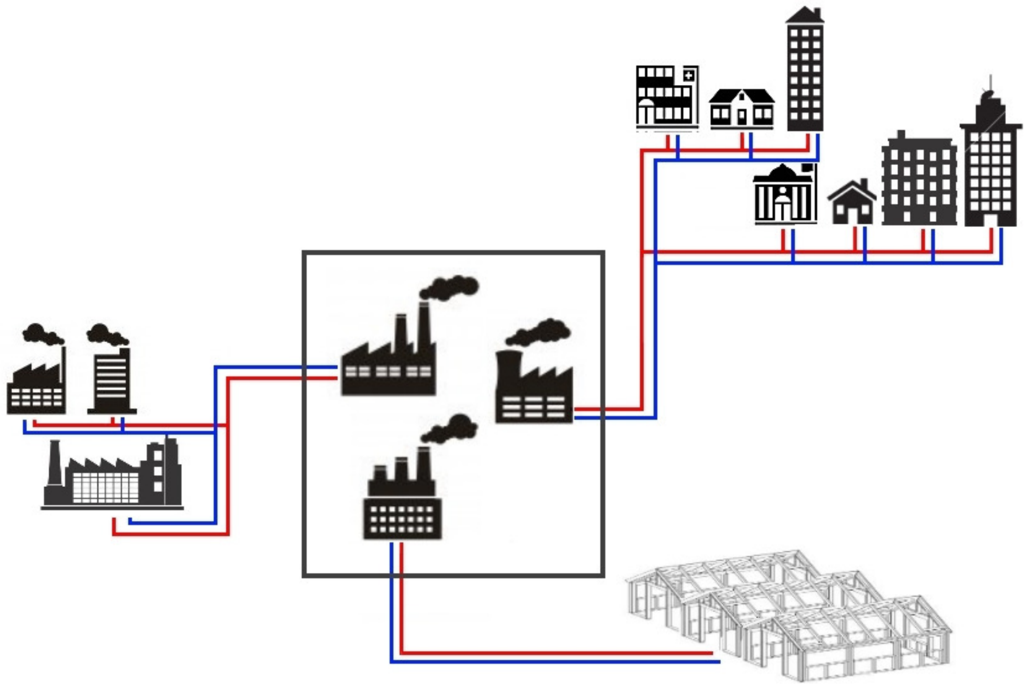
Business models for industrial waste heat utilization in the Netherlands

A cohesive and consistent approach to sustainability



Ines Buskermolen
3634523

Date: 11-07-2013

Universiteit Utrecht

TATA STEEL

Information

Name:	Ines Buskermolen
Student number:	3634523
Master program:	Sustainable Development: Energy and Resources
UU supervisor:	Robert Harmsen
Company:	Tata Steel in IJmuiden
TSIJ supervisors:	Marjan Olthof and Olivier Vree
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End date:	July 11th 2013

Summary

Industrial waste heat utilization is an attractive option for meeting sustainability targets and improving energy efficiency in the industry. While, the attractiveness seems to be large, there are not many industrial waste heat utilizations projects realized in the Netherlands (Energie Nederland, 2011).

Literature research reveals that common barriers that inhibit the establishment of these types of projects are; financial, organizational and cultural barriers. Furthermore, the long payback periods and high investment costs make the realization of industrial waste heat utilization projects difficult. The combination of these barriers and financial issues indicates that there is need for in depth research on business models for these types of projects. Hence, the aim of this thesis is to generate best practice business models and trends in new business models for industrial waste heat utilization projects in the Netherlands and identify the critical success factors that enable successful execution of these business models.

In order to analyze and categorize business models in this thesis the business model generation (BMG) theory by Osterwalder and Pigneur (2010) will be used as backbone. The BMG model consists of nine building blocks which are explained in Textbox 1.

Textbox 1: Building blocks BMG theory

Building blocks:

- *Customer segmentation:* the different customer segments that an industrial waste heat utilization project focuses on.
- *Value proposition:* the combination of benefits the partnership/project will yield for the involved stakeholders.
- *Channels:* parties that facilitate the connection and communication to the customers
- *Customer relationship:* the type of relationship the supplier wants/needs to have with the customer
- *Revenue streams:* cash flow that is generated by means of the project
- *Key resources:* assets needed to successfully implement the business model
- *Key activities:* the things a company must do in order to successfully implement the business model
- *Key partnerships:* the network and partners that are needed to make the business model work
- *Cost structure:* all the cost that have to be covered by the stakeholders

The method used in order to identify these business models is described in Figure 1. First industrial waste heat projects in the Netherlands are identified, where after the lessons learned, barriers and risks are extracted. These will be the core ingredients for the formation of best practices business models. Furthermore, trends in new business models will be researched and applied to industrial waste heat projects. Finally, a preconditions model will be drafted and conclusions will be drawn up.

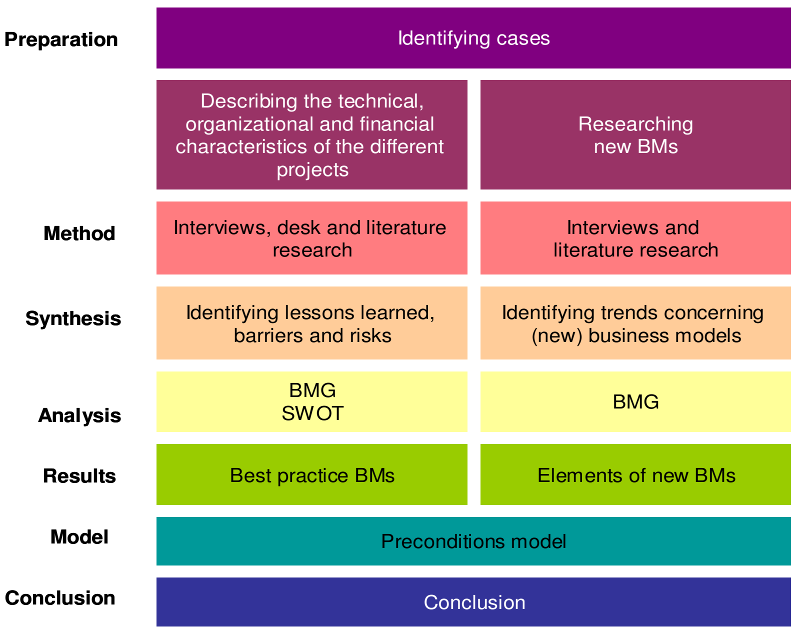

Figure 1: Method

Learning from existing cases in the Netherlands

To get an overview of the current situation in the Netherlands and the type of business models that are used, nine industrial waste heat utilization projects in the Netherlands were selected based on; different customer segments and the availability of data. The selected projects are displayed per customer segment in Table 1.

Built environment	Industry	Horticulture
Warmtebedrijf Delft	Rotterdam Botlek steam pipe	WarmCO_2 (Terneuzen)
Westpoort warmte (Amsterdam)	Eemshaven (Delfzijl) steam grid	OCAP CO_2 pipe
Warmtebedrijf Rotterdam	Energyweb Moerdijk	
Het groene net (Sittard)		

Table 1: Selected industrial waste heat utilization projects in the Netherlands

Of all the selected cases the technical, organizational and financial characteristics are highlighted and the lessons learned, barriers and risks were gathered.

Lessons learned

The lessons learned in the selected cases can be subdivided in general lessons learned and specific lessons learned aimed at the different customer segments (built environment, industry and horticulture).

- The general lessons learned stress the creation of a committed multidisciplinary group of partners; in which both the technical knowledge and access to the customer is represented and a trustful and transparent environment can be created. Within this core group it is important that the partners that have knowledge about and experience with the risk, take the risk. The cooperation between a public and a private party who have complementary characteristics is advisable. Finally, set a minimum amount of customers that is needed in order for the business case to be profitable.

- In the projects aimed at the built environment it is important to monitor the public opinion since the customers are crucial to the success of the project. The cooperation between an energy distribution company and a municipality in combination with the support of housing corporations within a special purpose vehicle (SPV) creates a complementary team which has the needed knowledge, skills and connection to the customers.

- In the industry the introduction of a third (independent) party, who finances the common assets and leads the process, accelerates the development of an industrial waste heat utilization project. In order to create an attractive and secure business case for the independent party a fixed payback period can be established by creating fixed costs (by means of a DCM contract) and fixed revenue streams (by means of a fixed yearly or monthly rent).

- In the horticultural sector the main issue lies in the assembly of enough customers, due to the scattered location and lack of an overarching organization that could serve as a channel. It is therefore advisable to set a minimum amount of customers that need to be reached before the project will start.

Barriers

The barriers identified in the cases, can be classified into five categories; financial, legal, technical, intra-organizational and inter-organizational barriers. An assessment of the occurrence of the barriers in the selected cases showed that primarily the financial, legal and inter-organizational barriers were named by the interviewees. Intra-organizational barriers also occurred but were not mentioned as much, since the partners with intra-organizational problems usually left the project in the start-up phase. Technical barriers did hardly occur in the assessed projects, mainly due to the maturity of the technology.

Risks

Identified internal risks in industrial waste heat utilization projects are:

- Financial risk: uncertainty of the future financing cost
- Technical risk: discrepancy between the foreseen and actual performance
- Continuity risk: continuous heat delivery to customer (when demanded)
- End user risk: having 'too little' end users
- Pricing risk: willingness of customers to pay
- Producer risk: relocation of producer
- PPP risk: development of partnership over time

External risks are; the development of the gas price, economic status, political climate, development of alternatives, public opinion, legislation and the organization of the energy market (public vs. private).

In conclusion one can say that, when linking the lessons learned, barriers and risks to the building blocks of the BMG theory, the majority apply to the; key partnerships, cost structure, revenue streams and channels. These building blocks will require extra attention when drafting a business model.

Business model development

The gathered data is used to draft four best practice business models for three customer segments:

- Built environment business to consumer (B2C)
- Built environment business to business (B2B)
- Industry
- Horticulture

Built environment B2C

In the built environment B2C model the main challenge is to commit a substantial customer base to the project consisting of:

- New (yet to be developed) buildings and homes
- Existing built environment:
    - Utility buildings (preferably owned by the municipality)
    - Apartment buildings (owned by a housing corporation)
    - Offices buildings
- Or by connecting an existing district heating network to a new producer

In order to reach these customers the following channels can be used; housing corporations and municipalities. These channels have an existing customer relationship and sometimes even customer relationship tools that can be utilized in order to maintain this relationship and communicate with the customer.

Furthermore, it is important to create a value proposition that fulfills both the needs for; the public party (CO_2 reduction) and the customer (cost reduction). The cost reduction for customers is extremely important in order to create support and divide the profit equally between the upstream and downstream supply chain. This does put extra pressure on the profitability of the business case but is essential to the public acceptance and the success of the project.

Other parties that are needed for a successful business model are; an SPV consisting of a municipality, an energy distribution company and possibly a housing corporation, producer(s), customers, a contractor and a bank. It is important that the SPV includes a party with technical knowledge and a channel which has legal knowledge, trust towards the customer and access to attractive financial options.

The cost structure and revenue streams need to be aligned in order to prevent discrepancies. Figure 2 shows the revenue streams and costs in this model.

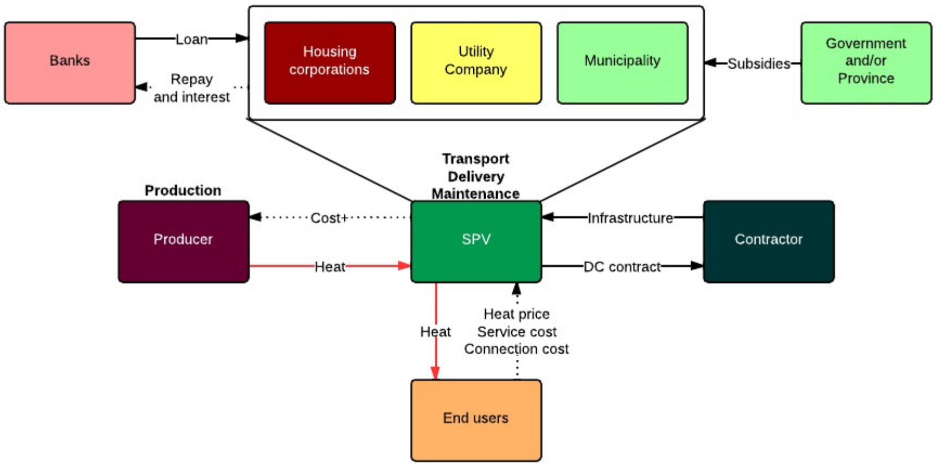

Figure 2: Built environment B2C[1]

The investment costs will be supplied by the SPV, in which the municipality can guarantee for a loan. When available, subsidies or other financial support from public parties can contribute to the investment costs. The construction of the infrastructure will be provided by a contractor via a design and construct (DC) contract, while the SPV (energy distribution company) will carry out the maintenance (economies of scope). The customer will pay the normal costs; heat price, service costs and connection cost, to the SPV, which uses the energy distribution company as front office. The producer will receive a compensation for the produced heat which is based on the cost price of producing the heat plus a certain margin (cost+).

<u>Built environment B2B</u>

The B2B business model delivers the heat to energy distribution companies, who distribute the heat to the customer. This requires a different value proposition in which risk reduction (committed customer base for energy distribution company) and branding (sustainable image) play an important role.

Since there is only need to approach one to three energy distribution companies, the channels are less relevant in this business model. The channels to the customer are the energy distribution companies who already have a relationship with these customers.

In this case two SPVs need to be formed; an organization that facilitates the investment of the infrastructure (consisting of a municipality, province and a grid operator or contractor) and an organization that facilitates the operations and transport of the heat to the substations (consisting of a municipality and a grid operator).

As stated before the investment costs will be supplied by the infrastructure SPV in which one of the public parties can guarantee for a loan. The exploitation SPV maintains the contact with the energy distribution companies and the producer.

[1] A legend explaining all colors and arrows can be found in appendix VI. Legend

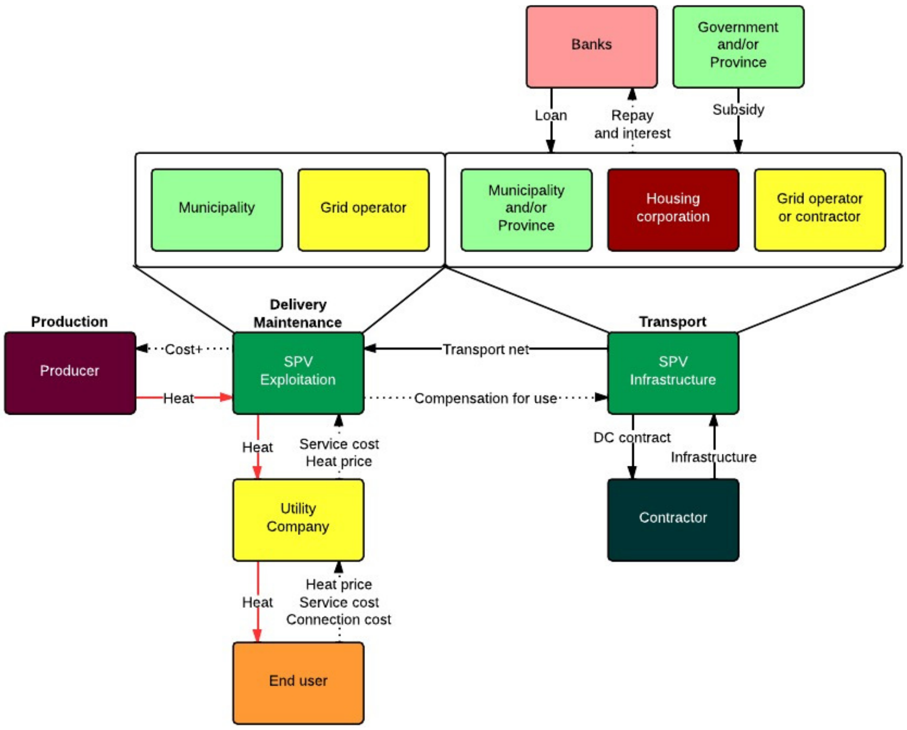

Figure 3: Built environment B2B

It is again crucial to prevent discrepancies between the costs and revenue streams. Therefore the energy distribution companies pay a fixed (service cost) and a variable price for the heat delivery and will the producer receive a variable price (cost+).

<u>Industry</u>

The most common industrial parties with heat demand are the chemical, petro-chemical and the food industry. All these industrial parties are searching for cost reduction options in the current market; this is therefore the main value proposition for these types of customers. Furthermore, branding (sustainability) is usually also involved as value proposition. Note, that energy prices in the industry are low compared to the built environment, which means that the formation of a profitable business case in the industry requires delivery of high quality heat (steam).

Since all of these companies are focused on their core business there is need for a third party, an independent party, who will bring them together and function as channel and leader. In order to create a suitable solution for all participating parties a time intensive co-creation process needs to be started in which the parties can draft a business case which benefits and satisfies all of them.

The parties involved in this type of business model are; an independent party (which could be a grid operator or (semi-)public party), producer(s), end users and a contractor (in case the independent party does not possess technical knowledge).

Both the producer and end user are willing to invest in equipment on their own site, but the independent party will need to finance the common assets. In return the independent party will require a secure payback period by means of a fixed rent (paid either by the producer or end user) and a fixed design, construct and maintain (DCM contract) with a contractor (see Figure 4). Note, that investment costs for construction of infrastructure in industrial areas will be lower than investment costs for construction of infrastructure in the built environment (due to less; obstacles and dense surroundings).

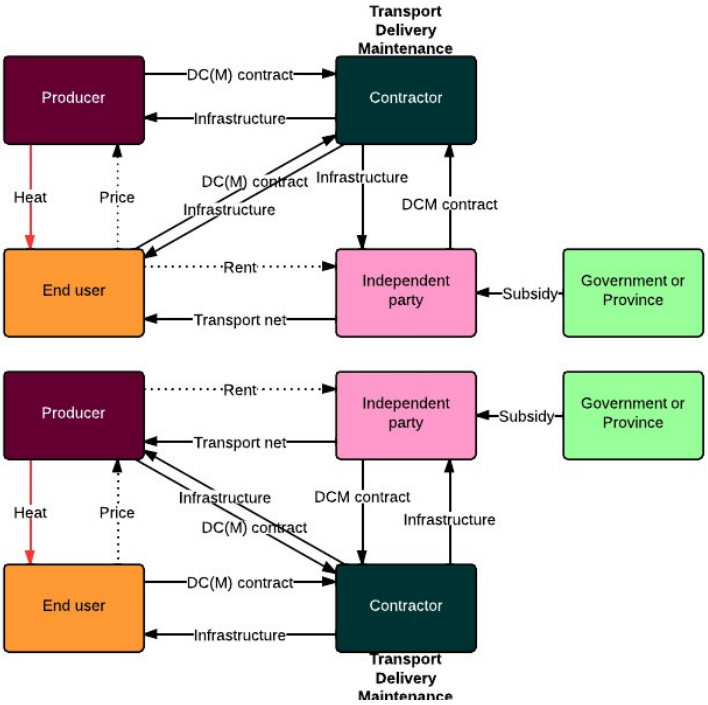

Figure 4: Industry

The cost for the heat will be handled between the end user and producer by means of one or a combination of the following pricing mechanisms:

- Usage fee: either cost price or cost price with a margin (cost+)
- 'Take or pay': The buyer and producer agree upon a X amount of heat per time unit for a set price, if the buyer does not meet this amount a fee must be paid to the producer.
- 'Take or put': The buyer and producer agree upon a X amount of heat per time unit for a set price, if the producer does not meet this amount a fee must be paid to the end user.
- Combination of the above

<u>Horticulture</u>

The horticultural sector is a difficult customer segment, due to the fact that the customers are usually scattered over a large area and have no overarching organization that can serve as channel. Organizations that could possibly fulfill this role as channel are; province, energy distribution company or an independent party with a connection to the area and the customers. In order to create a business case an extremely time intensive customer relationship needs to be build between the growers and the supplier, via dedicated personal assistance.

The value proposition for the horticultural sector is similar to the industry; cost reduction and branding (sustainability). While the organizational structure shows more similarities to a built environment B2C business model, with an SPV (including a public party and a technical party), producer(s), customers, contractor and (a) bank(s).

The cost structure and revenue streams are also very similar to the built environment B2C business model with a; heat price, service costs and connection cost, paid by the customer, a cost+ pricing mechanism used for the producer and a DC contract with the contractor (see Figure 5). While the pricing mechanism and cost structure are similar to the built environment, the investment cost will be lower (due to less; obstructions and dense surroundings) and revenue streams will be lower (due to lower energy prices in the horticultural sector).

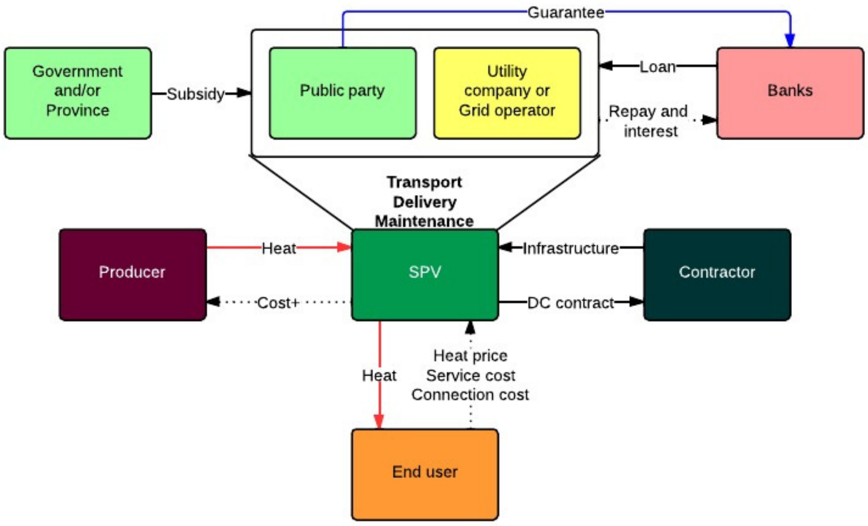

Figure 5: Horticulture

Another possibility is the opportunity to deliver CO_2 simultaneously to the heat delivery and strengthen the business case. Note, that the energy prices for the horticultural sector are low compared to the built environment and therefore additional CO_2 delivery seems to be a must in order to create a profitable business case.

One thing that should be kept in mind is the decrease of horticultural companies in the Netherlands. What will the horticultural sector look like in the future and will this generate a stable customer base?

<u>Trends in new business models</u>
On the other hand new trends in business models need to be kept in mind for the development of future industrial waste heat utilization projects. These trends are:

- Creating multiple values (environmental, social and economic)
- Shifting from products to services
- Moving from ownership to sharing and exchanging
- Involving the entire supply chain (especially the user)

When translating this to industrial waste heat utilization projects, the following possibilities occur; exchanging waste heat delivery for delivery of products, services or waste streams of another company, using new cost structures such as crowd funding, lease constructions or finding new investors such as pension funds. Furthermore, technological innovations such as electricity generation from waste heat and cold generation should be taken into account when developing an industrial waste heat utilization project.

<u>Preconditions model</u>
In order to decide which business model is most suitable in a particular situation a model was drafted, the preconditions model (see Figure 6). This model highlights the critical success factors which should be fulfilled in order to create a feasible business model.

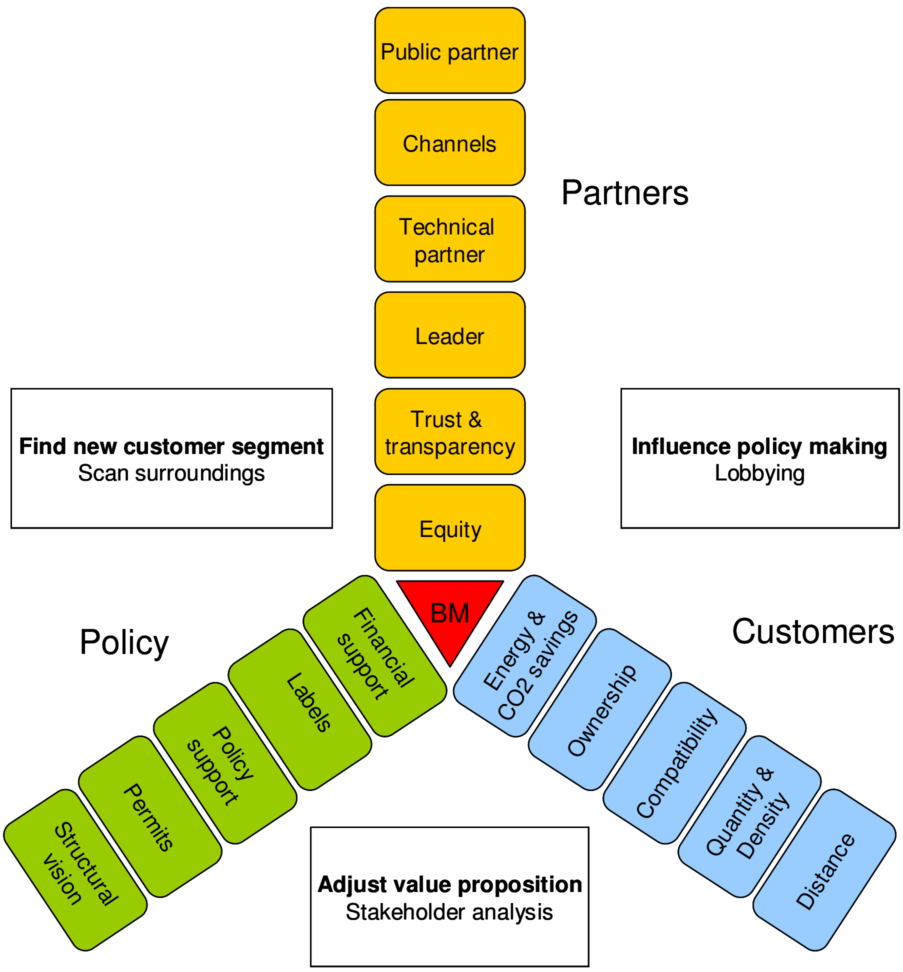

Figure 6: Preconditions model

Three overarching critical success criteria are identified; partners, policy and customers. When one of these criteria is missing the following actions can be taken:

- No partners: adjust the value proposition to the needs of the needed partners. Tools that can be used to identify the needs of the partners are a stakeholder analysis.
- No customers: a new customer segment needs to be found. This could be done by scanning the environment or looking into innovative solutions.
- No policy: influence the policy making by lobbying or requesting a green deal.

The definitions of the identified critical success factors will be discussed below.

<u>Customers</u>

- *Distance* describes the distance between the end users and the producer.
- *Quantity and Density* are used to determine the number and density of the end users.
- *Compatibility* describes the compatibility of; the quantity and quality of the heat demand and supply and the heat demand patterns of the producer and the end user(s).
- *Ownership* concerns the ownership of the assets of the end user(s).
- *Energy and CO_2 savings* includes the amount of energy and CO_2 saved by the end user.

<u>Partners</u>

- *Channels* describes the willingness of the channels (who enable the connection to the end user) to cooperate and possibly become a risk bearing partner.
- *Public partner* describes the willingness of a (semi-)public party (municipality, province, government, seaport etc.) to cooperate.
- *Technical partner* describes the willingness of a technical partner (energy distribution company, grid operator, contractor etc.) to cooperate.
- *Leader* concerns the leadership role during the project.

- *Trust and Transparency* describes the trust and transparency that is needed between the stakeholders in order to execute the project.
- *Equity* concerns the solvency of the risk bearing partners. Are they able to raise enough equity to establish the project or is there need for an extra partner or loan?

Policy

- *Structural vision* describes the spatial planning the municipality, province or government has made for a particular area. It is important that this structural vision permits district heating or even anticipates on this.
- *Permits* is related to structural vision but has a more local orientation. The assigning of permits is usually the responsibility of the municipality. It is crucial for the project that these permits are made available and assigned.
- *Policy support* is concerned with the policies that are applicable to district heating. Do these policies stimulate or hamper the development of district heating and in case of hampering are they willing to change these policies?
- *Labels* describes the ability to create recognition for the participating parties for their effort to reduce their emissions etc.
- *Financial support* describes the financial support lend to the project by a public party.

Conclusion

First of all it is important to mention that each industrial waste heat utilization project has different characteristics and thus needs a customized approach. This means that the generated business models are rather starting points and provide guidelines for potential industrial waste heat utilization projects.

The following observations were made for the different customer segments (Table 2).

Customer segment	Conclusions
Built environment	• *Not more than otherwise* principle creates positive effects (enables large revenue streams), but could create dissatisfaction among customers due to the uneven division of profit. • Connecting the existing built environment (offices, apartment and utility buildings) seems to be the most attractive segment within the built environment segment for future industrial waste heat projects • Channels that can facilitate a connection to the built environment are essential to the success of the business model and thus need to be closely involved in the development of the project. • Heat demand of the built environment is dependent on the outside temperature and therefore not constant. Back-up is needed to supply the peak load when low temperatures occur. Waste heat can be used as base load. • Public parties are interested in industrial waste heat utilization projects in order to lower their CO_2 emissions and are therefore willing to participate and invest. • High investment costs and high revenues.
Industry	• Delivery of high quality heat is necessary in order to generate a profitable business model. • An independent party that connects the different parties, takes the lead and invests in the public assets is essential to the success of the business model. • Heat delivery contracts can be drafted directly between the producer and the customer or be coordinated via an independent party. • The continuous heat demand of the industry is favorable for the business case. • Low(er) investment costs and medium revenues.

Horticultural sector	• Identifying channels and finding a large customer base in the horticultural sector is difficult • Due to low energy prices (compared to the built environment) additional delivery of CO_2 seems to be necessary in order to generate a profitable business case. • Heat demand of the horticultural sector is dependent on the outside temperature and therefore not constant. Back-up is needed to supply the peak load when low temperatures occur. Waste heat can be used as base load. • Low(er) investment cost and low revenues.

Table 2: Conclusions

From Table 2 can be concluded that generally speaking the horticultural sector is the least favorable customer segment for industrial waste heat utilization projects. The industry seems to be the most cost efficient option, but the built environment can count on more (financial) support from public parties and other key partners.

While initially it seemed that the main concerns lie in the financial area (cost structure and revenue streams), the analysis shows that the most important building block is the key partners. The assembly of the right partners, who have; enough equity, the right (supplementary) knowledge, leadership capabilities and the ability to create trust and transparency between the involved stakeholders, is crucial to the success of the business model. The right combination of partners enables hedging the majority of the risks and consequently lowers the uncertainty. This will result in more attractive loans and therefore a profitable business case.

Furthermore, the support from public parties in the form of financial support, policy and legislation is crucial to the success of all business models.

When establishing a business model for industrial waste heat utilization projects it is therefore important to have the right mix of partners, plans that comply with the policies and legal restrictions and a committed customer base which allows for a profitable business case to be drafted.

Preface

This thesis marks the end of my master program: Sustainable Development: Energy and Resources at the University Utrecht. During my academic career I have always dreaded the moment I would have to start my master thesis. Seven months of continuous research filled me with visions of endless piles of literature, sleepless nights and cramped fingers. Luckily, at the end of writing my master thesis I can conclude that these foresights are far from the truth. I must admit that I have enjoyed these past seven months.

Over the course of my thesis I have seen all corners of the Netherlands, spend hours in trains, buses and other public transportation, all for the greater good of gathering as much information and data as possible. This would not have been possible without the openness and participation of all interviewees, for this I would like to thank them.

I would also like to thank my university supervisor, Robert Harmsen, for guiding me in the right direction and recognizing my - as he calls it- 'intuitive' way of performing research. Furthermore, I would like to thank my Tata Steel supervisors, Marjan Olthof and Olivier Vree and the members of the waste heat recovery project for their feedback, questions and stimulating discussions. Thank you to the Energy Efficiency team of Tata Steel who have made me feel welcome and part of their team. Finally, a big thank you to my family and friends who have kept me sane during this process.

Ines Buskermolen
07-06-2013, Velsen

Content

FIGURES

TABLES

1. Introduction

The introduction of energy efficiency measures in the industry is both for the European Committee's sustainability strategy (EC, 2012) and the Dutch *green deals* (Rijksoverheid, 2011) an important focal point. Part of these initiatives is the stimulation of industrial waste heat utilization as a measure to improve efficiency and reduce CO_2 emissions (EC, 2012; Rijksoverheid 2011).

Waste heat is defined as: "*the net exergy that unavoidably leaves or is lost within an existing process after its integration, minus the exergy that cannot be recovered for technical or economic reasons*" (Bendig et al. 2013, p.8).This type of heat is considered -by the government- to be of equal sustainable value as renewable energy sources (NEN, 2011).

Next to the impulse initiated by the European Union and the Dutch government, several articles indicate the profitability, sustainability and potential for industrial waste heat utilization (Gebremedhin, 2000; Holmgren, 2006, Kapil et al., 2012; Sanaei & Toshihiko, 2012; Rezaie & Rosen, 2012). This underlines the attractiveness for large industrial companies to sell their waste heat to potential customers. While the attractiveness seems large, there are not a lot of projects realized in the Netherlands (Energie Nederland, 2011).

The main barriers concerning industrial waste heat projects identified in literature are related to financial, organizational and cultural issues (Grönkvist & Sandberg, 2006; Thollander et al. 2010; Patil et al. 2009). Furthermore, actors usually seem to agree about sustainability, but due to a lack of a good business case most industrial waste heat utilization projects are not executed (Patil et al. 2009). This indicates that there is a need for the development of business models that enable parties to enter into a profitable industrial waste heat utilization project. While there have been studies focused on financing heat projects (Hermans, 2010) and business models for biomass heat entrepreneurship in Finland (Okkonen & Suhonen, 2010), there are currently no articles focused on business models for industrial waste heat utilization projects. This thesis will therefore address the following research question:

Which business models for industrial waste heat utilization projects in the Netherlands can be identified and under which circumstances would these be applicable?

