Distribution: General

Final report

Heat in Flanders

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Study carried out on behalf of the Flemish Energy Agency (VEA)
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LIST OF ABBREVIATIONS

CapEx	Capital (investment) expenditure
cte	constant
DNM	Distribution network manager
EPA	Energy policy agreement
HTH	High-temperature heat
IEAR	Integrated environmental annual report
SME	Small or medium-sized enterprise
LTH	Low-temperature heat
MTH	Medium-temperature heat
nOK	Not OK
OpEx	Operating expenditure
UOM	Unit of measurement
CHP	Combined heat and power
MWh	Megawatt-hour(s)
MWh_{ele}	Megawatt-hour(s) of electrical energy
MWh_{th}	Megawatt-hour(s) of thermal energy
RESID	residential
SpHtg	Space heating
HWSan	Hot water for sanitary facilities
T	temperature
VBBV	The Flemish Benchmarking Verification Office

CHAPTER 1. INTRODUCTION

The Flemish Energy Agency is currently implementing Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (hereinafter referred to as 'the Energy Efficiency Directive').

Article 14 of the Directive relates to the promotion of efficiency in heating and cooling. The first element involved is that a comprehensive assessment of the application of high-efficiency cogeneration and efficient district heating and cooling must be carried out, in accordance with Article 14(1). This assessment should include a cost-benefit analysis covering the relevant territory and identifying cost-efficient solutions to meeting heating and cooling needs (Article 14(3)). Annexes VIII and IX to the Energy Efficiency Directive lay down further specifications for this comprehensive assessment of potential.

If, on the basis of the overall cost-benefit analysis, promising areas are identified where the benefits for the application of high-efficiency cogeneration and/or efficient district heating and cooling exceed the costs, Member States must take adequate measures for efficient district heating and cooling infrastructure to be developed and/or to accommodate the development of high-efficiency cogeneration. The heat map for Flanders will hopefully also provide an incentive to translate and give tangible realisation to the map at local level.

This study comprises a range of research steps that together give rise to a heat map for the current situation and a map of promising areas for energy-efficient heating in the future, in both cases for the territory of Flanders.

The four main steps in the research are as follows:

1. Determination of current demand for heat, existing and planned heat networks and current supply of residual heat, resulting in the AS-IS heat maps 2012: CHAPTERS 2, 3 and 4
2. Establishment of future scenarios for heat demand and supply of residual heat: CHAPTER 5
3. Identification of the technical potential for CHP, micro-CHP and heat networks: CHAPTER 6
4. Identification of the promising areas for CHP, micro-CHP and heat networks: cost-benefit analysis as described in CHAPTER 7. CHAPTER 8 also contains a short analysis in respect of cooling networks.

In the above, steps 1 and 4 lead directly to end results. Steps 2 and 3, together with the results of step 1, provide the information necessary to carry out the cost-benefit analysis. The figure below is a diagrammatic representation of the deliverables for the various research steps:

'AS IS' HEAT MAP **2012**	
DEMAND – Chapter 2	**SUPPLY – Chapter 4**
RESID/SERVICES/AGRICULTURE	Point sources:
Aggregation of sectors 100 x 100 m and 1 200 m x 1 200 m	Electricity generation > 20 GWh Waste incineration (Existing CHP systems) Industrial residual heat
INDUSTRY	**INFRASTRUCTURE – Chapter 3**
Large-scale industry (IEAR): demand points Small-scale industry: 300 x 300 m and 1 200 m x 1 200 m	Existing and planned networks
EVOLUTION OF DEMAND FOR AND SUPPLY OF HEAT **2012-2035**	**Chapter 5**
DEMAND	**SUPPLY**
RESID/SERVICES/AGRICULTURE	Point sources:
Evolution in Flanders Aggregation of sectors 1 200 m x 1 200 m	Electricity generation > 20 GWh: cte Waste incineration: cte (Existing CHP systems: cte) Industrial residual heat: cte
INDUSTRY	
Large-scale industry: cf. EPA Other businesses: Evolution in Flanders 1 200 m x 1 200 m	
Technical potential **Heat demand to be met via heat networks, CHP**	**Chapter 6**
Building heating (residential, service sector, agriculture)	
Heat networks supplied with residual heat or CHP CHP and micro-CHP	
Industrial heat	
CHP replacing combustion plants	
Costs/benefits map **Promising areas**	**Chapter 7**
RESID/SERVICES/AGRICULTURE	
1 200 m x 1 200 m	Residual-heat heat networks CHP heat networks
INDUSTRY	
Large-scale industry: demand points Small-scale industry: 1 200 m x 1 200 m	CHP at point sources: cf. EPA Residual-heat and CHP heat networks
Analysis of residential micro-CHP: sample calculation in Excel	
Analysis CHP in SMEs, agriculture and the service sector: sample calculation in Excel	

Figure 1: Outputs flowchart

CHAPTER 2. AS-IS HEAT AND COOLING MAP 2012

2.1. METHODOLOGY

We are basing our mapping of the heat demand in Flanders in 2012 on two key sources:

- Metered natural gas and electricity consumption for each customer in 2012 according to the distribution network managers Eandis and Infrax within their respective territories.
- Consumption data from the Integrated environmental annual reports (IEARs) for 2012 for large-scale industry.

Within the 'Heat Map Flanders' project, the distribution network managers for the household, services, agriculture and small-scale industry (i.e. non-IEAR industry) sectors determined and mapped the overall heat demand (diffuse heat demand). In addition, VITO determined the heat demand for large-scale industry (IEAR enterprises and enterprises connected to the Fluxys network). Below we describe the methodology that we used and provide an overview of the results.

2.1.1. DIFFUSE HEAT AND COOLING DEMAND: BUILDINGS AND SMALL-SCALE INDUSTRY (EANDIS/INFRAX)

The heat and cooling demand is determined based on the consumption of natural gas and electricity for individual consumers using the Heat Map Model. The following end vectors are calculated by Eandis/Infrax for the buildings sector (i.e. the residential, service and agriculture sectors taken together) and for small-scale industry:

- Space heating (SpHtg);
- Hot water for sanitary facilities (HWSan);
- Cooling.

These vectors were calculated in 2014 for the data year 2012. 2012 was the last available data year in the network managers' databases, for which reason it was chosen as the baseline year. The various steps that Eandis/Infrax go through in the model in order to establish the final demand are listed below.

1. Starting from the *electricity consumption data* for each connection/individual consumer: division into residential (households) and non-residential consumers by type of meter installed (annual reading vs more frequent) and subdivision of non-residential NACE sectors into the service, agriculture and small-scale industry sectors in accordance with the methodology followed in the Mayoral Covenant Tool (http://aps.vlaanderen.be/lokaal/burgemeestersconvenant/burgemeestersconvenant.htm).
   - Non-residential
     a. For each type of consumer (Mayoral Covenant Tool sector): allocation of a percentage of the electricity consumption to space cooling (based on Meijer, *Energie- en milieumanagement*, 2008). For the industry and agriculture sectors, cooling is considered to be zero, given that it is unknown at enterprise level.
     b. Assumption: no electricity consumed for space heating or hot water for sanitary facilities.

  c. Remaining electricity consumption is assigned to 'surplus'.

- Residential
  a. Consumption of space heating: all known night-time consumption, and 8 000 kWh for consumers with consumption exceeding 11 500 kWh, is allocated to space heating.
  b. Assumption: no consumption for cooling or hot water for sanitary facilities.
  c. Remaining electricity consumption is assigned to 'surplus'.

2. Starting from the natural gas consumption data for each connection:
   Division into residential (households) and non-residential consumers by type of meter installed (annual reading vs more frequent) and subdivision of non-residential NACE sectors into the service, agriculture and small-scale industry sectors in accordance with the methodology followed in the Mayoral Covenant Tool (http://aps.vlaanderen.be/lokaal/burgemeestersconvenant/burgemeestersconvenant.htm).
   - Non-residential
     Division of consumers: CHP (as listed in the CHP inventory of Flanders, *Gegevens WKK-installaties Vlaanderen 2008* [Data on CHP plants in Flanders, 2008], April 2014) versus other consumers (non-CHP)
     - CHP plants
       a. Known consumption data from the DNM are not used in the model.
       b. Known heat production from the CHP inventory is allocated to space heating on an integral basis (CHP inventory of Flanders, *Gegevens WKK-installaties Vlaanderen 2008* [Data on CHP plants in Flanders, 2008], April 2014).
     - Other consumers
       It is possible to break down consumption into temperature-dependent and non-temperature-dependent elements (for each individual consumer). The temperature-dependent element is for space heating, while the non-temperature-dependent element is for hot water for sanitary facilities.
   - Residential
       a. Consumption for cooking purposes is taken from the Heat Map model and deducted from the heat demand (Eandis, REG department, *Warm water, combineer comfort met lage rekeningen* [Hot water, combining comfort with low bills], April 2012).
       b. Breakdown of consumption (with the exception of cooking) into space heating and hot water for sanitary facilities based on empirically established subdivision criteria (summer/winter ratio, data on central gas receiving stations in residential regions).
3. Correction for temperature variations and plant efficiencies:
       a. Consumption of hot water for sanitary facilities, space heating and cooling are corrected for the impact of the temperature (AARDGAS, Klimaatdata, Statistische gegevens klimatologische omstandigheden, graaddagen België [Climate data, Statistical data on climatological circumstances, degree days in Belgium], October 2013 www.aardgas.be): 1 946 degree days 15/15.
       b. Consumption of hot water for sanitary facilities, space heating and cooling are corrected for the plant efficiencies of the appliances (*Energiebalans Vlaanderen, Rendementen verbrandingstoestellen* [Energy balance sheet for Flanders, Combustion unit efficiencies], April 2014; VITO & ECONOTEC, *Potentiële emissiereducties van de verwarmingssector tegen 2030* [Potential reductions in emissions from the heating sector by 2030], January 2011). The result of this

correction is the demand for space heating, hot water for sanitary facilities and cooling.

4. Correction for consumption of 'other fuels' (e.g. fuel oil, coal):
Based on the heat demand for space heating and hot water for sanitary facilities, derived from natural gas consumption. Remaining connection points to which no heat demand has yet been allocated (i.e. connection points for electricity with no natural gas connected) are allocated a percentage consumption of 'other fuels', calculated differently for residential and non-residential consumers.
   - Non-residential consumers: sector-based pro-rata coefficients by fuel relative to electricity consumption (*Energiebalans Vlaanderen, Cijferreeksen balans 2012* [Energy balance sheet for Flanders, Balance Sheet 2012 volume], April 2014 www.emis.vito.be/cijferreeksen).
   - Residential consumers:
      a. Pro-rata coefficient of the number of addresses without heat demand relative to the total number of addresses (calculated on a street-by-street basis).
      b. This pro-rata coefficient is multiplied by the overall heat demand (calculated on a street-by-street basis).
      c. This consumption is weighted according to the electricity consumption of those addresses for which no heat demand has yet been allocated.

2.1.2. Industrial demand points: large-scale industry

→ Division into industrial sub-sectors (including refineries):

The large-scale enterprises subject to IEAR are divided into the following sub-sectors, in accordance with the *Energiebalans Vlaanderen* [Energy balance sheet for Flanders]. For each of the sub-sectors below, we make different assumptions in order to derive the heat demand at enterprise level.

Industrial sub-sectors, including refineries
Refineries
Coke production
Iron and steel industry
Non-ferrous metals
Metalworking industry
Other industry
Food, drinks and tobacco
Textiles, leather and clothing
Mineral non-metal products
Paper and publishing
Chemicals

→ Total heat demand per industrial sub-sector and enterprise

Data sources:

1. IEAR – Liège Energy Data (2012): fuel consumption by type of fuel (400+ enterprises).
An enterprise or organisation must enter its energy data in an IEAR where:
   - *its operation involves primary energy consumption of over 0.1 petajoules*
   - *you have to fill in the air emissions part of the form for your operation*
   - *the operation relates to an IPPC enterprise.*

Any enterprise subject to IEAR that declares that it only needs to report because of its energy consumption should only fill in the specially developed Table 3 in the Energy Data section; electricity

consumption/year; fuel consumption/year per type of fuel.
2. CHP inventory 2012, collected in connection with the Flemish Ministerial Decree of 23 February 2005: heat production.

Method for the determination of heat demand:

For each industrial enterprise:
Heat demand = non-CHP heat demand + CHP heat demand

- Non-CHP heat demand
  = [Fuel consumption – CHP fuel consumption] x $\text{Efficiency}_{\text{industrial sector; fuel type}}$
- CHP heat demand = Heat demand according to the CHP inventory,

where
- CHP fuel consumption is taken from the CHP inventory
- Efficiencies for each industrial sub-sector and type of fuel are according to the Energy balance sheet for Flanders (see Table 1 – Reference efficiencies).

Exceptions/remarks
1. A total of 12 large-scale enterprises do not submit an IEAR or submit an incomplete electronic IEAR to Luik Energie via the official form. However, we know from the Energy balance sheet for Flanders that these enterprises are connected to the Fluxys network. Consequently, the fuel consumption for these 12 enterprises is based on data collected in connection with the Energy balance sheet for Flanders (covenants, ETS reporting, Essencia survey for the chemicals sector, etc.).

Company name	Sector	OK/nOK
Alco bio fuel	Chemicals	OK
BOREALIS POLYMERS NV BERINGEN	Chemicals	OK
Chevron Philips	Chemicals	nOK
Inbev	Food	OK
Kaneka	Chemicals	OK
Oleon Ertvelde	Chemicals	OK
Rousselot	Chemicals	OK
Sidmar Ghent	Iron/steel	OK
Tessenderlo chemie vilvoorde	Chemicals	OK
Bekaert zwevegem	Iron/steel	OK
ETERNIT	Mineral non-metal products	nOK
S.C.R. SIBELCO NV	Mineral non-metal products	nOK

However, three enterprises (nOK) did not give their consent for the Energy balance sheet to be used as a source of data. We therefore estimate the relevant heat demand based on non-detailed IEAR data, namely the total heat and production reported.

2. Iron and steel; refineries: only self-consumption, excluding input and output streams, is included when determining the heat demand, e.g. for iron/steel: excludes consumption of coal and coke – only consumption of blast furnace gas, coke oven gas and natural gas are taken into account.

We wish to put on record that we have not estimated the cooling demand on an enterprise-by-enterprise basis due to a lack of relevant data. Furthermore, the demand for cooling is very process-specific, which means that an estimate based on a generic method (e.g. key indicators) cannot be made use of.

Table 1. Reference efficiencies relative to the net calorific value, as used in the Energy balance sheet for Flanders

GREEN fuels	Biogasoline	Biodiesel	Biofuel	Rapeseed oil	Palm oil	Bio-oil	Landfill gas	Biogas	Sludge	Olive stones	Wood pellets	Chopped wood	Wood waste	Wood shavings	Sawdust	Wood pulp	Wood	Waste share of renewables	Coffee	
Source: Annex I-II to the Flemish Ministerial Decree laying down reference efficiencies by way of implementation of the conditions for high-quality combined heat and power plants, 6 October 2006. *Reference efficiencies for the separate production of heat*																				
Steam/hot water efficiencies	0.89	0.89	0.89	0.89	0.89	0.89	0.7	0.7	0.8	0.8	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.8	0.8
Steam/hot water efficiencies (STEAM 5 % lower)	0.84	0.84	0.84	0.84	0.84	0.84	0.65	0.65	0.75	0.75	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.75	0.75
Direct use of combustion gases	0.81	0.81	0.81	0.81	0.81	0.81	0.62	0.62	0.72	0.72	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.72	0.72
FOSSIL fuels	Co al	Co al	Co ke	To tal	Oil an	Re fin	LP G	Pe trol	Ke ros	Ga s	Ke ros	He av	Na pht	Pe trol	Ot he	To tal	Na tur	Co ke	Co ke	Ot he
Source: Annex I-II to the Flemish Ministerial Decree laying down reference efficiencies by way of implementation of the conditions for high-quality combined heat and power plants, 6 October 2006.																				
Steam/hot water efficiencies		0.88	0.88		0.89	0.89	0.89	0.89		0.89	0.89	0.89		0.88	0.89		0.9	0.8	0.8	0.8
Steam/hot water efficiencies (STEAM 5 % lower)		0.83	0.83		0.84	0.84	0.84	0.84		0.84	0.84	0.84		0.83	0.84		0.85	0.75	0.75	0.75
Direct use of combustion gases		0.8	0.8		0.81	0.81	0.81	0.81		0.81	0.81	0.81		0.8	0.81		0.82	0.72	0.72	0.72

Colour key:

Iron and steel	Metalworking industry
Non-ferrous metals	Textiles, leather and clothing
Chemicals	Other industries
Food, drinks and tobacco	Service sector
Paper and publishing	Households
Mineral non-metal products	

Method of locating individual enterprises:

For those enterprises lacking x and y coordinates (271), the coordinates were provided via:

- Known coordinates for enterprises from the heat map for 2013 (i.e. connection based on CE number and address): 163 enterprises.
- The Flanders Geographical Information Agency (FGIA)'s CRAB Match geolocation tool based on the address: 82 enterprises.
- The remaining 26 enterprises had an incomplete address or are located in a port area. Their coordinates were searched for manually via company websites, Google Maps/Streetview and FGIA's Lara application. In so doing, the connection was usually positioned in the centre of the various buildings on the site, in order to best reflect the location of the consumer.

2.2. Results

2.2.1. Diffuse heat and cooling demand: buildings and small-scale industry

The following results were supplied by the network managers Eandis/Infrax for the energy vectors Space heating, Hot water for sanitary facilities, Cooling and Other electrical applications:

- Demand for heat and cooling from the buildings sector (i.e. the residential, service and agriculture sectors taken together) using a 100 x 100 m grid
- Heat demand from small-scale industry using a 300 x 300 m grid
- Omission due to confidentiality: for privacy reasons, the energy vectors are not shown on the above maps where there are less than three consumers in a given grid cell. This omission is reflected on a 1 200 x 1 200 m map, where the dominant sector (industry vs households) is shown for each energy vector in each grid cell. We list the total omissions in Flanders per sector and energy vector in the table below. The energy demand for those cells where confidentiality is breached even in 1 200 x 1 200 m cells in the Eandis/Infrax results is summarised in a percentage of 'others'. This 'others' percentage is simply given for Flanders as a whole.
- Municipality of Voeren: the territory of Voeren is not present in the above-mentioned data set from Eandis/Infrax because the network manager is [Walloon public gas and electricity operator] ORES. For this municipality we do not have any results by supply point, but Eandis did establish an overall figure for each energy vector.

Table 2: Omission due to confidentiality: known energy demand at resolution 1 200 x 1 200 m plus 'others' percentage (excludes Voeren)

Flanders			
% demand	Cooling	SpHtg	HWSan
Industry	/	38 %	31 %
Buildings	16 %	16 %	20 %
TOTAL	**16 %**	**19 %**	**24 %**

The results supplied by Eandis/Infrax were compiled by VITO into a single heat map for 2012 for diffuse heat and cooling demand. For Voeren, we distributed the demand from small-scale industry across the industrial land use in the municipality. The location of these plots of land is known from VITO's 2014 land use map and is based on the data set of commercial land areas from the Flemish Business Agency and on the Belgian Enhanced Central Database for Enterprises. We distribute the demand from the buildings sector across the municipality in accordance with the population distribution from 2014.

The results (including the omissions due to confidentiality and Voeren) can be seen in the maps below. In the maps, it is clear to see that the patterns of the two network managers' areas overlap nicely. The patterns also follow a logical pattern: higher population density = higher demand from heat/cooling.

We list the totals for Flanders in 2012 per energy vector (diffuse demand) in the table below for each sector and resolution. The 'others' percentages cover those cells where confidentiality is breached even in 1 200 x 1 200 m in the Eandis/Infrax results.

Table 3. Diffuse demand: demand per end vector, per sector for the various spatial resolutions.

[GWh]	Spatial resolution	Cooling	SpHtg	HWSan
Industry	300 m		4 979.56	2 284.44
	1 200 m		2 847.42	1 004.02
	Voeren		0.08	0.02
	Other, Eandis		206.83	6.60
Buildings	100 m	1 162.93	39 901.91	5 298.31
	1 200 m	221.31	7 696.73	1 329.28
	Voeren	0.07	17.79	4.23
	Other, Eandis	5.78	75.10	8.30
Others	Flanders	2.07	18.59	2.71
Total		**1 392.16**	**55 744.01**	**9 937.90**

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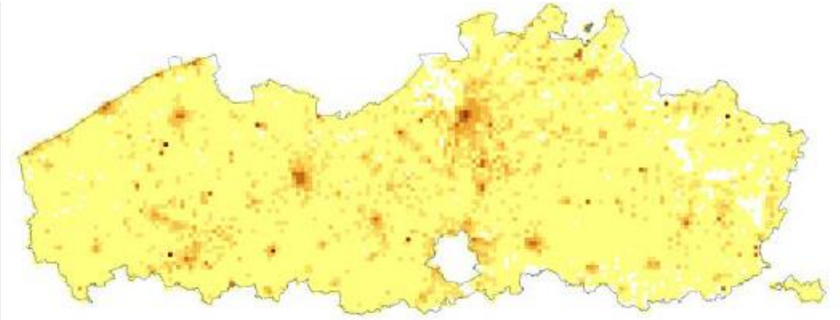
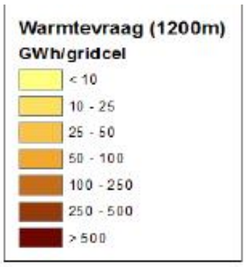
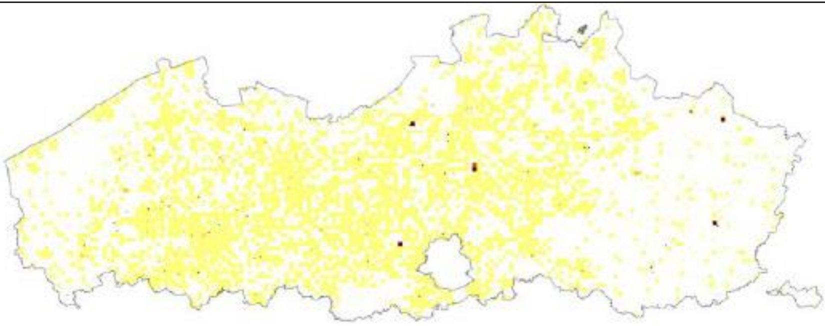
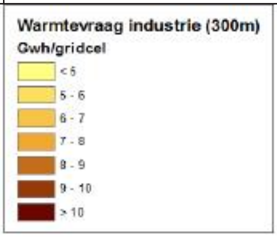
<tr><td></td><td>
</td></tr>
<tr><td>Heat map (= SpHtg + HWSan), 1 200 m
All sectors (buildings + industry)</td><td>Heat demand (1 200 m)