In order to analyze and categorize business models the *business model generation* model (BMG) introduced by Osterwalder and Pigneur (2009) will be used. This theory will be explained in chapter 2. Business model generation theory. The method and structure of this thesis will be explained in chapter 3. Methodology.

2. Business model generation theory

There are several methods available for the generation of business models but, since the *business model generation* theory by Osterwalder and Pigneur (2004 & 2009) is used in research papers written by Okkonen (2010) and Richter (2012) focusing on business model generation for innovative energy infrastructure, this model was chosen as theoretical backbone for this thesis.

The *business model generation* (BMG) theory identifies the following building blocks for a business model: *customer segmentation*, *value proposition*, c*hannels*, c*ustomer relationships*, r*evenue streams*, k*ey resources*, k*ey activities*, k*ey partnerships* and c*ost structure.*

Each building block will be explained in more depth in the next paragraphs.

Customer segmentation (CSE)
Customer segments are different groups or people/customers that a company tries to reach.

Value proposition (VP)
The value proposition is formulated as "*the combination of benefits the partnership will yield for the involved parties*" (Osterwalder and Pigneur p.22, 2009). Possible value propositions for district heating are:

- *Newness*: satisfies a new set of needs that the customer didn't know they had
- *Performance*: improving the performance of the current product or service
- "*Getting the job done*": delivering what is needed
- *Brand/status*: value of owning or using a product or service because it is of a specific brand or feature (for instance sustainability)
- *Price*: offering a lower price for the product or service
- *Cost reduction*: helping to reduce cost for the customer
- *Risk reduction*: reducing the risks the customer incurs when purchasing a product or service

Channels (C)
After the value proposition, the communication channels, which enable reaching potential customers, will be identified. These channels are the connection to the customer and will facilitate the communication to and from the customer.

Customer relationship (CR)
This building block describes the type of relationship the heat supplier has/wants with the receiver and vice versa. Osterwalder and Pigneur (2009) distinguish 6 types of relationships:

- *Personal assistance*: a relationship based on human interaction
- *Dedicated personal assistance*: dedicating a customer representative to an individual customer
- *Self service*: the company creates the necessary means for the customer to help themselves
- *Automated services*: a more sophisticated form of self service where the process is customized
- *Communities*: user communities where customers exchange knowledge and solve each others problems.
- *Co-creation*: creation value in cooperation with the customer

Revenue streams (RS)
The revenue streams represent the cash flows that are generated. Osterwalder and Pigneur (2009) distinguish 7 types of revenue streams:

- *Asset sale*: selling ownership rights of a product to the customer
- *Usage fee*: paying for the use of a service, the more a service is used the higher the price.
- *Subscription fees*: selling continuous access to a service

- *Lending/renting/leasing*: temporarily granting the customer the right to used the product for a fixed period of time
- *Brokerage fees*: paying for intermediate services performed on behalf of two or more parties

Another part of the revenue stream is the pricing mechanism, which can be divided into fixed pricing or dynamic pricing.

Key resources (KR)
The most important assets needed to successfully implement the business model will be identified.

Key activities (KA)
The key activities are the things a company must do in order to successfully implement this business model.

Key partnerships (KP)
The key partnerships are the network and the partners that make the business model work. Key partners can be attracted for the following reasons:

- *Optimization and economy of scale*: in order to optimize the allocation of resources and activities
- *Reduction of risk and uncertainty*: reducing risks in a competitive environment
- *Acquisition of particular resources and activities*: purchasing knowledge, licenses or access to customers

Cost structure (CS)
Finally, the cost structure, which represents all the costs that are made in the process. A distinction can be made between;

- *Cost-driven* cost structures: focusing on minimizing costs wherever possible
- *Value-driven* cost structures: increasing the value of the product as much as possible

Furthermore, the following characteristics of cost structure can be distinguished:

- *Fixed cost*: cost that remain stable despite the volume of the delivered goods
- *Variable cost*: cost that vary proportionally with the volume of the costs
- *Economies of scale*: cost advantages that are caused by an expanded output
- *Economies of scope*: cost advantages that are caused by a larger scope of operations

3. Methodology

In this chapter the method used and the steps taken during the process will be explained according to the figure presented below (Figure 1).

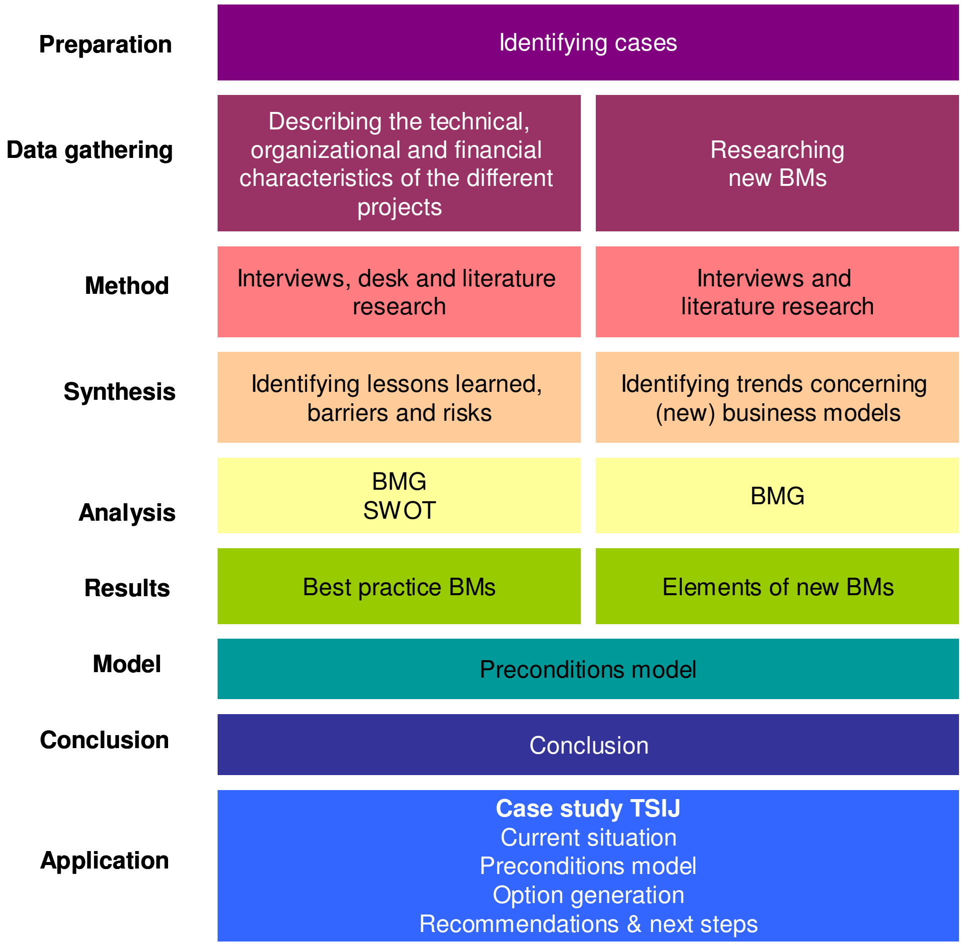

Figure 1: Methodology

In the first phase, the preparation phase, multiple industrial waste heat projects were selected based on:

- The waste heat producer is an industrial player who does not regard waste heat production as their core business
- Different customer segments need to be represented
- Availability of data and willingness to cooperate

For the identified projects participants will be interviewed (when available) about the technical, organizational and financial aspects of the project (see appendix I. Interview structure). These descriptions can be found in chapter 4. Industrial waste heat utilization projects. In order to facilitate the translation to the BMG theory a BMG canvas is filled in for each project, in order to compare the projects and identify the use of the different building blocks (see appendix II. BMG Canvas). Furthermore, an indication of the phase the project is in, is given by using the phases defined in the industrial waste heat utilization guide (NL: handreiking industriële restwarmte benutting) by Agentschap NL and Padiyar et al. (2004). These phases are the exploration, consolidation, elaboration, design and construction, start-up, operational and roll out phases (see appendix III. Phases). This part is referred to as the data gathering part.

After the data gathering part the gained information is synthesized in three categories; lessons learned, barriers and risks. First, the lessons learned identified will be listed according to customer segment. Second, the barriers that delay or prohibit the development of industrial waste heat utilization projects will be gathered. In order to gather the most common barriers, literature concerning this topic was consulted and barriers that surfaced in the identified projects were listed. This list of barriers is used to get an overview of which barriers were applicable in the identified projects (see chapter 5.2 Barriers). Furthermore, the risks that were identified in the different projects and literature will be listed and discussed. Finally, the translation to the BMG theory will be facilitated which leads to the identification of the most important building blocks in order to successfully execute an industrial waste heat project.

The information gathered in the synthesis will be used as input for the generation of best practice business models for waste heat utilization projects. The business models will be generated according to the BMG theory (explained in chapter 2. Business model generation theory). The generated business models will be assessed with the use of a; strengths, weaknesses, opportunities and threats (SWOT) analysis.

Next to best practice business models it is also important to identify new developments in the area of business models for industrial waste heat utilization projects. This will be done by identifying the trends in business models in general and applying these trends to industrial waste heat utilization projects. In order to make the connection to the rest of the thesis, the BMG model will be used to identify to which building block this trend/innovation applies.

All the findings of the previous parts will be combined in a model which will enable the comparison of the different business models and determine which business model would be most applicable in a particular situation. This model is based on the critical success factors and thus the preconditions in order for the business case of the project to be profitable.

This thesis will conclude with a conclusion which will summarize and reflect upon the findings.

PART I Data gathering

4. Industrial waste heat utilization projects

Nine identified waste heat utilization projects will be discussed, while highlighting their technical, organizational and financial structures. The projects are;

- Delft, warmtebedrijf Delft (built environment)
- Amsterdam, Westpoort warmte (built environment)
- Rotterdam, Warmtebedrijf Rotterdam (built environment)
- Sittard, Het groene net (built environment)
- Botlek, steam grid (industry)
- Delfzijl, steam grid (industry)
- Moerdijk, steam grid/district heating (industry)
- Terneuzen, Warm CO_2 (horticulture)
- OCAP, CO_2 (horticulture)

4.1 Delft: Warmtebedrijf Delft

The idea of starting a waste heat utilization project in Delft surfaced in 2001 when the municipality researched options, which would enable them to reduce energy consumption and CO_2 emissions. This ultimately led (among other plans) to the elaboration of a business case and implementation plan for a district heating company. This district heating company is operated and owned by an energy distribution company and priority shares are owned by the municipality of Delft, the municipality of Middenlanden-Delft and a housing corporation (Ligtvoet, 2012). In the start-up phase of the project the original supplier (DSM) quit the project due to the long term contracts that needed to be signed (ibid). DSM was replaced by the waste water treatment plant which delivers low quality heat that is first upgraded before delivered (ibid).

The project is currently delivering heat to 20,000 homes (apartment buildings and new homes) and is expected to avoid the emission of 90 ktonne of CO_2 in 2012 (Gemeente Delft, 2011). Unfortunately there was no possibility to interview a participant of the project due to internal issues.

<u>Technical</u>

The total length of piping network is 182 km (Ajah, 2007), whereof 25-30 km is transport net[2] (shown in red in Figure 2) and the remaining km are the distribution net[3] (SESAC, 2011). This system is divided in a northern and a southern part, due to different temperature regimes. In the northern part the waste water treatment plant supplies low quality heat, this is upgraded to 70 ºC by the use of a heat pump. This heat is only supplied to new buildings, since these buildings have a lower temperature demand (due to strict EPC standards for new buildings). A double piping system is used which means that the cooled water (40 ºC) will return to the producer to be reheated (ibid).

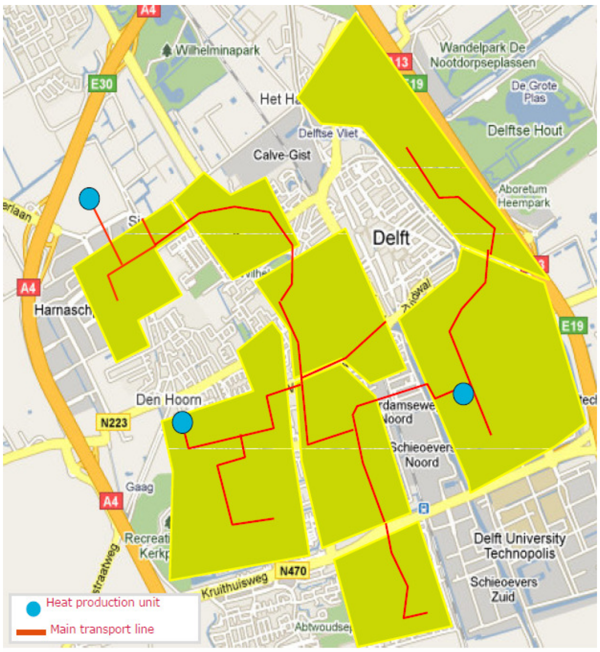

Figure 8: District heating network Delft

The southern part of the system has a temperature of 90 ºC and supplies heat to existing buildings, which have a higher

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[2] Transport net: piping network which connects the producer to the substations
[3] Distribution net: piping network which connects the end users to the substations

heat demand (ibid). The heat in this part of the system is produced by gas-fired boilers and combined heat and power (CHP), which are divided over two heat stations (these stations are also the back-up in case the waste water plant fails to deliver enough heat) (ibid). Again a double piping system is used, but in this case the water will return with a temperature of 50 ºC (ibid). When the return temperature is lower or higher than 50 ºC the system has to adjust the heat supply by changing either the temperature or the flow (Euroheat & power initiative, 2005).

Organizational structure

In Delft a public-private partnership (PPP) was established in the form of a special purpose vehicle (SPV). This SPV has the following shareholders:

- Energy distribution company (97% + 1% priority share): knowledge and expertise, economies of scope (maintenance services, helpdesk and interface)
- Municipalities (1% priority share): eradiating trust towards and communicating with the inhabitants (channel), supervising the pricing, service level and profits that are being made and secure the sustainability of the project (supervisor)
- Housing corporations (1% priority share): channel to the end user

PPPs usually have an equal division of shares, which means that this PPP appears to be more of a concession model in which the municipality permits the energy distribution company to operate a waste heat energy distribution company. The PPP structure in this case is a build, finance, own and operate (BFOO) structure. See appendix IV. Public-Private partnerships for an in depth explanation of PPPs and PPP structures.

The other key partners and their added value to this project are:

- Contractor: knowledge and expertise
- Producer: initially DSM was approached to supply waste heat, but due to long term contracts and lack of flexibility, they chose not to enter the project as producer. The water treatment plant stepped up as low quality heat supplier.
- End users: new homes and apartment buildings (via housing corporation)

Due to the division of shares, the municipality and the housing corporations do not have a say in the operational activities of the SPV, but do have equal voting rights (due to the priority shares) on the following subjects; new or substitutive production units, tariffs, (increase of) serviced area, service levels, climate change goals and "super" return on investments (SESAC, 2011). These contractual agreements are displayed in Figure 3.

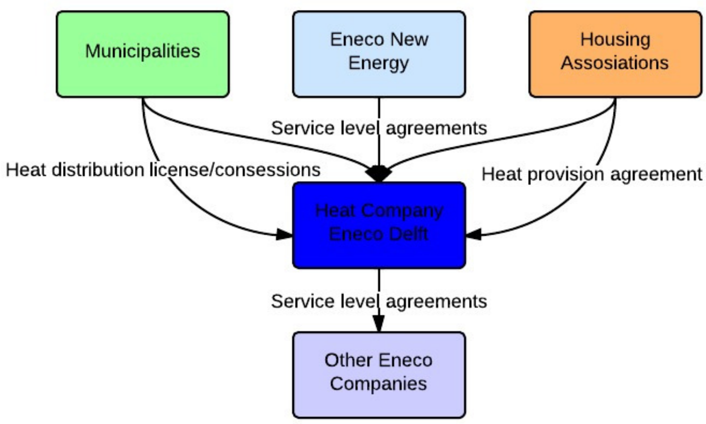

Figure 3: Contractual agreements Delft (SESAC, 2011)

Financial streams

The SPV collects revenue streams from the end users according to the *not more than otherwise principle*. The *not more than otherwise* principle (NL: niet meer dan anders principe) states that the cost (which includes; energy price, connection cost and service cost) for the consumer cannot be higher than the reference cost, which is partly based on natural gas (see appendix V. Not more than otherwise principle for an in depth explanation). This indicates that the SPV charges similar prices and uses a similar pricing system to the currently used natural gas pricing system.

These revenue streams are used to cover the following cost:

- Maintenance at the cost price (economies of scope due to partnership with energy distribution company)
- Compensation for the purchased heat to the producer
- Dividends for the shareholders
- Paying the employees

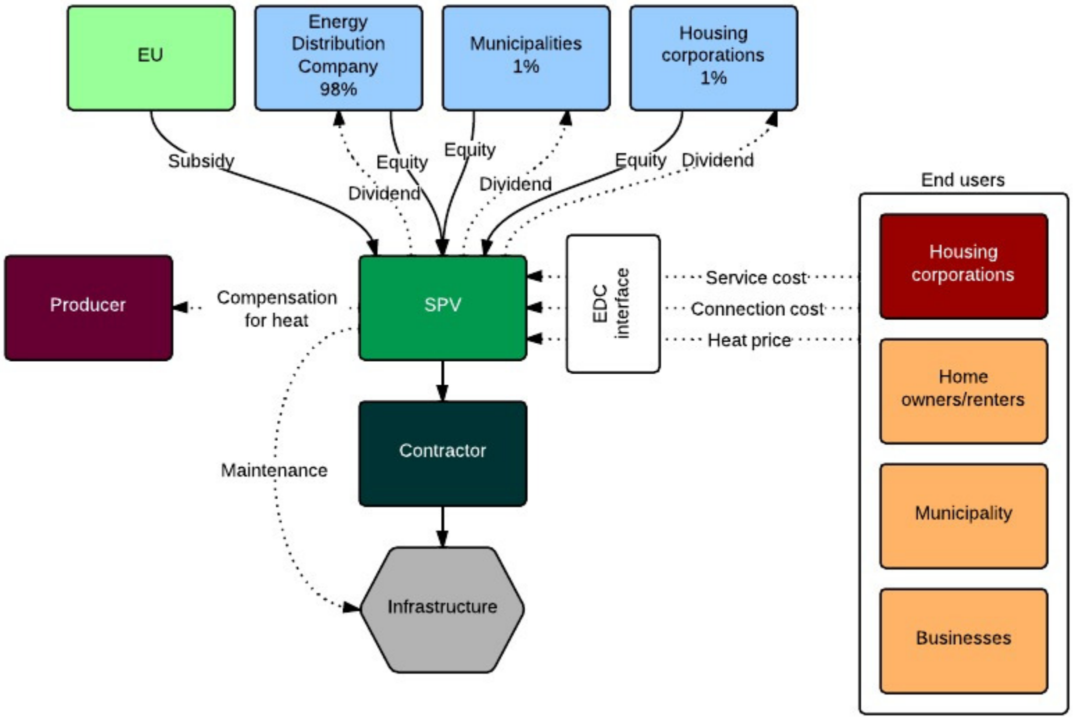

Figure 4: Financial streams Delft[4]

The investment costs of 120 million euro are covered according to the percentage of shares in the SPV, plus an additional subsidy (2.86 million) from the European Commission. Delft participated in the SESAC project where they exchanged knowledge with similar projects all over Europe (Endre Timar, 2010).

4.2 Amsterdam: Westpoort warmte

Amsterdam has an impressive track record for district heating, since starting in the early 90's. In this research the focus will be on Westpoort warmte (WPW), a joint venture of an energy distribution company and the municipality of Amsterdam, which buys heat from the waste incineration plant and sells it to businesses, homes and utility buildings in Amsterdam (new west, north and the port area). WPW was established in 1999 and delivered 345 TJ_{th} to 13,000 *home equivalents*[5] in 2011 (Gemeente Amsterdam, 2011). This resulted in 17.5 ktonne avoided CO_2 emissions in 2011 (ibid). This project is still expanding according to the targets set for 2050 (53.000 home equivalents and 52.5 ktonne reduced CO_2 emissions) (ibid). In order to reach this target, smaller projects are formed and assessed on economic and technical feasibility (van Gestel, 13022013). It is an ongoing process where the profits are used to invest in new infrastructure.

[4] A legend explaining all colors and arrows can be found in appendix VI. Legend

[5] Home equivalent: is the average yearly heat demand of one home. In 2011, one *home equivalent* was equal to 100 m^2 of utility building and was valued at 27 GJ (natural gas) per year (CE Delft, 2011).

The following persons were interviewed about this project:

- Rob van Kemmeren (Municipality Amsterdam)
- Arno van Gestel (Nuon warmte)

Technical

In Amsterdam a phased approach was chosen, which means that different sections are separately developed and connected in a later stadium of the project. When a section is developed, first a temporary heat production unit is used to fuel the developed distribution net. Later on the transport net will connect the distribution net to the producer (in this case the waste incineration plant). In Figure 5 the different producers and the different section which are and will be developed are displayed.

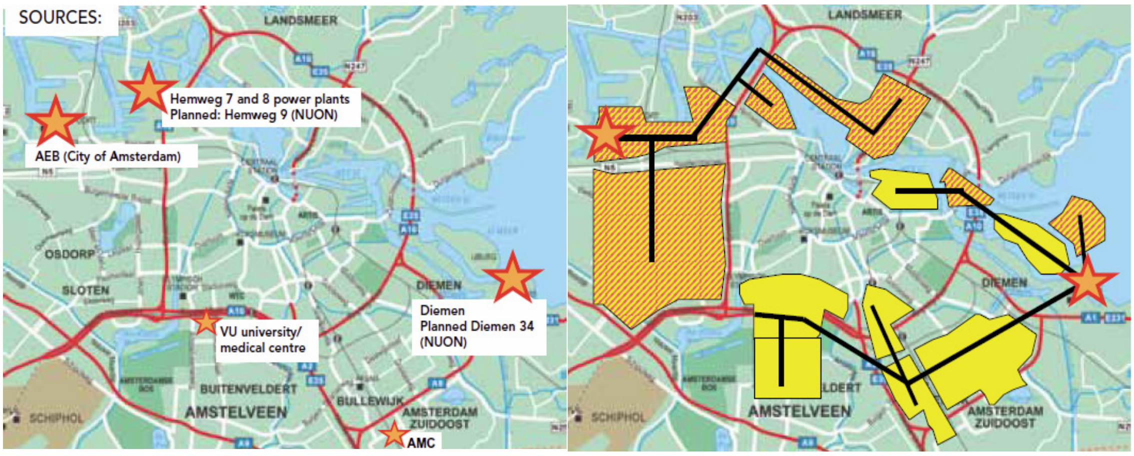

Figure 11: Sources and existing and contracted DH WPW (Gemeente Amsterdam, 2012)

The temperature of the supply side of the system is 90 ºC or 70 ºC, dependent on whether existing or new buildings are connected. The return temperatures are respectively 70 ºC or 40 ºC.

The heat demand pattern of the *built environment*[6] is dependent on the outside temperature, which means that the quantity of the heat demand fluctuates during the year (Figure 6). This creates a peak demand in the winter season which is in Amsterdam covered by thermal energy storage at the hospitals, the sewage treatment plant and fossil fuels (gas-fired boilers).

In the initial stages of the development of the district heating network, predominantly large users were connected, but over time the number of connected homes and apartment buildings increased significantly (Gemeente Amsterdam, 2012).

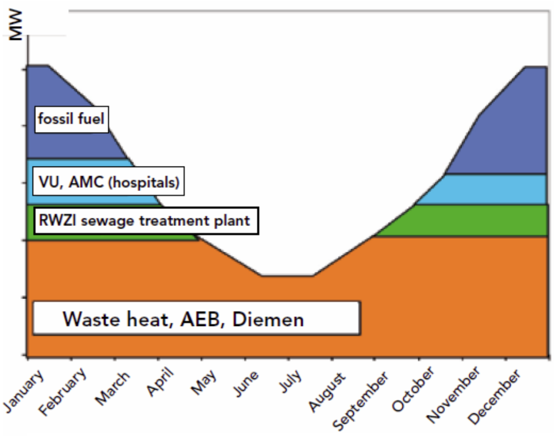

Figure 12: Heat load curve WPW (Gemeente Amsterdam, 2012)

Furthermore, Amsterdam has also developed a district cooling network, which uses water from the bottom of the surrounding lakes to supply cold water to facilitate cooling in the near by homes and offices (Gemeente Amsterdam, 2012).

[6] Built environment: homes (detached houses, terraced houses and apartments), utility buildings (offices, schools, hospitals and other public facilities) and private offices that are located in a city or a town.

Organizational structure

In Amsterdam a SPV was established in the form of a joint venture between the municipality (50%) and an energy distribution company (50%). They decided to keep the new established entity as flat as possible by each performing the tasks for which they posses the required knowledge and expertise (van Kemmeren, 06022013). As for the tasks that need to be performed, the municipality determines the strategic goals such as; CO_2 reduction targets, *heating unless policy* [7](NL: warmte tenzij beleid), *connection obligation*[8], spatial planning etc. The tactical tasks such as; pricing, service level etc. will be performed by the energy distribution company but will also be checked by the municipality in order to protect the customer. The operational tasks are all fulfilled by the energy distribution company who possess the right knowledge and manpower to do so (see Figure 7). All the activities performed by the shareholders will be performed for the cost price (economies of scope).

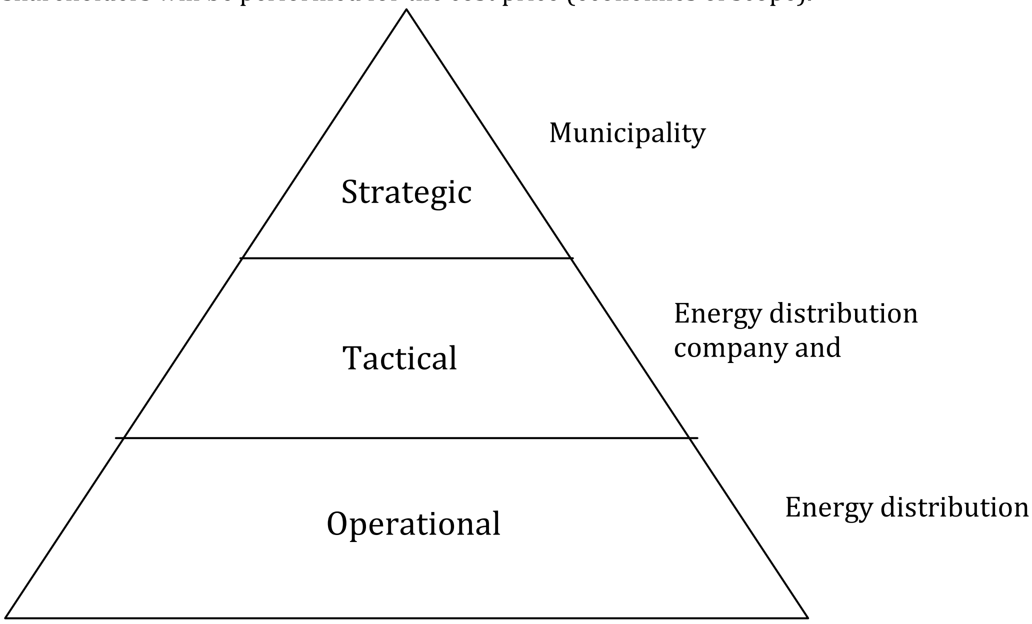

Figure 7: Task division Amsterdam (van Kemmeren, 06022013)

The used PPPs structure in this case is a build, develop and operate structure (BDO).

The producer (waste incineration plant) is owned by the municipality which makes the long term commitment, which is required for the execution of an industrial waste heat utilization project, less of a barrier. In addition the produced heat can be bought for the cost price, which will be further explained the in next section.

Other key partners and their added value to this project are:

- Contractor: knowledge and expertise
- Housing corporations: channel, but are bound by a connection obligation
- End users: new homes and apartments, businesses and utility buildings

Financial streams

The joint venture WPW generates income through the *not more than otherwise* principle and uses this income to cover the following expenses:

- Maintenance at the cost price (economies of scope)
- Compensation for purchased heat at cost price (economies of scope)
- Dividends for the shareholders
- Paying the employees at cost price (economies of scope)

[7] Heating unless policy: when a new home is build or an existing home is renovated they have to be connected to the district heating network, unless it is financially or technically unfeasible.

[8] Connection obligation: The municipality obliges that new buildings are to be connected to the district heating network. This is the tool that allows the municipality to execute the heating unless policy.

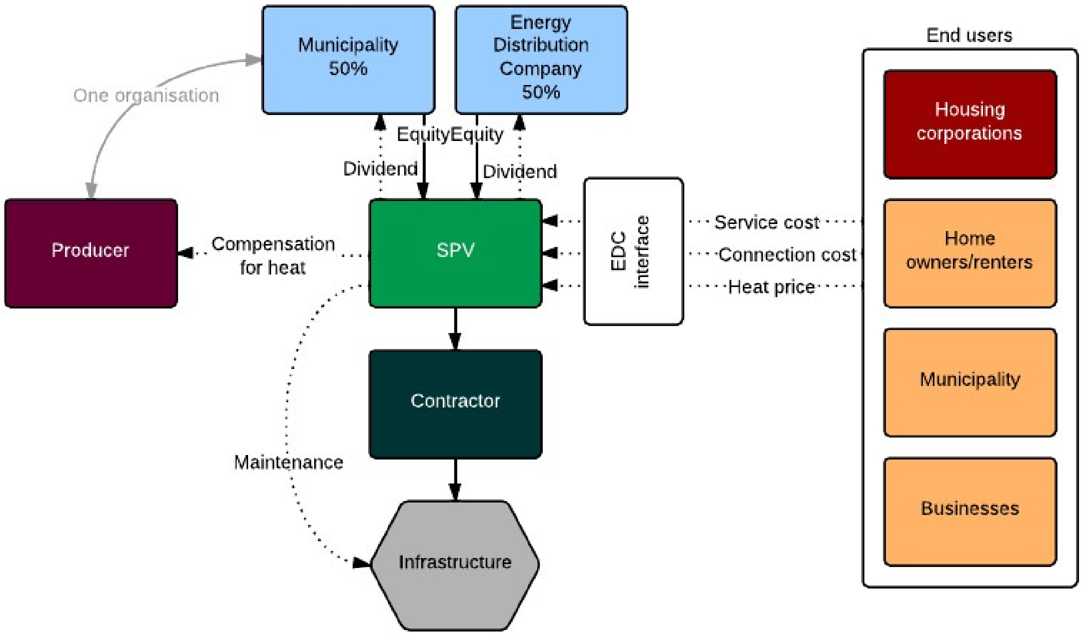

Figure 8: Financial streams Amsterdam

The purchase price (cost price) for the produced heat is determined by the operational cost of the waste incineration plant and the compensation of the not produced electricity (if applicable).

The investment costs are equally split between the municipality and the energy distribution company. Subsequently the dividends will also be divided equally between these two parties (van Kemmeren, 06022013).

4.3 Rotterdam: Warmtebedrijf Rotterdam

The district heating company established in Rotterdam had a turbulent start-up period. It all started in 2000 when ROM Rijnmond started a heating project on request of a housing corporation (Warmtebedrijf Rotterdam, 2011a). In 2001 this project was adopted by the municipality and different feasibility studies were carried out. This led to the establishment of a district heating company in 2005 with the municipality as largest shareholder (90%) and the province and a housing corporation who each owned 5% of the shares. In 2007 the municipality decided that a time-out was needed, since the established organization did not perform according to plan. The result of the evaluation indicated that there was not enough operational and technical knowledge within the organization to perform the required activities as efficient as possible (Hamers, 24012013). The municipality therefore decided to introduce a knowledgeable party, as in a grid operator, in the organization. While generating the business case it became clear that it would not be feasible to continue with one organization, but that the organization needed to be separated into two organizations; one responsible for the construction of the infrastructure (infrastructure) and one responsible for the exploitation activities (exploitation) (Warmtebedrijf Rotterdam, 2011a). The infrastructure part of the organization kept the same division of shares, while the exploitation organization became a joint venture of the municipality and the newly added grid operator.

The district heating company in Rotterdam does not directly deliver to the end user, but works according to a business to business principle by transporting and delivering heat to energy distribution companies (Hamers, 24012013). They facilitate the transportation of the heat from the supplier (waste incineration plant) to the substations, from which the energy distribution companies can construct a distribution net to the end users.

The transport net is currently being constructed and estimations are that 50.000 home equivalent will be connected to the district heating network (including the connection of the existing district heating networks). This will result in 95 ktonne CO_2 emission reduction per year (Eneco, 2013). The CO_2 reduction in Rotterdam is larger than in Amsterdam due to the use of different waste heat production sources, which are assigned different CO_2 reduction credits by the NEN 7120 norm (NEN, 2011).

The following person was interviewed about this project:

- Co Hamers (Warmtebedrijf Rotterdam)

Technical

Warmtebedrijf Rotterdam will only construct the transport net which has a length of 26 km and connects the producer (waste incineration plant) to two substations (4&5 in Figure 9). Since the distance to the substations is substantial, there is need for two booster stations (2&3 in Figure 9) that will restore the pressure (Warmtebedrijf Rotterdam, 2011b). This transport net has a transport capacity of 120 MW_{th}. Furthermore, there are back-up installations, which are also used for the peak supply. A buffer installation is used to optimize the system (producing heat at the most economic favourable times and collect it in order to use it in the peak periods -mornings and cold days-) (Gemeente Rotterdam, 2009).

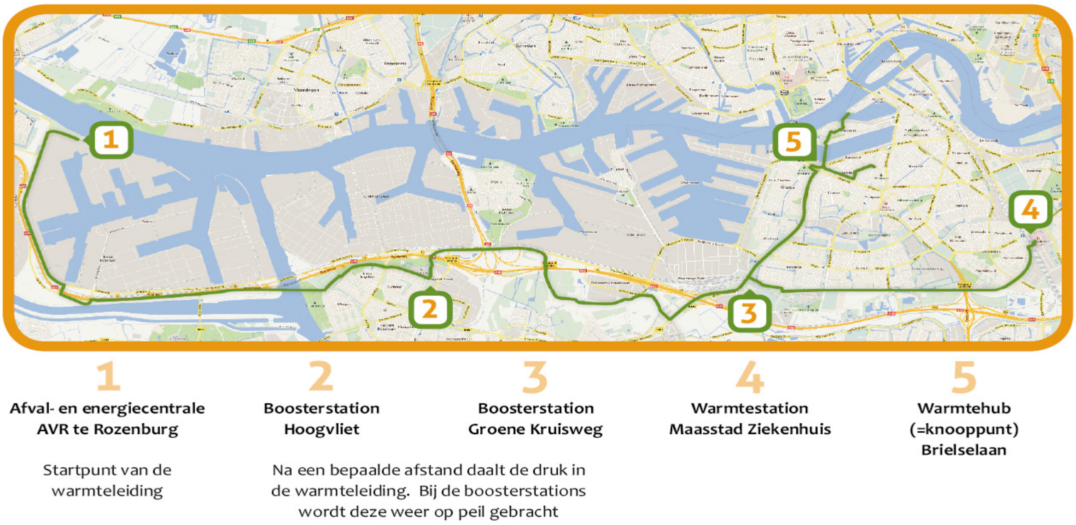

Figure 9: Transport net Rotterdam (Warmtebedrijf Rotterdam, 2011b

The heat that arrives at the substation will be delivered to new buildings, existing buildings that are being renovated, offices, hospitals and an existing district heating system (Gemeente Rotterdam, 2009).

The supplied water in the transport net could have a maximum temperature of 120 ºC and the return water a maximum of 70 ºC (Hamers, 24012013).

The long term vision of Rotterdam would be to connect more producers (and end users) located in the Botlek area to the transport net. CE Delft has recently conducted a study to identify the potential of the future scenario (see Figure 10).

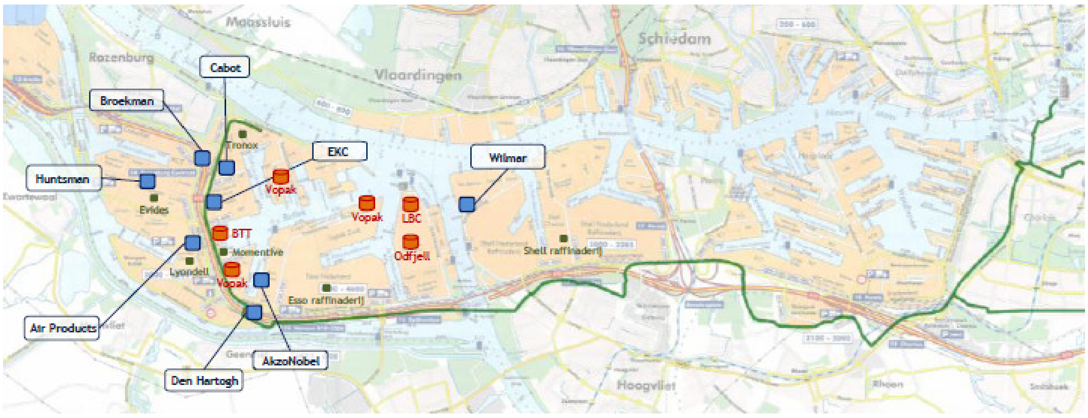

Figure 10: Future expansion district heating network (CE Delft, 2012)

Organizational structure

The two separate parts of the SPV; infrastructure and exploitation have different roles and responsibilities. Infrastructure, invests in the backbone of the district heating network, establishes the substations and arranges the maintenance, while exploitation regulates; procurement, dispatch, optimization and long term planning (see Figure 11).

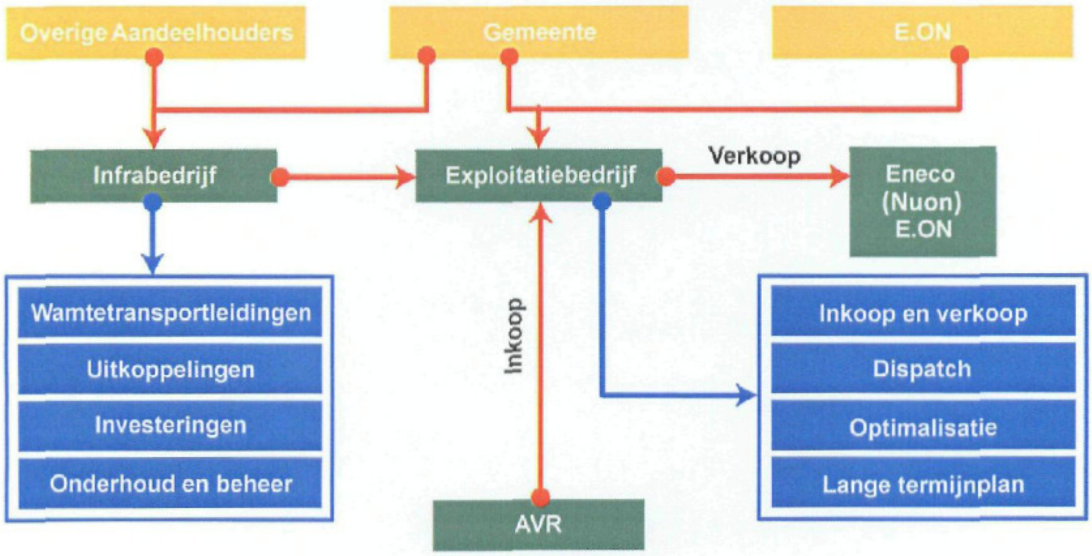

Figure 11: Organizational structure warmtebedrijf Rotterdam (Gemeente Rotterdam, 2009)

The exploitation company is a PPP, while the infrastructure company is a public energy distribution company. The PPP structure used in the exploitation company is a develop and operate (DO) structure.

The municipality of Rotterdam has established a *connection obligation*, which indicates that all new and renovated buildings will be connected to the district heating network.

Key partners in the organizational structure of Rotterdam are:

- Municipality: eradiating trust towards and communicating with the inhabitants (channel), supervising the pricing, service level and profits that are being made and secure the sustainability of the project (supervisor), issue permits, investor and initiator
- Housing corporation: channel and investor
- Province: investor and facilitator
- Grid operator: knowledge and expertise
- Bank: Investor
- Energy distribution companies: knowledge, expertise and customer relationship tools
- Contractor: knowledge and expertise

- Government and European commission: subsidies
- Producer: waste incineration plant

The organizational structure is displayed in Figure 12.

Financial streams

Since the company is divided into two separate parts, they will both have revenue streams and expenditures. Infrastructure has a stable revenue stream which is paid by exploitation; this is a fixed price (renting) in order for exploitation to use the infrastructure. This is recorded in a contract which will last for 30 years.

Exploitation generates income through the sold heat (€/GJ) to the energy distribution companies. This price is divided in a base price (85% of the purchased heat) and a peak price (15%). The operational cost for exploitation are; rent to infrastructure, purchase price for the delivered heat, FTE's and repay and interest for the loan (see Figure 12). This creates an unbalance between income and expenditures which could cause discrepancies, since the income is variable while part of the expenditure has a fixed price (Hamers, 24012013). This uncertainty lies within the exploitation part of the district heating company.

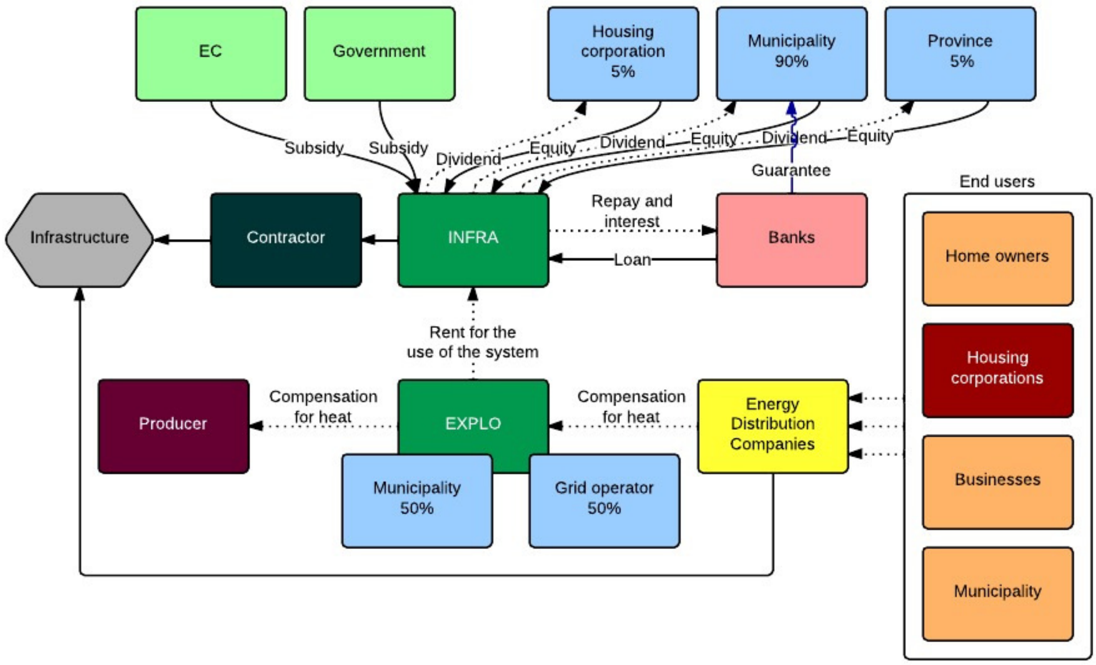

Figure 12: Financial streams Rotterdam

All contracts that are used - between producer and exploitation and between exploitation and the energy distribution companies- have a take or pay[9] structure which means that the buyer bears the financial risk (ibid).

The investment costs (120 million euro) are for 30% covered by equity supplied by the shareholders of the infrastructure enterprise, which are; the municipality (90%), the province (5%) and housing corporations (5%). The remaining 70% was supplied through a loan, for which the municipality guarantees.

The district heating company of Rotterdam agreed on a contract with the contractor which includes the design, construction and maintenance of the infrastructure (DCM contract). This

[9] 'Take or pay': The buyer and producer agree upon a X amount of heat per time unit for a set price, if the buyer does not meet this amount a fee must be paid to the producer.

places the technical risk at the contractor, but the price for maintenance increases significantly compared to insourcing maintenance.

4.4 Sittard: Het groene net

The municipality in Sittard conducted a research in 2010 similar to what happened in Delft. They identified the most cost efficient way to reach the CO_2 reduction targets in 2020. This resulted in the plan to construct a district heating network which will be fuelled by a biomass incineration plant and industrial waste heat from the Chemelot industrial area (Dieteren, 19022013). This plan is created by the municipality and resulted in the longest (47 km) transport net in the Netherlands. The exploration, deepening and elaboration phases of this project are partly facilitated by Agentschap NL, who offers process support according to the industrial waste heat utilization guide (NL: handleiding industriële warmtebenutting).

This project requires the establishment of a SPV, which will be a joint venture of the municipality and a construction company. This partner was found via the tendering process, which is obligatory for projects (which need a large investment) initiated by the municipality (Dieteren, 19022013).

The municipality has also secured a customer base (new and existing homes) by involving a housing corporation in the process and establishing small projects which are all separately signed by the housing corporation (ibid).

It is estimated that the project will generate 47 ktonne of CO_2 reduction per year, when the total project is operational (Het groene net, 2010).

The following person was interviewed about this project:

- Rogier Dieteren (Municipality Sittard-Geleen)

Technical

As mentioned before Sittard will construct the longest transport net in the Netherlands (47 km). This net connects two producers; Chemelot (industrial area with different heat producers) and a biomass plant. In Figure 13 the transport net (blue line) is displayed and the core installations and participants are visualized (yellow: producer, purple: temporary heat production installation, blue: large end user and red: back-up installations). The producers will provide a combined heat supply of 835 TJ/yr, with a capacity of 85 MWth (Het groene net, 2010). There will be five substations from where the heat can be transported to the customers via a distribution net.

The majority of the customers will be new buildings which will be provided with 70 ºC water (Het groene net, 2012).

The return temperature of the water will

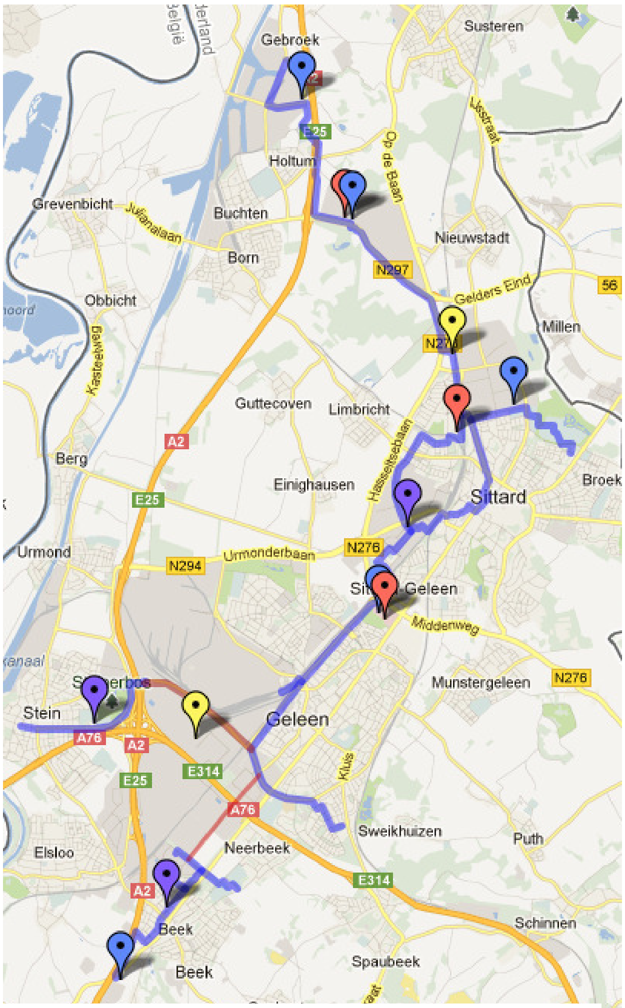

Figure 13: DH Sittard (Het groene net, 2010)

be approximately 40 ºC (ibid). Next to heat, the idea is to also provide cold with an input temperature of 12 ºC and a return temperature of 18 ºC. For existing buildings a customized approach will be necessary.

Organizational structure

In the start-up phase of the project the initiators (municipality) had to deal with a lot of uncertainties among which (USG, 2013);

- Diverging interest of the different parties
- Unclear roles
- Insufficient resources
- Insufficient knowledge

They solved these problems by creating a group, which contained people representing the different stake holders (municipality, industrial waste heat supplier and a housing corporation) and held frequent meeting. By means of this, the municipality tried to create support and find common interests, which would stimulate the project. In this process the roles were defined and a first draft of the business case was presented. Due to the lack of knowledge and sufficient resources an extra party which could supply both resources and knowledge needed to be attracted. They entered into a tendering process through which they found a motivated partner, a construction company.

The continuation of the process will require a set up of a SPV, in order to allocate the financial risk to a separate party. This SPV will be a joint venture where the municipality and the contractor will both participate equally. Furthermore, the municipality has a golden ticket when it comes to sustainability in the project.

The PPP structure used in this SPV is a design, construct, maintain and operate (DCMO) structure.

The key partners in this project are:

- Municipality: eradiating trust towards and communicating with the inhabitants (channel), supervising the pricing, service level and profits that are being made and secure the sustainability of the project (supervisor), issue permits, investor and initiator
- Contractor: knowledge and expertise, economies of scope (construction will be executed at the cost price)
- Government: revolving fund
- Bank: investor
- Producers: multiple producers lower the continuity risk and the project is divided in different phases, in which different producers will be introduced.
- Housing corporation: channel (the commitment of end users will be covered by including the housing corporation in the discussion and letting them sign different small proposals instead of one large proposal)

Since there is no energy distribution company included as partner, a new customer service centre must be established and employees must be trained and educated in order to execute their responsibilities.

Financial streams

The SPV will generate the standard revenue streams, but the municipality decided to lower the heat price for the consumer by 15%. This price reduction is possible due to a successful negotiation process in which they first identified the total profit and afterwards divided the profit over the participating parties.

The expenditures of the SPV will entail:

- Compensation for the purchased heat (producer introduced a; base load, peak and back-up price)
- Repay and interest
- Maintenance at cost price (economies of scope)
- Dividends to the shareholders (note, that the municipality will receive a lower dividend than the private (construction) party)
- FTE's

The investment costs (± 80 million euro) will be covered by equity provided by the shareholders and a revolving fund of 10 million which has been made available by the government. The remaining investment cost will be covered by a loan, wherefore the SPV guarantees.

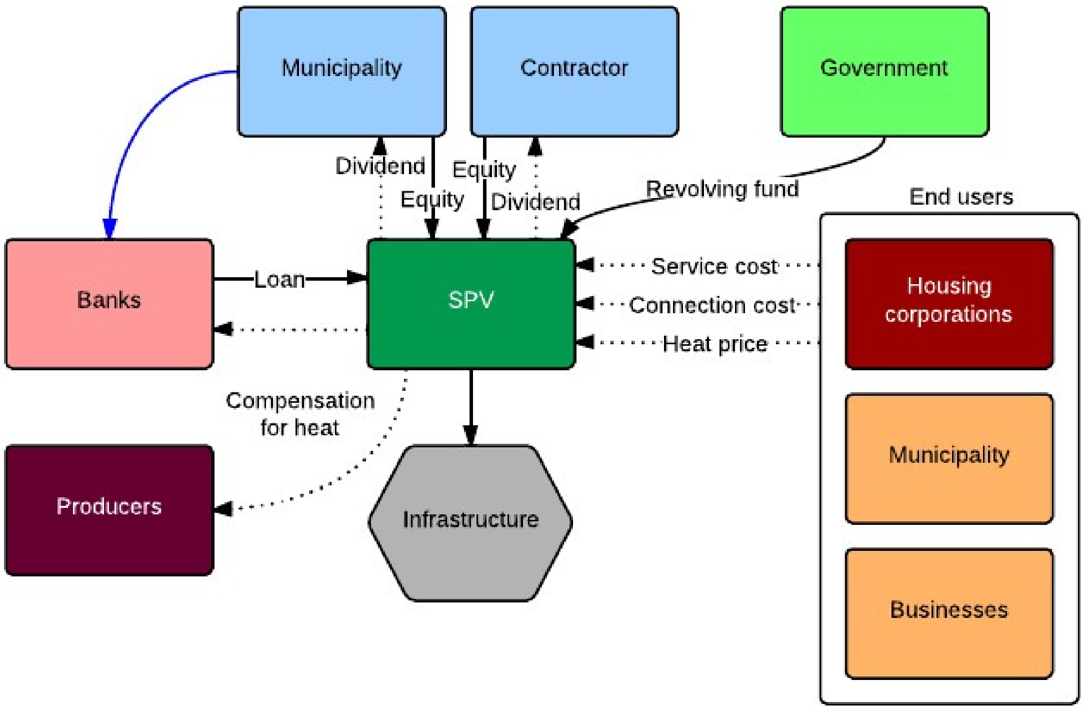

Figure 14: Financial streams Sittard

4.5 Rotterdam Botlek

Rotterdam has a large industrial area (Botlek) which could produce 45 MW of waste heat (high, low and medium pressure steam) in 2002 (CE Delft, 2002). Part of this waste heat will be used in the waste heat utilization project which was initiated in 1995 by the seaport of Rotterdam. This project aims to connect several companies and originally multiple suppliers to a large steam grid (6 km). In the process several suppliers and end users decided not to participate in the project, which leaves two supplier and seven end users. In the earlier stages of the project no progress was made, since the involved industrial parties were more concerned with their core business than the project (which is to be expected). Once a grid operator entered the project the business case was developed and signed within 2 years. The construction for the first part of the project (Botlek west), which connects one supplier to one end user, has recently started and is expected to be operational in 2013 (Port of Rotterdam, 2012). The total project is estimated to avoid 200 ktonne of CO_2 emissions, from which 70 ktonne will be avoided by implementing Botlek west (RCI, 2012).

The following person was interviewed about this project:

- Guy Konings (Stedin)

Technical

The Botlek steam grid will deliver 360 ºC at 40 bar to a number of chemical, petrochemical and food companies nearby (Deltalinqs, 2011). First the west steam pipe will be constructed, which will form a connection between a waste incineration plant and a chemical company. In the next phase 7 more industrial customers and one producer will be connected to the grid. Figure 15 shows an overview of the steam grid as proposed in 2011 (Deltalinqs, 2011).

The producer (waste incineration plant) is the same producer as for the district heating network in Rotterdam. As a consequence this could cause competition and limit the expansion possibilities.

Figure 15: Steam pipe Botlek (Deltalinqs, 2011)

Organizational structure

In the Botlek the introduction of a grid operator who coordinates the project, caused a major step forward in the development of the steam grid. This grid operator that acted as independent party connected the different producers and end users and eliminated some of the important inter-organizational barriers. In the earlier stages of the project the seaport was also involved as independent party but they stepped back when the grid operator was willing to fulfill this role.

The grid operator outsourced the construction and maintenance to a contractor with whom they have a design construct and maintain (DCM) contract. This shifts the risk on technical failure to the contractor.

The key partners and their added value in the project are:

- Grid operator: channel, knowledge and expertise, investor
- Contractor: knowledge and expertise
- Government: subsidy
- Seaport: channel
- Producers: multiple producers lower the continuity risk, investor
- End user: customer, investor

Financial streams

The gird operator facilitates the heat transport by; investing in the common infrastructure (100 million euro), taking care of the maintenance activities and the measuring. They receive a fixed price for these services, which is paid by the end users. On top of this fixed price is a variable price (which is kept as fixed as possible) for the maintenance activities (Konings, 24012013).

The producer and end user have to make individual agreements with each other for the delivery of waste heat. These types of contracts could be (Stibbe et al. 2013):

- Usage fee: either cost price or cost price with a margin (cost+)
- 'Take or pay': The buyer and producer agree upon a X amount of heat per time unit for a set price, if the buyer does not meet this amount a fee must be paid to the producer.
- 'Take or put': The buyer and producer agree upon a X amount of heat per time unit for a set price, if the producer does not meet this amount a fee must be paid to the end user.
- Combination of the above

Each end user-producer couple could choose a different agreement which fits best with their needs and wishes and will ensure cost reduction or profits for both.

As stated before, the investment in the common infrastructure will be covered by the gird operator, while the producer and end user will invest in the infrastructure at their own site. Since the parties have capital at their disposal and will ensure cost reduction by participating in the project, they are usually willing to invest in their own infrastructure. Another reason for this is the ownership of the equipment. When a third party invests in equipment and infrastructure at their site, the ownership will be theirs, this will cause complications for both parties.

Figure 16 gives an overview of the organizational structure and the financial streams of the Botlek project.

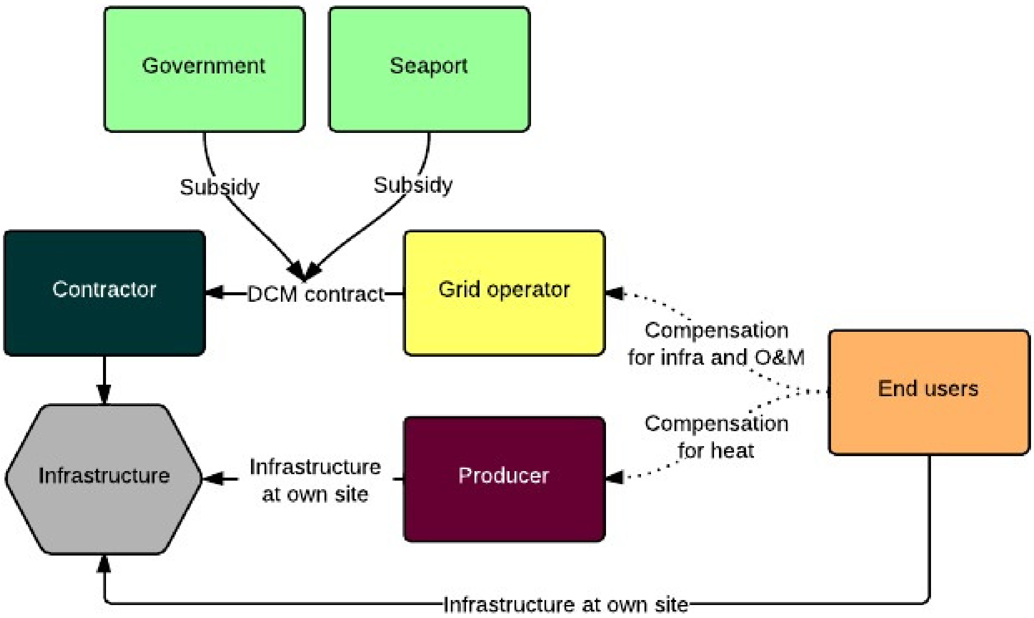

Figure 16: Financial streams Botlek

4.6 Delfzijl, Oosterhorn

The chemical industrial area (Oosterhorn) in Delfzijl has an intensive exchange of resources, such as heat, compressed air and nitrogen (Colmer, 17012013). Since heat was not the first exchange that required infrastructure, a template organizational and financial structure was available. The gained experience translated into a short development period of 4 years (2004-2008) and a construction phase of 1 year (2009-2010). The seaport of Groningen took the lead in this project, indicated the possible connections and invested in the public infrastructure.

The steam grid consists of two parts with different temperature and pressure. There is only one producer, which is the waste incineration plant and there are currently six industrial parties connected to this grid. The intention is to connect several more industrial players to this existing grid. The emission reduction as of now is 95 ktonne CO_2 per year (Agentschap NL, 2011a).

The following person was interviewed about this project:

- Herbert Colmer (Groningen Seaports)

Technical

In Delfzijl the steam grid distributes both 290 ºC at 23 bar and 210 ºC at 12 bar to industrial parties (Colmer, 17012013). The east steam grid (210 ºC) transports steam to P.P.G. (chemical), DOW Benelux (chemical) and Zeolyst (chemical), while the west steam grid (290 ºC) transports steam to Akzo Nobel (chemical), BioMCN (petrochemical) and Aldel (metal) (Agentschap NL, 2011a). See Figure 17 for an indication of the design of the system.

Figure 17: Steam pipe Delfzijl (Agentschap NL, 2011a)

Organizational structure

The seaport in Delfzijl had experience with creating resource exchange connections between the different companies at the port and already had a working organizational and financial model, which is also applied to waste heat exchange.

The seaport describes part of their core business as the facilitation of the “hardware” needed for transport. This formulation would also define the construction of a waste heat infrastructure as core business for the seaport. This is why they decided that they would invest in an infrastructure but will not be responsible for the operations and needed stable income in order to reduce the financial risk and create a set payback period. This was realized by outsourcing the; design, construction and maintenance to a contractor through a DCM contract and by introducing a fixed rental fee which is paid by the producer.

The key partners in the project are:

- Seaport: channel and investor
- Contractor: knowledge and expertise
- Producer: investor
- End user: customer, investor

Financial streams

The seaport will hire a contractor by the use of a DCM construction for 10.7 million euro. 8 million euro will be allocated to the construction of the steam grid, while the remaining 2.7 million euro is allocated to a maintenance contract for 15 years. In order to secure a stable revenue stream to payback the investment a renting construction was introduced. In this case the producer pays a fixed fee for the use of the infrastructure, which enables the seaport to establish a payback period of 15 years. After these 15 years the rent will remain in place and the profit will be used to finance new projects (revolving fund).

The producer and end user will have to establish contracts between them based on the following contracting forms:

- Usage fee (either cost price or cost price with a margin (cost+))
- 'Take or pay'
- 'Take or put'
- Combination of the above

The investment as stated before is partly covered by the seaport (common assets) and partly by the producer and end user. The latter two will invest in the infrastructure that is placed at their own site. Unique to this project is that this project was established without subsidies or governmental support.

An overview of the organizational structure and the financial streams is displayed in Figure 18.

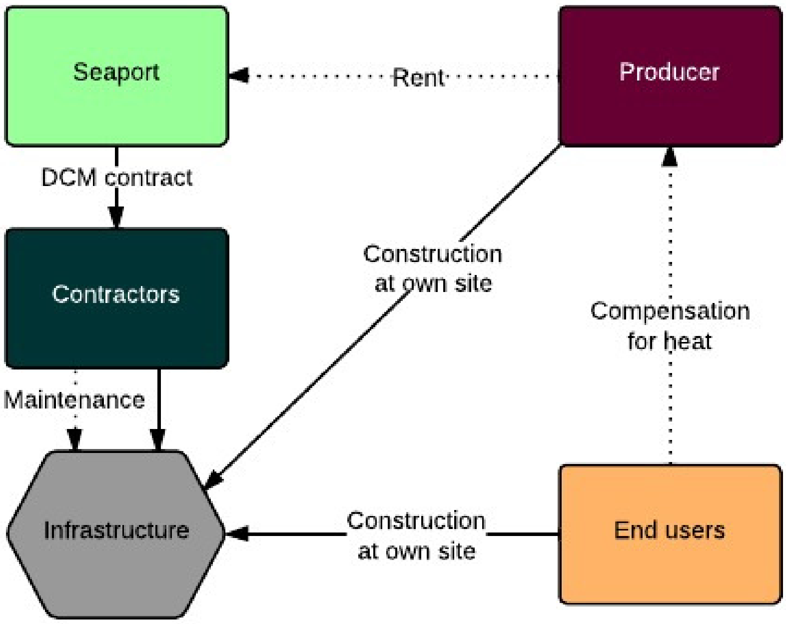

Figure 18: Financial streams Delfzijl

4.7 Moerdijk

In Moerdijk the waste heat utilization project is part of the sustainable connections (NL: duurzame verbindingen) Moerdijk, which is an intention agreement signed by; Seaport Moerdijk, Bedrijvenkring Industrieterrein Moerdijk (BIM), Province Noord-Brabant, Municipality Moerdijk, Rijkswaterstaat Zuid-Holland and Waterschap Brabantse Delta (Gemeente Moerdijk et al. 2011). The waste heat utilization project consists of four separate projects (Appelweg, Vlasweg, Middenweg and Westelijke Randweg). The Appelweg and the Westelijke Randweg are respectively in the operational and start-up phase, the Middenweg is in the elaboration phase and the Vlasweg is in the exploration phase. The ultimate goal of the project is a connection between all the separate nets, which would form a large district heating network that could fuel the surrounding companies and possibly other end users (Rentrop, 31012013).

When all projects are installed separately the total CO_2 emission reduction will be approximately 24 ktonne per year (Gemeente Moerdijk et al. 2011).

The following person was interviewed about this project:

- Jacco Rentrop (Havenschap Moerdijk)

Technical

Moerdijk is planning to construct four heat connections, of which two are already build and operational. All four have their own temperature regime and different customers who use the heat for different applications. The first project (Appelweg) is a district heating network which connects two end users to one producer. The other currently operational connection is a steam grid, which connects one producer to one end user, but expansion is part of the long term vision.

The network planned at the Middenweg is in the process of formulating a feasible business case. Once there is a feasible business case a steam connection between Ardagh Glass (producer) and Stolthaven, GCA and Frans de Wit (end users) will be established (Rentrop, 31012013; Intij, 2012).

The final project is the Vlasweg, which is currently still in the exploration phase. In this project a hot water and steam grid will be constructed.

The final step in this process is the connection of the different networks by means of a loop.

Figure 19: Moerdijk energyweb (Intij, 2012)

<u>Organizational structure</u>

In Moerdijk the seaport, the province and other parties drafted an intention agreement (duurzame verbindingen Moerdijk) which aims to stimulate sustainability at the port of Moerdijk. The waste heat utilization projects at the port are embedded in this overarching initiative. Within this initiative a steering committee, controlling group and different project groups (waste heat is one of these project groups) are established. A project group consists of different teams who focus on the following aspects; technical, financial, legal and organizational (Figure 20) (Intij, 2012).

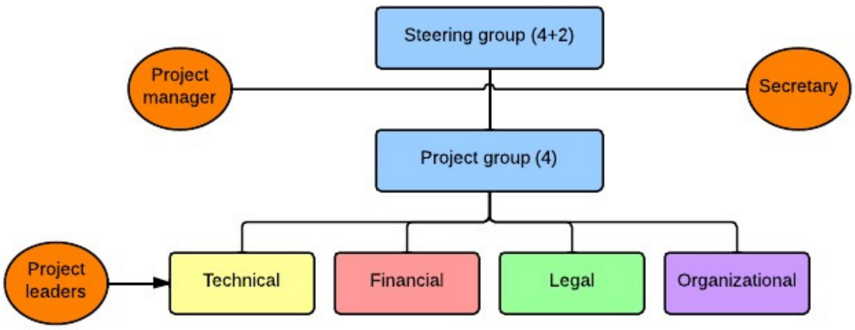

Figure 20: Organizational structure Moerdijk (Intij, 2012)

The first waste heat project was realized with the investment (common assets) of the province in the form of a subsidy, the following projects are being realized with an investment by the seaport in the common infrastructure. In contrary to the Delfzijl project the seaport does not see constructing infrastructure for heat transport as their core business. This resulted in the search for a partner which could establish an energy distribution company, lead the operations and bear the financial risk. Up until now this search was unsuccessful, due to the low return on investment of the projects.