GWh/grid cell</td></tr>
<tr><td></td><td>
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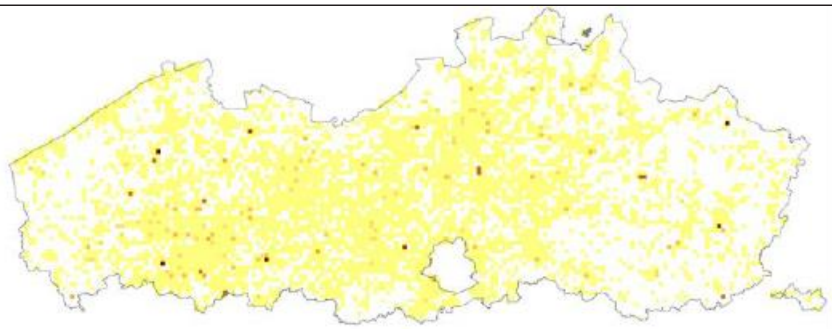
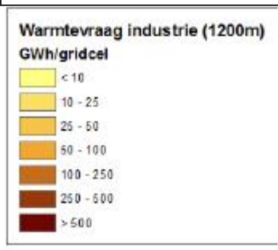
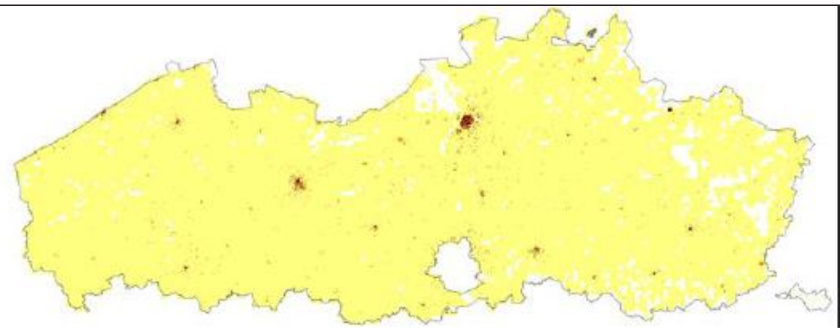
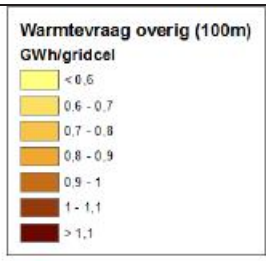
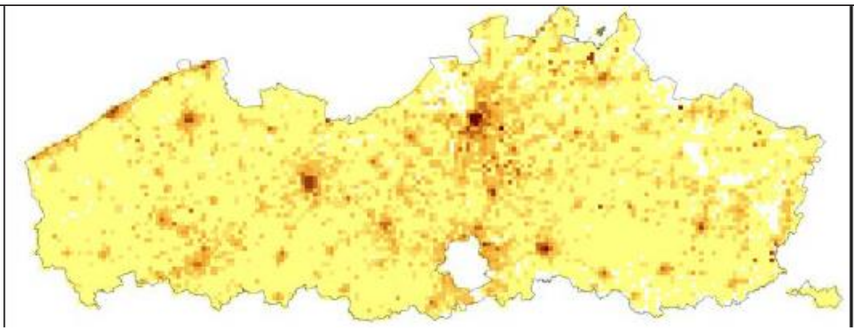
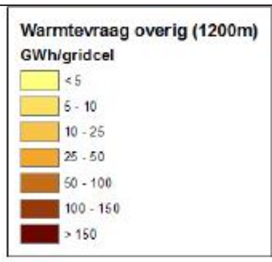
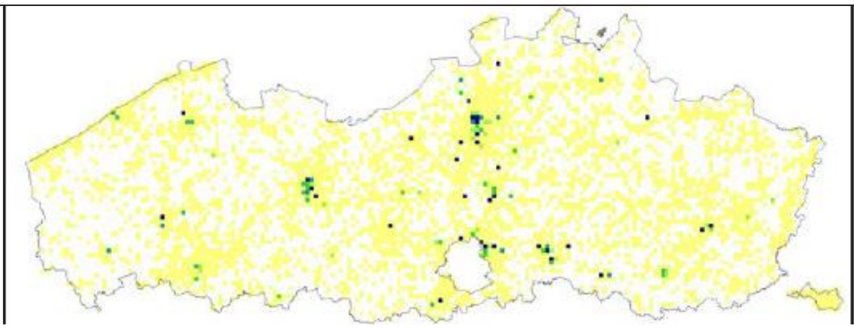
<tr><td>Heat map, 300 m, industry</td><td>Heat demand, industry (300 m)

GWh/grid cell</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td>Heat map, 1 200 m, industry</td><td>Heat demand, industry (1 200 m)

GWh/grid cell</td></tr>
</table>

	
Heat map, 100 m, buildings (residential, service sector and agriculture)	Remainder of heat demand (100 m) GWh/grid cell
	
Heat map, 1 200 m, buildings	Remainder of heat demand (1 200 m) GWh/grid cell
	
Cooling, 1 200 m, buildings (service sector, cooling is 0 for households (negligible), agriculture and small-scale industry (unknown at enterprise level)).	Cooling, buildings (1 200 m) GWh/grid cell

2.2.2. Industrial demand points: large-scale industry

We list the total, estimated heat demand for each enterprise (= enterprise subject to IEAR or connected to Fluxys network) using three ranges. As stated above, we are unable to provide a reliable estimate of the cooling demand on an enterprise-by-enterprise basis.

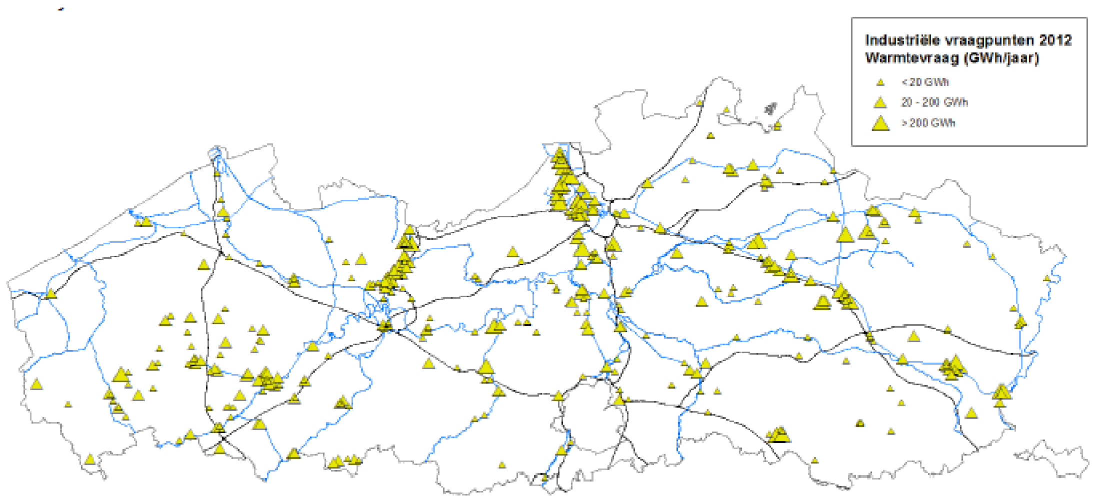


Figure 2. Heat demand [GWh/year] in 2012 for industrial demand points in Flanders.

Key to graphic
Industriële vraagpunten 2012 = Industrial demand points, 2012
Warmtevraag (GWh/jaar) = Heat demand (GWh/year)

CHAPTER 3. EXISTING AND PLANNED DISTRICT HEATING INFRASTRUCTURE

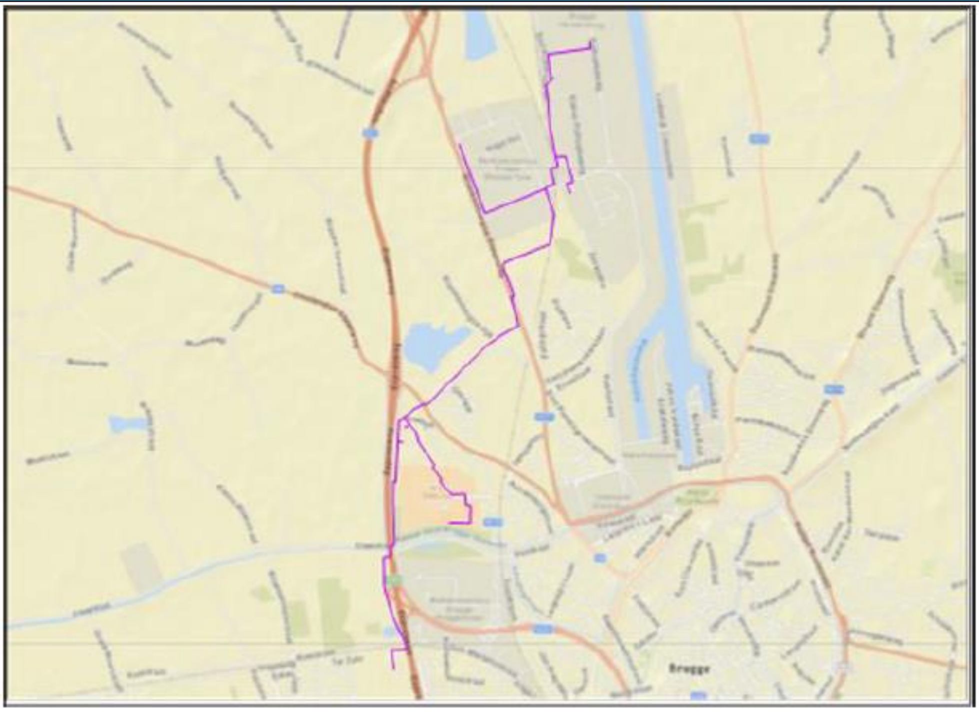
Heat networks are as yet little used in Flanders; the existing networks are mainly connected to a waste incinerator where both electricity and heat are produced. The surplus heat is often piped to neighbouring districts, buildings or businesses via a hot water or steam network. In this chapter we set out an overview of existing – and planned – heat networks in Flanders.

The operators/managers of existing and planned heat networks were written to and asked to answer the following questions:

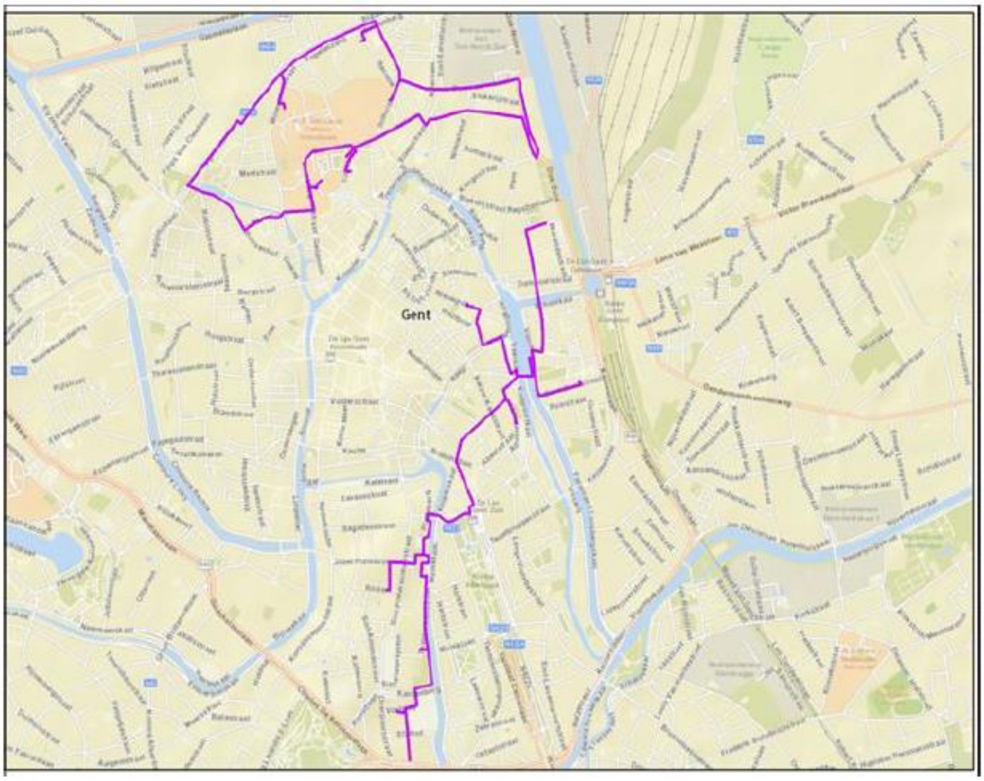
- How much heat did you supply in 2012?
- How many supply points did you have for each sector?
- What is the exact location of your heat network (map)?
- To what sectors did you supply heat?
- Do you plan to expand your network? If so, please attempt to answer the questions above.

The respondents' answers can be found in the boxes below by network. Where planned networks are referred to, these are networks that have been definitely decided upon and are due to enter into service in the near future (2015/2016).[1]

[1] We included those projects that were known in December 2014. The Niefhout project in Turnhout was thus not included in this report as it was not yet finalised/certain in December.

IVBO Bruges	
	
Contact	
Type of response	
Data?	As there was no response, the source was the Annual Report 2012: Waste-To-Energy – 43 009 MWh in 2012 for industrial uses ('IVBO thus provides heat to, inter alia, the St Jan University Hospital and the praline maker Kathy Chocolaterie').

SPE Ghent



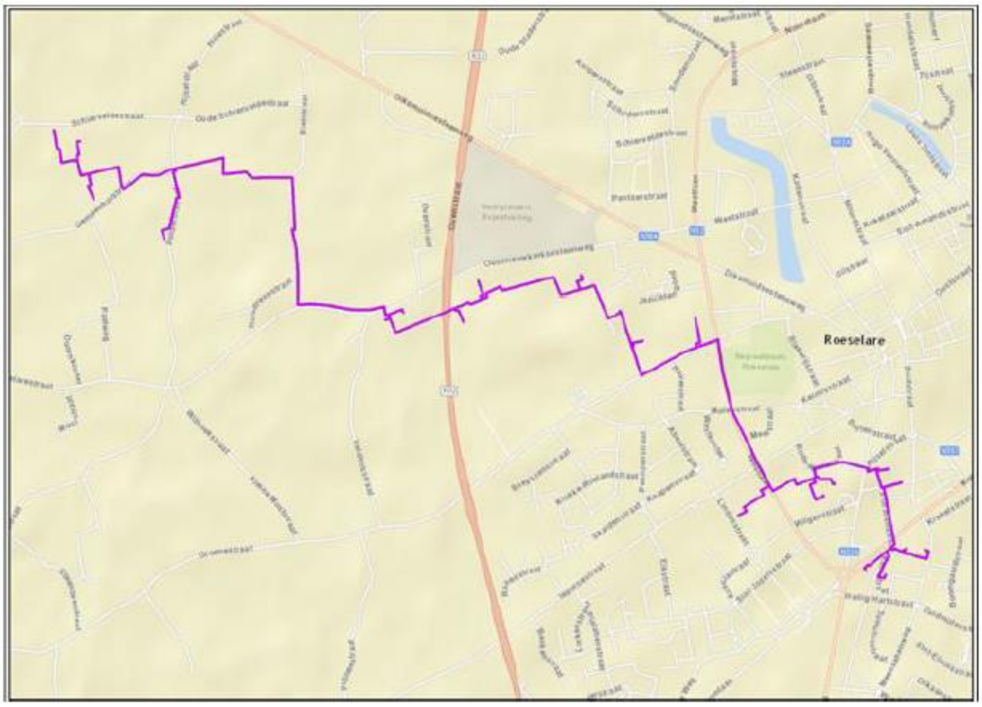
Contact	Kristof.vanhoorne@edfluminus.be
Type of response	Map and data by email
Data?	The heat supplied in 2012 was as follows:

	GJ	MWh
Industrial	6 241.32	1 733.70
Service sector	190 980.36	53 050.10
Private customers	60 069.44	16 685.95
Total	257 291.12	71 469.76

108 supply points

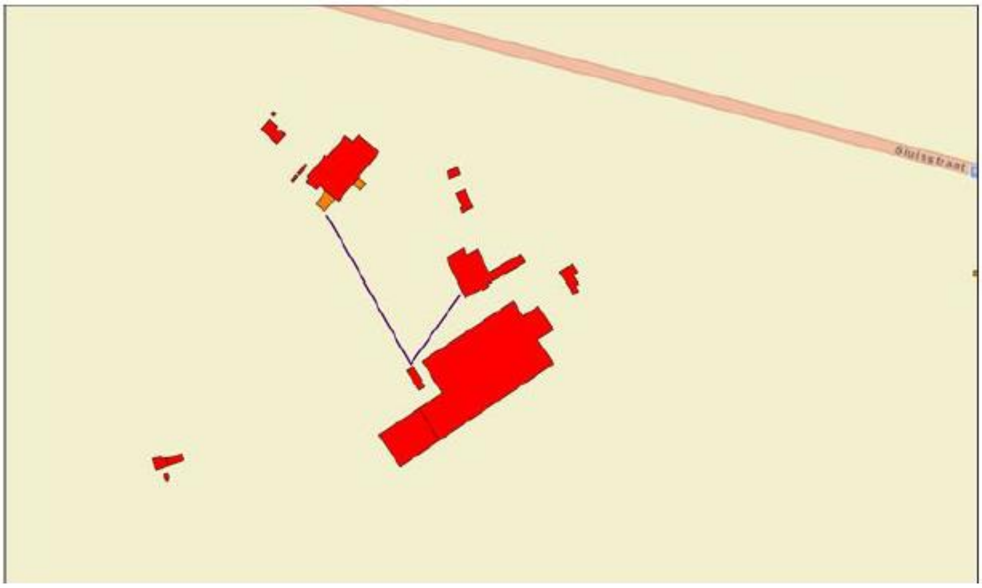
In Ghent, the EDF Luminus power plant has a heat network for the university, the law courts and residential districts and supplies steam to the University Hospital of St Lucas.

Mirom: existing network – Roeselare



Contact	koen.van.overberghe@mirom.be
Type of response	Map online, data by email
Data?	Heat supplied: 2011: 24 100 MWh 2012: 27 420 MWh Sectors: residential (1 apartment building: 74 homes), public buildings (hospital, swimming pool, etc.), schools, greenhouse cultivation (4 greenhouses), industry (1) and a monastery.
Mirom: planned – Roeselare	
Contact	koen.van.overberghe@mirom.be
Type of response	Data by email; no map
Data?	Definite: 75 000 MWh. (If the last project being prepared comes to fruition: 130 000 MWh) Sectors: Residential sector increases from 74 to ± 2 000; Industry: 1 enterprise to an 18-ha SME zone; Greenhouse cultivation: large expansion of glasshouse farm businesses; also numerous additional public buildings In service from 2015 (deadline envisaged)

Ivago Ghent	
Contact	
Type of response	
Data?	As there was no response, the source was IVAGO's brochure: *Van stroten tot hoogwaardige milieutechnologie* [From landfill to high-quality environmental technology]: Since early 2007, nearly half of the steam has been sent via a (1 500 m-long) underground pipeline to Ghent University Hospital, where this 200 °C steam is converted into 160 °C steam and 130 °C hot water. The cooled steam is then returned to IVAGO as condensate water via a separate pipe. Source: 20 years of IVAGO brochure: Steam supplied to Ghent University Hospital in 2012: 45 947 MW_{th}

<table>
<tr><th colspan="2">DALKIA, HVVI Knokke-Heist – Existing network and planned extension</th></tr>
<tr><td colspan="2">
Existing network, Knokke Heist</td></tr>
<tr><td>Contact</td><td>Freyne.l@DALKIA.BE</td></tr>
<tr><td>Type of response</td><td>Data by email</td></tr>
<tr><td>Data?</td><td>For 2012:
- 550 GJ of internal heat consumption (hot water)
- District heating: 2 glasshouses take 1 830 GJ (agriculture and horticulture)

Waste to energy/waste incinerator

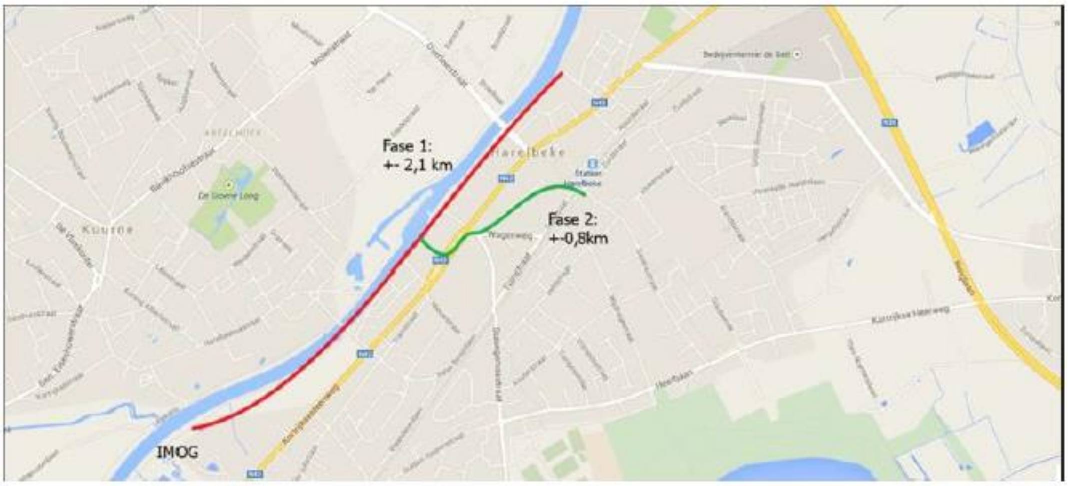
In 2016: Organic Rankine cycle (ORC) sites for electricity production: 3 ORC units with a maximum thermal absorption capacity of 3 500 kW and a maximum electrical production capacity of 370 kW per unit. These are to be located on the site of the incinerator.</td></tr>
<tr><th colspan="2">Dalkia – Aalst</th></tr>
<tr><td colspan="2">No data available</td></tr>
</table>

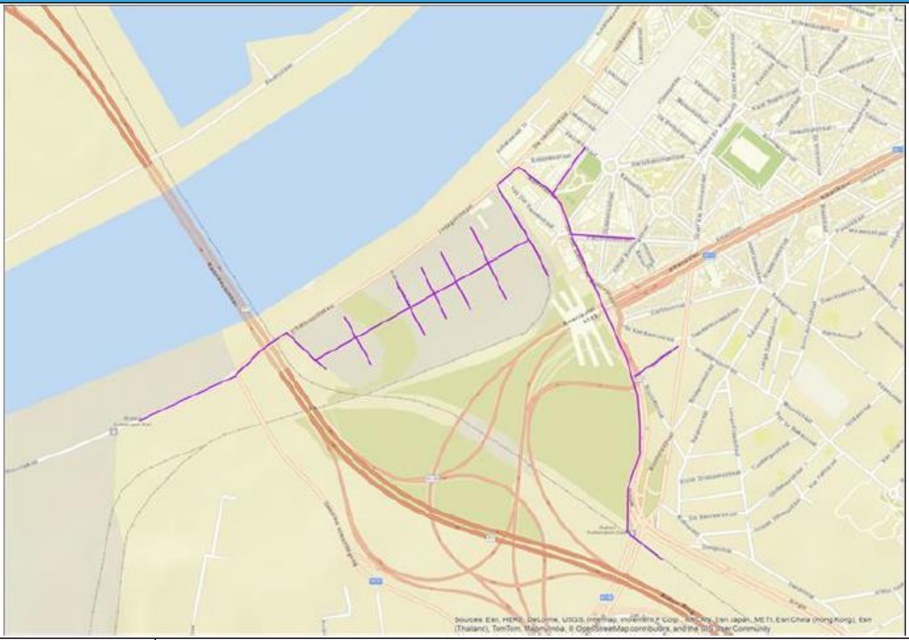
Indaver – Antwerp site	

Contact	An.Depauw@indaver.be
Type of response	Map and data by email
Data?	2012: 214 MWh of heat supplied to the enterprise Amoras (Other services: sludge processing) Waste-to-energy
Indaver – Doel site – Existing network and planned expansion	
Contact	An.Depauw@indaver.be
Type of response	Data by email; no map
Data?	2012: 173 724 MWh of heat supplied to the enterprise Ineos Phenol (chemical industry) Waste-to-energy Planned expansion: - Basis 400 000-500 000 MWh (potentially increasable to approx. 800 000-900 000 MWh) - Number of supply points per sector: 6 - Heat network in the Waaslandhaven area of the port of Antwerp to 6 local chemicals enterprises. - In service from 2016 (deadline envisaged)

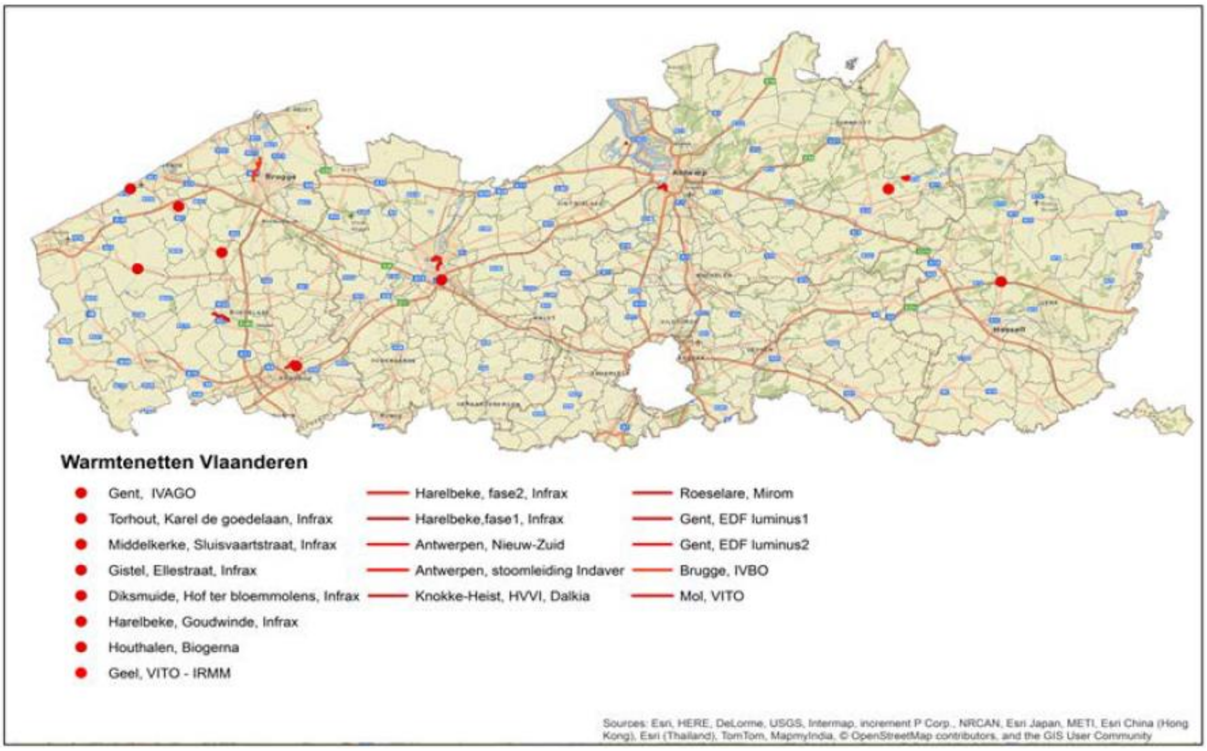
VITO – Mol site	
	
Contact	jan.vanroy@vito.be
Type of response	Map and data by email
Data?	Heat supplied, 2012: 20.83 MWh Heat supplied to three service sector enterprises: SCK, Belgoprocess, VITO Heat production via CHP, supplemented by gas-fired boilers.
VITO – Geel site	
Contact	jan.vanroy@vito.be
Type of response	
Data?	No data available

Bionerga – Houthalen	
Contact	Maarten.Meersschaert@bionerga.be
Type of response	Data by email; no map
Data?	Heat supplied to Aquafin (sludge drying) in Houthalen: 2013: 85 811 GJ 2012: 86 458 GJ Waste-to-energy

Infrax – Diksmuide, Gistel, Harelbeke, Middelkerke and Torhout – Existing network	
Contact	toon.lenaerts@infrax.be
Type of response	Addresses and data by email.
Data?	Residential districts: - Diksmuide, Hof Ter Bloemmolens - Gistel, Ellestraat & Warandestraat - Harelbeke, Goudwinde - Middelkerke, Sluisvaartstraat - Torhout, Karel De Goedelaan Heat supplied: 2012: 2 380 606 kWh 2013: 2 266 938 kWh Central, gas-fired boilers, operated by Infrax.
Infrax – Harelbeke – Planned	
	
Contact	toon.lenaerts@infrax.be
Type of response	Map and data by email
Data?	IMOG Waste incinerator/Waste-to-energy Entry into service: autumn 2016. Phased launch. - In 2016 a heat off-take of 2 727 MWh is planned. - Number of supply points in 2016: 5 (public buildings such as the fire service etc.). - An off-take of 9 188 MWh is aimed for by 2022, mainly through public buildings, but also residential properties.

Antwerp Nieuw-Zuid (New South) – Planned network	
	
Contact	Wouter.Cyx@stad.Antwerpen.be
Type of response	Map and data by email
Data?	- Multi-phase construction: entry into service 2015 – maximum capacity by 2030 ==> indicative planning: Primarily residential new-build, plus public buildings and commercial activities (retail, offices): a school, sports hall, residential (flats, detached houses, social housing), student accommodation, small-scale commercial activities, offices. In 2015: 311 residential units, 4 retail units, in 2020: 978 residential units, 35 offices and retail units. Continued growth expected up to 2030. - Heat take-off (including losses): approx. 2 000 MWh in 2015, approx. 6 000 MWh in 2020, rising to 12 000 MWh in 2030. - Heat production via a gas-fired boiler (eventually also biomass).

If we combine the position of the above heat networks (excluding the planned MIROM and the planned Indaver – Doel Site networks, due to lack of available data), we get the following summary map for Flanders. We can see that Flanders only has very few heat networks, including those planned. The map is also available as a .kmz file that can be easily viewed at the desired level of detail via Google Earth.



<u>Gloss for graphic:</u>

Heat networks in Flanders		
Ghent, IVAGO	Harelbeke, phase 2, Infrax	Roeselare, Mirom
Torhout, Karel de goedelaan, Infrax	Harelbeke, phase 1, Infrax	Ghent, EDF, luminus1
Middelkerke, Sluisvaartsrtaat, Infrax	Antwerp, Nieuw-Zuid (New South)	Ghent, EDF, luminus2
Gistel, Ellestraat, Infrax	Antwerp, Indaver steam pipeline	Bruges, IVBO
Diksmuide, Hof ter bloemmolens, Infrax	Knokke-Heist, HVVI, Dalkia	Mol, VITO
Harelbeke, Goudwinde, Infrax		
Houthalen, Biogerna		
Geel, VITO – IRMM		

Sources: Esn, HERE, Delorne, USGS, Intermap, increment P Corp, NRCAN, Esn Japan, METI, Esn China (Hong Kong), Esn (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors and the GIS User Community

Figure 3.

Location of existing and planned heat networks in Flanders, as known in 2015 (excluding the planned networks MIROM and Indaver – Doel).

CHAPTER 4. POTENTIAL HEATING SUPPLY POINTS

Directive 2012/27/EU on energy efficiency stipulates that, by 31 December 2015, each Member State must carry out an assessment of the potential for high-efficiency cogeneration and efficient district heating and cooling. As part of this, a map is to be made of the territory, identifying (while preserving commercially sensitive information) potential heating and cooling supply points, including:

- Electricity generation installations with a total annual electricity production of more than 20 GWh,
- Waste incinerators,
- Combined heat and power plants.

For each of the above-mentioned categories, this chapter sets out an overview of those plants in Flanders in 2012 that were operational or planned. Additional potential supply points for heat are enterprises with a supply of residual heat, the potential for which will also be discussed in this chapter. Only enterprises that are obliged to produce an IEAR (or connected to the Fluxys natural gas network) are included in this estimation of potential.

This chapter also sheds light on the methodology for estimating residual heat for each category of these potential supply points, as well as the results.

4.1. Electricity generating installations (>20 GWh/Year)

4.1.1. Overview

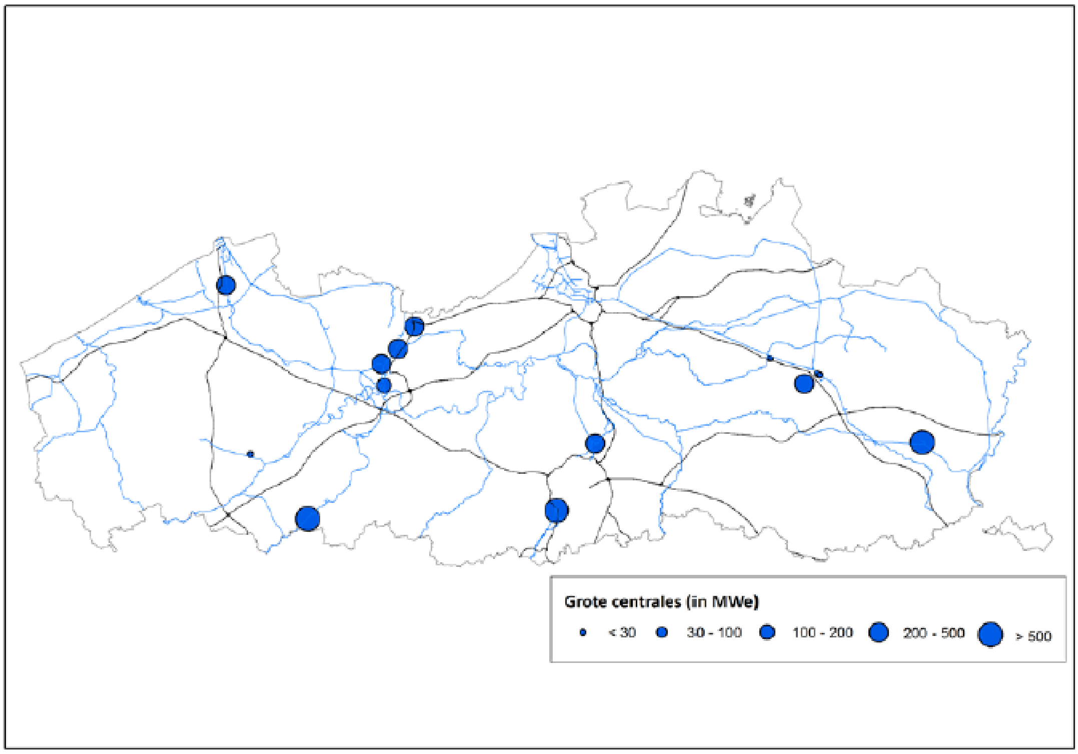
These are installations that only produce steam, rather than CHP plants or waste incinerators. Moreover, the Directive lays down a minimum level of electricity production, namely at least 20 GWh a year, which means that a number of installations could be excluded due to having too low a capacity (landfill gas plants) and/or too few hours of full load (turbojets). The following installations were in this category in 2012:

Name	Public or self-producer?	Description	Net kW_e
Langerlo (including Repow)		Conventional thermal	556 000
Rodenhuize	Public	Conventional thermal	268 000
Ruien	Public	Conventional thermal	627 000
Drogenbos	Public	Gas-steam turbine (combined cycle)	538 000
Vilvoorde	Public	Gas-steam turbine (combined cycle)	385 000
Herdersbrug	Public	Conventional thermal	460 000
Ghent Ham expansion	Public	Gas-steam turbine (combined cycle)	104 000
Ghent Ringvaart	Public	Conventional thermal	357 000
Knippegroen	Public	Conventional thermal	305 000
T-Power Beringen	Public	Gas-steam turbine (combined cycle)	422 000
Biokracht A&S energie	Public	Other	24 600
BP Chembel (PTA2)	Self-producer	Steam turbine with condenser	4 455

TC Ham sulphuric	Self-producer	Steam turbine with condenser	12 780
BP Chembel (PTA3)	Self-producer	Other	20 000
4HamCogen	Self-producer	Other	9 820

Table 4: Overview of electricity generating installations (not waste incinerators or CHP plants) with a production > 20 GWh in Flanders in 2012

These installations have been mapped, as follows:



Key to graphic
Grote centrales (in MWe) = Large plants (in MW_e)

Figure 4: Overview of installations that generate > 20 GWh of electricity (not waste incinerators or CHP plants) – [MW_e]

4.1.2. Method of estimating potential residual heat

In this section we estimate the potential residual heat from electricity generation installations with a total annual electricity production of over 20 GWh that were operational or planned in 2012. There are various categories of installations that generate electricity; we establish the list of installations with a potential for residual heat for heating via elimination:

- A couple of installations are located within industrial enterprises. We decided to exclude these as residual heat from industry is estimated separately (see Section 4.4).
- We also decided to exclude nuclear plants, since we consider it difficult to cost-effectively provide a heat take-off in such plants within the confines of the strict safety rules applicable. Moreover, we also worked on the assumption that there is no support for this in society.

After these exclusions, we are left with the following 12 installations, the installation type and the net capacity being derived from the Energy balance sheet for Flanders 2012.

Table 5: Overview of electricity generating installations with a potential for residual heat

Location	Installation	Technology	Primary fuels	Net MW_e	Remarks
Ostend	Biofuel	Diesel engine	Bio-oil	16.6	5 km from Ostend and 1 km from IVOO Electricity production < 20 GWh
	GreenPower	Diesel engine	Bio-oil	19.5	
Bruges	Herdersbrug	CCGT	Natural gas	460	1 km from IVBO from where a heat network already originates Now used as a peak load plant
Oostrozebeke	Biokracht A&S	Grate kiln	Biomass	24.6	
Ghent	Knippegroen	Conventional thermal	Blast furnace gas	305	
	Rodenhuize 4	Conventional thermal	Biomass and blast furnace gas	268	
	BEE	Conventional thermal	Biomass	215	In all likelihood will commence operation in 2017
	Ringvaart	Gas turbine	Natural gas	350	
	Ham	Gas turbine	Natural gas	104	Already supplies a heat network
Ruien	Ruien	Conventional thermal	Coal, biomass, natural gas	627	Closed in 2013
Vilvoorde	Verbrande Brug	CCGT	Natural gas	385	Now used as a peak load plant
Drogenbos	Drogenbos	CCGT	Natural gas	538	Now used as a peak load plant
Beringen	T-Power	CCGT	Natural gas	422	
Ham	4HamCogen	Grate kiln	Biomass	9.8	
Genk	Langerlo	Conventional thermal	Coal, biomass, natural gas	556	Is being taken over and converted into a biomass-powered station; will be 519 MW_e after conversion.

For the sake of completeness, Table 5 also includes three installations that are not included in the calculations:

- Ruien, which was still producing electricity in 2012 but has since been definitively withdrawn from service;
- BEE, a new biomass-powered station built at the Ghent coal terminal, but that will only supply electricity from 2017 at the earliest.

Some installations have an annual electricity production below 20 GWh, specifically the two bio-oil installations in Ostend. For the sake of completeness, these installations are in fact included in the calculations.

For the plants in Herdersbrug, Vilvoorde and Drogenbos, market conditions have led their operators to use them as peak load plants. As a result, it is possible that their annual electricity production will also fall below 20 GWh. Nonetheless, these plants are in fact included in the calculations.

For the above-mentioned installations, we estimate the residual heat potential. The supply of residual heat renders these installations de facto CHP plants. As the basic hypothesis for estimating this potential, we assume the highest possible conversion of fuel to electricity and heat. As a result of this assumption, the results of this estimate provide a technical upper limit for the potential supply of heat. The CHP inventory shows that the overall efficiency (electrical & thermal) of a CHP plant with a capacity over 20 MW_e is 80 % on average. We therefore assume this figure for the overall efficiency of these plants following their conversion to supplying heat.

Power plants are installations that are designed to generate as much electricity as possible from the fuel in question. However, if heat is removed from these plants in order to feed a heat network, this leads to a fall in electrical efficiency. We use two sources in order to be able to estimate this:

- JRC (2012) Background Report on EU-27 District Heating and Cooling Potentials, Barriers, Best Practice and Measures of Promotion:
  - Chapter 19 sets out how to take account of a loss in electrical efficiency. Ultimately, a Z factor equal to the ratio of increase in thermal efficiency with respect to the loss in electrical efficiency is used.
  - A number of examples are also given:
    - p. 151: Nordjylland plant (Denmark, coal-fired): Z factor of 7;
    - p. 153: a combined cycle gas turbine plant: Z factor of 5.6.
    - Gas-powered plants thus apparently have a lower Z factor.
- Ricardo-AEA (2011) A study into the recovery of heat from power generation in Scotland
  - A Z factor of 6.3 is assumed for 4 plants due to be converted;
  - 3 of the 4 plants burn coal (1 of them in combination with biomass); the other plant burns gas.

For our calculation, we assume a Z factor of 6. A limited sensitivity analysis shows that increasing or reducing this Z factor by 1 decreases or raises the potential residual heat by around 4 %. It is thus not a critical factor.

We therefore decided to apply this approach to the 12 plants listed above. However, since the operational data of these individual installations are confidential, we make the following assumptions:

- Electrical capacities are known (see Table 5); for Langerlo the expected capacity after conversion is used (519 MW).
- For electrical efficiency, we have taken the figures from a recent study by Ricardo-AEA, where research was conducted into electrical efficiencies of plants to update the reference efficiencies for CHP:[2]
  - 33 % for < 25 MW biomass-powered installations (Biokracht A&S; 4HamCogen)
  - 35 % for blast furnace gas-powered installations (Knippegroen)
  - 37 % for > 25 MW biomass-powered installations (Langerlo)
  - For Rodenhuize 4 (180 MW from biomass, 88 MW from blast furnace gas), a weighted average of the two efficiencies above was used
  - 44 % for the two bio-oil installations in Ostend
  - 53 % for the gas-fired plants.
- We assume the following percentages of hours at full load:
  - 5 % of the time throughout the year for peak load plants

[2] Ricardo-AEA (2014) Review of the Reference Values for High-Efficiency Cogeneration – DRAFT report to the stakeholders – Table 12: Proposed electrical and heat reference values, p. 23.

- 40 % for gas and bio-oil-fired plants
- 60 % for biomass and/or blast furnace gas-fired plants.

A combination of the capacity, electrical and thermal efficiencies and hours of full load provides an estimate of the potential supply of residual heat.

4.1.3. RESULTS

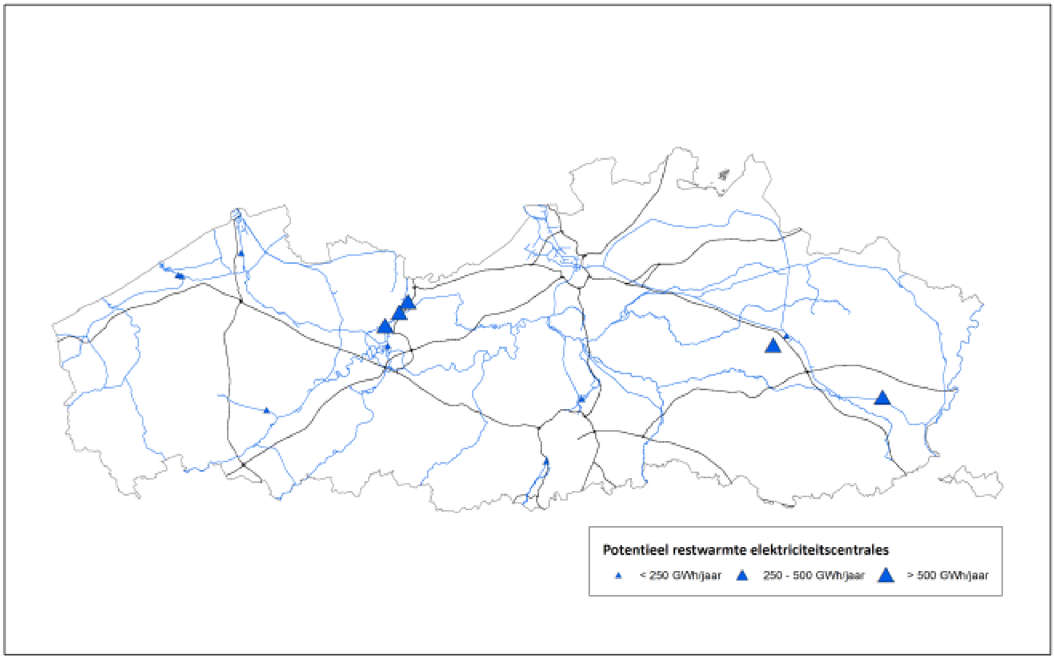
Table 6 and Figure 5 show the estimates of the residual heat potential for electricity generation installations obtained according to the method explained above.

Table 6: Estimated residual heat potential for plants with electricity generation > 20 GWh in Flanders in 2012

Location	Installation	Net MW_e	η_{elec} Before	η_{elec} After	η_{therm} After	Percentage of hours at full load (%)	Production of heat (GWh)	Reduction in electricity production (GWh)
Ostend*	Biofuel	16.6	44 %	37 %	43 %	40 %	60	10
	GreenPower	19.5	44 %	37 %	43 %	40 %	70	10
Bruges	Herdersbrug	460	53 %	48 %	32 %	5 %	120	20
Oostrozebeke	Biokracht A&S	24.6	33 %	24 %	56 %	60 %	220	40
Ghent	Knippegroen	305	35 %	26 %	54 %	60 %	2 470	410
	Rodenhuize 4	268	36 %	28 %	52 %	60 %	2 030	340
	Ringvaart	350	53 %	48 %	32 %	40 %	750	130
	Ham**	104	53 %	48 %	32 %	40 %	200	40
Vilvoorde	Verbrande Brug	385	53 %	48 %	32 %	5 %	100	20
Drogenbos	Drogenbos	538	53 %	48 %	32 %	5 %	140	20
Beringen	T-Power	422	53 %	48 %	32 %	40 %	900	150
Ham	4HamCogen	9.8	33 %	24 %	56 %	60 %	90	10
Genk	Langerlo	519	37 %	28 %	52 %	60 %	3 800	630
TOTAL							**11 000**	**1 800**

** Both installations generate less than 20 GWh of electricity.*
*** This installation already supplies a heat network (CHP) and thus does not offer any additional potential.*

The overall residual heat potential according to this estimate is 11 TWh, with a temperature level between 80 and 120 °C. As stated above, this is an upper limit, as we assume that all of the installations can operate in CHP mode with an overall efficiency of 80 %.



Key to graphic:
Potentieel restwarmte elektriciteitscentrales = Potential residual heat for electricity plants

Figure 5: Estimated residual heat potential for plants with electricity generation > 20 GWh in Flanders in 2012.

Three quarters of the potential is in three plants, half of which is in the shape of the Langerlo plant. Ideas have already been mooted for this plant in respect of the establishment of a local heat network. The Ghent facilities of Knippegroen and Rodenhuizen are also potentially important heat suppliers.

Half of the potential is located in the port of Ghent, which is thus deemed to be outside the future potential of the BEE plant, the residual heat potential of which we estimate to be 1 200 GWh a year using the same method.