Key partners in this project are:

- Seaport: channel and investor
- Contractor: knowledge and expertise
- Producer(s): investor, knowledge and experience (economies of scale)
- End user: customer and investor
- Province: subsidies and facilitator
- Advisor: knowledge and expertise (data gathering)

<u>Financial streams</u>

The organizational structure and financial streams are very similar to Delfzijl, with a seaport that fulfils the role of independent party and invests in the common infrastructure. In return the seaport receives a rental fee from the end user for the use of the infrastructure. In the case of Moerdijk there is no DCM contract which means that the contractor only designs and builds the system. The maintenance is performed by the producer, who receives a compensation for this service by the seaport. The producer will perform the maintenance for cost price, due to the economies of scale.

The end user and producer make individual agreements, but sustainable connections Moerdijk establishes the pricing, which is based on a cost+ mechanism. The cost price for the generation of heat is taken as starting point to determine for which price they can sell the heat. This heat price needs to be slightly higher than the cost price. For the end user the cost for generating heat is taken as starting point, they aim to establish a heat price + rent which is 10-15% lower than the cost for generating their own heat. The price for heat will thus be a balance between these two indicators. Moerdijk chose to regulate the pricing in order to prevent differentiation.

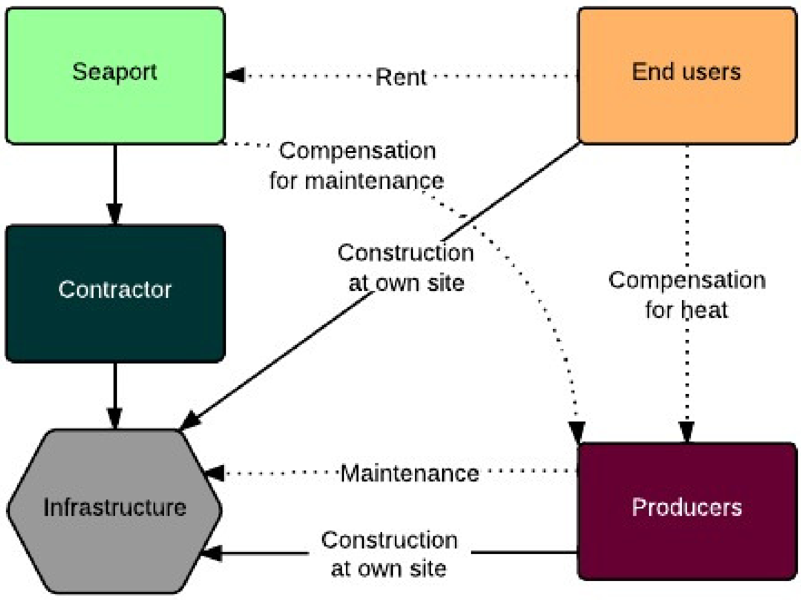

Figure 21: Financial streams Moerdijk

Again, as in all assessed industrial projects the producer and end user invest in the infrastructure at their own site.

4.8 Terneuzen: WarmCO_2

In Terneuzen the seaport and the province wanted to establish a project which would; generate employment, attract people to the region and help to reach the CO_2 reduction targets (Taks, 09012013). The province and the seaport therefore designated an area for which the zoning plan was adjusted, which enabled the establishment of a horticultural area. Furthermore, cooperation with Yara (fertilizer production) was initiated in order to supply heat and CO_2 to the prospective growers. This project started with the exploration phase in 2000, which led to the establishment of a SPV named WarmCO_2. WarmCO_2 is a cooperation between the seaport Zeeland and Yara (supplier), with a share division of respectively 80% versus 20%. In 2008 the construction of the infrastructure started and while the main infrastructure is completed, the distribution net is still in progress since there are currently only three growers residing in this area, while there is space for approximately 7-10 growers.

It is estimated that the project (when completed) will avoid 135 ktonne of CO_2 emissions, but due to the lack of end users the full potential is not reached yet (Taks, 09012013; Yara, 2011).

The following person was interviewed about this project:

- Jan Taks (WarmCO_2)

Technical

The waste heat producer in Terneuzen does not only supply heat, but also compressed CO_2. This requires extra piping and equipment. The district heating network itself is 2 km in length and supplies 1,652 TJ/yr to the growers. Currently, only 1/6th of the waste heat is used due to the lack of end users.

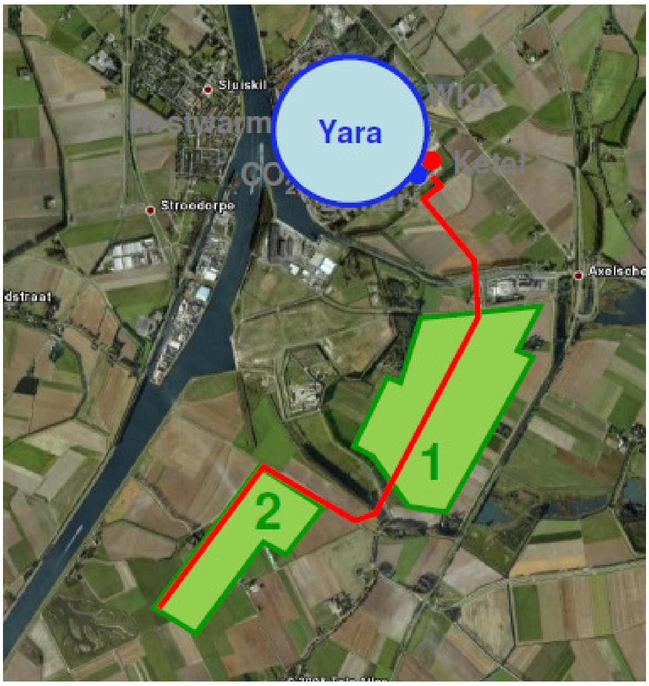

Figure 22: DH Terneuzen (Visser & Smit Hanab, 2012)

The input temperature of the system is 90 ºC, while the return temperature will be approximately 40 ºC (Taks, 09012013). The large delta T of this system (50) indicates that the system is very efficient.

The horticultural sector has a similar heat pattern as the built environment since their heat demand is also largely dependent on the outside temperature. Furthermore, the horticulture has one or more weeks a year that they do not produce and as consequence do not need heat (Taks, 09022013). Figure 23 shows the heat demand of the customers of WarmCO_2 in 2012.

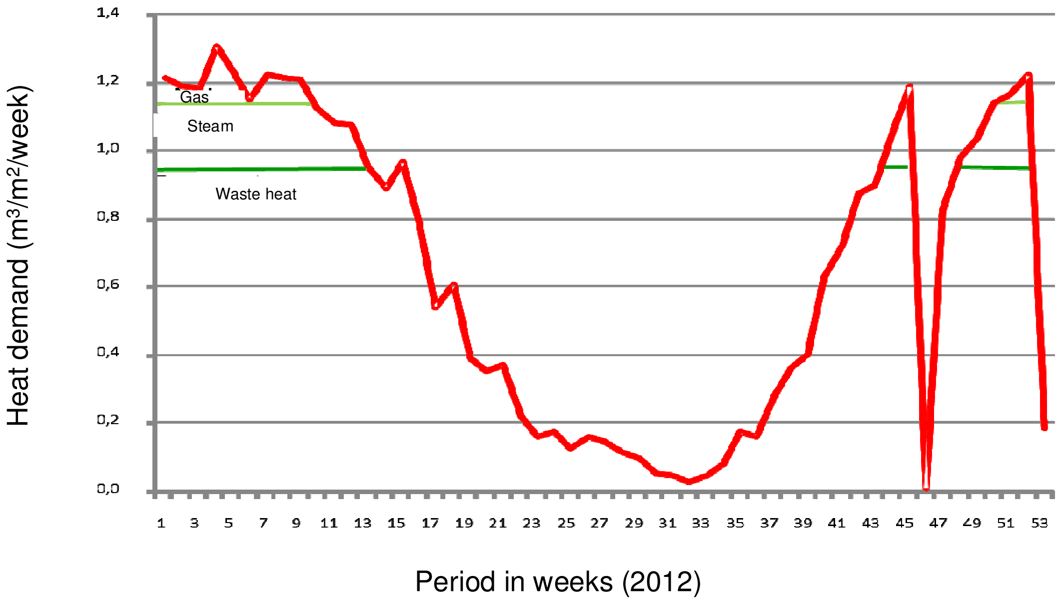

Figure 23: Heat demand pattern horticulture Terneuzen 2012 in m³ natural gas equivalent (Visser & Smit Hanab, 2012)

Organizational structure

In the case of Terneuzen a SPV was established by Zeeland Seaports and the producer. The fact that the producer is a risk bearing partner is unique, this could be because of the expansion of the business case by introducing CO_2 delivery or the profitability of the project (for the producer).

This construction is a PPPs construction but the majority of the activities are allocated to the SPV. The private party only acts on their own site, which means that this PPP construction is in fact a purchase relationship.

Key partners in this project are:

- Seaport: channel and investor
- Contractor: knowledge and expertise
- Producer(s): investor, knowledge and experience (economies of scale)
- End users: customer and investor
- Government: subsidies
- Province: channel and subsidies
- Banks: financing
- Maintenance service company: knowledge and expertise

Financial streams

The revenue stream of the SPV is based on one stream; the heat and CO_2 price paid by the horticulture. The out flowing financial streams are; the interest and repay toward the banks, the financial compensation toward the seaport for guaranteeing for the loan, the compensation toward the producer for the delivered heat and CO_2 and compensation toward the maintenance service company for their activities (Taks, 09012013). These expenditures are all set prices, with the exception of the maintenance fee. These set prices reduce the financial risk significantly. On the other hand, the discrepancy between the revenue streams (variable) and the cost (mostly fixed) causes a big risk for the SPV. Especially since the number of expected end users was not met and the heat demand is much lower than expected.

The producer receives a compensation for the delivered heat, but pays for the operations and maintenance on their own site. Since they have a take or pay contract the SPV will need to pay for the agreed amount of heat, which places the financial risk at the SPV. The end users only concern is if the price for the delivered heat and CO_2 is lower than the price they paid before. Since continuity is an important aspect of the heat supply, the end users are willing to invest in a back-up installation (both for insurance issues and continue heat supply). Figure 24 gives an overview of the financial streams in the Terneuzen case.

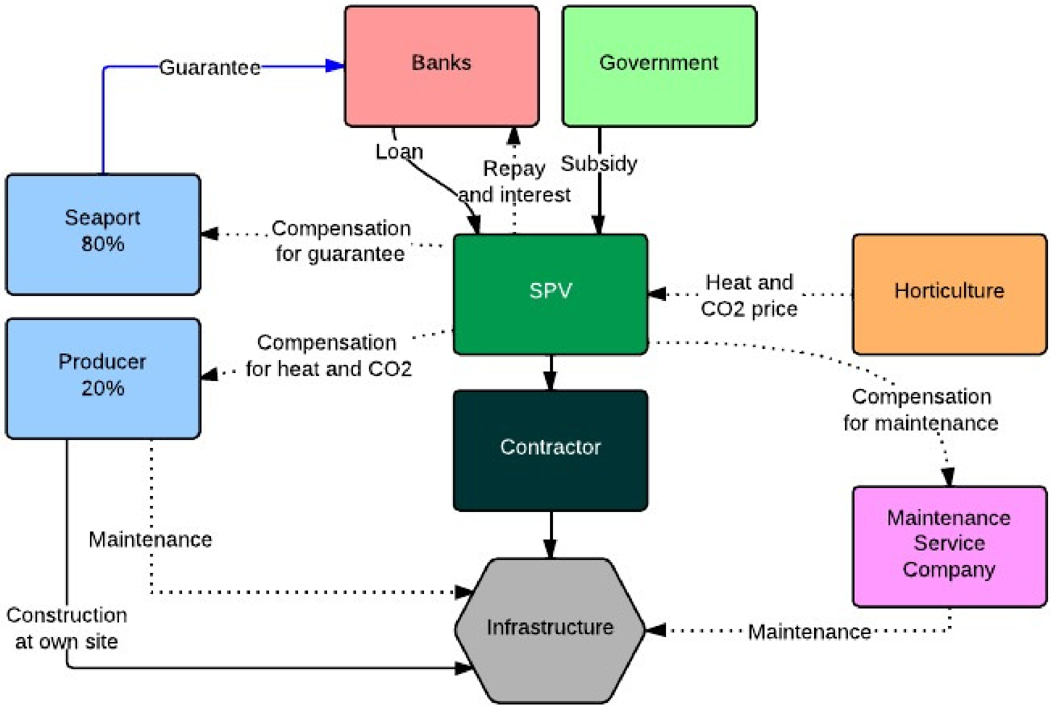

Figure 24: Financial streams Terneuzen

The investment costs (±78 million euro) are covered by the shareholders, subsidies and a loan. While the seaport guarantees for the loan, the producer invests in the infrastructure at their own site.

4.9 OCAP

The OCAP project is an outlier within the assessed projects since there is no heat delivered, but only CO_2. The project is included due to the large similarities (organizational structure and financial streams) and the lack of larger waste heat projects for the horticultural sector. OCAP stands for Organic CO_2 for the Assimilation of Plants (NL: organische CO_2 voor de assimilatie van planten) (Hoek loos, 2007). This project started in 1994 and used the already existing pipeline (83 km) which was historically used for the transportation of crude oil from the Botlek to Amsterdam (ibid). An SPV (joint venture) was established in which Linde gas and Volker Wessels group both took an equal share (Ligtvoet, 2012). In order for the project to be profitable, 500 growers needed to be gathered. This process was completed in 2004, where after the construction started (ibid).

In the earlier period of the operational phase, it became clear that Shell (producer) could not supply a continuous stream of CO_2 (maintenance stops, technical failure etc.) which was a problem for the growers which were solely connected to the CO_2 grid (Hoek loos, 2007). This problem was resolved by introducing an extra producer, who was connected to the network in 2012 (OCAP, 2012a).

The project is currently operational and looking for expansion possibilities in horticultural areas in Noord-Holland and CO_2 capture projects.

There was unfortunately nobody available to interview, but extensive reports from Hoek loos (Linde gas) (2007), WUR (2011), Ligtvoet (2012) and OCAP (2012b) gave some insight in the history and current operational processes.

Figure 25: CO_2 distribution network OCAP (Visser en Smit Hanab, 2012)

<u>Organizational structure</u>
In the OCAP project a SPV was established by a contractor and a supplier of gasses. These two parties have the knowledge and expertise concerning construction and operations of a gas transport net, but not the connection to the horticultural sector. The two shareholders experienced some difficulties due to cultural differences, but this did not influence the success of the project (Ligtvoet, 2012).The involved consultancy firm made the connection to the horticultural sector and acted as channel. This was done by visiting fairs and meeting organized for and by the horticultural sector (Hoek loos, 2007). This active recruiting was necessary in order to find 500 customers, which was the minimum amount of customers that was needed in order for the project to start and be profitable (ibid).

The PPPs structure of this project is a buy, build and operate (BBO) structure. This means that there is no public party involved, but that the SPV bought the infrastructure from a public party (in this case the national government).

The key partners in this project are:

- Gas supplier: knowledge and expertise and investor
- Contractor: knowledge and expertise and investor (economies of scope)
- Producers: multiple producers lowers the continuity risk and investor
- End users: customer
- Government: subsidies
- Banks: financing
- Advisor: channel and knowledge and expertise

<u>Financial streams</u>
The revenue stream of the SPV is based on the delivery capacity (kg/hr) and the load hours for each individual customer (Hoek loos, 2007). This means that this price is a variable price.

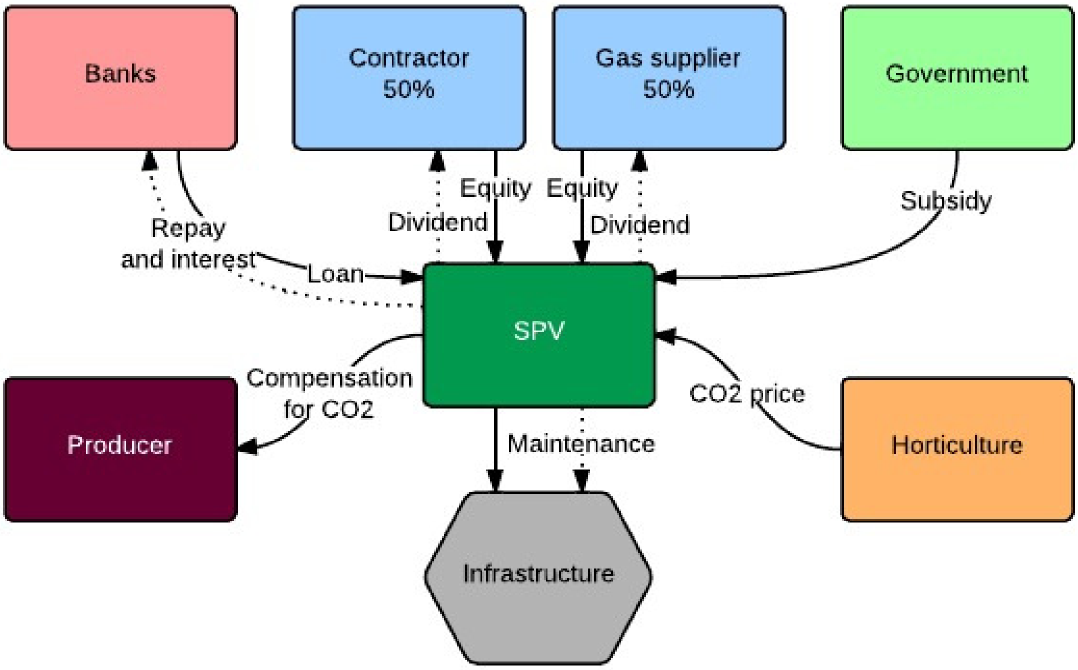

Figure 26: Financial streams OCAP

The costs of the project are:

- Compensation for the supplied CO_2
- Maintenance: economies of scope
- Repay and interest
- Dividends

Since a contractor is part of the SPV the construction will be executed for the cost price, due to economies of scope. The investment cost for the construction will be covered by equity provided by; the shareholders, subsidies and 70% senior debt (Ligtvoet, 2012).

PART II Synthesis

5. Lessons learned, barriers and risks

The data gathered in chapter 4. Industrial waste heat utilization projects will be used to extract lessons learned and identify the main barriers and risks. These lessons learned, barriers and risks will be linked to the corresponding building blocks of the BMG theory. In the last section of this chapter building blocks that require the most attention during the formation of a business model, in order to establish a successful project, will be identified based on the findings in chapter 5.1 Lessons learned- chapter 5.3 Risks.

5.1 Lessons learned

The lessons learned will be divided in general lessons learned, which are applicable to all district heating projects and more specific lessons learned that are applicable to the business models for the different customer segments (built environment, industry and horticulture). Furthermore an indication will be given to which building block of the BMG theory this lesson learned applies.

5.1.1 General

Lesson learned	Building block(s)
Participation in an EU project yields valuable knowledge and financial support (SESAC, 2011, Dieteren, 19022013).	KP and CS
Multiple producers guarantee continuous heat supply (Dieteren, 19022013; Konings 24012013; OCAP).	KP
Difference in revenue streams and operational cost (variable versus fixed prices) could cause discrepancies (Taks, 09012013; Hamers, 24012013).	RS
Creating a core group for the development of the project enables trust, transparency and an increased development speed (Dieteren, 19022013 ;Rentrop, 31012013).	KP
Having enough customers in order to fulfil the expected heat demand is crucial for the profitability of the organization (Taks, 09012013; Hoek loos, 2007).	CSE and KP
Phased approach makes the process manageable and distributes the investment cost over a longer period of time (van Kemmeren, 06022013; Konings, 24012013).	CS and KA
Creating teams within the project team that focus on the different aspects of the process (technical, legal, financial etc.) creates a multi-disciplinary team which posses the required knowledge and expertise to establish the project (Rentrop, 31012013).	KR
Reduction of risk by cooperation with a public party gives access to attractive financing options (all).	CS
Signing a letter of intent secures commitment and cooperation of the involved parties (Rentrop, 31012013)	KP

Table 1: Lessons learned general

5.1.2 Built environment

Lesson learned	Building block(s)
Golden shares for the municipality secure the environmental and social values and create trust toward the customer (SESAC, 2011).	C and KP
Using the energy distribution company as interface creates economies of scope and recognition and trust among customers (van Gestel, 13022013).	C, KP and CR
Using a familiar pricing system creates trust among customers.	RS and CR
Using economies of scope lowers the operational cost (van Gestel, 13022013)	CS and KP
Softening the connection obligation by introducing a margin of 15%, which means that minimally 85% of the newly constructed buildings must be connected to the district heating network, lowers the resistance and improves the public opinion of inhabitants (van Kemmeren, 06022013).	VP and C
Thermal storage could be used to facilitate the peak demand in the winter (Gemeente Amsterdam, 2012).	KR
When the producer is owned by the municipality the long term contracts do not form a barrier and the heat can be bought at cost price (van Kemmeren, 06022013; van Gestel, 13022013).	KP and RS
A SPV in which the municipality is the only shareholder (public utility company) does not have the knowledge and expertise to sufficiently run a district heating company (Hamers, 24012013).	KP
Outsourcing the construction of the distribution net and the connection of the customers to energy distribution companies allocates part of the risks to third parties (Hamers, 24012013).	KP
First identifying the total profit, where after the division of the profit can be determined, enables a cost reduction (Dieteren, 19022013).	RS
Differentiation in dividend between public and private parties provides more financial room and complies with the regulations for municipalities concerning profit making activities (Dieteren, 19022013).	RS

Table 2: Lessons learned built environment

5.1.2 Industry

Lesson learned	Building block(s)
Independent party brings producers and end users together, takes the lead and invests in the common assets (eliminates barriers) (Colmer, 17012013; Konings, 24012013; Rentrop, 31012013).	KP and C
Outsourcing maintenance transforms a variable cost in a fixed cost which lowers the financial risk (Colmer, 17012013; Konings, 24012013).	CS
A DCM contract shifts the risk of technical failure to a third party (Colmer, 17012013; Konings, 24012013).	KP and CS
Producers and end users are willing to invest in equipment at their own terrain when the supplied heat is cheaper than the currently produced heat (Colmer, 17012013; Konings, 24012013; Rentrop, 31012013).	VP and CS
Experience with resource exchange provides useful knowledge and increases the speed of the development (Colmer, 17012013; Rentrop, 31012013).	KR and KP
Exchanging high quality heat improves the business case (Botlek, Moerdijk and Delfzijl).	VP

Table 3: Lessons learned industry

5.1.3 Horticulture

Lesson learned	Building block(s)
There are producers that are willing to become risk bearing partner (Taks, 09012013).	CS and KP
Active recruiting of customers is necessary in the horticultural sector (Hoek loos, 2007; Taks, 09012013).	C
Setting a minimum amount of customers in order for the project to start is a good way to secure the profitability of the project (Hoek loos, 2007)	CSE and C

Table 4: Lessons learned horticulture

5.2 Barriers

The barriers discussed in this section are the barriers that inhibit the establishment of a district heating network, the supportive organizational and financial structures. Barriers identified in literature and in the current projects will be assessed and discussed. Note, that these projects are all executed, which means that these barriers did occur at some point in the process but did not hamper the execution since solutions were identified.

The identified barriers can be subdivided in five sub-categories; financial, legal, technical, intra-organizational and inter-organizational barriers. First, in the literature research multiple barriers were identified by Wüstenhagen & Boehnke (2008), Grönkvist & Sandberg (2006), Thollander et al. (2010) and Ligtvoet, (2012). Subsequently, barriers that are not mentioned in the literature, but did surfaced in the identified projects (chapter 4. Industrial waste heat utilization projects) are also included. All these identified barriers are summarized in the following Table 5 in order to indicate which barriers are encountered in which projects. Furthermore, the corresponding BMG building block(s) is/are coupled with the different barriers. Note, that the indication of which barrier occurred in which project is based on interviews and desk research and might not include all barriers that where encountered in the different projects.

Table 5: Barriers identified in current projects

Barriers	Delft	Amsterdam	Rotterdam	Sittard	Botlek	Delfzijl	Moerdijk	Terneuzen	OCAP	**BMG**
Financial										
Profitability BC (Wüstenhagen & Boehnke, 2008; Grönkvist & Sandberg, 2006; Thollander et al. 2010)	x	x	x		x		x	x		CS & RS
Long PBP (ibid)	x	x			x		x	x	x	CS & RS
Low ROI (ibid)	x	x	x	x	x		x	x	x	CS & RS
Split incentives (ibid)	x	x	x	x						RS
Finding investor(s) (ibid)	x	x	x		x			x	x	KP & CS
Legal										
Legal restrictions (Ligtvoet, 2012)	x	x	x	x						KA
Long lead times and contracts (Wüstenhagen & Boehnke, 2008; Grönkvist & Sandberg, 2006)	x			x	x	x	x	x	x	KP
Division CO_2 permits (Ligtvoet, 2012)	x			x		x		x	x	RS
Division of risks (Konings, 24012013; Colmer, 17012013)	x		x	x	x	x		x	x	KP
Unclear laws and regulations (van Kemmeren, 06022013)	x	x	x	x	x	x	x	x	x	KA
Technical										
Distance (Grönkvist & Sandberg, 2006)	x									KR
Competition with alternatives (Agentschap NL, 2012)										-
Covering losses (Konings, 24012013)					x					CS
Uncertainty technical data (Rentrop, 31012013)							x			KR
Intra-organizational										
Risk aversion (Thollander et al. 2010)	x				x		x	x	x	KP
Not core business (Ligtvoet, 2012)	x		x	x	x	x	x	x	x	KP
Split drivers (Wüstenhagen & Boehnke, 2008)										-
Inter-organizational										
Differences in views, values etc. (Ligtvoet, 2012; Thollander et al. 2010; Grönkvist & Sandberg, 2006)	x								x	KP
Trust and transparency (Thollander et al. 2010; Grönkvist & Sandberg, 2006	x	x	x	x	x	x	x	x	x	KP
Commitment end users (Taks, 09012013)					x	x	x	x	x	CSE & C
Public opinion (van Kemmeren, 06022013)	x	x	x				x			CSE

The identified barriers will be discussed in more depth in the following sections and examples will be provided per category.

5.2.1 Financial

The financial barriers manifested themselves in almost all -with the exception of Delfzijl, and Sittard- projects. Especially the drafting of a profitable business case was difficult. In some cases, Rotterdam and Delft, the theoretically profitable business cases proved to be unprofitable in practice due to changed circumstances or lack of expertise (Ligtvoet, 2012; Hamers, 24012013). In the end all assessed projects formulated a profitable business case, but in most cases this was only possible because all parties involved adjusted their criteria and settled for a lower profit (van Kemmeren, 06022013; Hamers, 24012013; Konings, 24012013). As for the projects that did not experience many financial barriers, the key was either experience with financial models for infrastructure (Delfzijl) or first identifying the full profit and afterwards dividing the dividends (Sittard) (Colmer, 17012013; Dieteren, 19022013).

The remaining theoretical financial barriers; long payback periods, low return on investment, split incentives and finding investors, are also mentioned but did not lead to large problems (Ligtvoet, 2012; van Kemmeren, 06022013; Rompelberg, 08012013; Konings, 24012013). There are parties that are willing to accept the low returns and risk because of the pay off (large client base and monopoly for energy distribution companies) or the long term vision and sustainability targets (public organizations). Note, that most of these barriers are part of the business case and are solved in this overarching problem.

5.2.2 Legal

As for the legal barriers, the PPP induced some problems, such as; the public tender which is required for large investment projects, cooperation between a commercial initiative and a public partner and the municipality as an investor and profit-making entity (van Kemmeren, 06022013). Public organizations are bound to rules which state that they need to operate in the interest of the people they represent, be transparent and they cannot make wind fall profits[10] (Rompelberg, 08012013; van Kemmeren, 06022013).These rules also apply to the company that is established and (partly) owned by a public organization, this limits the commercial activities of the new company (ibid). Even though these rules cause a barrier, in practice it appears there are ways to avoid this barrier. Amsterdam researched the possibilities of cooperating with or setting up a commercial company as a public organization. Even though the outcome remained slightly unclear, there are possibilities in this area (van Kemmeren, 06022013; Rompelberg, 08012013). Sittard did not experience the public tender as a barrier, rather a tool to find the right partner and negotiate a reasonable price (Dieteren, 19022013).

The long lead times and contracts formed a barrier for industrial companies since they would be restricted in their flexibility to move. In some cases the participating industrial players withdrew themselves because of this reason, for example DSM in Delft and Shell in Rotterdam (Ligtvoet, 2012; VNG, 2006).

When there are industrial parties involved there will be barriers concerning the division of CO_2 permits. Who gets the CO_2 permits, the supplier of the waste heat or the end user? In built environment projects the end user does not care for the CO_2 permits, but they are legally the receiver of the CO_2 permits (Dieteren, 19022013). This led to legal discussion and ended in a green deal submitted by the municipality of Sittard, in which they requested that it would be made possible for the industrial waste heat supplier to receive the CO_2 permits (ibid).

Another legal barrier is the division of risks in the form of contracts. The division of the found risks and how to hedge these risks in the contracts is a difficult process. Furthermore, the responsibility for the common assets (Colmer, 17012013; Rentrop, 31012013; Konings, 24012013) was in most industrial cases a barrier. It is important to thoroughly investigate the risks that are present in the project and discuss the division of these risks. Afterwards this division of risks can be captured in different contract forms.

[10] Profits that exceed the expectations which were set beforehand

Furthermore, the laws and regulation surrounding district heating and industrial waste heat utilization remain unclear and uncertain, mainly because of the lack of regulation. In each project legal issues needed to be researched ranging from whether the municipality could introduce a connection obligation to which permits are required (van Kemmeren, 06022013; Rentrop, 31012013). It is therefore advisable to include a legal member or division in the project development team, which was done in Moerdijk (Rentrop, 31012013).

5.2.3 Technical

Usually projects are designed according to the maximum distance a chosen network can cover, this is why there were not many distance related problems. The exception was Delft where the original plan was to connect Delft and the Botlek area. The plan turned out to be unfeasible (long distances jeopardized the profitability of the business case) where after a more regional approach was instigated (Agentschap NL, 2011b).

Most municipalities conducted a study to identify the most cost efficient way to reach their CO_2 reduction targets. In all cases district heating and waste heat utilization were the most cost efficient option (Dieteren, 19022013; Ligtvoet, 2012; Hamers, 24012013). Note, that only realized projects were identified, which means that in these cases waste heat utilization was identified as most favorable option from the start.

In the Botlek they discovered during the project that the losses of the system were of such a significant quantity that it was needed to charge for the lost energy. In the end the cost of the lost energy were divided among all participating parties (Konings, 24012013).

Another barrier that was identified in Moerdijk was the uncertainty of the technical data (quality and quantity of the heat etc.). This could be a barrier, since the profitability of the business case is largely dependent on this data. It is therefore needed to conduct a thorough investigation of the technical data, preferably by an independent party (Rentrop, 31012013).

5.2.4 Intra-organizational

The intra-organizational barriers; risk aversion and the interference with the core business were the main reasons for withdrawals of key partners. In the case of Delft and Rotterdam the producer decided to leave the project due to internal issues such as; long contracts and heating not being their core business, which meant that they would not be able to deliver a continuous stream of heat (Ligtvoet, 2012; VNG, 2006).

In the industrial projects both end users and producers quit the project in earlier stages because of the time and effort it would take to continue. The tasks that need to be performed would interfere with their core business and they therefore decided not to participate. Fortunately, these withdrawals occurred in the earlier stages which granted the project leaders time to find new partners or revise the plan and continue with the remaining partners.

Split drivers did not occur since energy distribution companies and grid operators are very keen to participate in the construction of a district heating network since it would guarantee them a monopoly and customers which are contracted for 10-20 years (van Gestel, 13022013).

5.2.5 Inter-organizational

All projects had to deal with a lack of trust and transparency, mostly between public and private parties. In some cases (Sittard, OCAP, Amsterdam and Moerdijk) this was resolved in earlier stages, due to frequent meetings and actively building trust between the involved parties, but in other cases this caused difficulties and slowed down the process (Dieteren, 19022013; Rentrop, 31012013). In the Botlek for instance, the parties were discussing the introduction of a district heating network for approximately 10 years, but due to a lack of trust and transparency between the industrial parties no concrete steps were taken (Konings, 24012013). Practice shows that in order to establish a successful waste heat utilization project trust and transparency are extremely important.

In some cases a difference in; views, values, drivers, cultures and goals, led to friction. For instance in the OCAP project a Dutch and a German company with different cultures found out during the process that one assessed the project based on internal rate of return and the other on payback period (Ligtvoet, 2012). Furthermore the public-private partnership causes problems, due to different drivers (CO_2 reduction versus profit), cultures (participation and in service of the inhabitants versus efficient and fast) and goals.

In practice it proves to be difficult to bind end users to a non-existing project. Project leaders have to put a lot of effort into creating support, attracting customers and finding the right channels to reach the customers. Especially in the current economic climate, when a limited number of new buildings are constructed and where industrial players are more concerned with their internal affairs in order to survive. When the required number of end users in not met when the project is constructed, this barrier becomes a large risk and could have significant influence on the profitability of the project, this is currently happening in Terneuzen (Taks, 09012013).

The public opinion towards district heating was mentioned as barrier in some projects. This is usually applicable in the case the end users are inhabitants of a city or town. These people usually have no say in whether they are connected to the gas or district heating network, this sometimes leads to discontent (van Kemmeren, 06022013). Mainly due to the fact that there is no freedom of choice, not to the use of a district heating network in general. A solution to this barrier is clear communication and information toward the end users (in this case the inhabitants of the city/town). Another reason for the discontent among the inhabitants is the discussion about the avoided EPC measures. In which case the economic benefits (due to using less and/or sustainable energy) are not allocated to the end user (see appendix V. Not more than otherwise principle).