The Herdersbrug plant is 1 km from IVBO waste incinerator, which already supplies a heat network, which increases the chances that this plant could be connected to a heat network. The plant is currently used as a peak load plant. If the position of the Hedersbrug plant were reviewed and consideration given to using it as a normal plant instead of a peak load one, that would have a positive impact on the potential. Assuming that the hours of full load will then increase from the 5 % we assumed to 40 % a year, the potential increases by 860 GWh (from 120 to 980 GWh).

As explained in the methodology, where electricity plants supply heat, this leads to a reduction in the production of electricity. Under the assumptions sketched out above, the total reduction in electricity production amounts to 1.8 TWh, which is equivalent to a fall of 19 %:

- This is more than the disconnection of a gas plant of around 500 MW_e at 40 % of full load hours; or
- more than the total production of electricity from wind and biogas in Flanders together in 2014 (1 655 GWh); or
- around one tenth of the total energy input in Flanders in 2014.

It goes without saying that this reduction in electricity production will have to be compensated for in some other way.

4.2. Waste incinerators

4.2.1. Overview

Table 7 provides an overview of those installations that were in the category of ‘waste incinerators’ in 2012. The origin of the waste that is handled by these installations and their capacity is taken from the Flemish Public Waste Agency, OVAM.[3] The type of installation and net capacity is taken from the Energy balance sheet for Flanders 2012.

Table 7: Overview of waste incinerators in Flanders in 2012.

Location	Name	Origin of waste	Incineration in 2012 (tonnes/ year)[3]	Installation type	Heat supplied, 2012 (MWh)
Ostend	IVOO	Household	61 651	Steam turbine with condenser	
	Bio-steam plant	Industrial	158 603	Diesel engine	
Roeselare	MIROM	Household	64 532	Other	27 420
Bruges	IVBO	Household	162 290	Back-pressure steam turbine	43 009
Knokke-Heist	Dalkia	Household	33 938	Other	508
Harelbeke	IMOG	Household	63 489	Steam turbine with condenser	
Eeklo	IVM	Household	95 460	Other	
Ghent	IVAGO	Household	104 161	Steam turbine with condenser	45 947
Beveren	SLECO	Industrial	585 739	Steam turbine	
Beveren	Indaver grate kiln	Household	414 318	Steam turbine with condenser	173 724
Antwerp	Indaver rotating drum combustion plants	Industrial	141 649	Steam turbine	214
Wilrijk	ISVAG	Household	152 020	Other	
Houthalen-Helchteren	Bionerga	Household	94 569	Steam turbine with condenser	24 016
TOTAL			**2 132 419**		**314 838**

In 2012 the waste incinerators supplied 315 GWh of heat to third parties (see the overview of heat supplied in Chapter 3), while they incinerated 2.1 million tonnes of waste, which equates to 5 900 GWh calculated at 10 GJ/tonne. This means that 5.3 % of the energy input into the Flemish municipal waste incinerators is supplied to a heat network as heat. Some of these installations do not supply any heat. If we only include those installations that do supply heat, this figure rises to

[3] OVAM (2014) Charges and capacities for landfill and incineration – Update 2013

11 %. The maximum supply of heat to the network is 15 to 16 % for MIROM, IVAGO and Indaver Beveren.

4.2.2. METHOD OF ESTIMATING POTENTIAL RESIDUAL HEAT

In order to estimate potential residual heat from waste incinerators, we looked to other countries.

The supply of heat from waste incinerators in the Netherlands was investigated in 2010 by CE Delft; see Table 8.[4]

Table 8: The efficiency of electricity generation and heat supply and CO_2 emissions prevented as a result of waste incinerators in the Netherlands (2008).

	Efficiency (as a percentage of the energy value of waste incinerated)		CO_2 emissions prevented
	Electrical (net supplied)	Heat supplied	Total, electrical + heat
AZN	25 %	13 %	482
AEB	26 %	2 %	423
EVI	27 %	0 %	422
ARN	16 %	21 %	389
SITA ReEnergy	22 %	5 %	379
HVC Dordrecht	21 %	4 %	361
AVR Rijnmond	15 %	17 %	339
HVC Alkmaar	21 %	1 %	336
Twence	15 %	12 %	316
Attero Wijster (formerly Essent)	18 %	0 %	289
AVR Duiven	10 %	15 %	258
AVR Rotterdam*	12 %	0 %	194

The figures show that in 2008 Dutch waste incinerators supplied 1 600 GWh of heat to heat networks, while they incinerated enough waste (plus supplementary fuels) to generate 20 000 GWh. This means that 8 % of the energy input into Dutch municipal waste incinerators in 2008 was supplied to a heat network as heat. Some of these installations do not supply any heat. If we only include those installations that do supply heat, this figure rises to 9.6 %. The maximum supply of heat to the network is 21 % for the ARM installation at Nijmegen. In 2008 this plant had an electrical efficiency of 16 %, or an overall efficiency of 37 %. The AZN waste incinerator at Moerdijk also has an overall efficiency of 38 %, although the electricity/heat ratio is different.

Next, we take a look at waste incinerators in Sweden, a country where heat networks are widely used and where waste incinerators provide a basic source of heat in over 30 towns and cities.

[4] CE Delft (2010) Better high-efficiency incineration than incineration close to home – How much waste transportation is useful for improving energy efficiency?

We were able to find the following data on the supply of heat for 26 of Sweden's 33 waste incinerators in 2012; see Table 9.[5]

In 2012 no less than 83 % of the energy input into these 26 Swedish municipal waste incinerators was supplied to a heat network as heat. A number of the Swedish installations supply all of the heat that they develop from waste incineration to a heat network.

Table 9: Efficiency of heat supplied via waste incinerators in Sweden (2012).

2012	Waste input (tonnes)	Waste input (GWh)	Heat production (MWh)	Heat production/ waste input
Avesta	54 444	176	176	100 %
Bollnäs	70 000	196	90	46 %
Borlänge	90 958	237	203	86 %
Eda	60 537	163	144	89 %
Esksjö	55 000	154	88	57 %
Gothenburg	539 118	1 662	1 317	79 %
Halmstad	185 000	517	388	75 %
Helsingborg	40 000	112	80	72 %
Hässleholm	50 000	140	101	72 %
Jönköping	165 000	461	270	58 %
Karlstad	48 389	152	152	100 %
Kiruna	65 995	195	136	70 %
Köping	28 670	67	67	100 %
Landskrona	12 000	34	28	83 %
Lidköping	100 000	280	280	100 %
Linköping	400 000	1 118	827	74 %
Malmö	549 365	1 579	1 325	84 %
Mora	19 000	55	53	96 %
Norrköping	205 169	514	514	100 %
Stockholm	520 000	1 565	1 537	98 %
Sundsvall	185 000	517	368	71 %
Södertälje	175 000	527	527	100 %
Uddevalla	98 000	274	141	52 %
Umeå	160 000	447	277	62 %
Uppsala	375 000	1 049	1 030	98 %
Västervik	56 000	157	123	79 %
TOTAL				**83 %**

We use the Swedish situation as a guide for estimating the potential residual heat from waste incinerators in Flanders:

- 20 % of the energy input into a waste incinerator is used to generate electricity;

[5] Sources: ISWA (2012), Waste-to-energy state-of-the-art-report; the Swedish Waste Management and Recycling Association (2013), *Kapacitetsutredning 2013 – afvallsförbränning till år 2020* [Capacity study 2013 – waste incineration up to 2020]; statistics from the Swedish District Heating Association: *Fjärrvärmens bränslen och produktion 2012* [District heating: fuels and production 2012].

- 80 % of the energy input into a waste incinerator can be supplied to a heat network as heat.

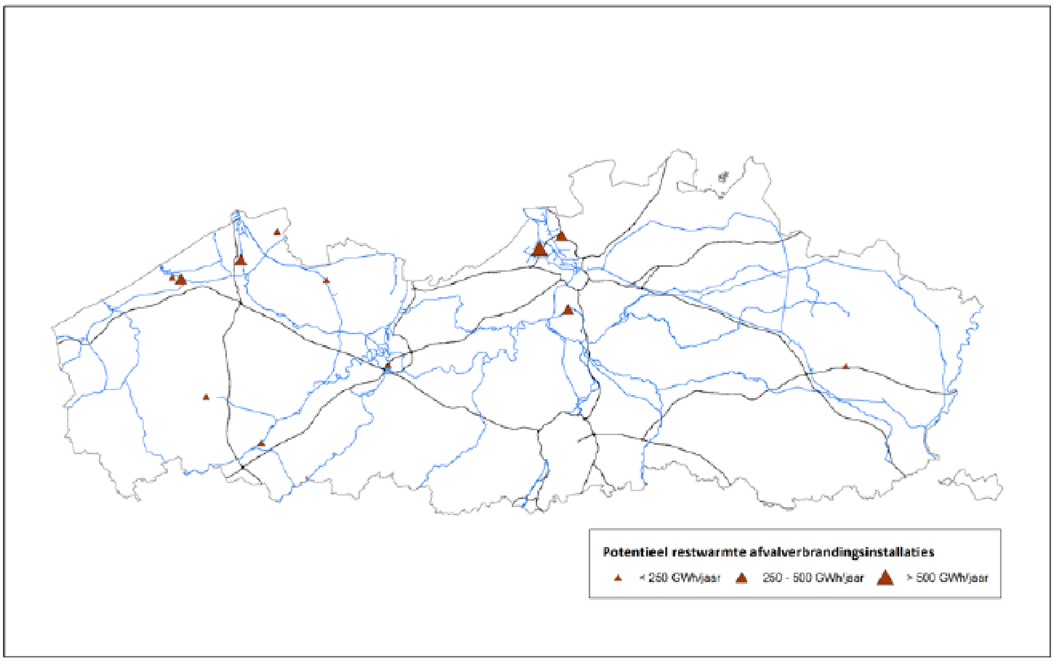
As with the electricity plants, this assumption leads to an estimation of the upper limit of residual heat potential. Such high thermal efficiencies can only be realised with large heat networks to which waste incinerators can act as a basic source of heat full time (as is currently the case in Sweden).

4.2.3. RESULTS

Table 10 and Figure 6 show the estimated potential residual heat from waste incinerators. As stated above, this is an estimate of the maximum potential.

Table 10: Estimated potential residual heat from waste incinerators in Flanders, 2012

Location	Name	Origin of waste	Capacity (kton/year)	Energy input (GWh/year)	Potential heat output (GWh/year)
Ostend	IVOO	Household	77	210	170
	Bio-steam plant	Industrial	180	500	400
Roeselare	MIROM	Household	68	190	150
Bruges	IVBO	Household	206.5	570	460
Knokke-Heist	Dalkia	Household	33	90	70
Harelbeke	IMOG	Household	84	230	190
Eeklo	IVM	Household	104	290	230
Ghent	IVAGO	Household	99.5	280	220
Beveren	SLECO	Industrial	466	1 290	1 040
Beveren	Indaver grate kiln	Household	382	1 060	850
Antwerp	Indaver rotating drum combustion plants	Industrial	150	420	330
Wilrijk	ISVAG	Household	158	440	350
Houthalen-Helchteren	Bionerga	Household	89	250	200
TOTAL					**4 700**



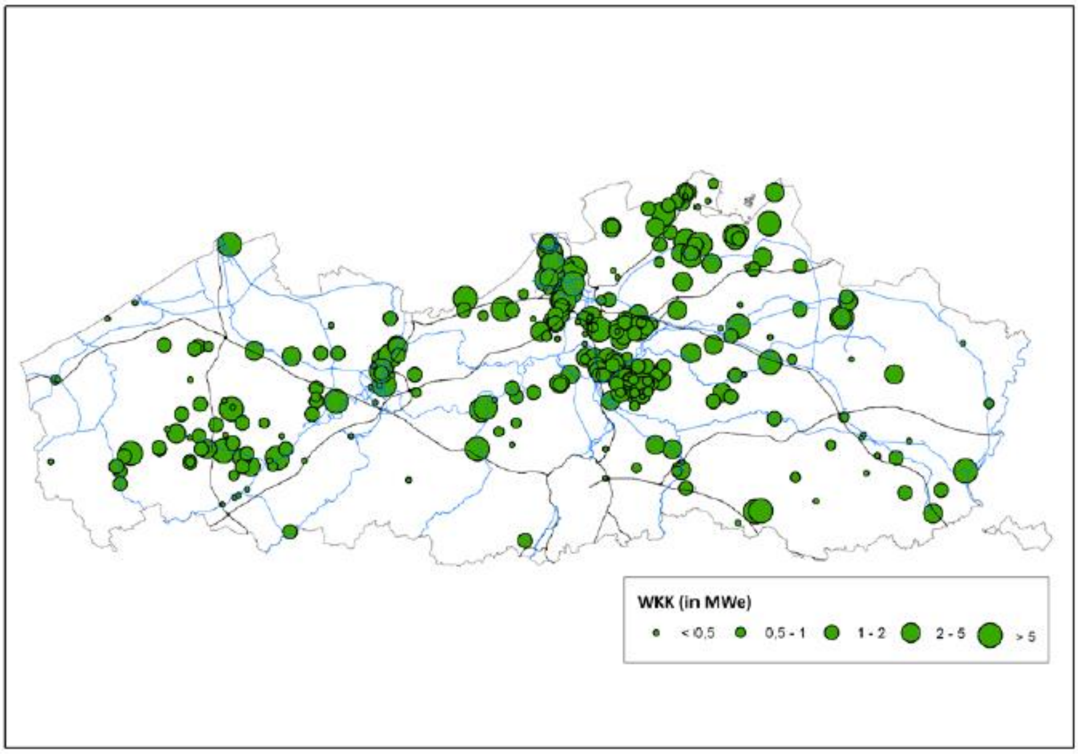
Key to graphic:
Potentieel restwarmte afvalverbrandingsinstallaties = Potential residual heat from waste incinerators

Figure 6: Estimated potential residual heat from waste incinerators in Flanders, 2012.

The overall (maximum) potential is 4 700 GWh. In accordance with their incineration capacity, the two largest potential sources of heat are the Indaver installations in Beveren. If we had applied a thermal efficiency of 20 %, which is the maximum that is realised in the Netherlands, the potential would decrease by a factor of 4 to 1 200 GWh.

4.3. COMBINED HEAT AND POWER PLANTS

The existing CHP plants from 2012 included in the following map (Figure 7) can also be seen in Table 18 in Annex A. CHP plants with a capacity < 50 kW_e have not been included (as yet). If a plant was replaced in the course of 2012, the most recent plant is the one to be found in the map below.



Key to graphic:
WKK (in MWe) = CHP plants (in MW_e)

Figure 7: Overview of the location of CHP plants in Flanders by capacity class (excluding plants < 50 kW_e) – [MW_e]

4.4. RESIDUAL HEAT IN INDUSTRY

The potential for industrial residual heat is made up of large industrial point sources (enterprises subject to IEAR). Residual heat has not been estimated for smaller enterprises, as we assume that their residual heat would be of too low a temperature for valorisation (< 80 °C).

4.4.1. METHOD OF ESTIMATING POTENTIAL RESIDUAL HEAT

For the format of the industrial residual heat map, we follow the same method as in the Netherlands. This method was developed by the consultancy firm PDC and is referred to in the rest of this report as 'the PDC method'.[6]

The PDC method first translates the net heat demand, i.e. the fuel consumption used for heat requirements, into a gross heat demand for the various industrial sectors split between:

- HTH: > 200 °C
- MTH: 120-200 °C
- LTH: < 120 °C

[6] Source: H. Vleeming, E. van der Pol (2011) *Ontwikkelen van methodieken voor het opstellen van industriële warmtekaarten* [Development of methodologies for the drawing-up of industrial heat maps]. Process Design Center B.V.

The PDC method then assumes that half of the heat demand of a higher level is available for internal use at a lower level. The other half is available as residual heat. Ultimately, all heat that is demanded degrades to residual heat. Text box 1 explains the method; Figure 8 illustrates it.

Text box 1: Example to illustrate the PDC method for estimating industrial residual heat.

Suppose an enterprise has a net heat demand of 50 GWh/year.

The PDC method provides a breakdown of heat demand by temperature level for each industrial activity/sub-sector. Suppose this enterprise has the following distribution:

- Percentage of heat demand > 200 °C: 30 %
- Percentage of heat demand 120-200 °C: 70 %
- Percentage of heat demand < 120 °C: 0 %

Under the PDC method, half of the heat at a higher level is available as heat at a lower level:

- All heat > 200 °C (30 %) is provided from external energy sources.
- A proportion of the heat at 120-200 °C is residual heat from > 200 °C: 15 %, i.e. half of the 30 %
- The rest of the heat at 120-200 °C is provided from external energy sources: 70 % - 15 % = 55 %
- The enterprise has no demand for heat at < 120 °C.

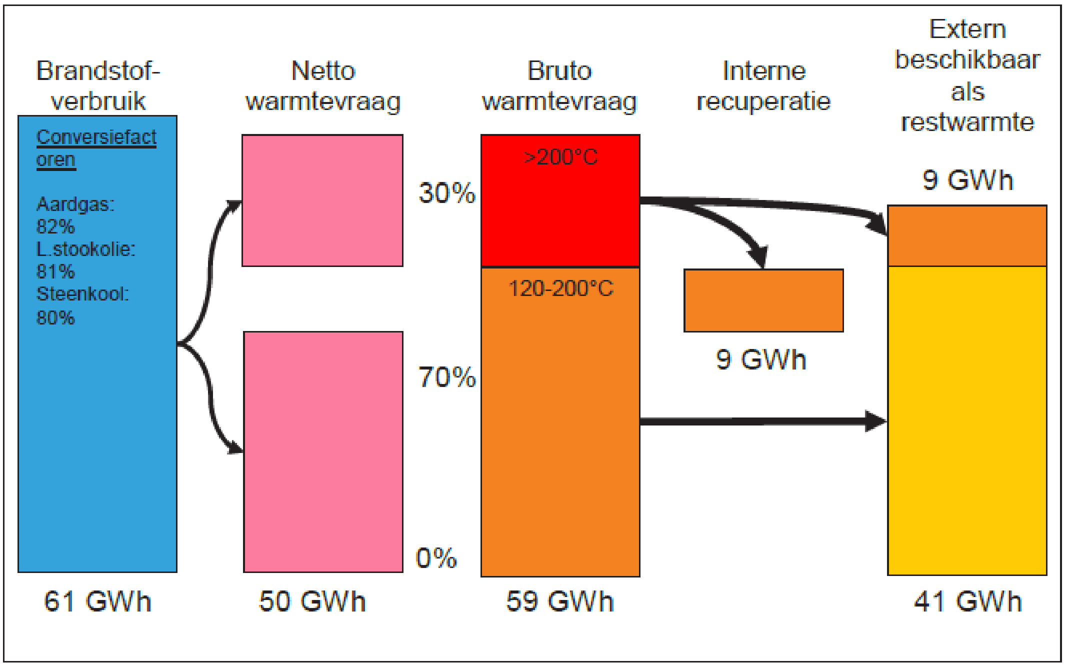
The GROSS heat demand is calculated from this:

GROSS = NET/proportion that has to be provided from external energy sources = 50/(30 % + 55 %) GWh/year = 59 GWh/year

Of this gross heat demand:

- 30 % is at > 200 °C: 18 GWh/year
  - of which half is available as *internal* residual heat at 120-200 °C: 9 GWh/year
  - of which half is available as *external* residual heat at 120-200 °C: 9 GWh/year
- 70 % is at 120-200 °C: 41 GWh
  - of which none is available as internal residual heat as the enterprise does not have any heat demand at < 120 °C;
  - therefore all of this is available as external residual heat at < 120 °C: 41 GWh/year

What results is an estimate of the residual heat supply for two temperature ranges: below 120 °C and between 120 and 200 °C, 41 and 9 GWh/year respectively.



Fuel consumption	Net heat demand		Gross heat demand	Internal recovery	Externally available as residual heat
Conversion factors			> 200 °C		
		30 %			9 GWh
Natural gas: 82 %					
Light fuel oil: 81 %					
Coal: 80 %			120-200 °C		
		70 %		9 GWh	
		0 %			
61 GWh	50 GWh		59 GWh		41 GWh

Figure 8: Illustration of the PDC method for estimating residual heat for industry.

The PDC method estimates the residual heat potential by first taking account of the first law of thermodynamics: in other words, all the fuel that is used in the enterprise also leaves the enterprise in one way or another as residual heat. The PDC method takes no account of the second law of thermodynamics; in other words, it does not pay attention to how the heat is made available and whether it is technically recoverable (e.g. widely dispersed release via dissipation as opposed to release in a concentrated stream as pressurised hot water at e.g. 150 °C). This estimate of potential is consequently to be regarded as a theoretical potential and provides an upper limit for the potential residual heat supply.

Another shortcoming of the PDC method is that, for a number of sectors, it puts the internal heat demand in the top temperature bracket (> 200 °C). According to this methodology, enterprises from the sectors in question thus have a potential supply of residual heat at 120-200 °C equal to their internal heat demand, which is an overestimation.
This applies to the following sectors specifically:

- The ceramics sector (manufacture of bricks, tiles, other earthenware, glass)

- The iron and steel sector (blast combustion plants, rolling mills, foundries).

For the chemicals and refineries sectors, the estimates under this PDC method were adjusted, in consultation with the VEA, the Belgian Federation for Chemistry and Life Sciences Industries (Essenscia) and the Belgian Petroleum Federation, in the light of the results of the MIP2 heat study.[7] The study in question concluded as follows (on pages 21 and 22):

'Figure 1 [included below as Figure 9] *shows a map bearing an inventory of heat losses by business cluster on industrial sites operating with integrated heat supplies (referred to as 'utilities')… The capacities given represent a summary of inventorised residual heat sources with a capacity of at least 1 MW_{th} and a temperature between 80 and 120 °C. Taken together, they have a capacity of approximately 433 MW_{th}.*

Alongside the heat losses on sites with integrated utilities, another 48 MW_{th} of residual heat was recorded on non-integrated industrial sites, which is to say sites with simpler heat supplies. This gives rise to a total of approximately 481 MW_{th} of residual heat at temperatures between 80 and 120 °C.

In the course of inventorising residual heat, it was observed that at higher temperatures, too, a good deal of residual heat is lost. This was not recorded or quantified in detail, but the experts estimate the total capacity involved to be of the same magnitude as the heat loss between 80 and 120 °C.'

The adjustment was implemented in this study as follows:
- For every cluster within Antwerp's port area, illustrated in Figure 9, the overall estimate of residual heat potential for the temperature range < 120 °C obtained under the PDC method was compared with the estimate of potential under the MIP2 heat study. This gives a ratio for each cluster that is applied as a correction factor to each of the individual enterprises within the clusters. In so doing, Cluster 2 is divided into BRC (refinery) and the rest (chemicals companies).
- The correction factor for Cluster 3 in Antwerp's port area acts as a model for the other large chemicals companies in Flanders (average heat demand in this cluster: 6.9 PJ). This factor is then applied to the following three enterprises:
    - BP Chembel Geel
    - Evonik, Antwerp
    - Ineos Chlorvinyls Belgium
- For the other chemical companies in Flanders we use the correction factor for Cluster 5 (average heat demand in this cluster: 1.67 PJ).
- These correction factors are applied to the temperature range < 120 °C. For the temperature range 120-200 °C – based on the last paragraph of the conclusions of the MIP2 heat study quoted above – the estimate for < 120 °C is copied.

Alongside this practice for the chemicals and refineries sector, for seven other enterprises residual heat estimates were submitted to VITO/the VEA by the enterprises themselves. These were used in the estimate of potential instead of our estimates under the PDC method.