5.3 Risks

Next to barriers it is important to identify the most important risks. In the following sections the internal and external risks are discussed based on the findings in the interviews and literature.

5.3.1 Internal risks

In a traditional energy production supply chain the risks are well distributed and it is partly legally recorded which company bears which risks. In an industrial waste heat utilization supply chain on the other hand, the risks are slightly different and can be allocated to whoever is willing to take responsibility for these risks. The risks that can be identified are summarized in Table 6.

Risk	Building block(s)
Financial risk: this risk entails the uncertainty of the evolution of the future financing cost (Stibbe et al., 2013).	CS
Technical risk: the discrepancy between the initially foreseen and realized technical performance of the system (Stibbe et al., 2013).	KR and KA
Continuity risk: is a risk that is only applicable to a waste heat utilization project, since the producer in this case is an industrial party and the heat production is usually bound to the production of the industrial party. If there is an irregular pattern of heat production there is a large risk that the end user will not receive heat at a certain time (van Kemmeren, 06022013).	KR and KA
End user risk (NL: volloop risico): is the risk of having "too little end users" to make the business case profitable (van Kemmeren, 06022013).	C and CSE
Pricing risk: the uncertainty of the willingness of the end users to pay for the delivered heat. (Stibbe et al., 2013).	VP and RS
Producer risk: is the risk of the producer relocating their activities to a different location, which would jeopardize the heat supply (Stibbe et al., 2013).	KP
PPP risk: how are the partnerships developing over a long period of time (Huisman, 2010)	KP

Table 6: Risks

5.3.2 External risks

Next to these identified internal risks there are also external risks that influence the feasibility of an industrial waste heat utilization project such as; the economic status of public and private organizations and the country, the development of the gas price, the political climate which influences the subsidies, development of costs for substitute products, consumer preference, regulation and legislation and the organization of the energy market (public vs. private) (Ligtvoet, 14012013; Huisman, 2010).

5.4 Translation to BMG

For each of the sections in this chapter the lessons learned, barriers and risks have been coupled to the building block of the BMG theory which matches the content. In order to determine which of these building blocks are currently experiencing difficulties and are crucial for the project to succeed, a graph is made which displays the number of times the building block is mentioned in the previous sections (see Figure 27).

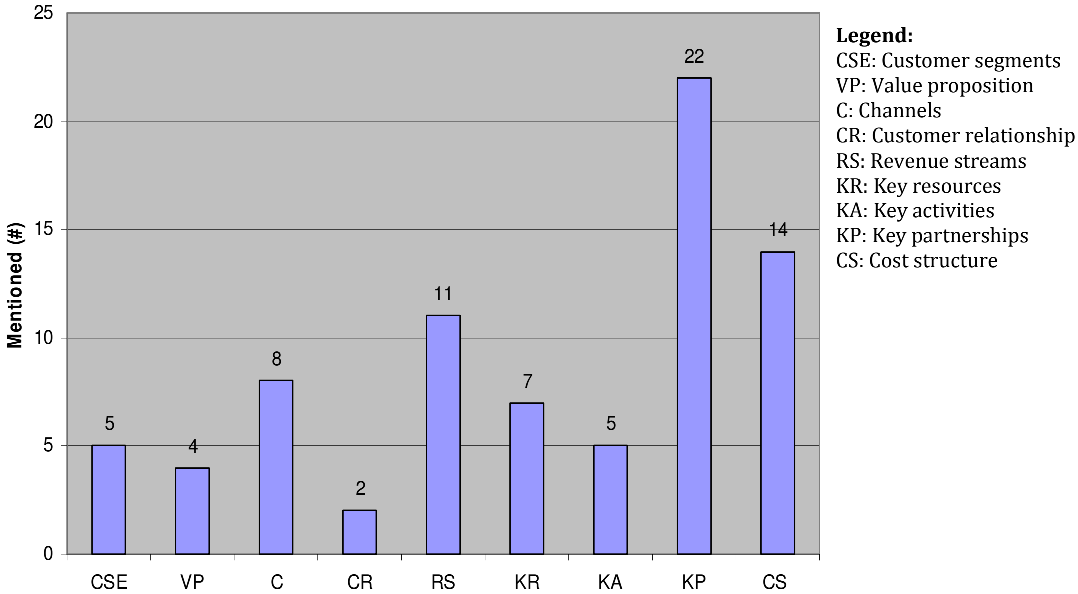

Figure 27: Evaluation of the translation to the BMG theory

When evaluating the number of times each building block is mentioned in this chapter the following building blocks can be identified as the building blocks that require the most attention in the formation of a business model; key partnerships, cost structure, revenue streams and channels. To these building blocks extra attention will be paid during the formation of best practice business models and new business models.

PART III Analysis

6. Business model generation

The found data in the previous chapters will be combined in this chapter. First, the identified lessons learned and barriers are processed in order to formulate best practice business models for the different customer segments (built environment, industry and horticulture) with the use of BMG theory. Where after these business models will be assessed using a SWOT analysis. Furthermore research on new business models will be applied to industrial waste heat utilization projects with the use of the BMG theory.

6.1 Best practice business models

The lessons learned gathered in the previous chapters are combined into four general best practice business models for the three identified customer segments; built environment B2C, built environment B2B, industry and horticulture.

6.1.1 Built environment B2C

Customer segment

When targeting the built environment there are multiple different customers that can be targeted. These segments are:

- New (yet to be developed) buildings and homes
- Existing built environment:
    - Utility buildings (preferably owned by the municipality)
    - Apartment buildings (owned by a housing corporation)
    - Offices buildings

Each of these segments has its pro's and con's but due to the need for a large customer base a mix of these different segments is required in order to create a profitable business case.

Targeting new buildings is preferable due to the lower connection cost (see appendix V. Not more than otherwise principle) but, has a lower energy demand (due to strict building regulation concerning sustainability standards). Furthermore, these strict building requirements will favor other renewable energy options and measures over the connection to the district heating network, which will limit the possibilities of connecting new (yet to be developed) homes.

Connection of the existing built environment to a district heating network is only profitable when one boiler is replaced that fuels multiple homes or a large space (see appendix V. Not more than otherwise principle). Furthermore, the targeted areas need to have enough space between the buildings to construct the distribution net and connect the buildings. On the positive side, the energy use of these buildings is much higher, which means more CO_2 reduction potential for the public party.

Public opinion of the potential customers is a concern in both the new and the existing built environment that needs careful attention. There is need for a transparent offer that benefits (financially and environmentally) both the upstream and the downstream part of the supply chain.

Value proposition

The value proposition for the municipality and housing corporations (who are the targeted organization in order to reach the end users) is usually sustainability. It is therefore important to clearly visualize the CO_2 reduction, energy savings and comparison with other solutions.

It is also advisable to introduce cost reduction as a value proposition, this will create larger support among the end users and channels. Due to the large investment burden and payback period, cost reduction is difficult to establish but not impossible. Cost reduction is especially important when new buildings are constructed and the connection costs are covered by avoided EPC measures. When no cost reduction is introduced the end user will receive sustainable heat but will not benefit economically from this construction (see appendix V. Not more than otherwise principle).

Channels

Channels are extremely important in an industrial waste heat utilization project, since a committed group of end users is required in order to draft a profitable business case. In the case of the built environment there are three important channels which should all be closely involved in the project. These channels are;

- Municipality: connection to citizens, trustworthy, owner of utility buildings and influence spatial planning.
- Housing corporations: customer base, influence design new built environment (could also be included by means of a connection obligation)

Note, that these channels are most valuable when they are combined with a technical party (energy distribution company) in a SPV, in which their strengths complement each other.

Customer relationship

The use of economies of scope, as in the use of the communication and customer relationship tools of an energy distribution company, municipality and housing corporation, will lower the time and financial investment in customer relationships.

Customer relationship tools which are already in place at the shareholders and/or channels are;

- Energy distribution company: Automated services (website with personalized data and information) and personal assistance (helpdesk, customer service centre)
- Municipalities: Communities (local paper, town hall meetings) and personal assistance (information meetings)
- Housing corporations: Personal assistance (information meetings)

Revenue streams

Fixed prices reduce the financial risk, but due to the variability of heat purchase there has to be a variable part in the revenue stream. It is therefore advisable to stick to the current pricing method used for natural gas and electricity, which is a; variable usage fee (heat price), fixed subscription fee (service cost) and an asset sale (connection cost). Furthermore, this is a familiar system which the end user knows and understands, a new pricing system could cause confusion and uncertainty.

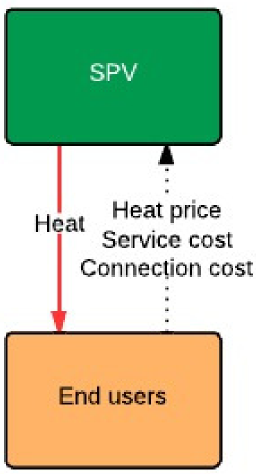

Figure 28: Revenue streams built environment B2C

As is stated in the value proposition a cost reduction value proposition needs to be introduced in order to let the end user benefit from this construction. When this is not done a negative impact on the public opinion and willingness to participate in this process could be the effect. This will largely impact the business case and therefore cancel the project. When a cost reduction is introduced, a positive influence on the public opinion and support for possible expansion of the project will be created.

Key resources
An industrial waste heat utilization project has in the exploration phase need for veracious data of the supply and demand side, feasibility studies and business cases. In the operational phase there is need for; waste heat, heat recovery equipment, (heat pump), heat exchanger, insulated pipes, pumps, (booster stations), water buffer, substations, measuring equipment, central heating system and (back-up equipment) (van der Post, 05022013). Furthermore, a customer service centre and a management team are needed to lead the operations, administration and communicate with the customer.

Key activities
The activities that need to be executed in the exploration phase are; frequent meetings, gathering of data, signing of a letter of intent (cooperation agreement) and draft feasibility studies and business cases. In the construction phase, the infrastructure and all the supporting equipment is build and installed and the customers are connected. Finally, in the operational phase; the operations must be managed (in the built environment the need for continuous heat supply must be at all times fulfilled), maintenance, measuring, billing and recruiting and connecting new customers.

Key partnerships
Since a waste heat utilization project is too complex, risky and expensive to be executed by one party, a group of stakeholders needs to be assembled to hedge the risks according to expertise and acquire the necessary resources and knowledge. The following parties are essential for a successful waste heat utilization project for the built environment:

- Municipality: channel, investor, facilitator[11], director[12] and/or mediator[13]
- Energy distribution company: channel, investor, knowledge and expertise and/or economies of scope
- Housing corporation: channel and/or investor
- Producer(s): resources and when multiple producers are connected continuity is guaranteed
- End users: customers
- Contractor: knowledge and expertise
- Bank: granting a loan

Other possible partners are;

- Grid operator: knowledge and expertise
- Province: investor, subsidy provider, facilitator, director and/or mediator
- Government: subsidy provider and/or facilitator
- Advisor/process facilitator: director, mediator and/or knowledge and expertise

Note, that a partner does not necessarily have to fulfill all the mentioned roles, but they are capable of fulfilling these roles. If the mentioned roles are not being fulfilled by the essential partner an extra partner needs to be attracted in order to fill this position and provide the necessary resources, knowledge or expertise.

Cost structure
The investment costs of a waste heat utilization project are large and it is therefore advisable to create a new entity (SPV) which will bear the financial risk. In order to finance the project a certain percentage of equity is needed (>30%). This equity could be supplied by the following partners, who would be risk bearing equity supplier and subsequently shareholder in the SPV;

- Municipality
- Energy distribution company
- Housing corporation

[11] Facilitating the process by; granting permits, arranging attractive loans, adjust spatial planning plans etc.
[12] Directing the process by; providing a project leader, arranging meetings, take the lead etc.
[13] Mediating between different parties, negotiate with commercial suppliers, informing the public etc.

The remainder of the investment needs to be acquired via senior debt issued by banks or pension funds. The most attractive loans can be acquired via a public party since these are stable organizations with low risk of bankruptcy (see Figure 29).

It is also possible that the province or the government will grant a subsidy, revolving fund or an attractive loan. This remains an uncertainty and differs in every project.

The operational cost include; FTE's, maintenance cost, purchase price heat, repayment and interest loan and dividends. It is important to align the revenue streams and the operational cost, in order to prevent discrepancies between the two. Since the revenue streams are partly variable (heat price) and partly fixed (service and connection cost) the operational cost need to be of a similar sort. Opposite the heat price there is the purchase price of the heat, which would preferably be a variable price. A cost price or cost+[14] structure would be most favorable. Note, that the continuity risk will be higher due to the lack of a set amount of heat that should be delivered. This should either be covered by connecting multiple suppliers, installing a back-up installation and/or making additional contractual agreements about continuity.

Furthermore, maintenance is a variable cost this could either be covered by the SPV (energy distribution company), since they have the needed knowledge and resources and thus the advantage of economies of scope or it could be included in a DCM contract with the contractor. It both has its pro's and con's but in order to lower the cost, in sourcing maintenance would be advisable.

The FTE cost can also be lowered by economies of scope, either employees of the energy distribution company and the municipality who possess the needed knowledge can be hired by the SPV or remain in their original company but work for the SPV. FTE's in a built environment project are a larger cost than in the other business models due to the large number of customers.

The interest and repay of the loan are fixed costs which need to be fulfilled by the SPV. When a public party guarantees for the loan -in this case the municipality- the interest will be significantly lower, due to the stability of the public party.

Finally, there are dividends to the shareholders. It is possible to equally divide the profits made in the project or differentiate based on being a public or a private organization (where the public organization receives a smaller dividend).

An overview of the business model is shown in Figure 29.

[14] Cost price plus margin

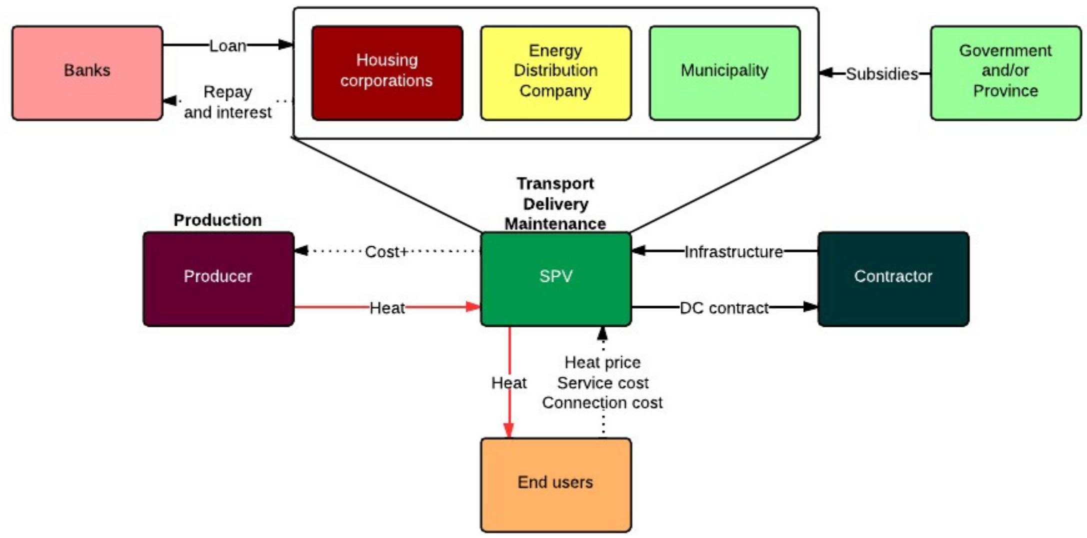

Figure 29: Built environment B2C[15]

6.1.2 Built environment B2B

Another possibility is the delivery of waste heat to energy distribution companies. This is a business to business concept. This business model will be described briefly since it is similar to the previous business model.

<u>Customer segments</u>
In the business to business concept waste heat is sold to energy distribution companies.

<u>Value proposition</u>
The value propositions for the B2B are sustainability, risk reduction and branding. First, most energy distribution companies are working on sustainability and are willing to participate in this type of projects. Partly because of sustainability targets, but also partly because they do not want to fall behind compared to the competition. Second, the participation in an industrial waste heat utilization projects will give them a monopoly position and a guaranteed customer base for the next 10-15 years. This is a great advantage in the current privatized market, where customers can easily switch between energy distribution companies. Furthermore, participating in these kinds of projects is good for branding and a "green" image.

In order to fulfill these value propositions a committed customer base needs to be generated (in cooperation with the energy distribution companies) and publicity about the project and the sustainability results of the project must be generated.

<u>Channels</u>
The channels in this business model are less important than in the previous model since a smaller amount of customers need to be reached. It is therefore sufficient to contact the energy distribution companies directly or via the following parties:

- Grid operator
- Municipality
- Housing corporations

<u>Customer relationship</u>
The relationship with the customer needs to be very intensive since there is great dependency on one another. This requires co-creation and dedicated personal assistance.

[15] A legend concerning all colors and arrows can be found in appendix VI. Legend

Revenue streams
The revenue stream of the SPV will be build up of a variable heat price and a fixed service cost. The energy distribution companies will transport the heat to the end users and use the same pricing mechanism as presented in the B2C business model.

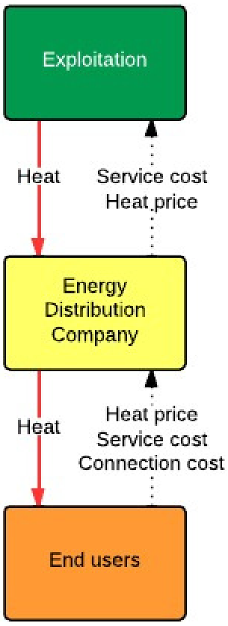

Figure 30: Revenue streams built environment B2B

Key resources
See key resources B2C model

Key activities
The activities that need to be executed in the exploration phase are; frequent meetings, gathering of data, signing of a letter of intent (cooperation agreement) and draft feasibility studies and business cases. In the construction phase, the infrastructure and the sub stations are built. Afterwards, the energy distribution company will construct the distribution net and connect the customers. Finally, in the operational phase; the operations must be managed (in the built environment the need for continuous heat supply must be at all times fulfilled), maintenance, measuring, billing and recruiting new customers.

Key partnerships
A SPV, divided in an exploitation and infrastructure part, would be the most favorable construction for the organization. In this case exploitation would be responsible for the buying and selling of heat, while the infrastructure part of the organization will be responsible for the construction of the infrastructure. The essential partners in these two parts of the organization are:

- Exploitation:
    - Municipality: channel, director and/or mediator
    - Grid operator: channel, knowledge and expertise and/or economies of scope
- Infrastructure:
    - Municipality: investor and facilitator
    - Grid operator or contractor: knowledge, expertise and economies of scope
    - Province: investor, subsidy provider, facilitator, director and/or mediator

Other essential partners:

- Producer(s): resources and when multiple producers are connected continuity is guaranteed
- Energy distribution companies: customer, investor, knowledge and expertise
- Housing corporation: channel and/or investor

Other possible partners are;
- Government: subsidy provider and/or facilitator
- Advisor/process facilitator: director, mediator and/or knowledge and expertise

Cost structure

The investment cost of the project could be covered by the following parties (also shareholder in the SPV):
- Municipality
- Grid operator
- Contractor
- Housing corporation
- Province

Note that, the inclusion of a contractor would generate economies of scope and the infrastructure cost would be lower.

When the involved parties cannot gather enough equity, a loan or other types of financial funds need to be acquired. This financial support is easiest and most attractively acquired via a public party, since these are stable organizations with low risk of bankruptcy.

It is also possible that the province or the government will grant a subsidy, revolving fund or attractive loan. This remains an uncertainty and differs in every project.

Operational cost consist of: fuel cost, FTE's, maintenance cost, purchase price heat, repayment and interest loan and dividends. Again it is important to align revenue streams and the operational cost, in order to prevent discrepancies between the two. Since the revenue streams are partly variable (heat price) and partly fixed (service cost) the operational cost need to be of a similar sort. Opposite the heat price there is the purchase price of the heat, which would preferably be a variable price. A cost price or cost+ structure would be most favorable. Note, that the continuity risk will be higher due to the lack of a set amount of heat that should be delivered. This should either be covered by connecting multiple suppliers, installing a back-up installation and/or making additional contractual agreements about continuity.

Furthermore, maintenance is a variable cost this could either be covered by the SPV, since they have the needed knowledge and resources and thus the advantage of economies of scope or it could be included in a DCM contract with the contractor. It both has its pro's and con's but in order to lower the cost, in sourcing maintenance would be advisable.

The FTE's cost can also be lowered by economies of scope, either employees of the grid operator and the municipality who possess the needed knowledge can be hired by the SPV or remain in their original company but work for the SPV. FTE's in a B2B built environment project are a smaller cost than in the B2C business model.

The interest and repay of the loan (if applicable) are fixed costs which need to be fulfilled by the SPV. When a public party guarantees for the loan -in this case the municipality- the interest will be significantly lower.

Finally, there are dividends to the shareholders. It is possible to equally divide the profits made in the project or differentiate based on being a public or a private organization (where the public organization receives a smaller dividend).

An overview of the business model is shown in Figure 31.

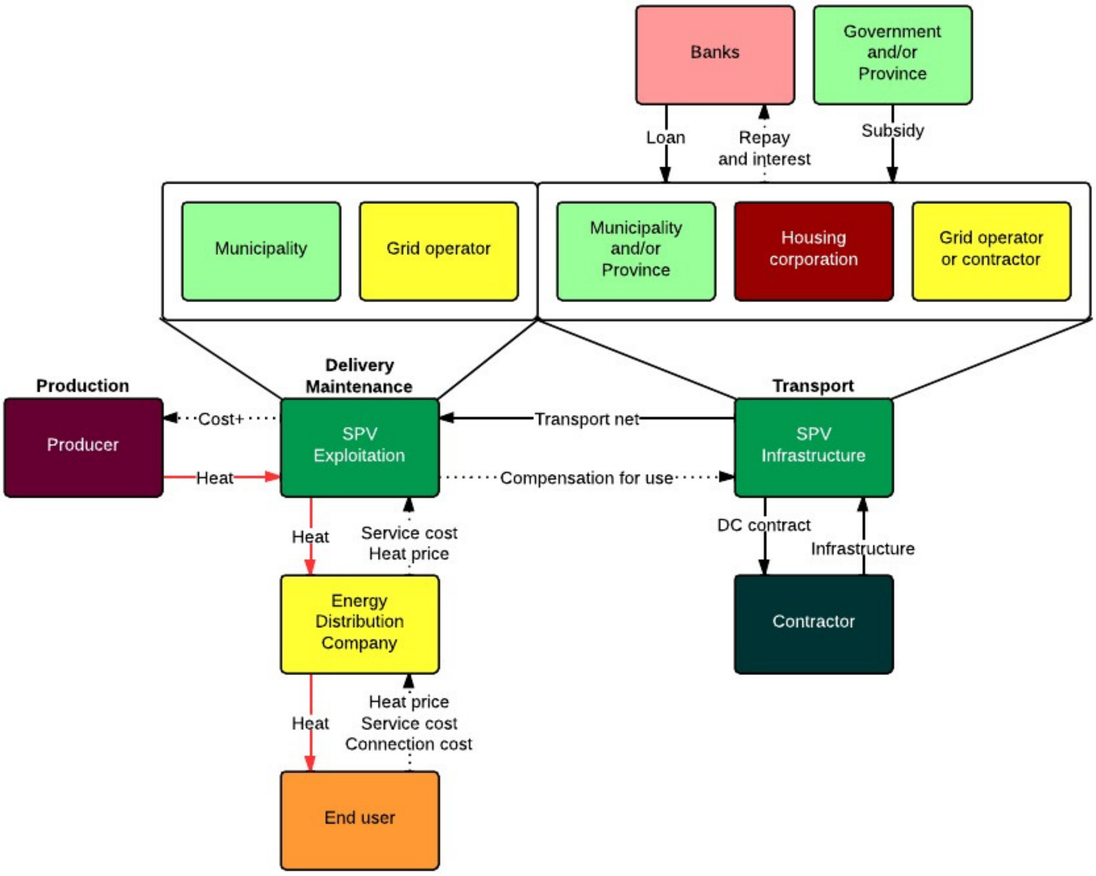

Figure 31: Built environment B2B

6.1.3 Industry

Customer segments

The most common customer segments for waste heat utilization for the industry are; chemical, petrochemical and food companies. These all have continuous processes that require continuous high quality heat (steam) in large quantities. This indicates that less end users are needed in order for the business case to be profitable.

Value proposition

The main value proposition is cost reduction, the industrial parties can decrease their energy cost by participating in a waste heat utilization project. It is thus very important to give insight in the current and future cost. Risk reduction is another important value proposition, since waste heat is less dependent on the natural gas prices. Furthermore, branding and newness is for some industrial parties an important driver to participate in a waste heat utilization project. Sustainability and innovation are values that have become more important for companies in the last years, which means that companies are looking for ways to achieve these values. In order to attract companies that value branding and newness -as in sustainability and innovation- the CO_2 reduction potential and energy savings must be clear and it would be preferable if media attention focused on these values of the project.

It is very important to distinguish the drivers of the different participants, in order to customize the offer to their wishes and needs.

Channels

Since industrial parties are usually very internally focused, it is important that an independent party indicates the possible cooperation's between the near each other located companies. This independent party needs to either have a connection to the companies via the location (area manager, province or municipality) or be an expert in heat exchange and transportation (energy distribution company or grid operator).

Customer relationship

Heat exchange connections between industrial companies needs a tailored approach, where both the producer, end user and independent party need to participate in the creation process. It is therefore necessary to facilitate a co-creation process in which all involved parties are involved in the establishment of a district heating network.

Revenue streams

The independent party -who is also the bearer of the largest financial risk- will need certainty and a fixed payback period. This is established by renting the system to either the producer or the end user. In this case the producer and end user need to establish contractual agreements and facilitate the operations. These contracts could include the following pricing mechanisms:

- Usage fee: either cost price or cost price with a margin (cost+)
- 'Take or pay': The buyer and producer agree upon a X amount of heat per time unit for a set price, if the buyer does not meet this amount a fee must be paid to the producer.
- 'Take or put': The buyer and producer agree upon a X amount of heat per time unit for a set price, if the producer does not meet this amount a fee must be paid to the end user.
- Combination of the above

Since both the producer and the end user benefit from this project, it is reasonable to divide the continuity risk among both parties. This can be done by creating a combination of the 'take or pay' and the 'take or put' mechanism or by using the cost+ mechanism.

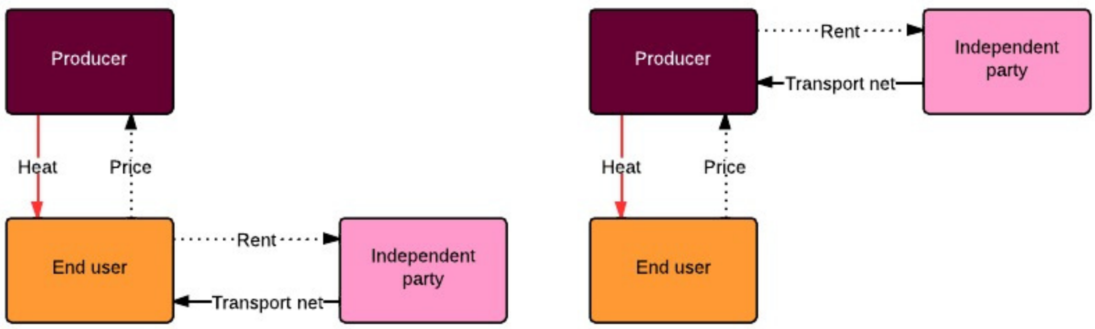

Figure 32: Revenue streams industry

The revenue streams for the producer are low(er) compared to the built environment case, due to low energy prices for the industry.

Key resources

An industrial waste heat utilization project has in the exploration phase need for veracious data of the supply and demand side, feasibility studies and business cases. In the operational phase there is need for; waste heat, heat recovery equipment, (heat exchanger), insulated pipes, pumps, (booster stations), (substations), measuring equipment and (back-up equipment) (van der Post, 05022013). Since there are less end users and a stable demand pattern, there is less need for human resources.

Key activities

The activities that need to be executed in the exploration phase are; frequent meetings, gathering of data, signing of a letter of intent (cooperation agreement) and draft feasibility studies and business cases. In the construction phase, the infrastructure and all the supporting equipment is build and installed and the customers are connected. Finally in the operational phase; the operations must be managed, maintenance, measuring, billing and recruiting and connecting new customers.

Key partnerships

Essential partnerships in an industrial waste heat utilization project with industrial parties as end users are;

- Independent party: channel, investor, facilitator, director, mediator and/or (knowledge and expertise and economies of scope)
    - Grid operator
    - Public party: province or area management
- Contractor: knowledge and expertise
- Producer(s): resources, investor and when multiple producers are connected continuity is guaranteed
- End user(s): investor and customer

Other possible parties that could be included in the project are;

- Municipality: channel, investor, facilitator, director and/or mediator
- Province: channel, investor, subsidy provider, facilitator, director and/or mediator
- Government: subsidy provider and/or facilitator
- Advisor/process facilitator: director, mediator and/or knowledge and expertise

Note, that a partner does not necessarily have to fulfill all the mentioned roles, but they are capable of fulfilling these roles. If the mentioned roles are not being fulfilled by the essential partner an extra partner needs to be attracted in order to fill this position and provide the necessary resources, knowledge or expertise.

Cost structure

The investment costs of an industrial waste heat utilization project are large, but lower than the investment costs of the built environment. This is due to the less dense surroundings and the limited amount of obstacles. Usually none of the participating parties (producers and end users) are willing to invest in the common assets. It is therefore necessary to attract an independent party that finances the common assets. This party will supply the required equity and guarantee for the loan (if necessary). Because of the cost reduction for all parties and the availability of equity, it is common that the producer and end user invest in the infrastructure at their own site. Another reason for this is; companies usually do not want assets on their site that they do not own.

The operational cost include; fuel cost, maintenance cost, rent, purchase price heat. The fuel cost are usually covered by the producer who incorporates these cost in the heat price. The maintenance cost are usually paid by the independent party -it is advisable to fix these cost in a DCM contract with the contractor- who receives a rental fee in return. The rent is a fixed cost which is paid by the producer or the end user. Either way these rental cost are split between the producer and the end user, by adjusting the purchase price of the heat, in a way that both parties benefit from the exchange. Since the number of end users is limited there is no need for a large number of FTE's, usually people within the participating organizations execute the required tasks.

An overview of the business model is shown in Figure 31.

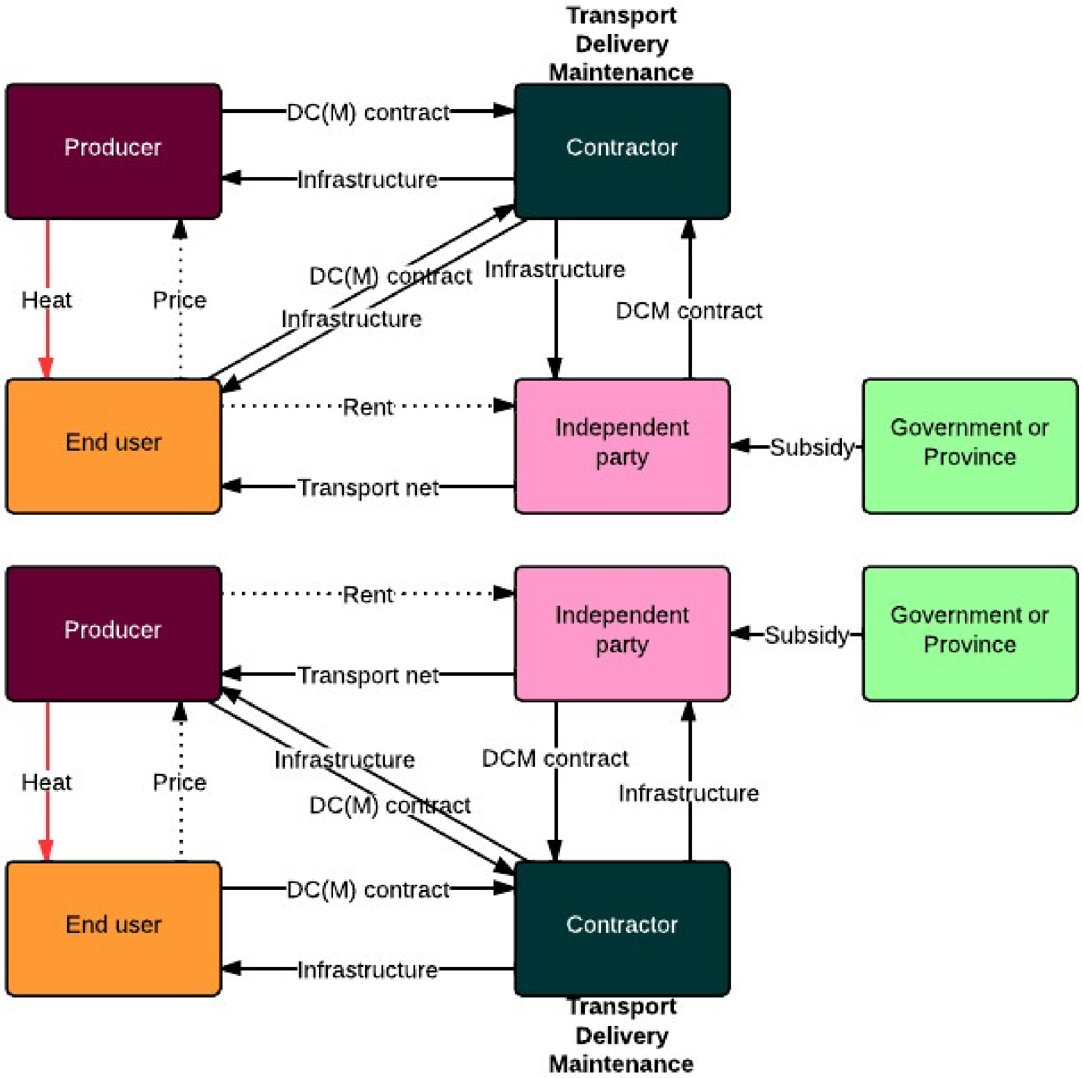

Figure 33: Industry

6.1.4 Horticulture

Customer segment

The targeted customer segment in this business model is the horticultural sector. These customers are entrepreneurs with a large heat demand and a large demand for CO_2. This combination could be attractive, since industrial waste heat suppliers could be in the position to simultaneously deliver CO_2. The additional CO_2 supply could increase the profitability of the business case.

Value proposition

The cost reduction and risk reduction are both important drivers for a grower to participate in a waste heat utilization project. Branding could also play an important role especially since the grower could apply for the label “green greenhouse” (NL: groen label kas). Furthermore, the producer and investor(s) are also attracted by the sustainability branding and media attention.

Channels

The channels for a waste heat utilization projects targeted at the horticultural sector are;

- Energy distribution company: customer base, expertise and knowledge create trust.
- Province: connection to growers present in the province, trustworthy, influence spatial planning and realization of new horticultural areas.
- Other independent party: connection to growers in the area, influence spatial planning and realization of new horticultural areas or knowledge and expertise that would create trust.

These channels do provide some openings to a customer base, but due to a lack of an overarching organization, securing a committed number of end users is difficult. It is therefore necessary to promote the project at for instance; trade fairs and meetings for and by the horticultural sector, in order to attract enough end users.

Customer relationship

Since there are end users involved, who are all separate entities with different heat demands, there is need for tailored solutions. Due to the larger number of end users, co-creation would require too much time and effort. This is why personal assistance would be the preferred customer relationship. Developing a tailored solution for each end user in consultation with the end user and a personal contact person.

Revenue streams

The revenue streams for projects aimed at the horticultural sector should be similar to the revenue streams for projects aimed at the built environment. These revenue streams are a; variable usage fee (heat price), fixed subscription fee (service cost) and an asset sale (connection cost). The combination of fixed and variable prices spreads the financial risk.

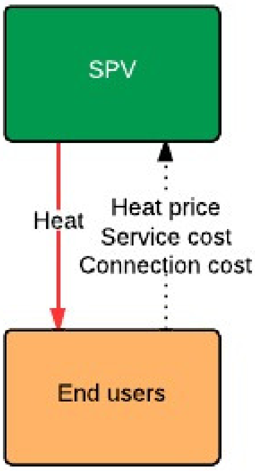

Figure 34: Revenue streams horticulture

The revenues streams for the SPV are low compared to the built environment and the industry, due to the lower energy prices, the unfavorable operating time and value proposition of cost reduction for the end user.

Key resources

An industrial waste heat utilization project has in the exploration phase need for veracious data of the supply and demand side, feasibility studies and business cases. In the operational phase there is need for; waste heat, heat recovery equipment, (heat pump), heat exchanger, insulated pipes, pumps, (booster stations), water buffer, substations, central heating system and (back-up equipment) (van der Post, 05022013). It is possible that the growers already have a decentralized heat source, which could be used as a back-up installation. Furthermore, a small customer service centre and a management team are needed to lead the operations, administration and communicate with the customer.

Key activities
The activities that need to be executed in the exploration phase are; frequent meetings, gathering of data, signing of a letter of intent (cooperation agreement) and draft feasibility studies and business cases. In the construction phase, the infrastructure and all the supporting equipment is build and installed and the customers are connected. Finally in the operational phase; the operations must be managed (in the horticultural sector the need for continuous heat supply must be at all times fulfilled), maintenance, measuring, billing and recruiting and connecting new customers.

Key partnerships
The essential key partners in a waste heat utilization project for the horticultural sector are;

- One or more of the following:
    - Independent party: channel, investor, facilitator, director, mediator and/or knowledge and expertise and economies of scope
    - Province: channel, investor, facilitator, director and/or mediator
    - Energy distribution company: channel, investor, knowledge and expertise and economies of scope
- Contractor: knowledge and expertise
- Producer(s): resources, investor and when multiple producers are connected continuity is guaranteed
- End users: investor and customer

Other additional partners could be;

- Municipality: investor, facilitator, director and/or mediator
- Government: subsidy provider and/or facilitator
- Advisor/process facilitator: director, mediator and/or knowledge and expertise

Note, that a partner does not necessarily have to fulfill all the mentioned roles, but they are capable of fulfilling these roles. If the mentioned roles are not being fulfilled by the essential partner an extra partner needs to be attracted in order to fill this position and provide the necessary resources, knowledge or expertise.

Cost structure
The investment cost of a waste heat utilization project aimed at the horticultural sector are large, but not as large as the investment cost of the built environment. This due to the less dense surroundings and the limited amount of obstacles. Even though it is still advisable to establish a new organization (SPV) which will bear the financial risk. In order to finance the project a certain percentage of equity is needed (>30%) (Rebel, 2012). This equity could be supplied by the following partners, who would be risk bearing equity supplier and subsequently shareholder in the SPV;

- Independent party
- Producer
- Energy distribution company
- Province

The remainder of the investment needs to be acquired via senior debt issued by banks or pension funds. The most attractive loans can be acquired via a public party since these are stable organizations with low risk of bankruptcy.

The operational cost include; fuel cost, FTE's, maintenance cost, purchase price heat, repayment and interest loan and dividends. The fuel cost are usually covered by the producer who incorporates these cost in the heat price. The fixed cost such as the interest and repayment and the dividends need to be paid by the SPV. The remaining cost (FTE's and maintenance) are usually also covered by the SPV, but can either be insourced or outsourced, depending on if the knowledge and expertise is available within the organization. When insourcing these cost, economies of scope could be applicable, this could lead to significant cost reductions. When outsourcing cost, it is favorable to fix the prices as much as possible, by means of a DCM contract.

An overview of the business model is shown in Figure 35.

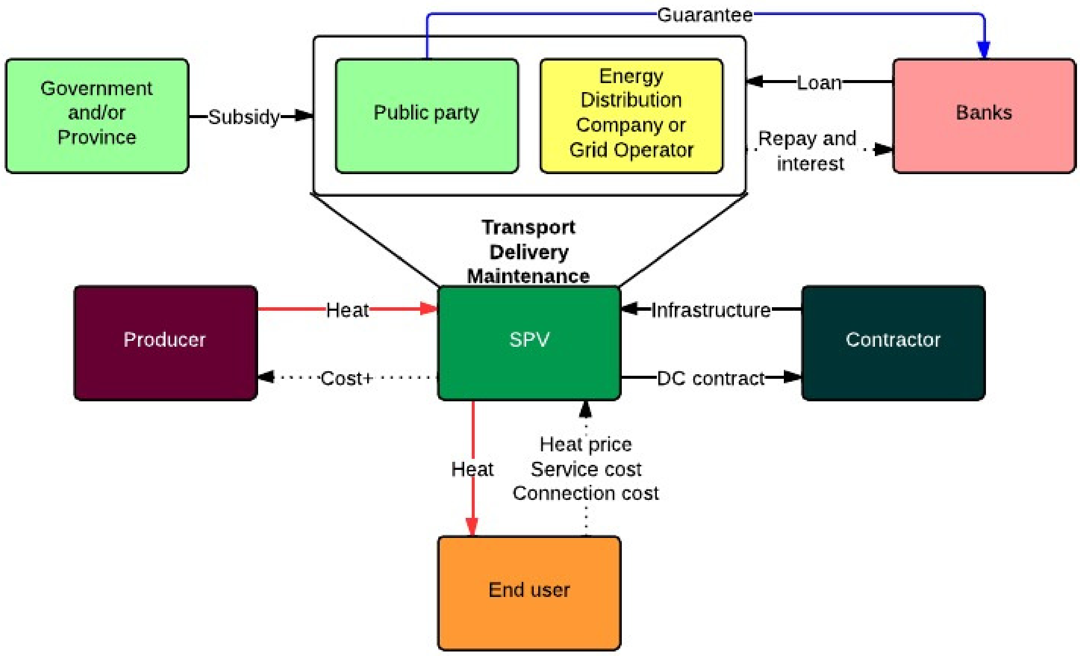

Figure 35: Horticulture

6.2 SWOT analysis

The identified business models (built environment B2C & B2B, industry and horticulture) will be assessed based on their strengths (internal), weaknesses (internal), opportunities (external) and threats (external).

6.2.1 Built environment B2C

Strengths

• Including channels in SPV lowers the end user risk
• Multiple producers lowers the continuity risk
• Economies of scope lower the operational cost
• Municipality as stable partner and investor, which enables attractive loans/financing
• Establishing a SPV shifts the financial risk to a separate entity
• Letting the parties that are familiar with the risk, take the risk
• Municipality and utility company eradiate trust (respectively; transparency and expertise) which could attract customers and lower resistance
• Connection obligation reduces the end user risk

Weaknesses

• Possible discrepancy between income and expenses
• Multiple parties involved, which requires split profits and good communication
• Public-private partnership could cause friction because of different; cultures, drivers and objectives
• Since the shareholders have different expertise and core businesses the control of the correct execution and competence is difficult.
• Customers have no say in whether they are connected or not, this could lead to discontent
• Continuity risk puts pressure on the business case due to the required purchase of back-up equipment
• Large investment, long payback period
• Demand pattern of the build environment is not continuous

Opportunities

• Large potential customer base
• Government, province and municipality are keen on lowering their CO2 emissions
• High energy prices for the built environment compared to industry or horticulture
• Natural gas price is increasing
• Not more than otherwise principle (advantage of not having to pay tax)
• Policy and labels focused on energy efficiency and sustainability in the built environment
• Regulation concerning waste heat discharge is becoming more of an issue and forces industrial companies to research their possibilities
• Delivering waste heat to the community increases the chance of receiving subsidies

Threats

• Producer moves or stops supplying
• Public opinion towards district heating
• Economic crisis caused a building stop which lowers the potential customer base
• Other EPC lowering measures could be preferred (electric heating, insulation etc.)
• Interference with insulation measures (benefit not for the end user)
• Scattered customer base (lots of different small end users)
• Producer moves or the heat supply decreases
• Not more than otherwise principle (connection cost are much higher)
• Decreasing natural gas price
• Alternatives (geothermal, solar)

6.2.2 Built environment B2B

Strengths

- Incorporation of channels in SPV lowers the end user risk
- Outsourcing of distribution net and connection of customers lowers the end user risk
- Multiple producers lowers the continuity risk
- Economies of scope lower the operational cost
- Municipality as stable partner and investor, which enables attractive loans/financing
- Separation of exploitation and infrastructure divides the financial risk over two entities
- Letting the parties that are familiar with the risk, take the risk
- Municipality and grid operator eradiate trust (respectively; transparency and expertise)
- Separation of exploitation and infrastructure will give both organizations a specific core business

Weaknesses

- Possible discrepancy between income and expenses
- Multiple parties involved, which requires split profits and good communication
- Public-private partnership could cause friction because of different; cultures, drivers and objectives
- Since the shareholders have different expertise and core businesses the control of the correct execution and competence is difficult.
- Continuity risk puts pressure on the business case due to the required purchase of back-up equipment
- Extra chain in the supply chain causes lower profits, thus longer PBP
- Large investment, long payback period
- Partly dependent on utility companies in order to hedge the end user risk
- Demand pattern of the build environment is not continuous

Opportunities

- Large potential customer base
- Government, province and municipality are keen on lowering their CO2 emissions
- High energy prices for the built environment compared to industry or horticulture
- Natural gas price is increasing
- Not more than otherwise principle (advantage of not having to pay tax)
- Connection obligation reduces the end user risk
- Policy and labels focused on energy efficiency and sustainability in the built environment
- Utility companies are willing to participate due to the gained monopoly and sustainability targets
- Regulation concerning waste heat discharge is becoming more of an issue and forces industrial companies to research their possibilities

Threats

- Producer moves or stops supplying
- Public opinion towards district heating
- Economic crisis caused a building stop which lowers the potential customer base
- Other EPC lowering measures could be preferred (electric heating, insulation etc.)
- Interference with insulation measures
- Scattered customer base (lots of different small end users)
- Producer moves or the heat supply decreases
- Not more than otherwise principle (connection cost are much higher)
- Decrease natural gas price
- Alternatives (geothermal, solar)

6.2.3 Industry

Strengths	Weaknesses
• Multiple producers lowers the continuity risk • Set payback period (due to the renting mechanism) for independent party provides certainty • Independent party as stable partner and investor, which enables attractive loans/financing • Letting the parties that are familiar with the risk, take the risk • Due to short distance and high quality of the heat, all involved parties are able to make a reasonable profit • Industrial parties have capital and are willing to invest in equipment at their own site (since this is a financially attractive project for them)	• Multiple parties involved, which requires split profits and good communication • Industrial parties focus on their core business and are not willing to invest too much time and financial resources in the project • Co-creation takes a lot of time • High quality heat transfer is limited to a short distance • Large investment, long payback period
Opportunities	**Threats**
• Government, province and municipality are keen on lowering their CO_2 emissions • Natural gas price is increasing • Economic crisis shifts focus of industrial companies to lower their energy cost • Continuous demand pattern • Large heat demand per end user • Industry is usually located near each other (shorter distances to cover) • Delivering steam generates more profit than hot water • Policy and labels focused on energy efficiency and sustainability in the industry • Regulation concerning waste heat discharge is becoming more of an issue and forces industrial companies to research their possibilities	• Producer moves or stops supplying • Decrease natural gas price • Economic crisis could lower the heat demand and supply, due to less production activity • Economic crisis could put a hold on the investments of the participating parties • Lower energy prices for industrial companies • Alternatives (geothermal heat, CHP)

6.2.4 Horticulture

Strengths

- Incorporation of channels in SPV slightly lowers the end user risk
- Multiple producers lowers the continuity risk
- Economies of scope (created by including a technical/supply party in the SPV) lower the financial risk
- Combination of heat and CO2 delivery strengthens the business case
- Independent party or public party as stable partner and investor, which enables attractive loans/financing
- Letting the parties that are familiar with the risk, take the risk

Weaknesses

- Multiple parties involved, which requires split profits and good communication
- Growers focus on their core business and are not willing to invest too much time and financial resources in the project
- Dedicated personal assistance takes a lot of time
- Possible discrepancy between income and expenses (variable vs. fixed prices)
- Public-private partnership could cause friction because of different; cultures, drivers and objectives
- Large investment, long payback period
- Scattered customer base
- Demand pattern of the horticultural sector is not continuous, need for peak load coverage and a large amount of surplus in the summer
- Difficult to find suitable channels that give access to a large customer base

Opportunities

- Government and provinces are keen on lowering their CO2 emissions
- Natural gas price is increasing
- Economic crisis shifts focus of the horticultural sector to lower their energy cost
- Policy and labels focused on energy efficiency and sustainability in the horticultural sector
- Large heat demand per end user
- Regulation concerning waste heat discharge is becoming more of an issue and forces industrial companies to research their possibilities

Threats

- Producer could move or stop supplying
- Decrease natural gas price
- Economic crisis could lower the heat demand and supply, due to less production activity
- Lower energy prices for the horticultural sector
- Alternatives (geothermal heat, CHP, etc.)
- End users are scattered over a large area

6.3 New business models

In the previous chapters the focus was to generate best practice business models based on the experiences, lessons learned and barriers identified in executed projects in the Netherlands. Since this approach limits the business model generation to already existing ideas, it is therefore also valuable to research new/innovative business models, which could be interesting for future development of industrial waste heat business models. First literature on new business models will be gathered and an overview will be supplied. Second, the new concepts, findings and other insights will be discussed according to the BMG theory.

6.3.1 New business models for sustainable innovation

Since the late 90's the integration of sustainability in business models was introduced by Elkington (1997). Who proposed the triple bottom line, which is the inclusion of social and environmental values next to economic values (currently known as: people, planet, profit). This multi value creating approach is also supported by Waage et al. (2005), Brennan et al. (2009), Boons & Lüdeke-Freund (2012) and Jonker et al. (2012). Note, that while new values are introduced the economic value is remaining the most important factor, since making a profit is essential for the survival of the business.

Furthermore, Chesbrough (2006) introduced the notion of open business models where innovation within a firm relies both on internal and external resources. This exchange and sharing of knowledge and assets are concepts which are used frequently in new business models (Jonker et al. 2012). It is important to involve the entire supply chain (Boons & Lüdeke-Freund, 2012) and especially focus on creating value for the user (Pablos-Heredero, 2012).

A shift from product driven business models to more service driven business models is visible (Osgood, 2009). The credo "buying less, selling more" is aimed at sharing resources or selling experiences instead of products (ibid).

In conclusion, the main trends in the new business models are:

- Creating multiple values (environmental, social and economic)
- Shifting from products to services
- Moving from ownership to sharing and exchanging
- Involving the entire supply chain (especially the user)

But how could these trends be applied to industrial waste heat business models? This will be done according to the BMG theory in the next chapters.

6.3.2 New customer segments

A side from producing waste heat it is also possible to produce cold or electricity, which will open up new markets and customer segments. Next to new products for new customer segments also new customer segments for old products can be identified. Finally, bundling of different products could also instigate innovation. The new identified combinations are summarized below.

- Hot water
  - Algae cultivation (37 ºC) (WUR, 2012)
  - Vertical greenhouses (20-30 ºC)
  - Fish cultivation (20-30 ºC)
  - Tropical plants/crops (20-30 ºC)
- Steam
  - Energy distribution companies or organic rankine cycle (ORC) companies (sell steam to third party who will generate electricity)
- Cold
  - Data centres (<22 ºC) (Agentschap NL, 2011c)
  - Built environment (4 ºC) (Gemeente Amsterdam, 2012)
  - Industry (Process cold)
- Electricity
  - Energy distribution companies

- Households
- Internal use

- Combination of hot and cold
    - Built environment

Note, that converting heat to cold or electricity requires an extra step and thus extra losses. Furthermore, due to the newness of the technology the price will be higher and the performance uncertain (this is especially applicable to electricity generation from waste heat).

6.3.3 Channels

Channels who have access to knowledge, new products and/or technology and start-ups are for instance universities. Universities usually have a technology transfer office (TTO) which manages the commercial spin-offs which are developed within the university. This office could function as a channel in order to reach start-ups or knowledge which could be valuable for the development of district heating. Another possibility is incubators, who give people with interesting business ideas, the resources they need, in order to establish an innovative start-up. Furthermore, fairs and meetings for district heating or technological innovation are good ways to gain knowledge and create a network. Finally, consultancies could be hired to identify new chances and form connections between different initiatives and knowledge.

In summary, new channels could be:

- Universities (Technology Transfer Office)
- Incubators
- Fairs and meetings
- Consultancies

6.3.4 Revenue streams

Currently revenue streams are only expressed in money, but in new business models other values may also count as revenue stream. For instance; CO_2 emission reduction, social values and improved corporate image. In this case revenue streams will be expressed in economic as well as social and environmental values. Note, that economic revenue streams will remain the most important value since an organization needs to be able to cover their cost and subsist, but other revenue streams are becoming more important and will create value for the participating parties.

Another possible way to fulfil the revenue streams is the exchange of resources. In the case of industrial waste heat there are several options:

- In the case of waste heat supply to industrial parties, a partner could be selected based on the further exchange of resources. This industrial partner could for instance; be a producer of one of the core ingredients or have waste products which could be used in as an ingredient in the process of the industrial waste heat supplier.
- In the case waste heat will be supplied to more innovative processes or start-ups like; algae cultivation or ORC applications, the fuel that is produced by the process could be used as exchange for the supplied waste heat.
- The supplied waste heat could also be exchanged for services, manpower or other resources or activities.

This exchange of resources requires determination of the value of the different resources, which is a difficult task to execute. Furthermore, there are more risks involved and a lot of logistics, since there is not only waste heat that is being delivered but also other resources. Note, that trust and transparency are crucial in order for these types of revenue streams to be effective.

The built environment and the horticultural sector do not have the quantity and type of resources that could be used in an exchange for waste heat.

6.3.5 Cost structure

How could the large investment costs be less of a barrier by the use of new business models? Several options related to the identified trends could be introduced, such as; crowd funding, leasing or renting or pension funds.

Crowd funding uses the crowd to finance a project, instead of attracting specialized investors (Belleflamme et al, 2012). A distinction can be made between crowd funding where; the future customer can pre-invest in the product or individuals can invest in a project where they do not necessarily need to become a customer of (ibid). This financial gesture can either be; a donation for which the investor gets nothing in return, a sponsoring which is a donation, but the investor receives in return a product, service or advertisement, an investment through which the investor becomes co-owner and value developer or a loan which means that the investor will receive its money back, plus interest (Liefland, 2012). Note, that the investment costs of an industrial waste heat utilization project are of such magnitude that crowd funding as lone financial input is most likely not sufficient. It can therefore be used as tool to create support and commitment and raise part of the investment costs.

Leasing or renting uses a third party to finance the infrastructure, where after this party will rent out the use of this equipment to the participating parties. When a lease is agreed upon the ownership of the infrastructure will pass on to the participating parties when the investment is paid in full, plus an agreed upon margin.

Pension funds serve a similar purpose as banks; they can grant a loan to projects and receive repay and interest in return. While this is a very common solution in other projects, none of the industrial waste heat projects have used a loan granted by a pension fund.

PART IV Model

7. Preconditions model

When are the formulated best practice models most successful, which factors influence this and how could these factors help determine which business model would be most appropriate? These are important questions which determine the success of an industrial waste heat utilization project. It is therefore needed to construct a model which; summarizes these critical success factors and could be used as a tool to determine which business model would be most appropriate in a certain situation. This model is established from a viewpoint of the producer, since this is the party that generates the product that is delivered.

In order to shape this model, first the decision process and the associated questions concerning the establishment of an industrial waste heat utilization project are mapped via a decision tree exercise (see appendix VII. Decision trees). This exercise gives a good overview which factors are important in the formation of a successful industrial waste heat utilization project. These identified factors can be subdivided into three overarching categories; policy, partners and customers. In this case policy focuses on the available laws, policy and permits which are needed or encountered (legal feasibility), partners focus on the required partners and their willingness to cooperate (organizational/financial feasibility) and customers focuses on the technical aspects (technical/financial feasibility). Together these overarching criteria assess the general feasibility of the business model (Figure 36).

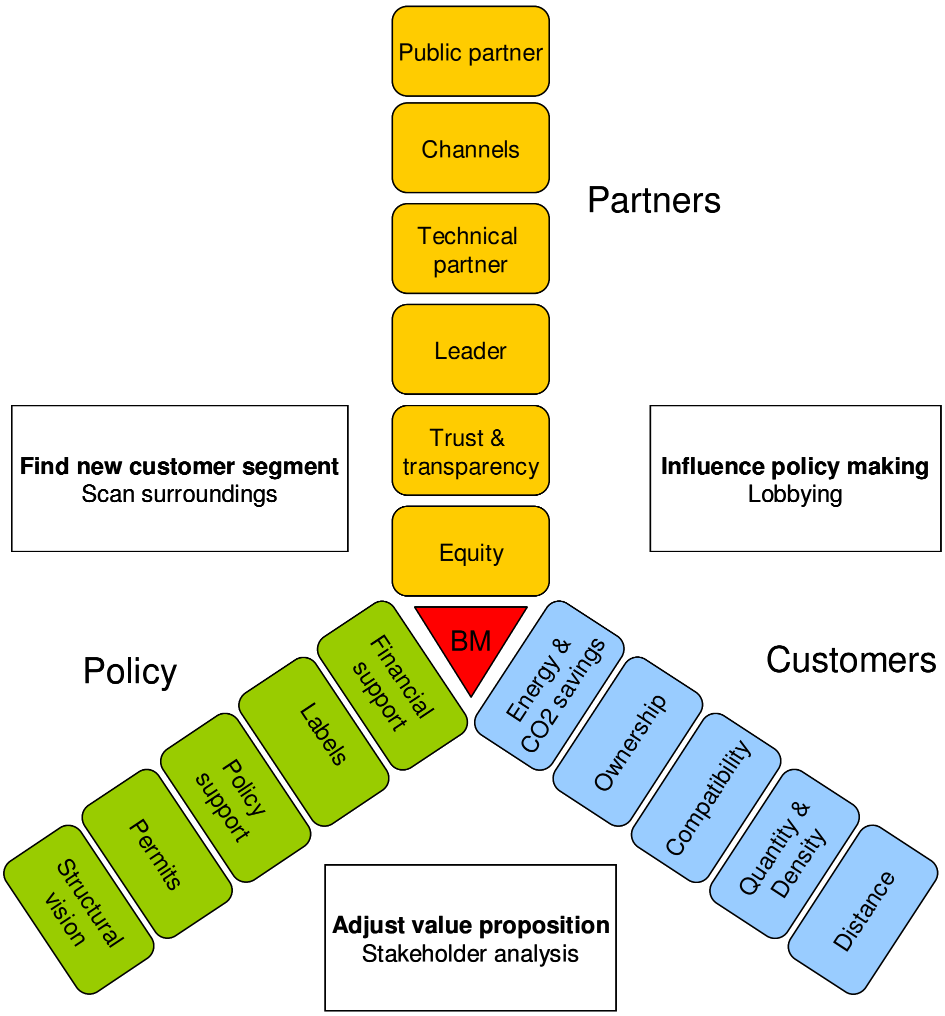

Figure 36: Preconditions model

The three overarching criteria; policy, partners and customers all have different sub categories which are labelled: critical success factors (green: policy, yellow: partners and blue: customers). The sum of these critical success factors determines the feasibility of each of the overarching categories. When all overarching criteria generate a feasible result, the business model will likely be successful.

When starting an assessment it is advisable to score all different customer segments/business models (identified in chapter 6.1 Best practice business models) according to all the critical success factors. This will give a complete overview of the possibilities. The sum of all the found results will determine which business model is most favorable in this particular situation. Note, that it is possible to start from each of the overarching criteria, since it is the compatibility and combination of the three that determines the success.

When the assessment of one of the overarching criteria does not generate a feasible result, there are the following options:

- No partners: adjust the value proposition to the needs of the needed partners. Tools that can be used to identify the needs of the partners are a stakeholder analysis.
- No customers: a new customer segment needs to be found. This could be done by scanning the environment or looking into innovative solutions.
- No policy: influence the policy making by lobbying.

In the following chapters the identified critical success factors will be explained in more depth.

7.3.1 Customers

Distance describes the distance between the end users and the producer. The shorter the distance the more feasible the project becomes. Note, that the different customer segments have different maximum distances. For instance the industry (when exchanging steam) has a maximum distance of 6 km, while the build environment and horticulture have a maximum distance which is more in the range of 30 km. Furthermore, the distance can also be bridged by adding more producers to the network.

Quantity and Density are used to determine the number and density of the end users. This factor is most important when the end user is the built environment or the horticultural sector, due to the relatively low heat demand per end user. In this case there is need for a certain number of end users in order for the business case to be profitable. The industry on the other hand usually has a high heat demand per end user, which could enable one-on-one connections.

Compatibility describes the compatibility of; the quantity and quality of the heat demand and supply and the heat demand patterns of the producer and the end user(s).

Ownership concerns the ownership of the assets of the end user(s). The most favorable situation is a small number of owners which makes the cooperation easier, since the number of stakeholders decreases.

Energy and CO_2 savings includes the amount of energy and CO_2 saved by the end user. This is first of all important for the cost saved by using a different energy source, but also for the branding and sustainability value proposition.

7.3.2 Partners

Channels describes the willingness of the channels (who enable the connection to the end user) to cooperate and possibly become a risk bearing partner. These channels can vary per project, but need to be identified and included as important stakeholders.

Public partner describes the willingness of a (semi-)public party (municipality, province, government, seaport etc.) to cooperate. In some cases this requires becoming a risk bearing partner, in other cases it is more of a supporting role (financially or practically).

Technical partner describes the willingness of a technical partner (energy distribution company, grid operator, contractor etc.) to cooperate. This requires becoming a risk bearing partner.

Leader concerns the leadership role during the project. There is need for an organization or person to become an active leader who brings the stakeholders together and keeps pace.

Trust and Transparency describes the trust and transparency that is needed between the stakeholders in order to execute the project. This might not be present from day one, but it is essential to establish this trust and transparency.

Equity concerns the solvency of the risk bearing partners. Are they able to raise enough equity to establish the project or is there need for an extra partner or loan.

7.3.3 Policy

Structural vision describes the spatial planning the municipality, province or government has made for a particular area. It is important that this structural vision permits district heating or even anticipates on this.

Permits is related to structural vision but has a more local orientation. The assigning of permits is usually the responsibility of the municipality. It is crucial for the project that these permits are made available and assigned.

Policy support is concerned with the policies that are applicable to district heating. Do these policies stimulate or hamper the development of district heating and in case of hampering are they willing to change these policies?

Labels describes the ability to create recognition for the participating parties for their effort to reduce their emissions etc. Are there sufficient labels or other visible branding tools to fulfill the branding value proposition?

Financial support describes the financial support lend to the project by a public party. This could be a subsidy, a revolving fund or a guarantee for a loan.

PART V Conclusion

8. Discussion

First of all it is important to mention that the identified projects are all projects that are executed and were successful in overcoming the barriers that they encountered during their start-up phase. Note, that this does not mean that all of these projects have evolved into successful businesses.

Each industrial waste heat utilization project has different characteristics and thus needs a customized approach. This means that the generated business models are rather starting points and provide guidelines for potential industrial waste heat utilization projects.

Furthermore, policy and legislation developed by the government and province is subject to regular change, which means that it is uncertain whether waste heat utilization will be stimulated or counteracted in the future. It is therefore important to keep abreast of new development in politics.

Future developments of the different customer segments, alternatives and technological innovations are uncertain, but need to be taken into account. Especially, since the establishment of an industrial waste heat utilization project is usually executed over a large time period (between 2-10 years). Examples of this are:

- Development of the horticultural sector. Will this sector decrease, move or be enforced by law to connect to a sustainable heat source? These are all factors that could positively or negatively influence the attractiveness of the horticultural sector.
- Future building requirements in the built environment will have a negative effect on the attractiveness of the new (yet to be build) built environment. What kind of impact will this have on the district heating market?
- Development of alternatives for sustainable heat generation such as; geothermal heat, co-generation and solar water heating. Will these alternatives become more attractive than industrial waste heat over time?
- Which alternatives for conversion of waste heat will be available in the future? Would it become more cost efficient to convert the waste heat into electricity or to cold?

Another interesting exercise would be to test the robustness of the generated best practice business models to the introduction of the trends in new business models. Would these business models support these trends or do new business models need to be developed. This would be an interesting topic for further research.

Furthermore, failed industrial waste heat projects could be assessed in order to research barriers that causes projects to fail. Another interesting topic would be an European comparison in which business models from different European countries will be compared.

9. Conclusion

There are three customer segments that are identified, which could benefit from waste heat delivery. These customer segments are respectively the; built environment, industry and horticultural sector. Each of these customer segments requires a different business model, which will enable the creation of a successful industrial waste heat utilization project.

The generated best practice business models show possible structures that contain elements of business models that have proved to be successful in the past and the lessons learned that were encountered along the way. Some general conclusions that can be drawn from the formation of business models are summarized in Table 7 per building block.

Building block	Conclusions
Key partnerships	Let the parties that know and understand the risk, take the risk
	A cooperation between public and private (technical) parties creates a good balance between technical knowledge and expertise (private) and access to a customer base, eradiation of trust and knowledge of legal procedures (public)
	Create a core group of participants who have committed themselves to the project (by investing time and/or money) and create trust and transparency between these parties
	Find a leader or an organization that will take the lead and coordinate the process
	Create a multi-disciplinary project team in order to address all aspects of the project (technical, organizational, financial and legal)
Cost structure	A phased approach spreads the investment over a longer period of time
	Use economies of scope to lower the operational (and investment) cost
Revenue streams	Align the revenue streams and cost to prevent discrepancies
Channels	Find a suitable channel that already has a trust relationship with the potential customers and possibly customer relationship tools that can be used to reach them.
Customer segments	Hedge the end user risk by setting a minimum amount of customers before the project can take off

Table 7: General conclusions best practice business models

Furthermore, conclusions per customer segment (built environment, industry and horticultural sector) can be drafted (Table 8: Conclusions per customer segment).

Customer segment	Conclusions
Built environment	• *Not more than otherwise* principle creates positive effects (enables large revenue streams), but could create dissatisfaction among customers due to the uneven division of profit. • Connecting the existing built environment (offices, apartment and utility buildings) seems to be the most attractive segment within the built environment segment for future industrial waste heat projects • Channels that can facilitate a connection to the built environment are essential to the success of the business model and thus need to be closely involved in the development of the project. • Heat demand of the built environment is dependent on the outside temperature and therefore not constant. Back-up is needed to supply the peak load when low temperatures occur. Waste heat can be used as base load. • Public parties are interested in industrial waste heat utilization projects in order to lower their CO_2 emissions and are therefore willing to participate and invest. • High investment costs and high revenues.
Industry	• Delivery of high quality heat is necessary in order to generate a profitable business model. • An independent party that connects the different parties, takes the lead and invests in the public assets is essential to the success of the business model. • Heat delivery contracts can be drafted directly between the producer and the customer or be coordinated via an independent party. • The continuous heat demand of the industry is favorable for the business case. • Low(er) investment costs and medium revenues.
Horticultural sector	• Identifying channels and finding a large customer base in the horticultural sector is difficult • Due to low energy prices (compared to the built environment) additional delivery of CO2 seems to be necessary in order to generate a profitable business case. • Heat demand of the horticultural sector is dependent on the outside temperature and therefore not constant. Back-up is needed to supply the peak load when low temperatures occur. Waste heat can be used as base load. • Low(er) investment cost and low revenues.