[7] Antwerp Port Authority (2012) *Havenwarmte – Haalbaarheidsonderzoek naar de valorisatie van industriële restwarmte in de haven van Antwerpen* [Port heat – Feasibility study into the valorisation of industrial residual heat at the Port of Antwerp].

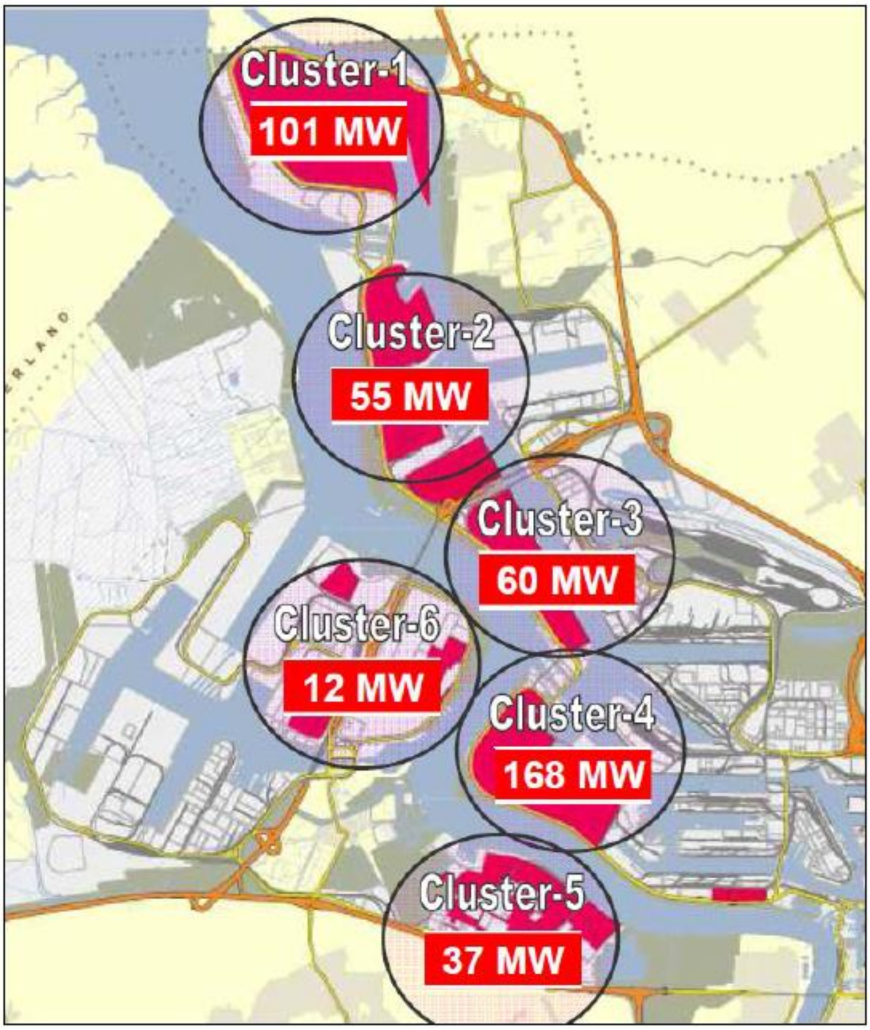


Figure 9: Clusters of industrial residual heat losses (source: Antwerp Port Authority), Port of Antwerp.

4.4.2. Results

Table 11 shows the results for Flanders by industrial sub-sector under the PDC method, while Figures 10 and 11 show this residual heat supply by point source for the temperature ranges < 120 °C and 120-200 °C, respectively. Those businesses without residual heat supply are not included on the map. As stated above, this estimate of potential provides a theoretical potential or an upper limit for the residual heat supply. Thus, the residual heat > 120 °C will not necessarily be available for external provision of heat, but it could be internally recovered within companies if suitable applications are available. It is therefore important that more detailed feasibility studies are carried out to investigate what application is feasible for such residual heat.

Table 11: Supply of residual heat by industrial sub-sector in Flanders (< 120 °C and 120-200 °C) for the base year 2012 – [GWh]

	Heat demand (GWh)	Supply of residual heat <120 °C (GWh)	Supply of residual heat 120-200 °C (GWh)
Refineries	17 300	900	900
Iron & steel	4 300	0	4 300 (*)
Non-ferrous metals	1 500	200	800
Chemicals	33 600	4 900	4 900
Minerals	2 100	600	1 400 (*)
Food	5 600	500	0
Textiles	600	0	0
Paper, printing	3 000	0	0
Technology	900	0	0
Plastics, wood	1 200	200	0
TOTAL	**70 100**	**7 400**	**12 300**

(*) Overestimation of the potential due to failure to take adequate account of the possibilities for internal heat recovery under the PDC method; see previous remark in the description of the method.

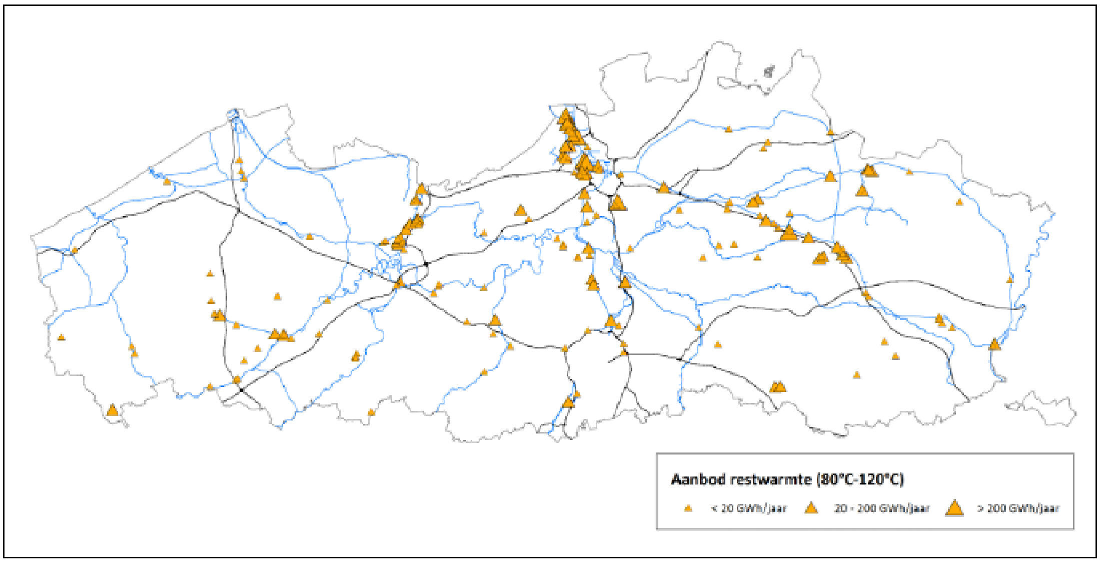


Figure 10. Supply of residual heat at < 120 °C from large-scale industry in Flanders in 2012 – [GWh/year]

Key to figure:
Aanbod restwarmte (80˚C-120˚C) = Supply of residual heat (80 ˚C-120 ˚C)

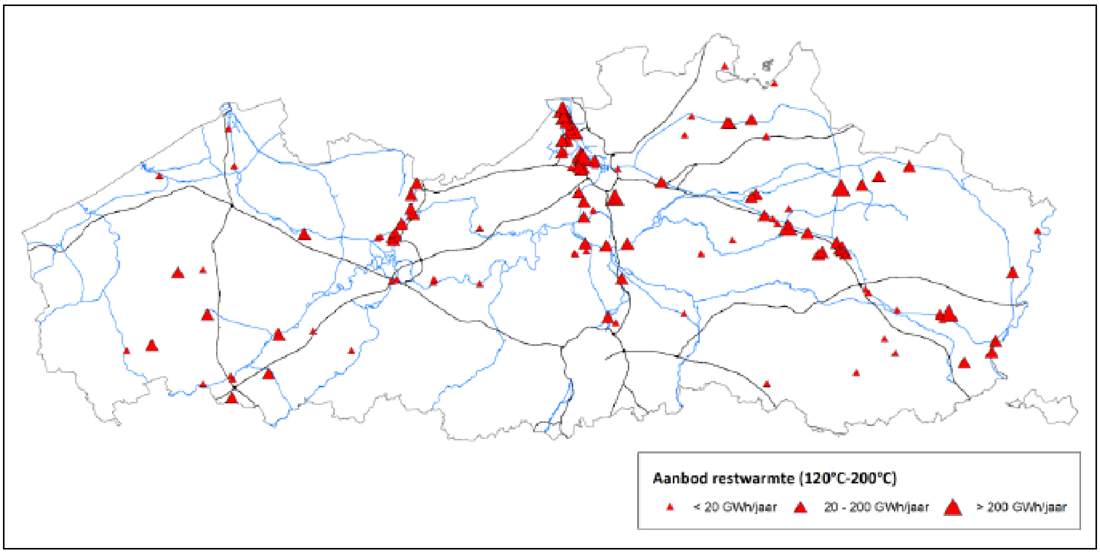


Figure 11. Supply of residual heat at 120-200 °C from large-scale industry in Flanders in 2012 – [GWh/year]

Key to figure:

Aanbod restwarmte (120˚C-200˚C) = Supply of residual heat (120 ˚C-200 ˚C)

NB: Overestimation of the potential in the ceramics and iron and steel sectors due to failure to take adequate account of the possibilities for internal heat recovery under the PDC method; see previous remark in the description of the method.

According to this estimate the overall supply is 7 400 GWh in the temperature range 80-120 °C and 12 300 GWh in the temperature range 120-200 °C. The latter is an overestimation as, in the ceramics and iron and steel sectors, there is a failure to take adequate account of the possibilities for internal heat recovery under the PDC method.

Table 12 and Figure 12 provide more detail on the residual heat supply. As is to be expected, there is a great deal of variation in potential supply between enterprises. It varies from around 3.5 TWh to practically nothing. In total, 23 of the 384 enterprises that are required to produce an IEAR have a residual heat potential over 200 GWh a year, equivalent to 73 % of the total residual heat supply from industry in Flanders. The PDC method allocates no residual heat to a number of sectors such as food and textiles, in contrast to the practice in other European countries.

Table 11: Number of enterprises and total residual heat supply derived from large-scale industry in Flanders for the base year 2012.

Supply GWh/year	Supply of residual heat at < 120 °C		Supply of residual heat at 120-200 °C		Supply of residual heat at <200 °C	
	Number of enterprises	Total supply (GWh)	Number of enterprises	Total supply (GWh)	Number of enterprises	Total supply (GWh)
Zero	206	0	244	0	171	0
≤ 20	116	500	73	400	120	700

20 – ≤ 200	54	3 500	56	4 200	70	4 600
> 200	8	3 300	11	7 700	23	14 300
TOTAL	**384**	**7 400**	**384**	**12 300**	**384**	**19 700**

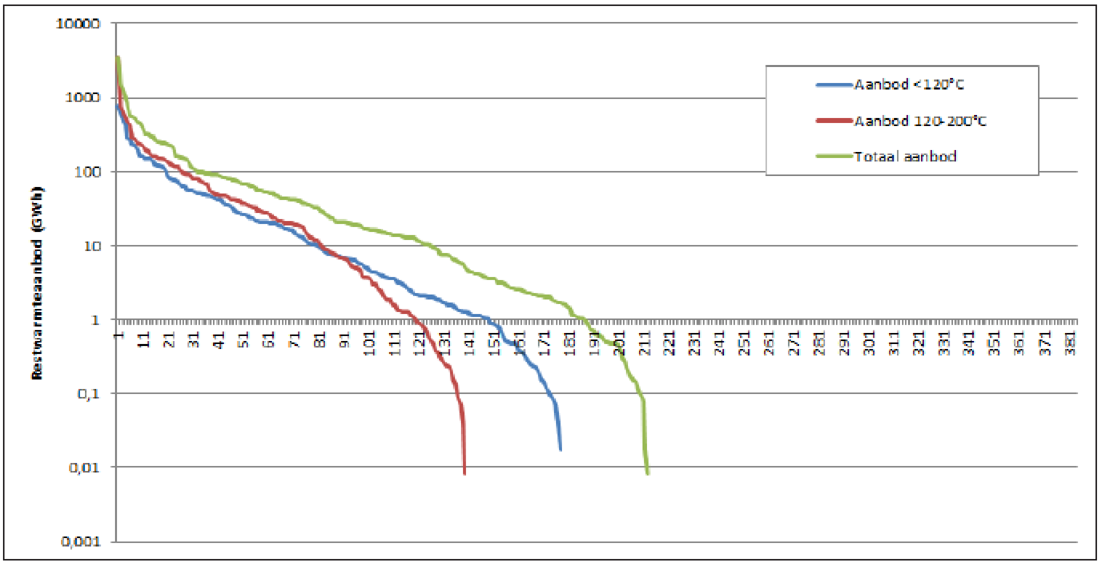


Figure 12. Pareto chart of the supply of residual heat by industrial point source for the base year 2012 – [GWh].

Key to figure:
Restwarmteaanbod = Residual heat supply
Aanbod <120˚C = Supply at < 120 ˚C
Aanbod 120-200˚C = Supply at 120-200 ˚C
Totaal aanbod = Total supply

CHAPTER 5. SCENARIOS FOR HEAT DEMAND AND SUPPLY

Annex VIII to Directive 2012/27/EU (the Energy Efficiency Directive or EED) stipulates that 'a forecast of how this demand [for heating and cooling] will change in the next 10 years, taking into account in particular the evolution of demand in buildings and the different sectors of industry' must be carried out. This forecast – along with the estimate of technical potentials – is preparatory to a cost-benefit analysis in order to be able to identify areas of economic interest in relation to connection to heat networks and the roll-out of high-efficiency cogeneration. In order to be able to portray differing possible evolutions of heat demand, the Directive requires that one or two alternative scenarios be developed along with the main forecast. Given the limited availability of energy forecasts for Flanders, it was decided, in consultation with our commissioning body, to only produce one main forecast in this study. In this chapter, we elucidate the methodology that we used to estimate future heat demand and provide an overview of the results.

5.1. Methodology

5.1.1. Existing energy forecasts taken as starting point

To derive the future evolution of demand for heat at Flanders level we utilise the WM scenario (the 'With Measures' scenario, also known as the BAU or 'Business As Usual' scenario) submitted to the Commission by the Flemish Department for the Environment, Nature and Energy (LNE) in 2015 in connection with the Monitoring Mechanism Regulation. These scenarios provide a recent reflection of the impact of current, known energy and climate policy, as well as independent developments, on the expected energy consumption in Flanders up to 2035. We would like to make it clear that only a WM scenario is being submitted, and no WAM ('With Additional Measures') scenario, as there is no clear evidence of any additional new policy.

In drawing up the WM scenario, the LNE used a simulation tool developed by VITO, together with the input of various government agencies, including the Flemish Energy Agency (VEA). The simulation tool enables forecasts to be simulated for greenhouse gases and air pollutants for the various CRF/NFR sectors (energy, industry, agriculture, service sector, households, etc.) up to 2035. The forecast for energy-related emissions in this connection is based on energy projections by sector (where appropriate by sub-sector) and energy source.

The WM scenario takes account of the following packages of policy measures and independent developments:

- Residential: existing and planned energy efficiency measures up to 2020, as submitted under the National Energy Efficiency Action Plan (NEEAP) 2014 (primarily Rational Use of Energy (RUE) actions); energy consumption (E-level) standardisation for new buildings up to 2020; Increased use of heat pumps in new buildings and solar boilers on renovation; in accordance with Ecodesign, mandatory use of condensing boilers in the case of gas/oil-fired boilers from 2016; developments in terms of numbers of families. For the degree of implementation of policy measures between 2020 and 2030, the 2020 policy level was maintained (or slightly increased).
- Service sector: independent developments in this sector, taking account of economic

growth and demographic developments; RUE actions, plus the tightening-up of energy performance for new buildings, were adopted as policy measures. Here, too, the policy for 2020 was continued to 2035.
- Buildings and industry: anticipated independent growth of activities up to 2035; anticipated improvement of energy efficiency given known policy/independent developments; increased use of CHP.

5.1.2. Resizing evolution in Flanders by grid cell

The evolution in energy consumptions from the WM scenario was converted into the evolution of heat demand, taking account of the expected increase in numbers of CHP plants and the expected progress in plant efficiencies. For the industrial sectors, we assume that future boiler efficiencies will remain constant in comparison to 2012 and we therefore assume these to be the same as the reference efficiencies in the AS-IS heat map (Table 1).

For the translation of future heat demand at Flanders level to local level (grid cell level), as much account as possible is taken of geographically specific information. At grid cell level, the following information is known with regard to local heat demand:

- Overall heat demand for the residential, service and agriculture sectors taken together (i.e. the buildings sector) and the overall heat demand for the industry sector (diffuse demand among enterprises not subject to IEAR). For large-scale industry (enterprises that are subject to IEAR), the overall heat demand is known for each specific enterprise.
- A further sub-division into sub-sectors in the industry sector or the buildings sector is not known at grid cell level, or at a higher geographical level such as a municipality.

Given the availability of heat demand at grid cell level, we aggregate the forecasts for heat demand at Flanders level so that we can get forecasts for the buildings sector (services, agriculture and residential) and for industry. These Flemish developments up to 2035 are then applied to every grid cell.

5.2. Results

5.2.1. Evolution of diffuse heat demand: buildings and small-scale industry

The table below sets out the evolution of heat demand at Flanders level for the industry and buildings sectors in relation to the base year 2012. This evolution is assumed for each grid cell within the Heat Map Flanders project.

Table 13: Evolution of heat demand in Flanders, based on WM scenario 2015.

	2012	2015	2020	2025	2030	2035
Residential, service sector and agriculture	100 %	98 %	94 %	92 %	91 %	90 %
Small-scale industry (excluding iron and steel)	100 %	99 %	104 %	107 %	111 %	116 %

5.2.2. Evolution of heat demand, industrial demand points and associated residual heat supply

For large-scale enterprises (those subject to IEAR), we believe it is better to assume no change in the heat demand. After all, producing an enterprise-level forecast involves a lot of uncertainty.

We then assume the residual heat supply and associated T subdivisions remain constant up to 2035. This reasoning is also supported by the fact that the current economic climate and energy prices provide a stimulus towards the efficient use of energy. We thus assume that, in new plants, residual heat will be utilised within the enterprise or prevented.

5.2.3. EVOLUTION OF RESIDUAL HEAT SUPPLY, WASTE INCINERATORS AND ELECTRICITY GENERATING INSTALLATIONS

Here, too, we apply a constant supply up to 2035, given the uncertainties.

CHAPTER 6. TECHNICAL POTENTIAL FOR HEAT NETWORKS AND CHP

To continue the study, it is necessary to produce an estimate of the technical potential for the various technologies for producing heat. We distinguish between the following technologies: CHP or micro-CHP replacing a combustion plant (in the industry or buildings sector), CHP installed to provide heat to a heat network, and a heat network. This technical potential forms the upper limit for the economic potential calculated in the cost-benefit analysis.

6.1. CHP REPLACING A COMBUSTION PLANT IN THE INDUSTRY, SERVICE AND AGRICULTURE SECTORS

We break down the estimate of the technical potential for CHP plants with a capacity > 50 kW_e into two groups, based on the calculations that we will later be performing in the cost-benefit analysis. Firstly, we have CHP plants that replace a combustion plant in the industry, service and agriculture sectors. Then we have the possibility of supplying heat to additional heat networks via new CHP plants.

For CHP plants that replace a combustion plant in the industry, service and agriculture sectors no current Flemish estimates of the technical potential are available. The most recent bottom-up analysis of the technological potential for Flanders dates back to 1997 (Martens and Dufait, 1997[8]) and is out of date, both in terms of realised CHP capacity and in the make-up of the Flemish economy. Other CHP scenario studies have always been partially or entirely based on the said study and are thus not directly usable as a basis for establishing the technical potential (Briffaerts et al., 2005) (Briffaerts et al., 2009) (De Decker et al., 2010) (Meynaerts et al., 2011).[9] A good estimate of the technical potential specifically for Flanders would require an additional study beyond the scope of the present study.

In consultation with the VEA, we have taken the following approach:

1. In contrast, under the *Energy Policy Agreement*, the enterprises involved are obliged (under Article 6.6) to carry out a study into the economic potential of high-quality combined heat and power in the establishment. To that end, the technical potential and the crude IRR are to be reported to the Flemish Benchmarking Verification Office (VBBV) by the Undertaking by 30 June 2015. Where this appears not to be economically feasible, the undertaking must substantiate this. We adopt the figures for technical potential for the enterprises connected, as reported to the VBBV, as the *overall potential in large-scale industry* (enterprises subject to an IEAR requirement). The VBBV's report can be seen in Annex B. It states that '86 enterprises together represent a technical potential of approximately 187 MW_e. The capacity of these CHP plants varies from 0.07 to 15 MW_e; the estimated number of hours of operation is between 4 000 and 8 600.'

[8] Martens Adwin, Dufait Nadine (1997), *Energetisch potentieel warmtekrachtkoppeling in België* [The energy potential of combined heat and power in Belgium], study commissioned by Electrabel.

[9] Briffaerts K. et al. (2005), *Prognoses voor hernieuwbare energie en warmtekrachtkoppeling tot 2020* [Forecasts for renewable energy and combined heat and power up to 2020], VITO on behalf of the VEA; Briffaerts K. et al. (2009), *Prognoses voor hernieuwbare energie en warmtekrachtkoppeling tot 2020* [Forecasts for renewable energy and combined heat and power up to 2020], VITO on behalf of the VEA; Meynaerts et al. (2011), *Doorrekeningen ter ondersteuning van evaluatie GSC en WKC- system* [Cost pass-ons to support the evaluation of the GSC and WKC system], VITO on behalf of the VEA.

2. We assume the technical potential of CHP in small-scale industry and buildings (agriculture and services) equates to 100 % as a result of a lack of reliable information, *with the important proviso that this is not always possible in practice for various reasons*.

6.2. CHP FOR HEAT NETWORKS

CHP plants installed in order to provide heat to an additional heat network are not limited by any technical potential. In other words, the full heat demand for small-scale industry/heating buildings that is met by new heat networks can be supplied from CHP heat. It is possible that this option is not economically feasible but analysing this forms part of the cost-benefit analysis.

When evaluating CHP for new heat networks, no existing CHP plants should be taken into account as the networks in question should always be new heat networks and thus constitute a new CHP potential.

6.3. MICRO-CHP IN THE BUILDINGS SECTOR

Micro-CHP plants installed in buildings are similarly not limited by any technical potential. We thus assume that the full heat demand for heating buildings can be met, in principle, by micro-CHP heat. To what extent this is economically feasible will be shown by the cost-benefit analysis.

6.4. HEAT NETWORKS

For heat networks there is no such thing as a purely technical limitation, which means that an identified heat demand can always be supplied from another location. This fact is not surprising, given that a heat network in itself is no more than a means of conveying heat, and the real technical limitations are in fact to be found in converting energy.

Although there is no purely technical obstacle to heat networks, limitations could arise from the regulatory framework when installing new heating pipes (e.g. Natura 2000). After consulting with Eandis, we were unable to identify any legal limitations on heat networks. We thus assume an unlimited technical potential for heat networks.