Table 8: Conclusions per customer segment

From Table 8 can be concluded that generally speaking the horticultural sector is the least favorable customer segment for industrial waste heat utilization projects. The industry seems to be the most cost efficient option, but the built environment can count on more (financial) support from public parties and other key partners.

While initially it seemed (in the synthesis) that the main concerns lie in the financial area (cost structure and revenue streams), the analysis shows that the most important building block is the key partners. The assembly of the right partners, who have; enough equity, the right (supplementary) knowledge, leadership capabilities and the ability to create trust and transparency between the involved stakeholders, is crucial to the success of the business model. The right combination of partners enables hedging the majority of the risks and consequently lowers the uncertainty. This will result in more attractive loans and therefore a profitable business case.

Furthermore, the support from public parties in the form of financial support, policy and legislation is crucial to the success of all business models.

Therefore, the following three overarching success criteria were included in the generated preconditions model; customers, partners and policy. Each of these criteria contains multiple factors that influence the success of the business model. These factors are displayed in Table 9.

Customers	Partners	Policy
Distance	Channels	Structural vision
Quantity and density	Public partner	Permits
Compatibility	Technical partner	Policy support
Ownership	Leader	Labels
Energy and CO_2 savings	Trust and transparency	Financial support
	Equity	

Table 9: Critical success factors

This model could be used to assess the applicability of the generated best practice business models to a situation in which a potential industrial waste heat producer would like to determine which option would be the most feasible and could be most successful.

Finally, it is important to highlight that during the formation of a business model for industrial waste heat project, special attention needs to be paid to the; key partnerships, cost structure, revenue streams and channels. These building blocks are essential to the success of the project and will cause the main barriers.

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Participating organizations: Seaport Groningen, USG, Deltalinqs, Provincie Noord-Brabant, Seaport Zeeland, Seaport Moerdijk, Agentschap NL and Tata Steel Europe
Date: 13-03-2013

Akerboom, S.
Organization: Universiteit van Amsterdam, centrum voor energie vraagstukken

Function: Phd
Date: 07-02-2013

Bormans, J. & van der Weiden, A.
Organization: Agentschap NL
Date: 22-01-2013

Bosma, A. & Visser, L.
Organization: Provincie Zuid-Holland
Function: Senior energy policy advisor
Date: 12-02-2013

De Bruijn, F. & van Dijk, H.
Organization: Provincie Noord-Brabant
Project: Moerdijk
Date: 22-05-2013

Burborf, E.
Organization: Provincie Noord-Holland
Project: district heating in the metropolis region of Amsterdam
Date: 17-05-2013

Colmer, H.
Organization: Groningen Seaports
Function: Projectleider WTB/E
Project: Eemshaven, Delfzijl
Date: 17-01-2013

Dieteren, R.
Organization: Gemeente Sittard-Geleen
Function: beleidsmedewerker duurzaamheid
Project: Het groene net
Date: 19-02-2013

van Drimmelen, R.
Organization: Breed of builds
Function: Directeur
Date: 18-04-2013

Everse, C.A. & van Twuijver, T.
Organization: Grondmij
Function: Projectmanager & adviseur duurzame energie
Date: 06-02-2013

Van Gestel, A.
Organization: Nuon Warmte
Function: Manager acquisitie
Project: Westpoort warmte, Rotterdam
Date: 13-02-2013

Hamers, C.
Organization: Warmtebedrijf Rotterdam
Function: Directeur
Project: Rotterdam
Date: 24-01-2013

De Jonge, J.
Organization: Dalkia
Date: 27-05-2013

Van Kemmeren, R.
Organization: Gemeente Amsterdam
Project: Westpoort warmte
Date: 06-02-2013

Konings, G.
Organization: Stedin
Function: Markt manager new business development
Project: Rotterdam Botlek
Date: 24-01-2013

Kooper, S.
Organization: Greencrowd
Function: Director
Date: 21-02-2013

Ligtvoet, A.
Organization: TU Delft
Function: PHD
Date: 14-01-2013

Van der Post, M.
Organization: Post Fossil
Function: Zelfstandig ondernemer
Date: 05-02-2013

Rentrop, J.
Organization: Havenschap Moerdijk
Function: Programma manager
Project: Moerdijk
Date: 31-01-2013

Rompelberg, P.
Organization: Gemeente Maastricht
Function: Senior beleidsmedewerker duurzaamheid
Project: Maastricht
Date: 08-01-2013

Taks, J.
Organization: WarmCO_2
Function: Directeur
Project: WarmCO_2
Date: 09-01-2013

Van der Veen, F.
Organization: Rebel group
Date: 05-02-2013

Appendix

I. Interview structure

The list of questions and the structure of the interview will be listed below. Note, that during the interviews all of these subjects were discussed but in a conversational manner.

List of questions

Organizational

- What does the organization look like?
- Which parties are involved in this cooperation and what are their roles and responsibilities?
- Who initiated the cooperation?
- What was the driver to cooperate or start this project? Which values does this project create for your organization?
- What is the role of your organization?
- Which responsibilities are attached to this role?
- What were the largest barriers that you encountered during the project?
- How were these barriers solved?
- What are the risks for your organization?
- What are the lessons learned/what would you do differently?
- If you would start over, what would the organization look like?

Technical

- What does the system look like and do you have a schematic overview of the system?
- What is the temperature of the heat?
- What is the energy carrier?
- What is the flow of the heat?
- What is the length of the transport and distribution net?
- What is the heat loss of the system/what is the efficiency?
- Is the heat directly delivered to the DH network or does it need upgrading?
- Is there a back-up system? If yes, what kind?
- Who is the owner of the DH system?
- Who takes care of the maintenance?
- Which obligations concerning heat delivery are included in the contract?

Financial

- What are the investment costs of the total system?
- How is this investment established/which parties were involved?'
- Were there unexpected cost?
- What is the price for the delivered heat? Is there a set price or a variable price?
- What are the expenses for maintenance (per year)?
- What is the payback period of this project?
- What are the revenue streams of your organizations?
- How is this captured in a contract?
- What is the lead time of the project

II. BMG Canvas

Moerdijk

Key Partners

Seaport
Contractor
End users
Producers
Province
Advisor

Key Activities

Construction
Operations
Maintenance
Measuring
Billing
Connecting (attracting new customers)

Key Resources

Waste heat
Infrastructure
Measuring equipment
Project group
Investment

Value Proposition

Cost reduction

Risk reduction

Appelweg: 700,000 m3 natural gas (per year)
Vlasweg : 5,000,000 m3 aardgas
Middenweg: 3,500,000 m3 aardgas (per year)
Westelijke Randweg: 3,500,000 m3 aardgas (per year) (Gemeente Moerdijk, 2011)

Branding

Customer Relationships

Co-creation

Channels

Seaport

Customer Segments

Chemical industry

Cost Structure

Seaport: 100% public assets
End users + producers: Own infrastructure
Province: Subsidies

Producer: fuel cost, maintenance cost
Seaport: repay and interest
End users: purchase price heat + rent

Revenue Streams

Seaport: Renting (end user)
Producer: Usage fee (end user) + brokerage fee (seaport)

BC

Exploration	Consolidation	Elaboration	Construction	Start-up	Operational	Roll out
Vlasweg Energyweb		Middenweg	Westelijke randweg		Appelweg 2009	

Delfzijl

Key Partners

Seaport
Contractor
End users
Producers

Key Activities

Construction
Operations
Maintenance
Measuring
Billing
Connecting (attracting new customers)

Key Resources

Waste heat
Infrastructure
Measuring equipment
Project group (facilitating exploration phase)

Value Proposition

Cost reduction

Risk reduction

Use: 2,800 TJ per year
95 ktonne CO2 reduction per year (AgentschapNL, 2011a)

Branding

Customer Relationships

Co-creation

Channels

Seaport

Customer Segments

Chemical industry

Cost Structure

Seaport: 100% public assets
End users + producers: Own infrastructure

Seaport: maintenance cost (fixed DCM) +repay and interest
Producer: fuel cost + rent
End users: purchase price heat

Revenue Streams

Seaport: Renting (producer)
Producer: Usage fee (end user)

BC

Exploration	Consolidation	Elaboration	Construction	Start-up	Operational	Roll out
2004		2008	2009		2010	2013

Rotterdam Botlek

Key Partners

Grid operator (Stedin)
Contractor
End users
Multiple producers
Seaport
Government

Key Activities

Construction
Operations
Maintenance
Measuring
Billing
Connecting (attracting new customers)
Guarantee continuity

Key Resources

Waste heat
Infrastructure
Measuring equipment
Project group (facilitating exploration phase)

Value Proposition

Cost reduction

Risk reduction

200 ktonne CO_2 reduction yearly when Total project is executed
EKC → 70 ktonne CO_2 reduction per year (RCI, 2012)

Branding

Newness

Customer Relationships

Co-creation

Channels

Grid operator (Stedin)
Seaport

Customer Segments

Chemical and petrochemical industry

Cost Structure

Grid operator: 100% public assets
End users + producers: Own infrastructure
Seaport + government: Subsidies

Grid operator: maintenance (DCM)
Producer: fuel cost
End users: rent + purchase price heat

BC

Revenue Streams

Grid operator: Renting (end user)
Producer: Usage fee (end user)

Exploration	Consolidation	Elaboration	Construction	Start-up	Operational	Roll out
1995	2010	2012	2013			

Rotterdam

Key Partners

Municipality
Grid operator (E.oN)
Energy distribution companies
Contractor
End users
Multiple producers
Housing corporations
Province
Advisor

Key Activities

Construction
Operations
Maintenance
Measuring
Billing
Connecting
Guaranteeing continuity

Key Resources

Waste heat
Infrastructure
Buffer
Back-up
FTE's (helpdesk, management)
Measuring equipment

Value Proposition

Risk reduction (CO_2 reduction)

Branding

95 ktonne CO_2 reduction per year (in 2014 when AVR is connected)

105 ton NO_x per year in 2020 (Warmtebedrijf Rotterdam, 2011)

Customer Relationships

Co-creation
Dedicated personal assistance

Channels

Municipality
Housing Corporation
Grid operator

Customer Segments

Energy distribution companies

Indirectly: homes and utility buildings

Cost Structure

Infra: Municipality: 90%, Housing corporations: 5%, Province: 5%
Explo: Grid operator: 50%, Municipality: 50%
Energy distribution companies: distribution network 100%
Government: subsidies

INFRA: price purchased heat + rent
EXPLO: maintenance cost (fixed) + repay and interest + dividend + FTE's
Producer: fuel cost
Energy distribution companies: price purchased heat
End users: price purchased heat + service cost +

Revenue Streams

Producer: Usage fee (EXPLO)
EXPLO: Usage fee (utility)
INFRA: rent (EXPLO)
Shareholders: dividend (INFRA)
Utility: usage fee + asset sale + subscription fee (end user)

BC

Exploration	Consolidation	Elaboration	Construction	Start-up	Operational	Roll out
2000	2004	2004 & 2010	2005-now	2013		

Amsterdam

Key Partners

Municipality
Energy distribution company (Nuon)
Contractor
End users
Multiple producers
Housing corporations

Key Activities

Construction
Operations
Maintenance
Measuring
Billing
Connecting
Guaranteeing continuity

Key Resources

Waste heat
Infrastructure
Buffer
Back-up
Measuring equipment
FTE’s (helpdesk and management)

Value Proposition

Risk reduction (CO_2 reduction)

2011: 17.5 ktonne CO_2 reduction

2011: 345,000 GJ (from which 69% waste heat) (Gemeente Amsterdam, 2012)

Customer Relationships

Automated service
Personal assistance
Communities

Channels

Westpoort warmte:
Municipality
Energy distribution company (Nuon)

Housing corporations

Customer Segments

Homes + utility buildings

Cost Structure

Municipality: 50%
Energy distribution company: 50%

Producer: fuel cost
WPW: maintenance cost + price purchased heat + dividend
End users: price purchased heat + service cost + connection cost

BC

Revenue Streams

Producer: usage fee (WPW)
WPW: usage fee + asset sale + subscription fee (end user)
Shareholders: dividend (WPW)

Exploration	Consolidation	Elaboration	Construction	Start-up	Operational	Roll out
End 90s		WPW: 1999	1993-now	1994		

Delft

Key Partners

Municipalities
Energy distribution company (Eneco)
Contractor
End users
Producers
Housing corporations
EU

Key Activities

Construction
Operations
Maintenance
Measuring
Billing
Connecting
Guaranteeing continuity

Key Resources

Waste heat
Infrastructure
Buffer
Back-up
Measuring equipment
FTE's (helpdesk and management)

Value Proposition

Risk reduction (CO2 reduction)

20 ktonne per year CO2 reduction at full potential (Gemeente Delft, 2011)

Customer Relationships

Automated service
Personal assistance
Communities

Channels

Warmtebedrijf Delft:
Municipalities
Housing Corporation
Energy distribution company (Eneco)

Customer Segments

Homes + utility buildings

Cost Structure

DW: Eneco: 98%, Municipality: 0,5%, municipality: 0,5%, housing corporation: 1%
EU: subsidy

Producer: fuel cost
DW: maintenance cost + price purchased heat + dividend + FTE's
End user: price purchased heat + service cost + connection cost

BC

Revenue Streams

Producer: usage fee (DW)
DW: usage fee + asset sale + subscription fee (end user)
Shareholders: dividend (DW)

Exploration	Consolidation	Elaboration	Construction	Start-up	Operational	Roll out
2001	2006	2009	2010-now	2010		

Sittard

Key Partners

Municipalities
BAM
End users
Producers
Housing Corporation
Government

Key Activities

Construction
Operations
Maintenance
Measuring
Billing
Connecting
Guaranteeing continuity

Key Resources

Waste heat
Infrastructure
Buffer
Back-up
Measuring equipment
FTE's (helpdesk and management)

Value Proposition

Risk reduction ($CO2$ reduction)

26 million m3 natural gas and 47 ktonne $CO2$ emission reduction per? (USG, 2012)

Cost reduction 15%

Customer Relationships

Automated service
Personal assistance
Communities

Channels

Warmtebedrijf Sittard: Municipality

Housing Corporation

Customer Segments

Homes + utility buildings

Cost Structure

SW: Municipality: 50%, BAM: 50%
Producer at own site
Government: subsidy

Producer: fuel cost + maintenance cost
SW: maintenance cost + price purchased heat + dividend + interest and repay + FTE's
End user: price purchased heat + service cost + connection cost

BC

Revenue Streams

Producer: usage fee (WS)
WS: usage fee + asset sale + subscription fee (end user)
Shareholders: dividend (WS)

Exploration	Consolidation	Elaboration	Construction	Start-up	Operational	Roll out
2010	2012	2013				

Terneuzen

Key Partners

Horticulture
Seaport
Contractor
Producer (Yara)
Province
Government

Key Activities

Construction
Operations
Maintenance
Measuring
Billing
Connecting (attracting new customers)
Guaranteeing continuity

Key Resources

Waste heat
Infrastructure
Back up
FTE's (management and recruitment)

Value Proposition

Cost reduction

Risk reduction

Branding (Yara)

60 - 80 million Nm3 natural gas

Total: 135 ktonne CO2 reduction

Customer Relationships

Dedicated personal assistance

Channels

WarmCO2

Customer Segments

Horticulture

Cost Structure

Zeeland Seaports: 80% (via loan)
Yara: 20% Own infrastructure
Horticulture: Back up
Province and municipality: Subsidies

Producer: fuel cost + maintenance cost
Warmco: price purchased heat and CO2 + compensation guarantee + maintenance cost + repay and interest + FTE's
End user: price purchased heat

BC

Revenue Streams

Producer: asset sale (warmco)
Warmco: usage fee (end user)
Seaport: renting (warmco)

Exploration	Consolidation	Elaboration	Construction	Start-up	Operational	Roll out
2000		2008	2008-now	2009		

OCAP

Key Partners
End users (Horticulture)
Grid operator & supplier (Linde gas)
Contractor (Volkerwessels)
Producers (Shell & Abengoa)
Energy distribution company
Province
Government
Advisor/process leader

Key Activities
Construction
Operations
Maintenance
Measuring
Billing
Connecting (attracting new customers)
Guaranteeing continuity

Key Resources
CO_2
Infrastructure
Back-up CO_2
5 FTE's (management and recruitment)

Value Proposition
Cost reduction

Risk reduction

Branding

Convenience/usability

Performance

In 2012: 115 million m3 natural gas reduction/yr

205 ktonne CO_2 reduction/yr

Customer Relationships
Dedicated personal assistance

Channels
Trade fairs
Meeting for and by the horticultural sector

Energy distribution company

Customer Segments
Horticulture

Cost Structure
Investment cost: 50% Volker Wessels, 50% Linde gas
Government: subsidies

Operational cost: Compensation for CO_2 fines (producer)

Revenue Streams
Producer: Usage fee?(OCAP)
OCAP: usage fee (fixed payment per month + what is used extra) (end user)

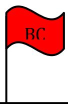
BC

Exploration	Consolidation	Elaboration	Construction	Start-up	Operational	Roll out
1998			2004	2005	2012	2013

III. Phases

A combination of the orientation phases formulated by Agentschap NL in the industrial waste heat utilization guide (2012) and the operational phases formulated by Padiyar et al (2004), creates a complete overview of the different phases of an industrial waste heat utilization project. The identified phases will be explained below:

- Exploration: in this phase the feasibility of the project is generally assessed and the prospective partners are approached in order to instigate cooperation.
- Consolidation: the economic, technical and legal feasibility is thoroughly assessed and a group of partners is assembled.
- Elaboration: the business case is completed and the tendering process is executed (if necessary).
- Construction: the design of the system is finalized and after all the contracts have been signed the construction can take place.
- Start-up: the project is operational but has to overcome issues such as; connecting all prospective customers, infrastructure is tested and optimized, services need to be set-up etc.
- Operational: project is operational and the planned systems is fully constructed and connected to all prospective customers.
- Roll out: knowledge and expertise is used to start-up similar projects or expand the current project.



Exploration	Consolidation	Elaboration	Construction	Start-up	Operational	Roll out
Concept Orientation meetings Rough indication feasibility	Feasibility study Commitment stakeholders	Formation business case and model Cost structure	Design Construction	Operational Testing and development	Operational Full planned potential is reached	Use gained knowledge for new projects

IV. Public-Private partnerships

There are several forms of public-private cooperation's, ranging from full service by the public party to privatization (see Figure 37). The public-private partnership (PPP) is a cooperation form in which the public and the private party share the risk, the different risks are allocated to the different parties according to who has the expertise and skills to bear these risks (Huisman, 2010).

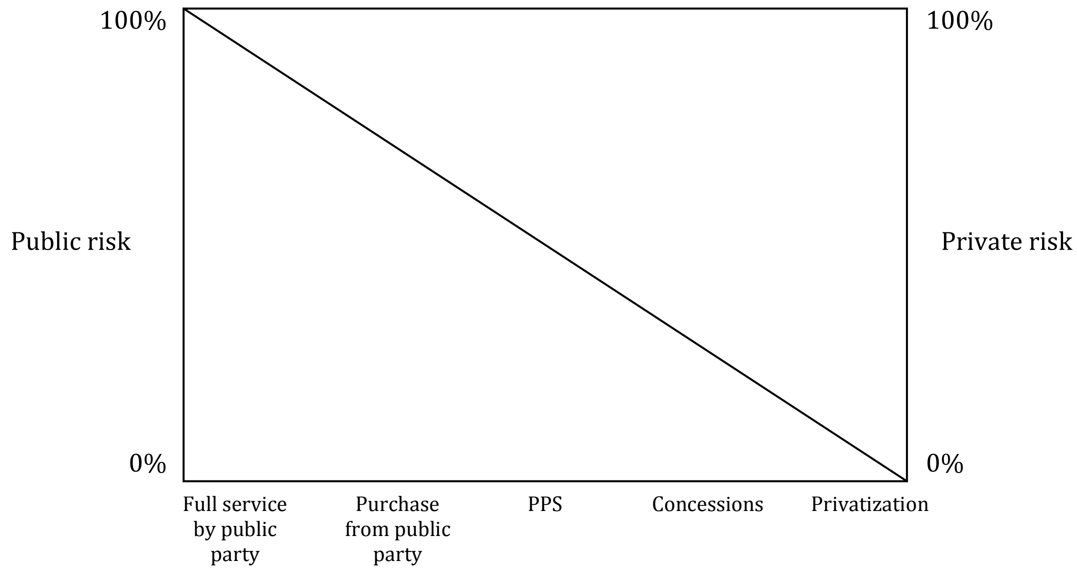


Figure 37: Public-private cooperation (OECD, 2008)

Within the PPP there are also several different cooperation schemes and modalities. These have been listed by the International Monetary Fund (2004). These identified PPPs will be used to classify the cooperation forms of the assessed projects.

Box 1. PPP Schemes and Modalities

Schemes	Modalities
Build-own-operate (BOO) Build-develop-operate (BDO) Design-construct-manage-finance (DCMF)	The private sector designs, builds, owns, develops, operates and manages an asset with no obligation to transfer ownership to the government. These are variants of design-build-finance-operate (DBFO) schemes.
Buy-build-operate (BBO) Lease-develop-operate (LDO) Wrap-around addition (WAA)	The private sector buys or leases an existing asset from the government, renovates, modernizes, and/or expands it, and then operates the asset, again with no obligation to transfer ownership back to the government.
Build-operate-transfer (BOT) Build-own-operate-transfer (BOOT) Build-rent-own-transfer (BROT) Build-lease-operate-transfer (BLOT) Build-transfer-operate (BTO)	The private sector designs and builds an asset, operates it, and then transfers it to the government when the operating contract ends, or at some other prespecified time. The private partner may subsequently rent or lease the asset from the government.

Figure 38: Public-private schemes and modalities (IMF, 2004)

The listed structures are not the only possible options, any combination of the tasks mentioned in Figure 38 could be used in an industrial waste heat utilization project.

V. Not more than otherwise principle

Heat delivery to the built environment is bound to a maximum price, through the *not more than otherwise* principle. This maximum price is based on the reference of; the energy price, service cost and connection cost determined by Energie Nederland (2012) and partly based on the natural gas prices (see Table 10 for reference prices).

Table 10: Reference prices heat 2013 (Energie Nederland, 2012)

Category	**Reference cost**
Connection cost	Connection cost natural gas (1,897 euro) + saved EPC measures (1,908 euro) = 3805 euro
Service cost	Saved service cost for natural gas (?) + lifetime difference (36.16) + saved expenses on maintenance (97-63 euro)
Heat price (tap water and space heating)	6.89 euro/GJ
Heat price (space heating)	6.52 euro/GJ

This principle is both beneficial and a disadvantage. First, the benefit of this principle is that the industrial player already paid tax over the purchase of the primary energy carrier, which means that the end user of the waste heat is exempt from tax payments. Furthermore, the purchase price of waste heat is usually lower than the purchase price of natural gas. These benefits result in a lower price for the heat, but due to the *not more than otherwise* principle the vendor of the waste heat can sell the waste heat for the reference price indicated in Table 10.

On the other hand there is the problem of the higher connection cost. The connection cost of a new building to a district heating network is approximately twice as high as connection a new building to the natural gas grid. This difference in cost can be bridged by the "saved cost" that did not needed to be invested in energy efficiency measures, due to the EPC standard that builders are obliged to meet (0.6 EPC) (Eerste Kamer, 2012b). This means that the connection cost of new built environment could pass the *not more than otherwise* principle (see Figure 39).

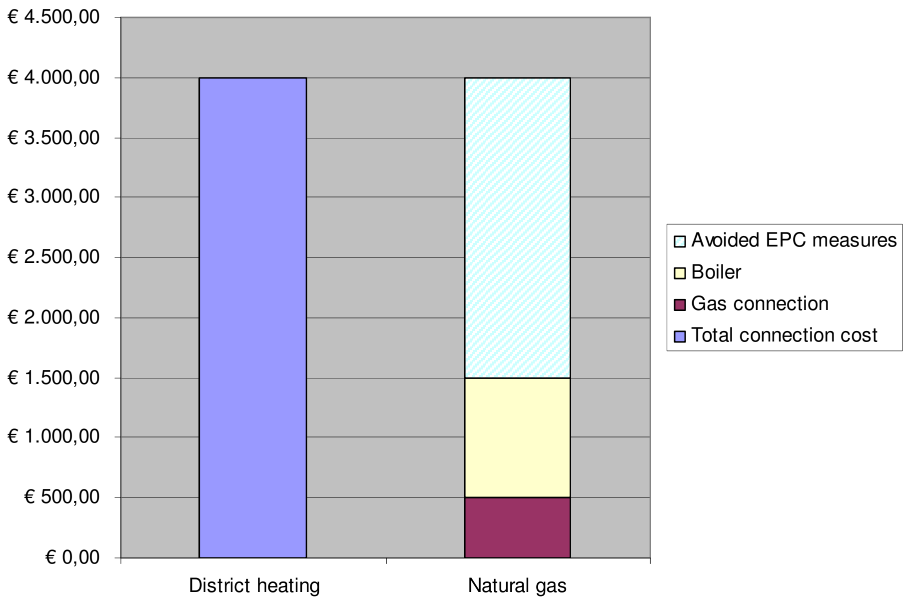


Figure 39: Connection cost new built environment (van Gestel, 13022013)[16]

Note, that the above presented graph is an indication, which means that this is not applicable to all waste heat utilization projects. The connection cost for district heating as well as the

[16] This graph contains estimates

connection cost for natural gas and the avoided EPC measures are project specific and can differ. This graph represents a feasible business case.

The down side of this mechanism is the disadvantage for the customer who gets a "sustainable" home (according to the EPC standard), but will not receive economic benefit from this. Since the connection to the district heating network will replace the extra insulation measures (this would be the avoided EPC measures). This means that the energy use will not decline (significantly) and if the *not more than otherwise* principle is used, the energy bill will also not decline. In this case there is no profit for the customer and clearly a split incentive, since the district heating company does make a profit.

The connection costs of the existing built environment are even higher than the connection cost for the new built environment. Connecting an existing home[17] to a district heating network is approximately two times as expensive as connecting a new home and four times as expensive as connecting a new home to the natural gas grid (van der Post 05022013; van Gestel, 13022013). This difference in cost is caused by; the natural gas network that is already present needs to be replaced instead of starting with a level playing field when there is no connection at all. Second, the digging activity is solely for the purpose of constructing the district heating network, while in new built environment it is part of the construction plan (which has more digging activities such as pipes, streets etc.). It is possible that a house needs to replace their gas stove for an electric stove, which causes nuisance and extra cost.

Note that, connecting existing large utility buildings and apartment buildings is beneficial due to number of end users or the large area (m^2) that can be connected, while paying one connection fee (Rezaie, 2012).

On the other hand a study by *Servicepunt duurzame energie* (2013) shows (see Figure 40) that the introduction of sustainable heat plus energy efficiency measures has a lower payback period than only energy efficiency measures. This indicates that sustainable heat is a feasible option for the existing built environment, when a label higher than C needs to be established.

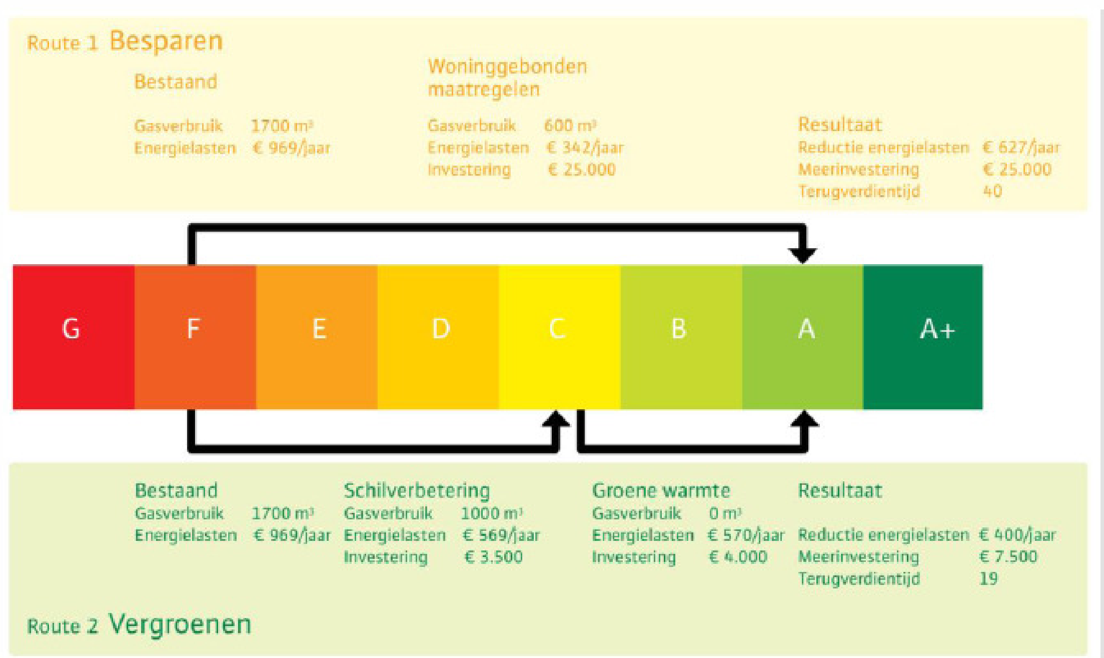


Figure 40: Routes to improving the energy label of existing built environment (Servicepunt duurzame energie, 2013)

[17] This statement only covers individual homes, apartments and utility buildings are less costly to connect to the grid.