Finally, there could be an economic obstacle to the installation of a heat network. This aspect is analysed in the cost-benefit analysis. By way of illustration we make reference to the study by Pöyry, which takes a similar line. It states that there is absolutely no technical limitation, but that an economic limitation has a key influence: '*While technically, district heating schemes may be applied to the whole housing stock, this is not a realistic figure for its national potential. Our analysis of the UK potential for district heating is grounded in economics…*' (Pöyry, 2009).[10]

[10] Pöyry (2009) The potential and costs of district heating networks, study performed on behalf of the UK Department of Energy and Climate Change.

CHAPTER 7. COST-BENEFIT ANALYSIS FOR HEAT

The result of the cost-benefit analysis is an evaluation for Flanders of the economic potential (using the net present value) of heat networks and CHP plants as required under Article 14(3) of Directive 2012/27/EU. Based on this evaluation, under Article 14(5) of Directive 2012/27/EU, an additional cost-benefit and financial analysis may be required if a relevant energy investment is planned.

For the heat map of Flanders we aim to state for each grid cell whether it is a promising area (economically interesting or benefits greater than costs) for one of the following investments:
- Heat networks based on residual heat (supplied from industry, electricity generating installations and waste incinerators);
- Heat networks based on heat from a new high-efficiency cogeneration installation.

The cost-benefit analysis for high-efficiency cogeneration for individual incorporated enterprises is completely based on the CHP potential studies for each enterprise under Article 6.6 of the Energy Policy Agreement (EPA). For micro-CHP and CHP plants in smaller enterprises (small-scale industry, service sector), on the other hand, we provide a rough indicator of the potential via a sample calculation.

7.1. METHODOLOGY

The calculation of costs and benefits for heat networks and CHP is based on the provisions of Annex IX to Directive 2012/27/EU. In order to carry out this analysis, prior cost calculations/assumptions must be carried out/made in order to value both the heat and the electricity. In addition, we assume a technical potential for the above generation and distribution technologies that was determined in an earlier step in CHAPTER 6.

We would like to point out that the level of detail of the AS-IS heat map also determines the level of detail of the cost-benefit analysis. This means that the residential, service and agriculture sectors cannot be dealt with individually in the cost-benefit analysis, and the same for the industrial sub-sectors for small-scale industry.

The calculations that we carry out and assumptions that we make for the cost-benefit analysis are as follows:

[B0] Basic assumptions such as discount rate (no calculation)
[B1] Cost of generation of heat in gas-fired combustion plants for industrial applications
[B1] Cost of generation of heat in gas-fired condensing boilers for heating buildings
[B4] Costs and benefits of CHP plant for a heat network
[B5] Costs and benefits of distributing heat for heating (local supply of heat)
[B5] Costs and benefits of conveying heat (conveying heat without supplying locally).

Alongside the calculations under the above algorithm (GIS-related calculations), we carry out sample calculations for the cost-benefit analysis for micro-CHP in buildings and CHP in SMEs, the service sector and agriculture.

The cost-benefit analysis for large-scale enterprises (those subject to IEAR) entirely matches the economic potential indicated by the CHP potential studies under the Energy Policy Agreement. Under Article 6.6 of the Energy Policy Agreement, the undertakings involved are obliged to carry out a study into the economic potential of high-quality combined heat and power in the establishment. To that end, the technical potential and the crude IRR are to be reported to the Flemish Benchmarking Verification Office (VBBV) by the Undertaking by 30 June 2015. Where this appears to be not economically feasible, the undertaking must substantiate this. The results reported by the VBBV can be seen in Annex B. The aim is to determine whether there is economic potential in the establishment for the application of a high-quality CHP plant for the combined production of heat and mechanical energy or electricity. The ultimate implementation may be regarded as a flexible measure pursuant to Annex 7 to the EPA.

In the following sections we further explain the necessary calculations and associated algorithms.

7.1.1. Algorithms at grid cell level

The algorithm is a sequence of combinations of the above calculations.

The steps are as follows and are carried out for each grid cell on the heat map:

- [A1] Calculation of the value of heat already present on the heat map
- [A2] Calculation of the costs and benefits of a heat network based on residual heat within a given grid cell
- [A3] Calculation of the costs and benefits of a heat network based on residual heat in neighbouring grid cells
- [A4] Calculation of the costs and benefits of a combinatory heat network based on residual heat in neighbouring grid cells
- [A5] Calculation of the costs and benefits of a heat network involving new CHP plant(s) within a given grid cell

→ [A1] Value of heat on the heat map

As a first step, the replaceable heat demand (according to the technical potential determined earlier) must be valued. This is necessary because the heat supplied by alternative technologies can be included as a benefit in later steps in the algorithm. We value this heat based on the cost of generation by a classical, gas-fired combustion plant (known as the 'baseline of reference technology'). The nominal cost per energy unit is used as a result in further cost-benefit calculations.

The technical and economic assumptions for the *classical combustion plants are differentiated for the different sectors (buildings versus industry).*

Combined calculation: [B0] + [B1]; [B0] + [B2]

→ [A1] Costs and benefits of a residual-heat heat network within a given grid cell

For each grid cell with available residual heat, a cost-benefit calculation is performed that evaluates the economic potential of a local heat network within that grid cell. The cost-benefit calculation takes account of the CapEx and OpEx of the heat network, the value of residual heat extracted, the value of heat supplied to consumers and the CapEx of a back-up installation. The CapEx and OpEx of the heat network are based on the urbanisation rate in the grid cell (number of connections per grid), which is a reflection of the density, energy intensity, etc. In this study we assume that the value for residual heat is considered to be the same as the cost of extraction. We consider this cost of extraction to be zero (avoidance of underestimation of potential + great uncertainty due to case-specific nature). The value of heat supplied is based on a calculation with reference to installation as described in [A1]. The CapEx for the back-up installation is based on the costs of a classical installation. We do not include the fuel costs for the back-up installation, as ideally this installation will never be used. It is only there to ensure certainty of supply.

Combined calculation: [B0] + [B2] + [B5]

→ [A3] Costs and benefits of a residual-heat heat network in neighbouring grid cells

For each grid cell (with a heat demand), a cost-benefit calculation is performed that is similar to the calculation in [A2], but based on available residual heat in neighbouring grid cells, known as the grid cell with a 'heat source'. The conveying of residual heat to the grid cell in question entails additional costs. The cost side of these costs and benefits is thus expanded to include conveying costs. The distance of conveying is calculated as the Manhattan distance between a cell and the closest cell with residual heat (cf. Figure 13).

Combined calculation: [B0] + [B2] + [B5] + [B6]

→ [A4] Costs and benefits of a combinatory residual-heat heat network in neighbouring grid cells

In step [A3] the starting basis is that residual heat from the 'heat source' is supplied directly to the grid cell being assessed. In reality, an economy of scale is possible if intermediate grid cells move to establish a heat network as calculated in [A3]. In order to encourage this option, we carry out calculation [A3] with reduced conveying costs for those intermediate grid cells with an economic potential according to [A3].

In greater detail, the costs/benefits on the map are calculated as follows: each grid cell C examines a series of 7 cells (i.e. 7 * 1 200 m = 8 400 m) for a neighbouring cell with a positive cost-benefit ratio. The joint heat demand is passed on to the cell that is closest to a source of residual heat, with the remaining heat demand being passed on to the neighbouring cell. The conveying costs involved are compared with the total conveying costs to each cell individually according to calculation [A3]. The potential savings involved are allocated to grid cell C in their entirety. If there are no neighbouring cells with a positive cost-benefit ratio or if collaboration does not deliver any savings, then there is no extra benefit for grid cell C in comparison with the previous calculation [A3]. If there are indeed neighbouring cells with a positive cost-benefit ratio, connection is made to the neighbouring cell that offers the greatest cost savings. If the cost-benefit ratio for grid cell C was negative, while the cost-benefit ratio for the combinatory solution was positive, the procedure is repeated so that other cells have the opportunity to connect to grid cell C. There is still an overestimation of the costs of conveying, since the gain is made simply by connecting two neighbouring cells.

Combined calculation: [B0] + [B2] + [B5] + [B6]

By way of clarification, a diagram of the concept [A4] can be found below. Suppose you have two grid cells, cells 22 and 32, that both build a heat network. If you examine them individually, the conveying costs are overestimated in terms of distance, as can be seen from the separate arrows from the heat source in cell 11 to cells 22 and 32, respectively.

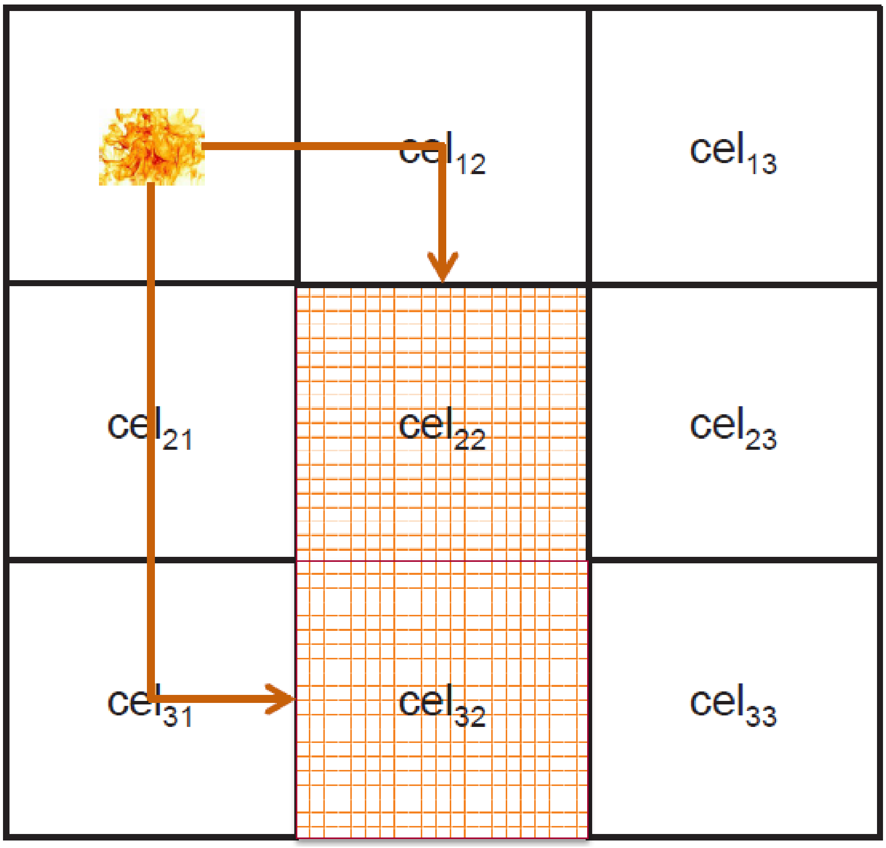


Figure 13: Diagrammatic overview of combinatory conveying of heat with overestimation of distance.

Key to figure:
cel = cell

In practice, the conveying of heat to cell 32 can take advantage of the conveying of heat that already takes place to cell 22. This would result in the following diagram.

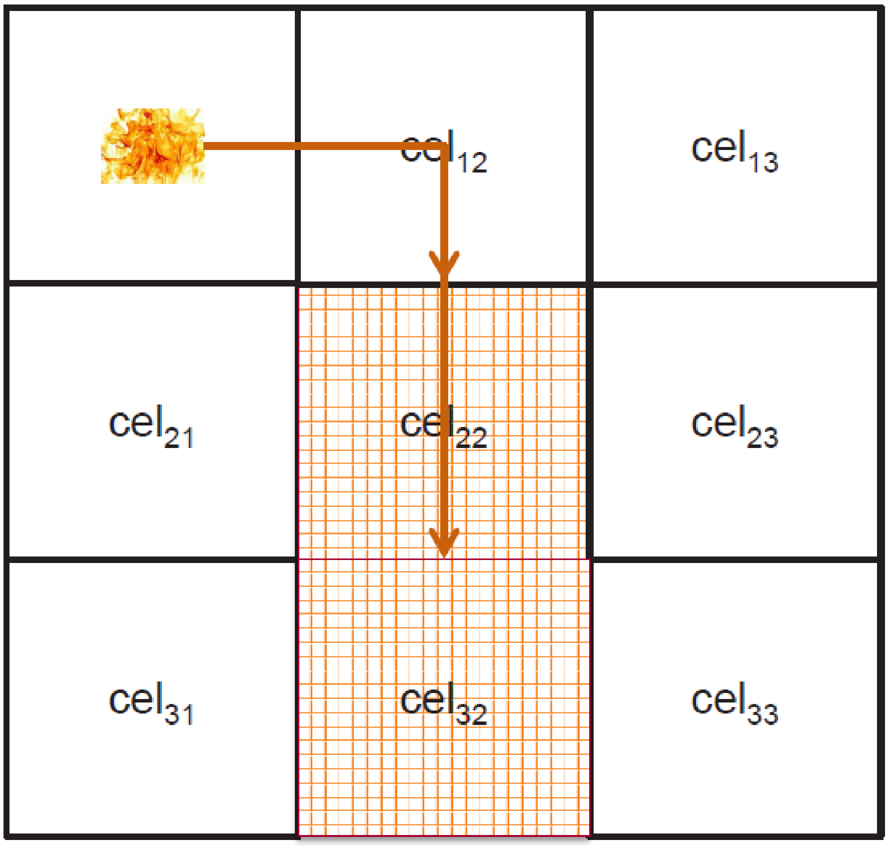


Figure 14: Diagrammatic overview of combinatory conveying of heat without overestimation of distance.

Key to figure:
cel = cell

→ [A5] Costs and benefits of a heat network involving CHP

For each grid cell, a cost-benefit calculation is performed in relation to the installation of a new CHP plant (gas turbine) that would supply its heat within that grid cell via a heat network. This option is similar to [A2], with the residual heat replaced by heat from a new CHP plant (gas turbine). The cost-benefit analysis includes both CapEx, OpEx and fuel expenditure for the CHP plant. These costs are offset against the heat and electricity produced. The heat is valued using the value per energy unit based on a classical combustion plant as calculated in [A1]. The electricity generated is valued according to the assumptions in respect of the cost of generation.

Combined calculation: [B0] + [B1] + [B4] + [B5]

7.1.2. Sample calculations, micro-CHP and CHP in SMEs, the service sector and agriculture

The cost-benefit analysis for micro-CHP for buildings, like that for CHP in the services, agriculture and SMEs sector, does not follow the above algorithm. The analysis of both types of CHP, after all, is dependent on the specific heat demand within the residence/building/enterprise in question. This heat demand, and the heat demand profile, can vary greatly from enterprise to enterprise and from building to building.

Moreover, the AS-IS heat map does not contain these data for the base year 2012. We therefore decided to carry out a sample calculation in each case.

→ Micro-CHP in the buildings sector

For micro-CHP for buildings, a cost-benefit analysis is carried out for a typical plant for a household of 1 kW_e/7.82 kW_{th}. The cost-benefit analysis includes both CapEx, OpEx and fuel expenditure for the micro-CHP plant. These costs are offset against the heat and electricity produced.

The heat is valued using the value per energy unit based on a classical combustion plant as calculated in [A1]. The fuel input is valued using the price for type category D3 (23 360 kWh a year) [*Marktmonitor VREG 2014* [Flemish Electricity and Gas Market Regulator (VREG) Market Monitor 2014]].

The electricity generated is valued using the price for average consumption (DC – 1 600 kWh daytime use and 1 900 kWh night-time use per year for 3 people) [*Marktmonitor VREG 2014* [Flemish Electricity and Gas Market Regulator (VREG) Market Monitor 2014]]. It is assumed that the electricity generated is entirely self-consumed.

The cost of investment is determined in consultation with Cogen Vlaanderen. The cost of maintenance is based on the expert knowledge at Cogen Vlaanderen and the article *Micro-CHP systems for residential applications* by M. De Paepe.

An overview of all the parameters can be found in the table below.

Parameter	
Hours of full load (hours)	2 000
Conversion efficiency – thermal (%)	86 %
Conversion efficiency – electrical (%)	11 %
CapEx (EUR/MW_{th})	1.8 million
OpEx (EUR/MWh_{th})	5.85
Reference efficiency for heat, CHP savings (%)	90 %
Reference efficiency for electricity, CHP savings (%)	47.30 %
Value of fuel (EUR/MWh)	60
Value of electricity (EUR/MWh)	179
Value of heat	Calculated cost of generation in accordance with reference installation
Technical lifespan (years)	10
CHP certificates	/

Table 14. Parameters for cost-benefit calculation for a micro-CHP plant

The costs and benefits are calculated in the same way as for the technologies of heat networks based on residual heat and heat networks based on heat from new a high-efficiency cogeneration or combustion plant.

With the above parameters and the cost-benefit calculation applied, the net present value for a micro-CHP plant results in EUR -13 000 over a 10-year lifespan.

→ **CHP plants in SMEs, the service sector and agriculture**

For CHP plants in SMEs, the service sector and agriculture a sample case was worked out: CHP in a hospital. The typical installation for this case is a CHP plant in the capacity class 200 kW_e to 1 MW_e.

The heat is valued using the value per energy unit based on a classical combustion plant as calculated in [A1]. The fuel input is valued according to the price used by Monitoring and Evaluation in calculation of inevitable front-end losses and the banding factor [Evaluation Report 2014/1, Part 1].

The electricity generated is valued according to the price used by Monitoring and Evaluation in calculation of inevitable front-end losses and the banding factor [Evaluation Report 2014/1, Part 1].

The other parameters are as used by Monitoring and Evaluation in the calculation of inevitable front-end losses and the banding factor [Evaluation Report 2014/1, Part 1].

An overview of all the parameters can be found in the table below.

Parameter	
Hours of full load (hours)	3 800
Conversion efficiency – thermal (%)	51 %
Conversion efficiency – electrical (%)	36 %
CapEx (EUR/MW_{th})	0.8 million
OpEx (EUR/MWh_{th})	16.94
Reference efficiency for heat, CHP savings (%)	90 %
Reference efficiency for electricity, CHP savings (%)	49.56 %
Value of fuel (EUR/MWh)	44
Value of electricity (EUR/MWh)	58.88
Value of heat	Calculated cost of generation in accordance with reference installation
Technical lifespan (years)	10
Value of CHP certificates	EUR 31/MWh_{th}

Table 15. Parameters for cost-benefit calculation for a sample CHP plant in a hospital

The costs and benefits are calculated in the same way as for the technologies of heat networks based on residual heat and heat networks based on heat from a new high-efficiency cogeneration or combustion plant.

With the above parameters and the cost-benefit calculation applied, the net present value for a CHP plant results in EUR -331 000 (including CHP certificates).

7.1.3. Deliverables

The result of the cost-benefit analysis is GIS map layers (1 200 m x 1 200 m for diffuse heat demand and individual demand points for large-scale industry), together with an indication of what level of economic interest the grid cells have (very little up to major: --- to +++), for the following technologies:

- Heat networks supplied via residual heat, for heating buildings and for small-scale industry;
- Heat networks supplied via a new CHP plant, for heating buildings and for small-scale industry.

For micro-CHP and CHP plants in SMEs, the service sector and agriculture, we perform the cost-benefit analysis using an example in order to provide an indication of economic viability. For the results of the CHP potential studies under the Energy Policy Agreement, please refer to Annex B.

7.1.4. Parameters

The calculations are based on a wide range of parameters. Some parameters are valid for all calculations, while others vary in relation to the year, sector group, type of CHP and capacity group for the heat pipeline. The only parameters that vary with time (year) are the heat demand for the buildings sector and that for small-scale industry. Other parameters, such as investment costs, fuel costs, etc., do not evolve.

Account is also taken in the calculations of aid mechanisms from the Flemish Government:

- CHP certificates: EUR 31/MWh of combined heat and power savings
- Investment support for residual heat under the ‘Calls recovery residual heat – Group exemption ordinance, 2008-2014’: we assume a 20 % support percentage (in relation to classic gas-fired combustion plants), which are referred to in this call as ‘large-scale enterprises’. After all, we assume residual heat only for enterprises that are subject to IEAR. Consequently the heat network (distribution + transport) is to be supported by the government up to 20 %.

For this analysis, we take the heat map (1 200 x 1 200 m) as our starting point, as well as a map showing the number of connection points per grid cell, also made up to a resolution of 1 200 m. The data come from Eandis and Infrax and provide the total number of connection points per grid cell, in respect of confidentiality.

For Voeren, the location of individual connections is not known. In this case, the number of connections per grid cell is calculated by applying the average number of connection points per kWh of heat demand to the heat demand in Voeren. To calculate the average number of connection points per overall heat demand, we take as our basis only those municipalities with a similar degree of urbanisation. The average comes to 0.1 connection point per MWh of heat demand.

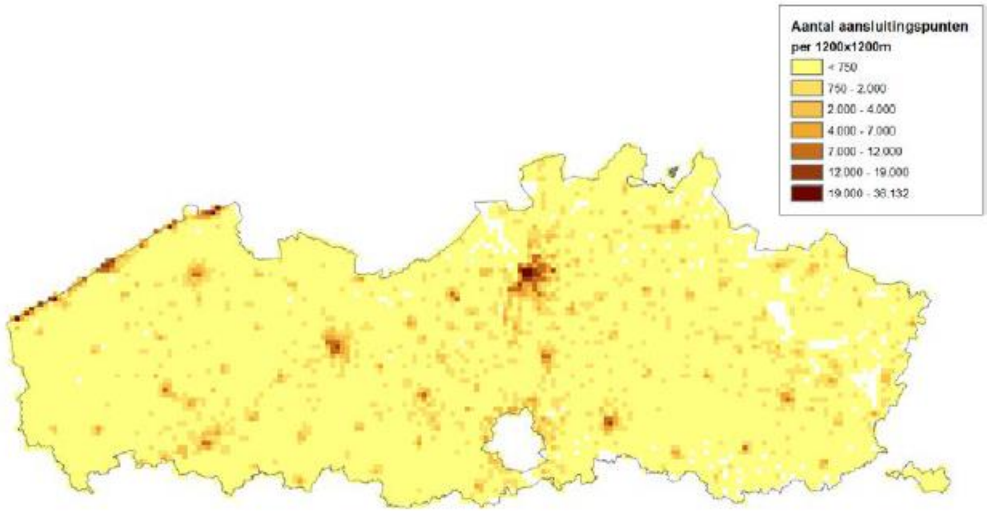


Figure 15. Number of connection points (1 200 x 1 200 m) in Flanders (2012) – excluding large-scale industry.

Key to graphic:
Aantal aansluitingspunten per 1200x1200m = Number of connection points per 1 200 x 1 200 m

7.1.5. Scenario exercise

The concrete expression of the range of parameters brings with it uncertainty. The cost-benefit analysis does attempt to estimate the net present value of a potential district heat network and/or CHP for both buildings and industry located within a grid cell, and over the lifetime of the technology, but neither the exact location of the heat network, nor the exact demand and supply profiles, etc., are known. Moreover, a generic approach is taken to the elaboration of the various financial parameters over this period and for the wide range of users/investors. The choice of parameters is based on plausible assumptions or reference values, yet – given the uncertainty – we intend to vary some of the parameters in order to identify the impact on the results. In the table below, we list the parameters included in the scenario exercise, as well as their standard values and their possible upper and lower limits.

Table 16. Financial parameters for scenario exercise: standard – lower limit – upper limit

Parameter	**Standard**	**Lower limit**	**Upper limit**
Discount rate	1.34 % Source: European reference rate of return for State aid, indicative of market interest rates, http://ec.europa.eu/competition/state_aid/legislation/reference_rates.html	/	14 % Source: Investment in an energy policy agreement is deemed 'viable' from 14 % (ETS)
Price of residual heat	0 Reason: avoidance of underestimation of potential + case-specific nature	/	EUR 25/MWh_{th}
Price of natural gas	EUR/MWh_{th}		
Gas turbine 20-50 MW_e	30.3	19.11	34.62
	Source: Inevitable front-end loss, VEA, including CO_2 cost	Source: ENDEX TTF – minimum 2012-2015 – Belgian Commission for Electricity and Gas Regulation (CREG) Scoreboard, incl. transmission, taxes, CO_2 levy	Source: ENDEX TTF – maximum 2012-2015 – Belgian Commission for Electricity and Gas Regulation (CREG) Scoreboard, incl. transmission, taxes, CO_2 levy
Small-scale industry	44.00	31.34	/ (= standard)
	Source: Eurostat 13 – Gas price for industrial consumers	Source: Eurostat 13 – Gas price for industrial consumers – minimum 2010-2014	
Buildings	60 Source: Flemish Electricity and Gas Market Regulator (VREG) Market Monitor 2014 – average consumption D3 – 2014	/ (=standard)	69.65 Source: Flemish Electricity and Gas Market Regulator (VREG) Market Monitor 2014 – average consumption D3 – Minimum 2011-2014
Electricity price	EUR/MWh_{ele}		
Gas turbine 20-50 MW_e	52.80 Source: Inevitable front-end loss, VEA, costs avoided by own off-take	47.50 ENDEX – minimum 2011-2015 – Belgian Commission for Electricity and Gas Regulation (CREG) Scoreboard, incl. transmission, taxes	71.50 ENDEX – maximum 2011-2015 – Belgian Commission for Electricity and Gas Regulation (CREG) Scoreboard, incl. transmission, taxes

7.1.6. Considerations

The methodology put forward is an iterative calculation on a heat map with the purpose of identifying areas of economic interest for heat networks/CHP in Flanders. This approach has some specific features that we would like to make clear.

The methodology states for each cell on the map whether it could be economically viable to implement CHP or a heat network. This analysis is carried out in a vacuum for each cell. This means that the evaluation of any given cell does not take account of what is happening in other cells (with the exception of [A5], where minimal prior knowledge is assumed). Every cell that could make use of a potential for residual heat in an economically viable way receives a positive evaluation of costs and benefits. This does not mean that this cell will use the residual heat from an economic point of view. It is possible, after all, that another cell may use the residual heat, as a result of which none of the potential in question is left over for this cell. The methodology thus provides *the economic possibilities, not a system optimum*. A system optimum would not, after all, provide the full potential to satisfy the intention of Article 14(3) of Directive 2012/27/EU. It would only identify one optimum, with the maximum cost-benefit surplus, and not all the possibilities with a favourable cost-benefit structure. In an ideal scenario, the two would be combined.

In establishing the method of calculation and parameters, we also always kept the following in mind: *it is important that the results should indicate all promising areas and that the outcome does not indicate the minimum in terms of opportunities.* In a subsequent research step, after all, viable areas should be given a closer look, with account being taken of specific characteristics of the beneficiaries and enterprises in order to get as close as possible to the practical feasibility of a project. Taking an overly narrow view in this study would risk ruling out interesting solutions for collective heating projects or CHP. This assumption leads, for example, to us taking as a starting point EUR 0/MWh for the extraction of residual heat, that all buildings connect to the network immediately, without any delay, etc.

7.2. Results

7.2.1. Heat networks in buildings and small-scale industry – 1 200 x 1 200 m

→ Costs and benefits of a residual-heat heat network within a given grid cell

The residual heat is supplied to buildings/small-scale industry located in the same grid cell as the industrial residual heat source (large-scale industry subject to IEAR). The heat demand within the cells with a residual heat source is 5 TWh. This is 8 % of the total heat demand in Flanders. As Figure 16 shows, cells with little heat demand have a negative benefit, while cells with a higher heat demand have a positive benefit. For the heat demand covered in this way, 99 % have a positive benefit, and only 1 % have a negative benefit.

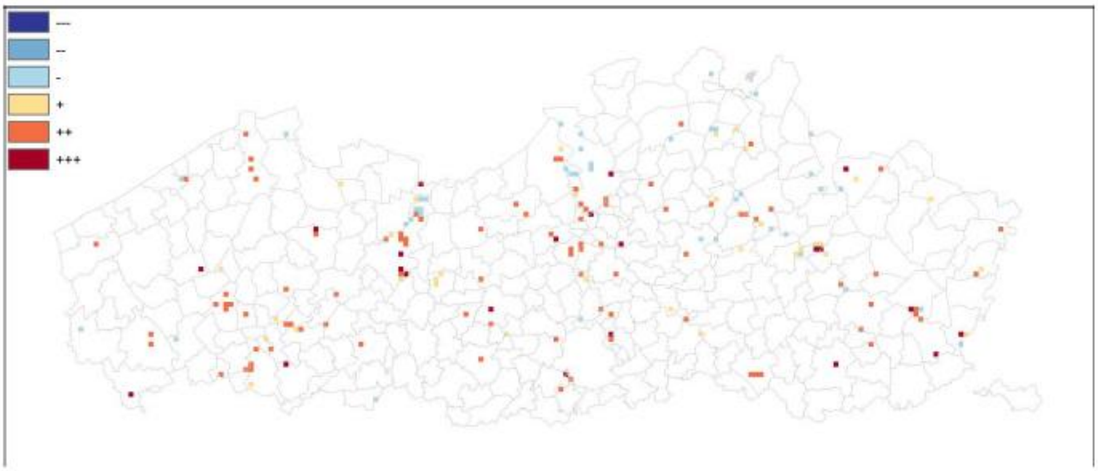


Figure 16: The benefits of a heat network for the use of residual heat from large-scale industrial enterprises in the same grid cell.

→ Costs and benefits of a residual-heat heat network in neighbouring grid cells

The residual heat is conveyed to neighbouring grid cells and supplied to buildings/small-scale industry with a heat demand. The distance is calculated as the Manhattan distance between a cell and the closest cell with residual heat. Clusters form around the sources of residual heat with a positive benefit, depending on the heat demand, the number of connections and the distance (see Figure 17). The higher the demand for heat, the less important the distance: the two positive cells in Zedelgem under Bruges are located far from any residual heat source, yet due to their very large heat demand, they are still coloured dark red. The percentage of the heat demand with a positive benefit is 60 %. We would like to make it clear that, for the use of residual heat – from whatever kind of installation (electricity plant, waste incineration or industry) – we do not balance up the supply of residual heat and the demand for heat locally. After all, we calculate all possible promising areas and not a system optimum.

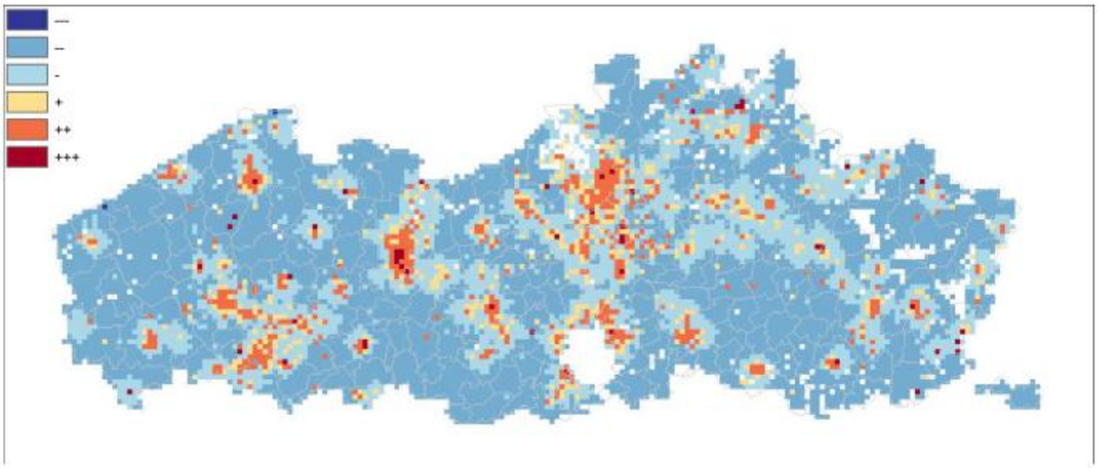


Figure 17: The benefits of a heat network (including investment support) where the residual heat is conveyed to neighbouring cells.

As stated above, account is also taken of aid mechanisms from the Flemish Government, specifically the *Investeringssteun restwarmte* [Investment support for residual heat]. If we omit this aid when examining the introduction of residual heat into neighbouring cells, the viability of heat networks falls and the percentage of heat demand with a positive benefit drops to 55 %.

→ Costs and benefits of a combinatory heat network in neighbouring grid cells

Each grid cell C examines a series of 7 cells (8 400 m) for a neighbouring cell with a positive cost-benefit ratio. The joint heat demand is passed on to the cell that is closest to a source of residual heat, with the remaining heat demand being passed on to the neighbouring cell. The conveying costs involved are compared with the total conveying costs to each cell individually according to calculation [A4]. The potential savings involved are allocated to grid cell C in their entirety. If there are neighbouring cells with a positive cost-benefit ratio, connection is made to the neighbouring cell that offers the greatest cost savings. If the cost-benefit ratio for grid cell C was negative, while the cost-benefit ratio for the combinatory solution was positive, the procedure is repeated so that other cells have the opportunity to connect to grid cell C.

The percentage of the heat demand with a positive benefit is now 62 % with investment support and 56 % without it. This is not much better than under the previous calculation. Figure 18 does show, however, that the cost-benefit ratio is less negative for many cells. The 95 cells that change from a negative benefit to a positive one are to be found, inter alia, to the north of Antwerp, in and around Hamme, around Zaventem, in Sint-Genesius-Rode, along the axis from Waregem to Roeselare and in eastern Limburg.

Figure 18 also indicates the existing and planned heat networks in Flanders (see CHAPTER 3). The majority of these existing networks make use of residual heat from waste incinerators. According to the cost-benefit analysis, the networks in Bruges (IVBO), Torhout (Infrax), Roeselare (Mirom), Harelbeke (phases 1 and 2, Infrax), Ghent (IVAGO and EDF Luminus), Antwerp (Indaver), Mol (VITO) and Houthalen (Bionerga) are located in promising areas. The heat network in Antwerp Nieuw-Zuid [New South] is on the edge of a promising area.

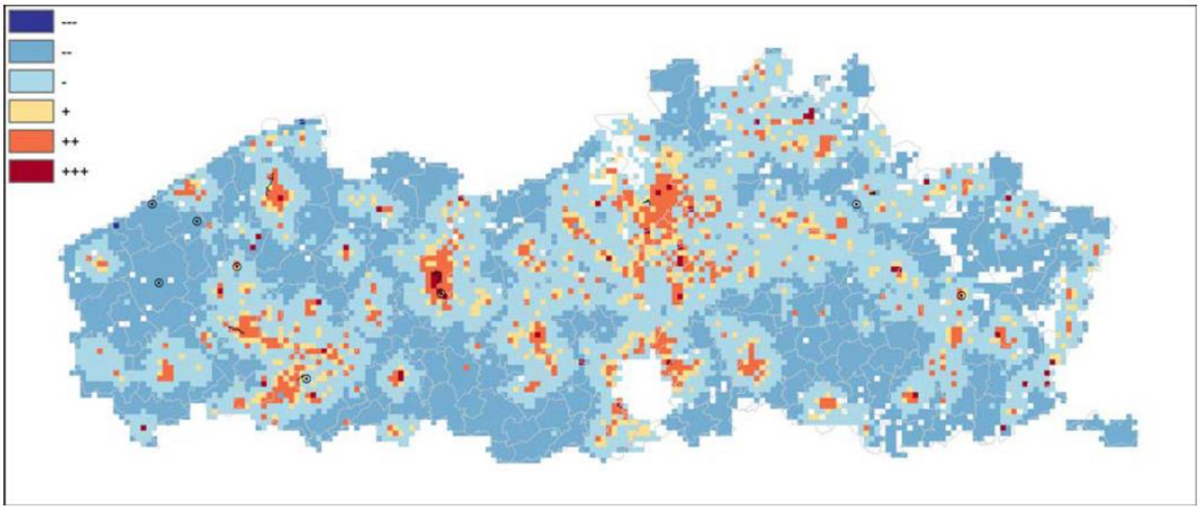


Figure 18: The benefits of a heat network (including investment support) where the residual heat is not taken directly from the source but via an adjacent cell. The existing heat networks in Flanders from Figure 3 are shown in black.

→ **Costs and benefits of a heat network involving CHP**

Instead of conveying residual heat, the heat demanded is now produced locally by a CHP plant and distributed via the connections. Given that only low numbers of hours of full load are demanded in order to satisfy the diffuse heat demand (i.e. buildings and small-scale industry), this is not viable; see Figure 19. Only those cells with a high proportion of heat demand from small-scale industry score well. This is as a result of higher numbers of hours of full load in comparison to buildings, as well as the higher heat demand per connection. The urban areas (e.g. the centre of Antwerp) and the coast have low heat demand per connection, which results in less favourable situations despite the high heat density in these areas. With a CHP certificate at EUR 31/MWh, 17 % of the total heat demand is operated positively, whereas without a CHP certificate, this falls to 0 %.

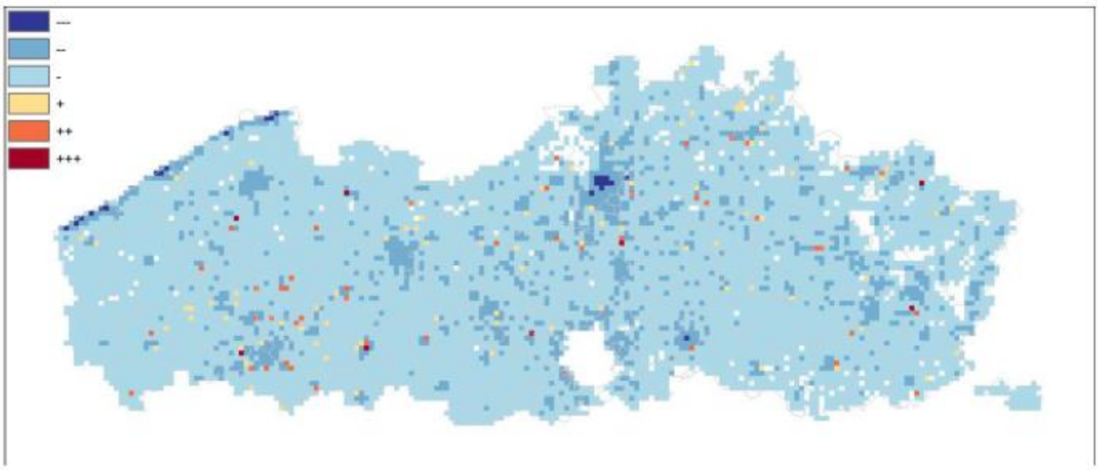


Figure 19: The benefits of a local heat network with CHP (with CHP certification).

7.2.2. Scenario exercise

Although our choice of parameters for the cost-benefit analysis is based on plausible assumptions or reference values, we do vary some of the parameters – given the uncertainty – in order to identify the impact on the results. The table below outlines the results of the variation in parameters for the various types of maps.

	Residual heat, neighbouring cells	Residual heat, neighbouring cells, combinatory	CHP and heat network
BAU	60 %	62 %	17 %
Max. discount rate	25 %	25 %	11 %
Max. value residual heat	24 %	24 %	
Max values, fuel	65 %	68 %	16 %
Min. values, fuel	59 %	62 %	45 %
Max. values, electricity			33 %
Min. values, electricity			13 %

Table 17: Percentage of total heat demand in Flanders with a positive benefit for the various scenarios.

A rise in the discount rate or the value of the residual heat has a major impact on the costs, and thus also on the percentage of the heat demand that has a positive benefit. The sharp decline in the deployment of residual heat (neighbouring cells) indicates that the viability of many heat networks using residual heat is heavily dependent on the specific financial context (e.g. the price of residual heat). However, at the viable discount rate of 14 %, 11-25 % of the total heat demand in Flanders remains cost-effective, even though heat networks are capital-intensive investments (in comparison to operating costs). This 11 % of the heat demand is concentrated, above all, around existing residual heat sources. The impact of a high value for residual heat on a combinatory heat network in neighbouring grid cells can be seen in Figure 20 (compare with Figure 18).

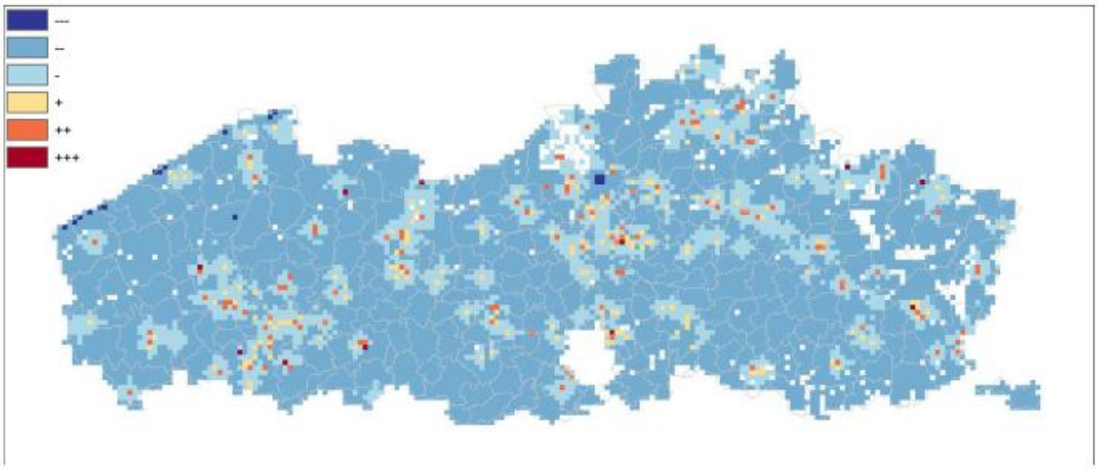


Figure 20: The benefits of a heat network where the residual heat is not taken directly from the source but via an adjacent cell, in the scenario where there is a high value for the residual heat.

The rise and fall of fuel prices has less of an impact on whether or not a residual-heat heat network is viable. There is, of course, an impact on the financial benefits and costs per network. For the costs and benefits of a heat network with CHP, however, the impact is larger, given that not only the reference technology (a natural gas boiler), but also the technology being evaluated (CHP for producing heat), is affected by fuel prices. The major increase in the percentage of positive benefit with a low fuel price is due to the fact that the price of the fuel falls more strongly for production (CHP) than the price of the fuel for consumers (reference technology – natural gas boiler). The rise in the positive benefit is clear to see in Figure 21 (compare with Figure 19). Antwerp and the coast continue to retain a negative benefit due to the large number of connections and the low heat demand per connection.

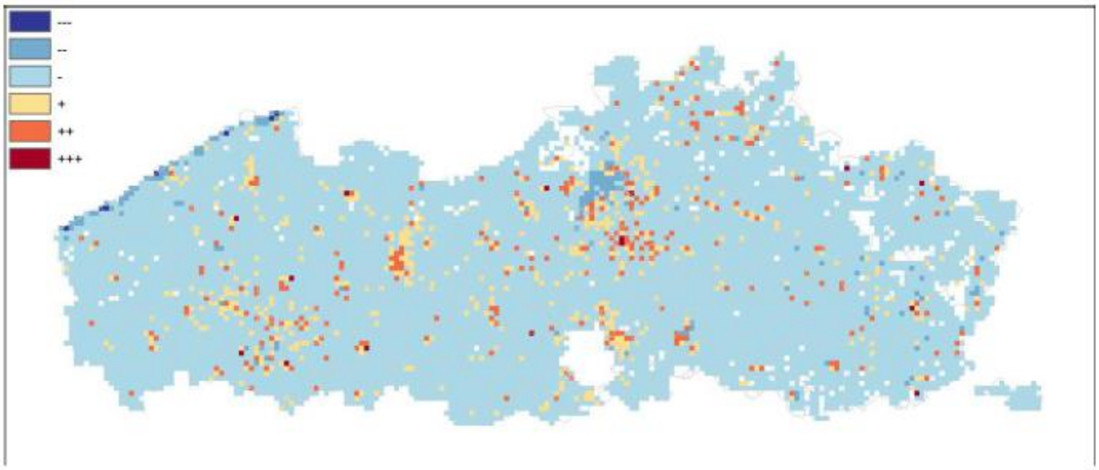


Figure 21: The benefits of a local heat network with CHP, in the scenario with a low value for the fuel.

The scenarios with high or low value for the electricity only have an impact on a heat network with CHP. A high electricity price provides significantly greater output and a lower electricity price provides lower output, and this is translated directly into a significantly higher or lower percentage, respectively, of heat demand with a positive benefit.

7.2.3. SAMPLE CALCULATIONS, MICRO-CHP AND CHP IN SMEs, THE SERVICE SECTOR AND AGRICULTURE

A cost-benefit calculation is performed for a CHP micro-plant for a household and CHP in a hospital. For both installations, the net present value – with the parameters in use – is negative and amounts to EUR -13 000 and EUR -331 000, respectively. The CHP at the hospital takes account of CHP certificates. The negative viability of these medium-sized CHP plants matches the findings in respect of inevitable front-end losses.

7.2.4. CHP IN LARGE-SCALE INDUSTRY – POTENTIAL STUDIES UNDER THE EPA

We fully align the economic potential of high-efficiency cogeneration in large-scale enterprises (those subject to IEAR) with the aggregated results for the individual studies into potential (see Annex B). The VBBV report states that 26 enterprises together represent an overall economic potential of approximately 59.5 MW_e.

CHAPTER 8. COST-BENEFIT ANALYSIS FOR COOLING

The Energy Efficiency Directive also requires, alongside a cooling map, that the costs and benefits of cooling networks be evaluated. The cooling demand for Flanders was estimated for service-sector buildings, which resulted in the AS-IS cooling map for the base year 2012 (see CHAPTER 2). Cooling is also required in the industry sector, but given the specific needs and the lack of individual data, we are not estimating this demand for cooling.

The principle with cooling networks, along the same lines as heat networks, is that the cooling is produced elsewhere at a central location and then conveyed via a network of pipes to offices, hospitals, etc. After cooling buildings via heat exchangers, the heated cooling water is fed back to the production plant to be cooled once more. The temperature of the water fed to users averages 6 °C, while the return water will hover around 16 °C (Source: http://www.svenskfjarrvarme.se/In-English/District-Heating-in-Switzerland/District-cooling/What-is-district-cooling/).

The cooling within district cooling systems is often produced in a number of different ways. One such method is to utilise ‘free cooling’, where the cold is extracted from a lake, sea or other waterway. Another technique is to cool buildings using absorption cooling, where the residual heat from industry or waste incineration is utilised to generate cooling. One example of such an application is the cooling system at the St Jan University Hospital in Bruges (VITO, 2009[11]). The application of absorption cooling[12] can also make use of waste heat even during the summer months, thus increasing the viability of a heat network. The installation (the absorber and the condenser) is cooled using canal water. It is therefore indispensable to have an aquifer, waterway, etc., close by for absorption cooling. Another option is cooling using heat pumps. Many district heating networks in Sweden use the heat present in treated wastewater to produce cooling via heat pumps.

The economic viability of district cooling is heavily dependent on the density of cooling demand, as illustrated in the figure below. Within Flanders, this density is somewhat low, given the temperate climate. Hot countries, such as Qatar, the UAE and elsewhere, thus have higher benefits in respect of the establishment of a cooling network.