VI. Legend

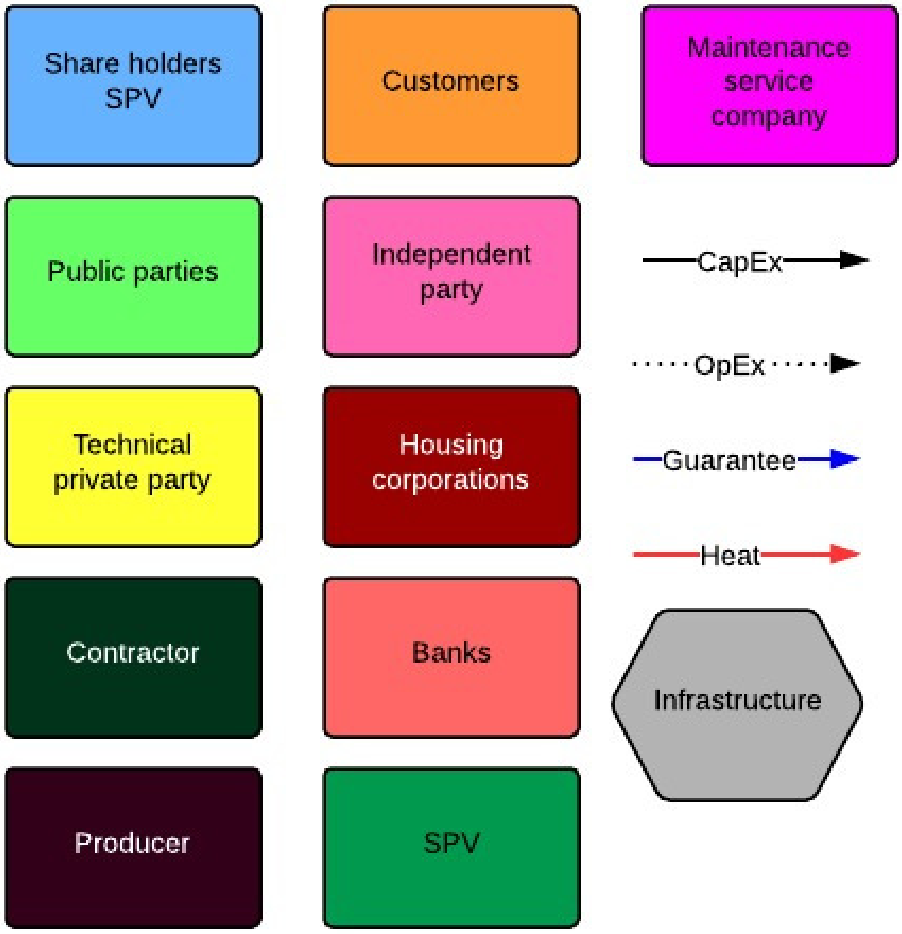
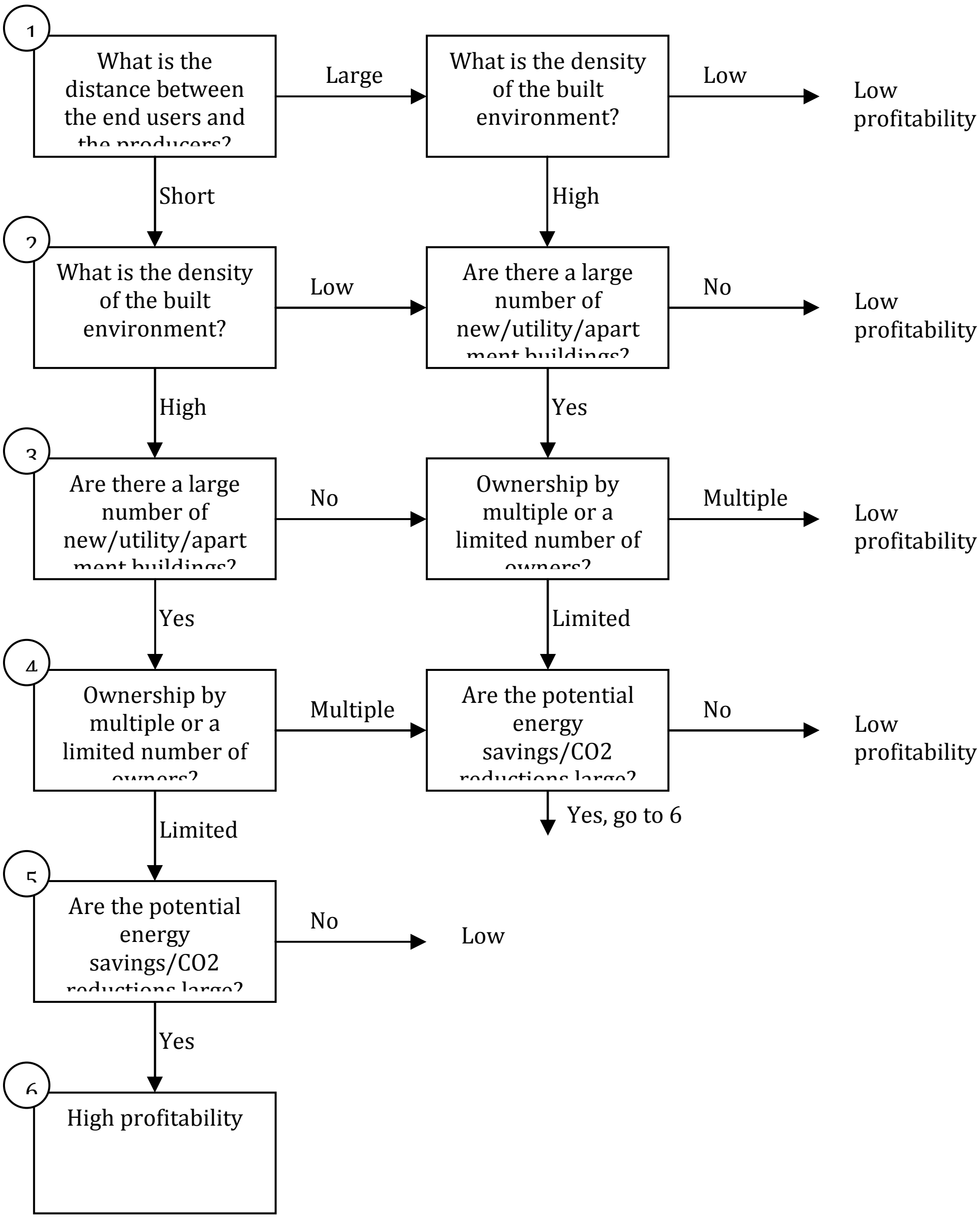


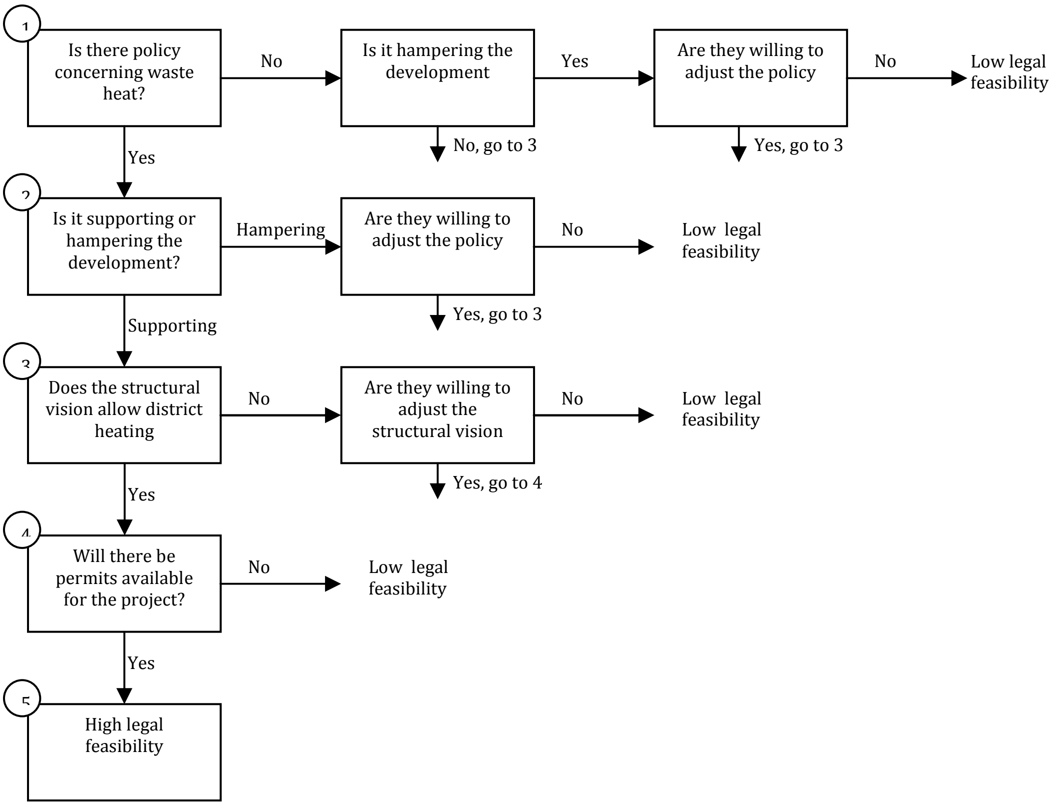
Figure 41: Legend

VII. Decision trees

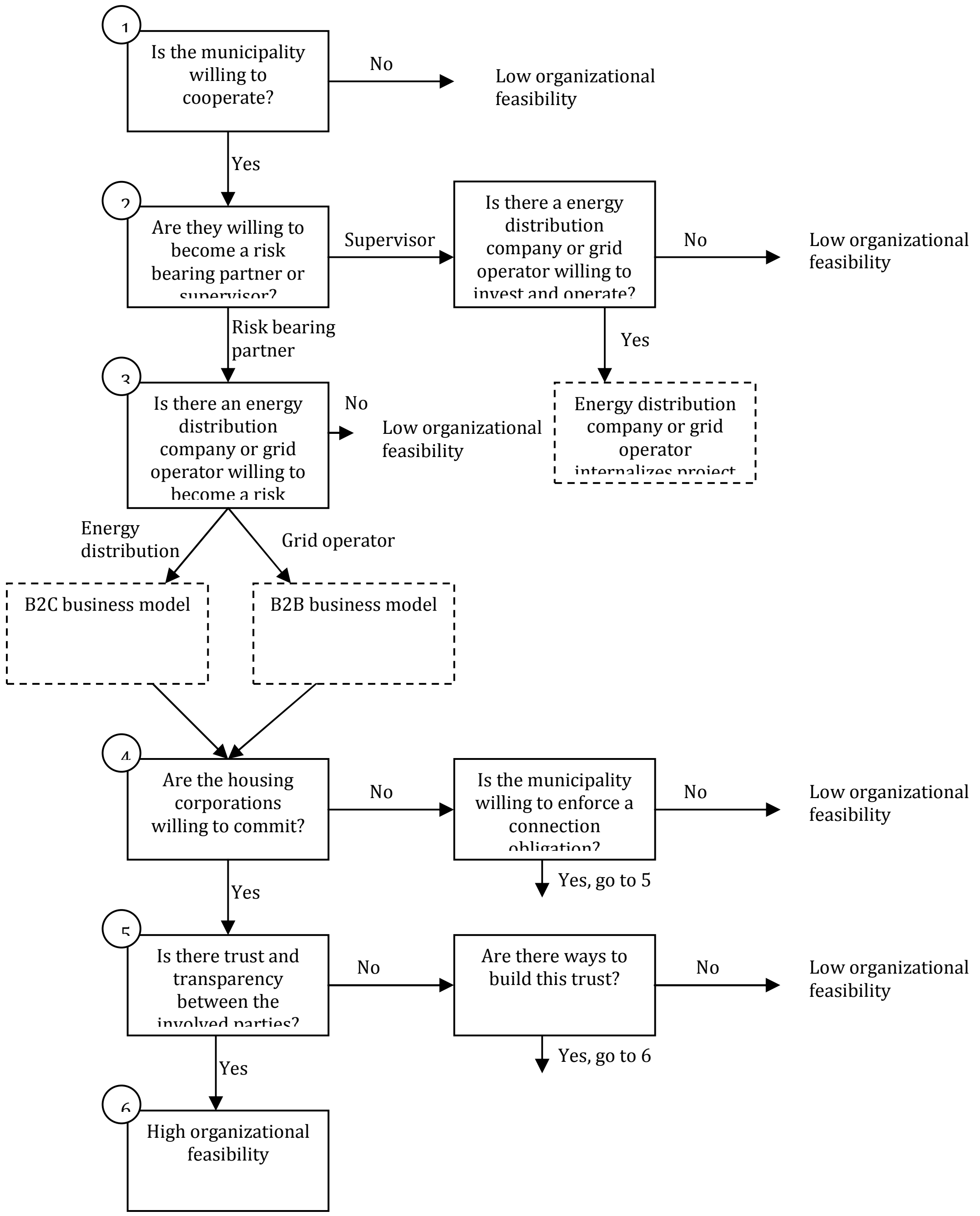
Built environment: Customers



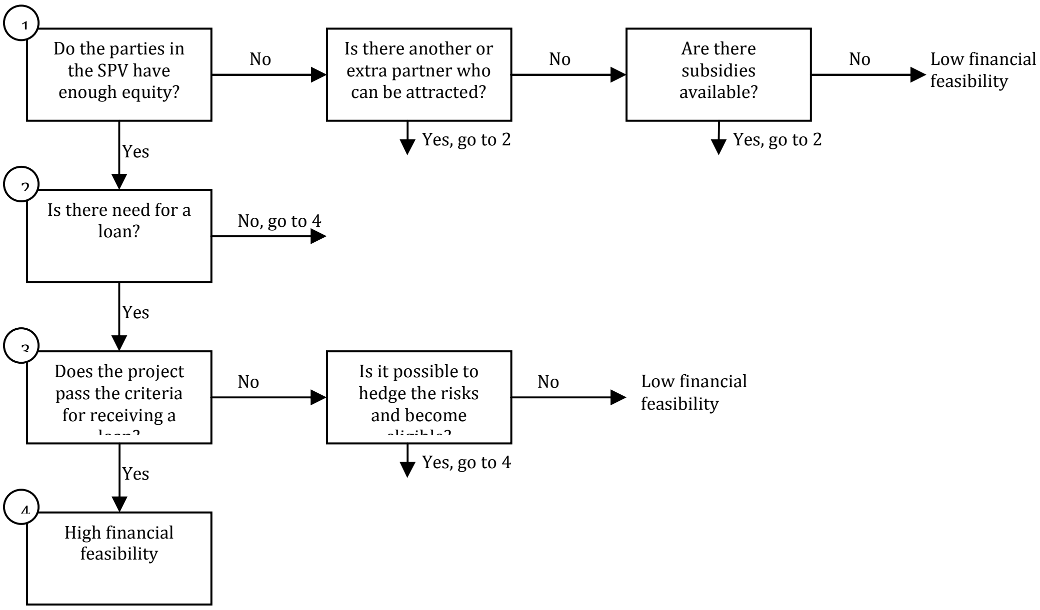
Built environment: Policy



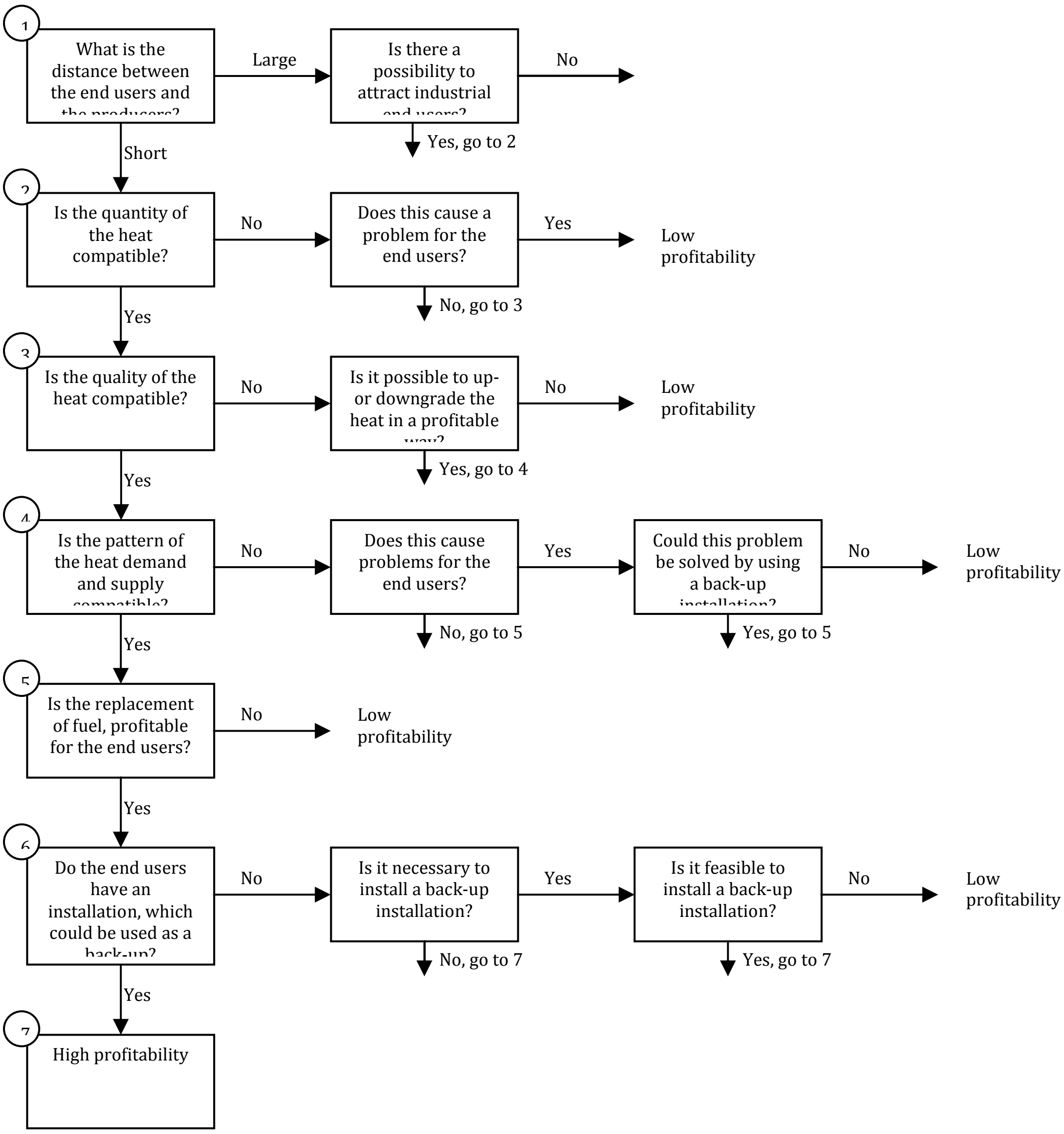
Built environment: Organizational



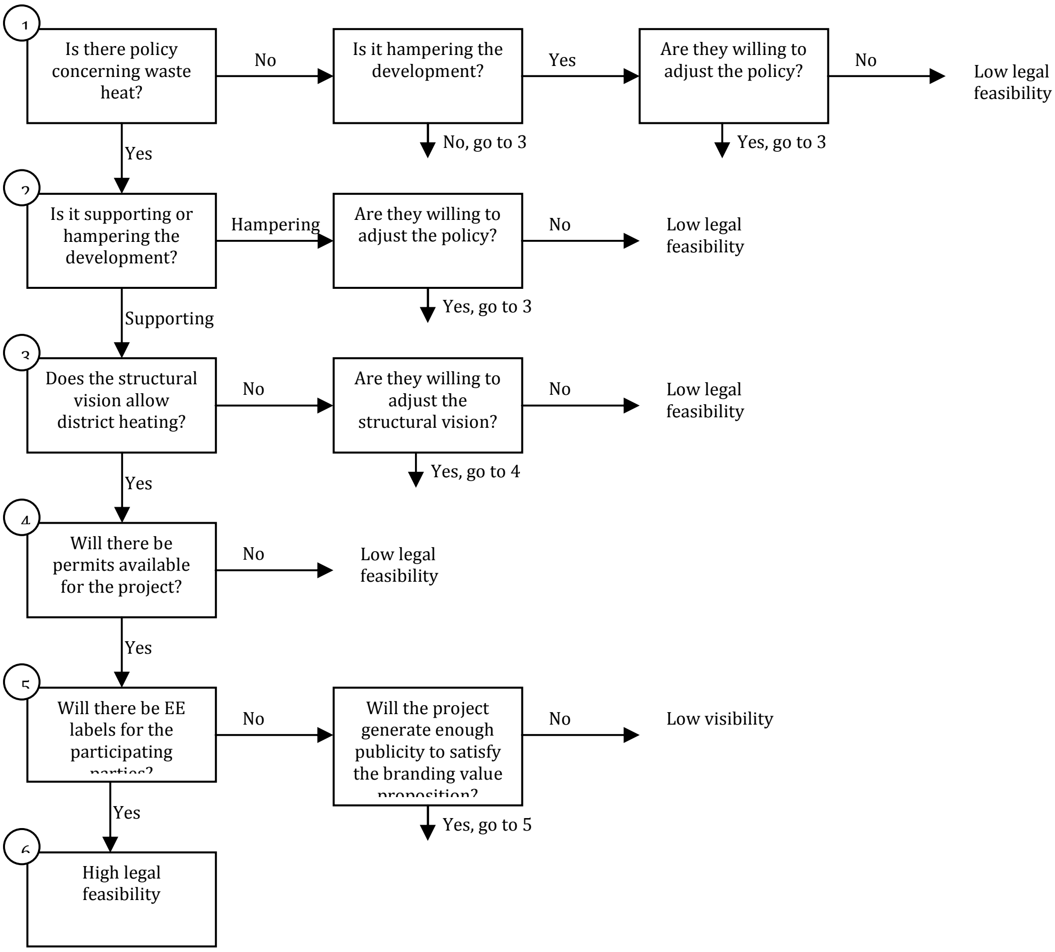
Built environment: Investment



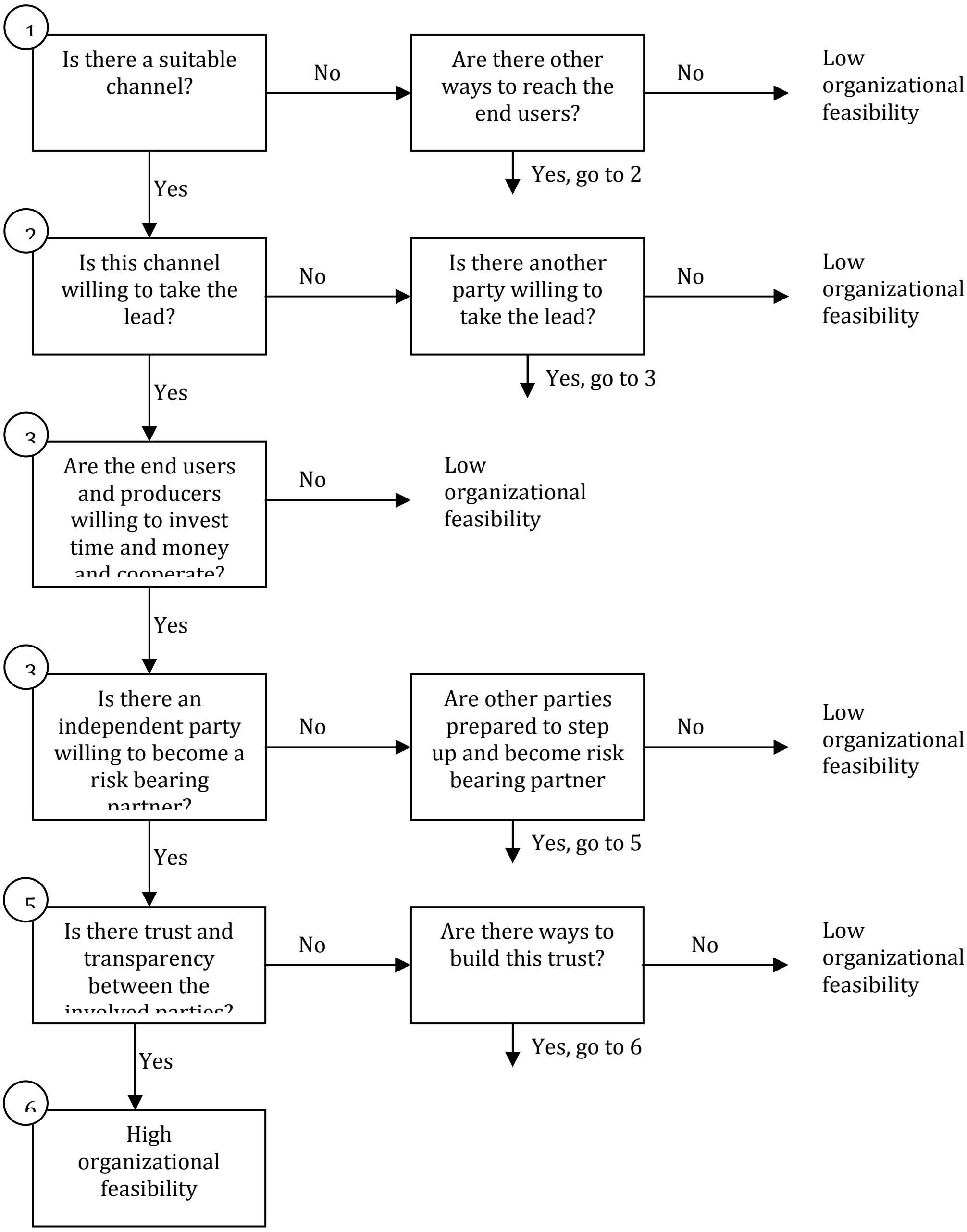
Industry: Customers



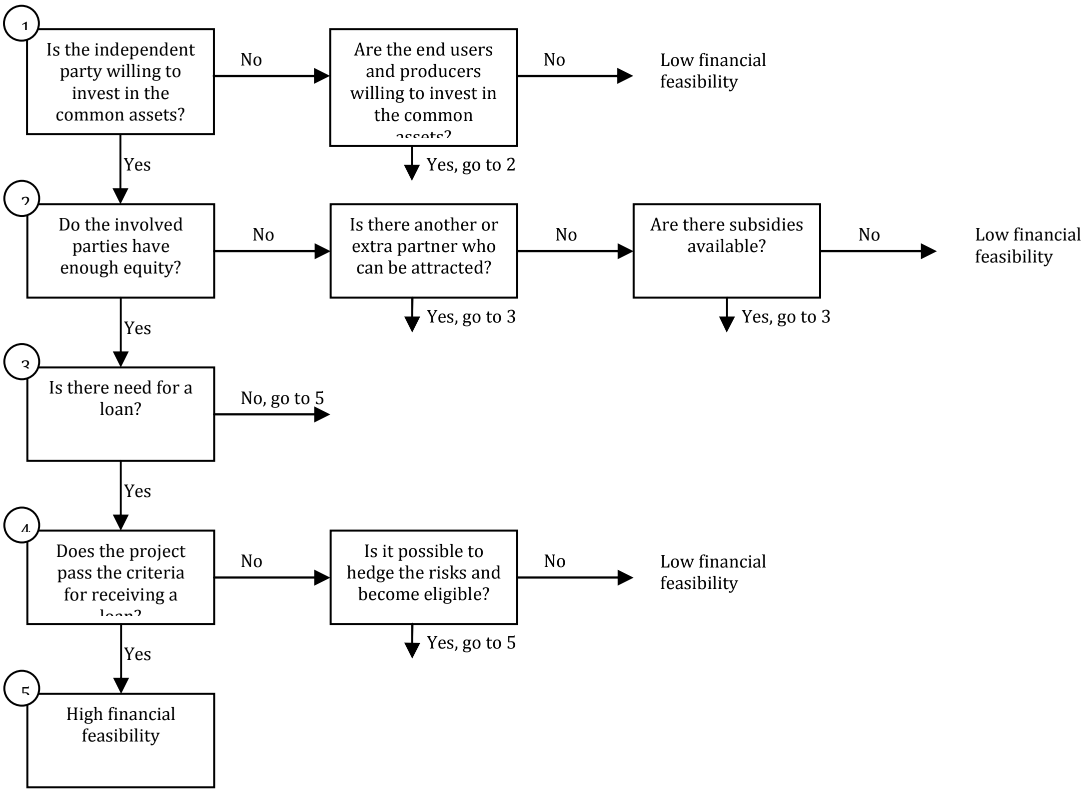
Industry: Policy



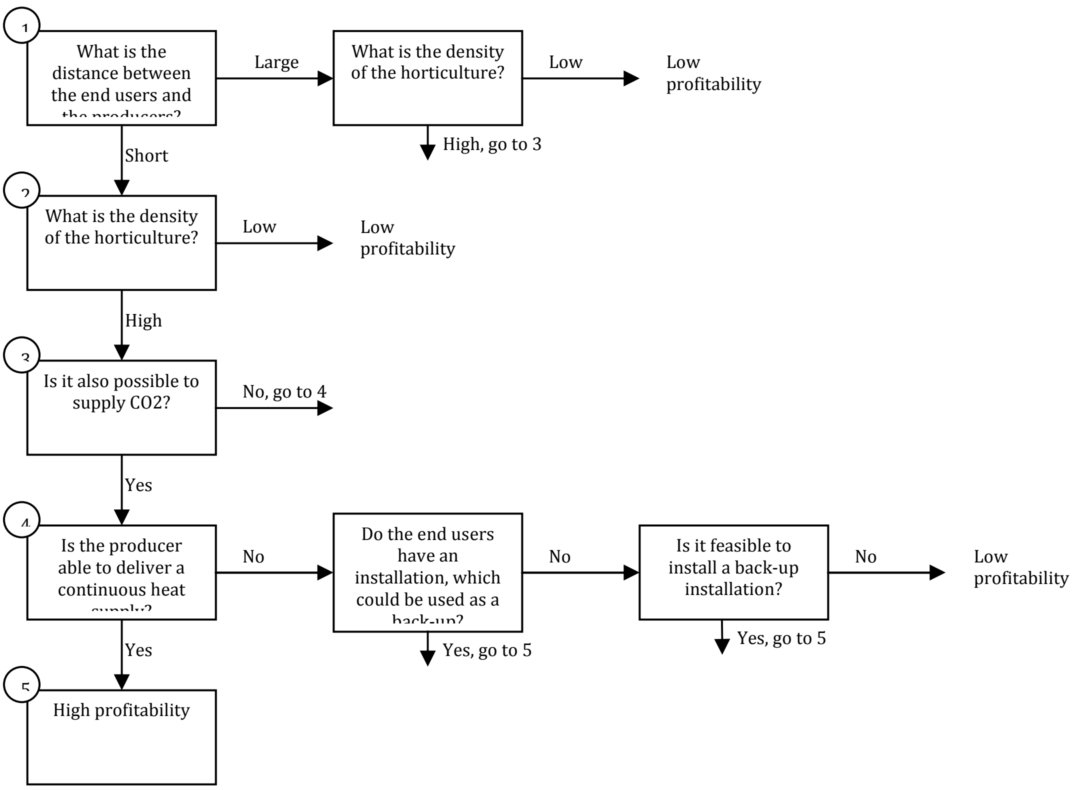
Industry: Organizational



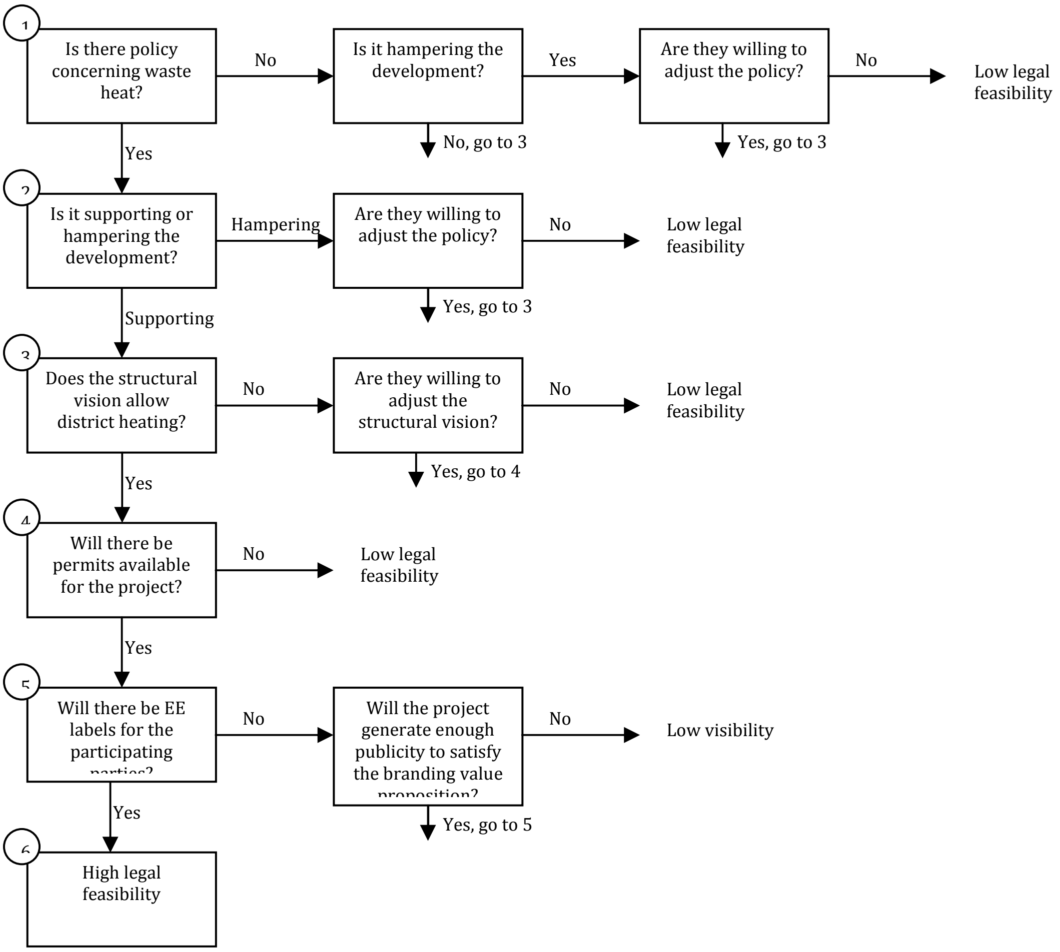
Industry: Investment



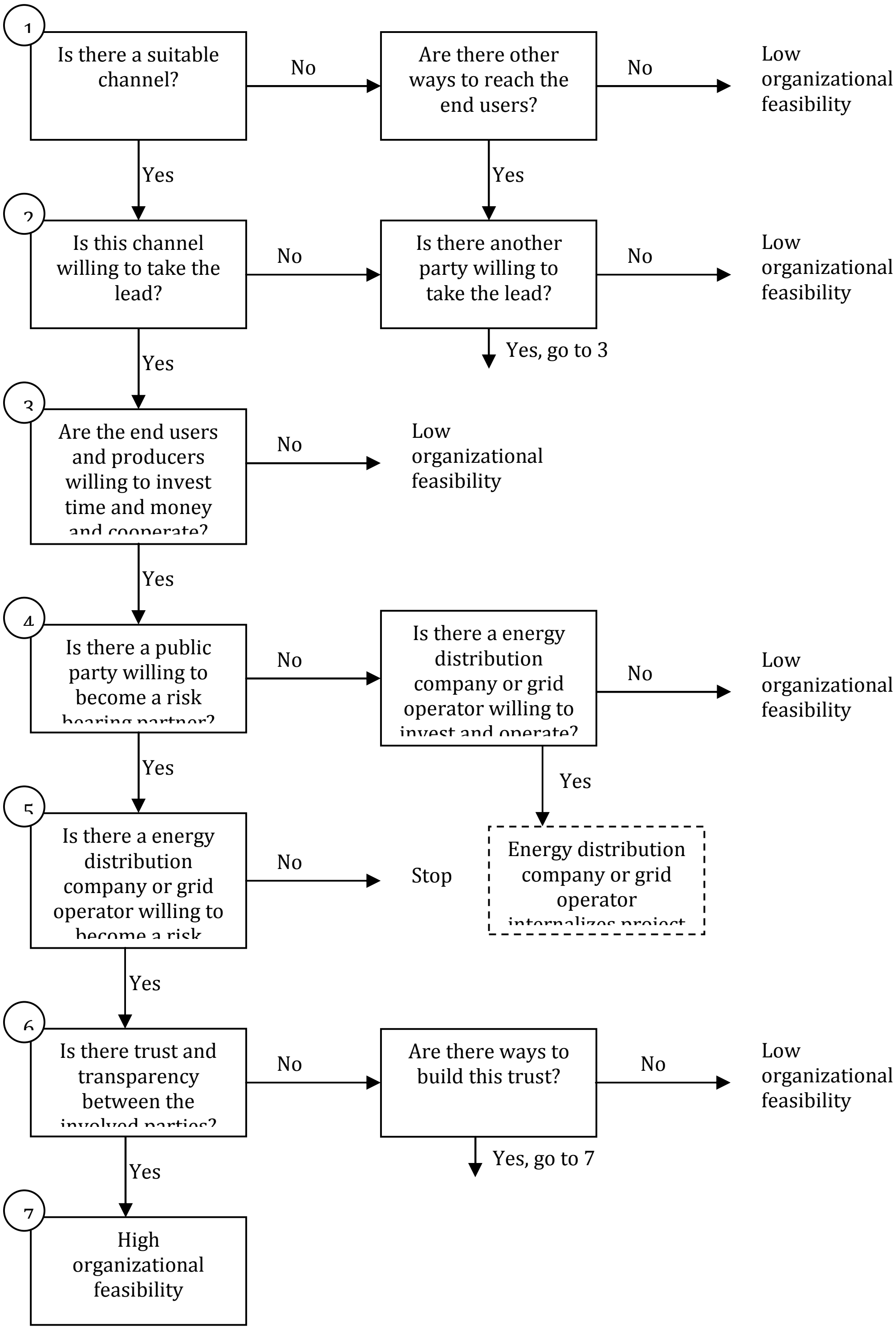
Horticulture: Customers



Horticulture: Policy



Horticulture: Organizational



Horticulture: Investment