[11] *Waste heat as an energy source for absorption refrigeration at St Jan hospital*, RCC Total Energy – Schoon & zuinig koelen en verwarmen, http://www.koudeenluchtbehandeling.nl/wp-content/files/12607p20_24.pdf

[12] Absorption cooling relies on the effect that, on evaporation, a liquid absorbs heat that it gives off again on condensation at a higher pressure and temperature. What is different about absorption cooling is that, in contrast to a traditional refrigeration unit, no compressor is used. Molecular forces of attraction and heat or waste heat are used as the energy source. The absorption refrigeration unit in this project operates using water and lithium bromide salt. The water acts as the coolant and evaporates under vacuum in the refrigeration unit’s evaporator at low temperature. Evaporation is achieved via the force of attraction of a strong lithium bromide/water solution in the absorber, which is in open connection with the evaporator. The solution in the absorber attracts water vapour, just as table salt gets damp if a salt cellar is left open. To keep the process going, the concentration of salt in the absorber must be maintained and fresh water must be continuously fed into the evaporator. Liquid is therefore pumped from the absorber to the generator, where water is evaporated by means of applying heat. The concentrated liquid flows back into the absorber, where it exchanges heat with the solution from the absorber via a heat exchanger. The water vapour from the generator is condensed with the aid of coolant water. This water can then return to the evaporator, thus completing the circle.

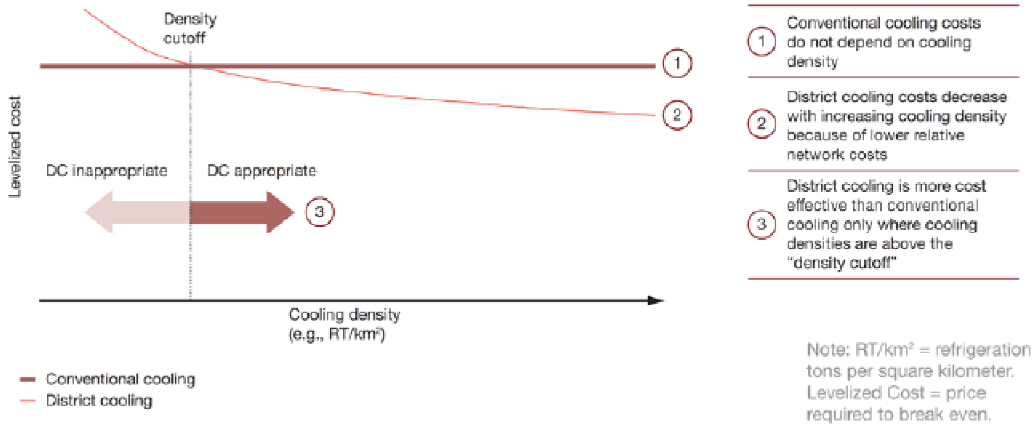


Figure 22. District cooling is more viable in areas with a dense cooling demand. (Strategy&, 2012[13])

In order to determine the cost-benefit ratio of a cooling network, let us focus on the most financially favourable situation, in other words the application of absorption cooling where there is a residual heat-fed heat network. The example of the St Jan University Hospital in Bruges enjoyed some favourable location factors: there was already a residual-heat heat network in place, and the nearby Ghent-Bruges-Ostend canal also offers the necessary cooling water. The hospital has a considerable demand for cooling for much of the year (March to November, inclusive). Although the total quantity of primary energy savings in comparison with a classical compression refrigeration unit is 55 %, the payback period was calculated to be 58 years at the time (2007). In the current economic climate payback periods should be lower, as energy prices have risen and investment costs are continuing to fall. Nonetheless, the viability is low, which relates amongst other things to the low efficiency of absorption cooling (coefficient of performance (COP) of just 0.69 in the case of Bruges (VITO, 2009)). This example shows that district cooling does not represent a favourable option in terms of costs and benefits for the cooling of buildings in Flanders.

[13] Unlocking the potential of district cooling – The need for GCC governments to take action, http://www.strategyand.pwc.com/global/home/what-we-think/reports-white-papers

CHAPTER 9. CONCLUSION

This study both literally and figuratively maps various aspects of the use and provision of heat in Flanders. In order to identify promising areas or economically interesting areas for the implementation of heat networks or CHP we brought together the following ingredients.

AS-IS HEAT MAP for the base year 2012, in which we have determined the diffuse demand for heat for buildings (residential, service sector and agriculture) and small-scale industry (enterprises not subject to IEAR), based on consumption data from Eandis/Infrax for gas and electricity for each connection point. The resulting heat map follows a logical guiding principle: areas with a high population density or industrial activity have a high heat demand. In 2012 the overall diffuse heat demand in Flanders was 65 682 GWh. For large-scale industry (IEAR enterprises and enterprises connected to the Fluxys network), we estimate the heat demand for each demand point. The map also served as the basis for the estimation of the residual heat supply in accordance with the Dutch PDC method corrected for the MIP2 heat study and specific data for seven enterprises. These calculations show that large-scale industry could provide 7 400 GWh of residual heat at 80-120 °C and 12 300 GWh of residual heat at > 120 °C. We would like to emphasise that there is a great deal of uncertainty in these figures and that they represent an upper limit to the residual heat supply in Flanders. The potential supply at > 120 °C in particular is an overestimation as, in the ceramics and iron and steel sectors, there is a failure to take adequate account of the possibilities for internal heat recovery under the PDC method. Furthermore, the residual heat at > 120 °C will not necessarily be available for external provision of heat, but it could be recovered internally within companies. It is therefore important that more detailed feasibility studies are carried out to investigate what application is feasible for such residual heat.
Along with the supply from industry, we also estimate the supply at 80-120 °C from existing electricity plants (11 TWh) and existing waste incinerators (4.7 TWh). Today, waste incinerators represent the most important heat source for the few heat networks in Flanders. As is generally known, the use of heat from electricity plants would reduce their electricity output.

In a second step, we have laid down or defined the ingredients ‘evolution of heat demand up to 2035’ and the ‘technical limitations on the use of CHP or heat networks’. In determining these scenarios/parameters, the following points came to our attention:

- It is important that the results of this study should indicate all promising areas and that the outcome does not indicate the minimum in terms of opportunities.
- The lack of data per sector/sub-sector/connection point forces us into generic assumptions. Thus, we cannot estimate a technical potential for CHP given the limited information additional research requires at building/enterprise level.

In the cost-benefit analysis we brought the above sources of data and assumptions together – via the net present value (NPV) – in order to map and evaluate the following technologies:

- Heat networks based on residual heat (supplied from industry, electricity generating installations and waste incinerators);
- Heat networks based on heat from a new high-efficiency cogeneration installation.

The figures below summarise the results for heat networks.

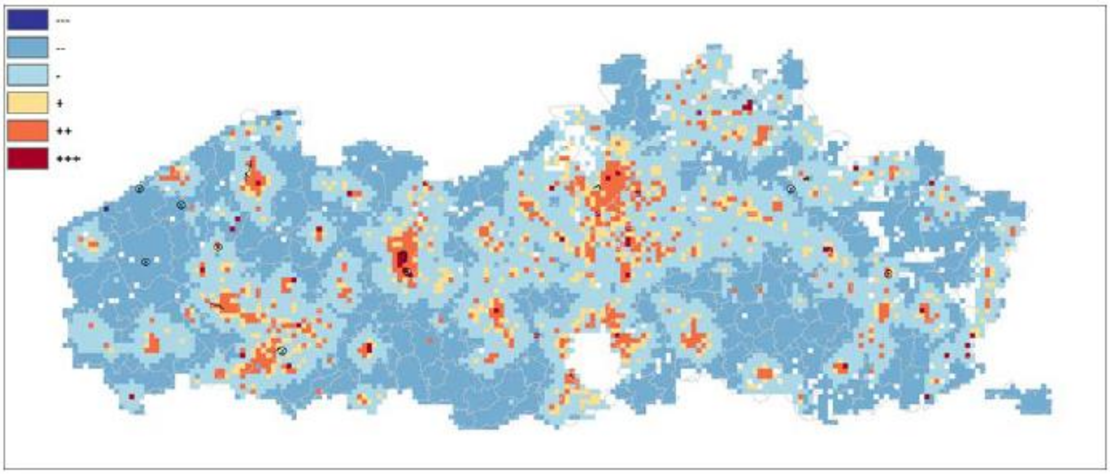


Figure 23: The benefits of a heat network (including investment support for residual heat) where the residual heat is taken not just directly from the source but also via an adjacent cell (1 200 x 1 200 m).

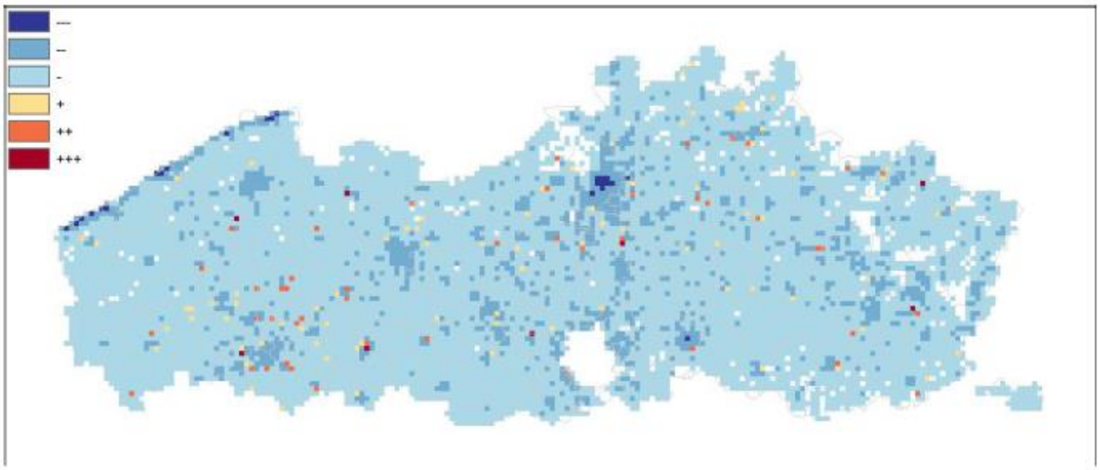


Figure 24: The benefits of a local heat network with CHP (with CHP certification) at the level of 1 200 x 1 200 m grid cells.

According to the cost-benefit analysis, 62 % of the heat demand in Flanders can be cost-effectively satisfied by a heat network supplied with residual heat (including investment support). During the scenario exercises (variation in parameters), we learnt that, even under financially unfavourable circumstances (a high discount rate at 14 %, a price of extracted residual heat of EUR 25/MWh), 11-25 % of the overall heat demand in Flanders remains cost-effective, even though heat networks are capital-intensive investments. Yet the sharp fall indicates that there is significant sensitivity in the cost-benefit ratio to specific environmental conditions. We therefore recommend that, in more concrete projects relating to the establishment of heat networks, specific analyses and estimates of potential are developed for the areas involved. The results of this study will hopefully also provide an incentive to translate and give tangible realisation to the possibilities at local level. We would like to reiterate that this study highlights those economic possibilities with a favourable cost-benefit structure, not a system optimum.

The application of CHP purely to feed a heat network, on the other hand, is not interesting, given the low number of hours of full load demanded (cf. the limited demand for heating in the summer): with a CHP certificate at EUR 31/MWh, 17 % of the total heat demand is operated positively, whereas without a CHP certificate, this falls right down to 0 %. The use of CHP within large enterprises has an economic potential of 59.5 MW_e. This was analysed at enterprise level in the CHP feasibility studies as requested under the Energy Policy Agreement, with account being taken of both technical and economic limitations.

ANNEX A

Table 18: Overview of CHP plants in Flanders in 2012 – [kW_e]

Name of CHP facility	Net kW_e
RWZI Zwalm (new in 2010)	60
WKK biogas	291
WKK-0345 Limburgs Galvano Technisch Bedrijf	50
Hogeschool West-Vlaanderen, Departement Phi + Pti	280
WKK D'Ieteren Zaventem (WKK 0343)	178
WKK AZ alma (EVW/perkins 4006)	286
Interbrew anaerobe waterzuivering	161.9
WKK De Backer	120
Deweja WKK 0249	640
WKK Ysebaert	182
WKK Sportoase elshout	53.7
VZW Monica – AZ Monica Antwerp	60
RWZI Grazenweg 13 3803 St Truiden	177
RWZI Hoebenschot 20B 2460 Lichtaart	200
RWZI Kwarekkendreef 2 2260 Westerlo	200
WKK-0317 Zorg-Saam Zusters	80
RWZI Wiekevorstse weg 44 2200 Herentals-Morkhoven	200
RWZI Drongensesteenweg 254 9000 Ghent	350
WKK Slamotra	528
RWZI Slachthuisstraat 62 2300 Turnhout	200
V.Z.W. Domino (formerly Volkskliniek)	300
Domarco	733
WKK-0297 Herman Vervoort	173
WKK Albrecht	1 400
WKK ZNA sint vincentius	213.4
RWZI Driebek 9 9200 Dendermonde	500
WKK Henri Serruys ziekenhuis	260
WKK-0314 Hydroponic	528
RWZI Rollekens 4 2320 Hoogstraten	200
WKK-0308 Proefstation voor Groenteteelt	265
Biogas-Wkk Alpro	209.4
WKK-0274 REO Veiling	500
AZ Sint-Augustinus Veurne	291
WKK AZ Klina	140
Cassaer	800
Alken Maes (Meerdegatstraat 151, Alken)	250
RWZI Diepenbekerbos 2 3600 Genk	216
RWZI Aarschotseswg 208 3010 Leuven	312
WKK Beaulieu (WKK 335)	254
WKK-0311 + BMS-0088 Rozenkwekerij Van Biesen	294

RWZI Kortrijksesteenweg 308 8530 Harelbeke	200
WKK-0367 Guido Verschueren	1 160
aardgas Wimceco	1 359
A.Z. Sint Dimpna	500
WKK AZ groeninge	142.5
WKK Desta	122
RWZI Rode Okstraat 200 3511 Hasselt-Kuringen	240
RWZI Kielsbroek 5 2020 Antwerp – Zuid (South)	300
WKK-0312 + BMS-0090 Willy Jacobs	950
WKK-0342 GRL-Glasrecycling	810
WKK Militair kwartier Peutie	300
WKK D'ieteren 0240	526
WKK Christophe Pieters	877
WKK Axima Leopoldsburg	294
lissens palmolie	720
Imelda Vzw	662
WKK Knauf Isolava	254
WKK-0286 Dirk Mermans	1 286
campus Maria-Middelares WKK	320
Dens PPO (WKK-0199)	2 457
AZ St Elisabeth Vzw (gasmotor HPC 320 M)	300
WKK-0097 vzw Jessa Ziekenhuis (formerly CAZ Midden-Limburg)	213
WKK Dacoveg	1 058
De Rese Roger	625
WKK-0368 Rovana	1 560
WKK Scana Noliko	350
WKK-0227 VLS-Group Ghent	2 200
WKK-0265 + BMS-0078 Guido De Weerdt	1 058
WKK-0363 Neegro	1 400
WKK Tecoma	1 325
De Maeyer Werner	485
WKK-0273 Raf Bossaerts	800
WKK-0176 Steenfabrieken Vandersanden – Lanklaar-Dilsen	773
WKK Catala 1 (Aardgas)	1 535.4
WKK-0304 Gromo	1 640
WKK-0272 Paul Geerts	800
WKK 0045 Senergho	1 064
palmolie WKK	1 930
WKK-0263 Frans Tuinbouwbedrijf	800
Steenfabrieken Vandersanden – Spouwen Bilzen	1 030
WKK-0092 Hans De Weerdt	1 790
Walcarius	1 006
WKK Tonny De Smet	800
UNIPRO	806

WKK-0268 Johan Bossaerts	1 008
WKK Tuinderij Joosen	1 169
Ideco Tielt WKK	990
WKK Van Lommel Van Reusel	1 008
WKK-0333 Josikem	1 415
WKK-0283 Bertels	1 008
WKK-0271 Mave	1 008
WKK-0350 Alex Allemeersch	1 485
WKK-0252 Baanheidehof	4 309
WKK Verdonck-Van Dessel	1 635
WKK VITO 0241	834
WKK Anne Mortelmans (WKK 351)	1 184
WKK groeikracht Lierbaan (Putte)	1 464
WKK-0300 Groeikracht Bavikhove	2 057
WKK-0305 Cummins (Dockx Putte)	1 400
WKK lavalo bvba	1 147
WKK Wervic	1 006
WKK-0330 Supra-Natura	1 415
WKK Almo energie	1 127
WWK Vervloet	1 169
Groeikracht Broechout Hellestraat 80	1 415
Vitaetom WKK 0246	2 067
WKK-0073 Didier Algoet	1 147
WKK-0015 Willaert Moerzeke	1 152
WKK-0323 Franky Galle	1 485
WKK-0341 Husagro	1 477
WKK Agrikracht NV	835
WKK Agrikracht Moorslede (wkk 324)	1 486
WKK Coghe Luc 2009	1 925
WKK Solae	1 413
WKK Adriplant	1 400
WKK vandaele	1 038
WKK-0135 Hamerlinck	1 400
WKK Hortigro	1 400
biogas De Biezen WKK 0237	1 151
Fikoplant en Konaplant	1 562
WKK Hagewest bvba (WKK 186)	2 000
WKK Bloemen Scheers	3 370
WKK Costermans Marc	1 147
WKK Lanckpaep Geert	1 532
WKK Peemat bvba	1 147
WKK GSL bvba	1 131
WKK-0326 Ceulemans Slacenter	2 014
WKK-0198 Wauters Energy bvba	1 065
WKK Reneco Serilge	1 400
WKK-0221 René en Johan Vermeir	1 400
WKK-0306 Groeikracht Vrasene	1 994
Bio energie Herk	1 000
WKK Groeikracht De Boskapel NV	2 732
Groeikracht Abelelaan	2 016

WKK Hagewest (WKK 0357)	2 000
WKK Middendorp Ronny	2 014
Depovan WKK00197	1 074
WKK Groeikracht merksplas (WKK 0012)	2 758
biogas installatie Calagro energie bvba	1 670
WKK-0091 Van De Ven	1 372
WKK De Wit Dirk	1 147
WKK groeikracht Rielbro (Meer)	2 028
WKK Ludo Van Rompaey	1 558
Grobar	1 558
WKK Schiettekatte Marc	1 158
WKK Tomaver	1 564
WKK Frani bvba	1 532
WKK Costermans bvba	1 532
WKK Van Den Heuvel bvba	1 562
Lytoma	1 562
WKK Biocogen (Oudegem Papier)	1 400
WKK-0171 De Sprong	1 558
WKK Tovabo bvba	2 000
Sibon bvba	2 014
Rousselot NV	1 900
WKK Horizon (2008)	2 000
WKK-0160 Uytterhoeven Dirk bvba	2 014
Biofors	2 262
WKK Paulanco	1 562
Agri-power grote wkk (WKK-0042)	3 854
WKK Tomerel	1 562
WKK BIO7	1 416
WKK Vlaemynck	2 000
WKK Pomidory (new)	1 600
WKK groeikracht waver	1 747
Rovak	1 998
WKK Gemapa	2 000
Toon Mulders WKK234	2 014
WKK-0216 Johan Opdebeeck	2 014
WKK Rudy Franco – Topas bvba (Jabbeke)	2 000
WKK Pittori	1 995
Storg	4 000
WKK Celson bvba	2 000
WKK HDS glastuinbouw	2 014
Patoma bvba	2 000
De Groentuin Merksplas	1 960
WKK-0302 Beltomex	1 998
biogas installatie biomass center Ieper	1 021
Varegro	2 014
WKK-0202 Mark Vertommen	2 014
WKK-0205 Kris Ceulemans	2 014
WKK Peetrima (ingr.wijz.)	2 333
WKK-0063 Tom Vermeiren	1 575
WKK teepak	2 000

den Breyn Weelde	5 210
WKK Vergo Energie	2 000
WKK Alnica NV	2 000
BASF 2003 tegendrukstoomturbine zonder noodcondensor (turbine STU)	2 700
Umicore Balen (T4 condensing extraction turbine)	9 500
Green Power Pittem WKK0236	1 975
BASF 2004 tegendrukturbine zonder noodcondensor (ethylene oxide)	2 000
WKK groeikracht Hooikt	2 425
Umicore Balen (T5 back pressure turbine)	3 900
WKK Ria Krijnen	2 014
WKK Verlinden Dirk	1 984
WKK Pfizer Manufacturing Belgium NV	2 014
WKK-0316 Benteltom	2 680
WKK Power energy Kalmthout	2 014
Bijhuis Cargill France SAS (WKK-0207)	2 586
WKK Bio-electric	2 461
WKK Pijl NV	2 731
WKK-0071 Groeikracht Marvado	3 256
WKK-0096 Eric Van Den Eynde	4 008
WKK groeikracht de Blackt	2 028
WKK groeikkracht Boechout (flex 9 kwekerij A&D Naenen)	3 777
WKK Tomana	2 425
Mepetom	2 941
WKK Prayon	3 716
WKK groeikracht zwarthout	3 538
WKK ESD	2 423
WKK Beirinckx Luc	3 041
Greenenergy WKK 0247	2 226
WKK groeikracht Wommelgem	2 732
WKK Barka	1 558
WKK-0072 Groeikracht Marveco	4 141
WKK Bio-energy	4 026
WKK Pittoors (2008)	3 116
Varom bvba	4 028
WKK-0126 Dielis Kurt FV	2 014
WKK-0034a Groeikracht Markvallei Horst 12	7 314
biogas installatie Shanks	4 024
WKK Mildevan	1 584
WKK Den Boschkant	3 041
WKK VGT (2004 expansion of installation)	5 150
WKK Tomwatt	5 120
WKK-0124 V.W. Tuinderijen	5 140
WKK Meer Fresh Products	2 425
WKK-0250 Algist Bruggeman	4 652
WKK Agfa (WKC 0057)	8 029.1
Citrique Belge (TU001 & T003)	8 700

Monsanto Europe	7 550
WKK-0294 Hortipower	8 585
WKK AOP	7 148
Den Berk WKK 0243	8 020
WKK Belgomilk Langemark	7 589
Cargill NV	4 600
WKK Tiense Suikerraffinaderij NV (back pressure turbine)	18 500
VPK Oudegem Papier (coal boiler + turbine 4)	9 000
Stora Enso	9 350
Umicore Olen	19 065
centrale Lillo	23 000
WKK BRC	14 810
Stora enso EC2	36 125
WKK esso raffinaderij	130 220
WKK Inbev (wkk 332)	4 581
Gent ham (WKK)	54 300
Remo	1 365
Ivarem (expansion, Dec 2004)	2 798
Dranco II (all of Dranco together)	2 261
IVVO GFT vergisting en composteringsinstallatie	1 208
WKK Vanremoortel	617
WKK Sint Augustinus	800
WKK Sobelgra	5 200
WKK Balta Avelgem	1 758
WKK Balta St-Baafs-Vijve	5 922
WKK Ocmw De Ril	165
WKK 210 Ocmw Sint Augustinus Torhout	165
WKK-0036 Vandevelde (Vandtra)	1 145
TOTAL Antwerpen	148 500
WKK VPK Oudegem Papier	15 090
WKK BP Chembel	47 922
WKK Bayer	43 000
Lillo Energy (degussa, new in 2011)	85 000
WKK Sappi (Albertcentrale)	40 700
WKK Monsanto	43 000
WKK Ineos- Phenolchemie	22 990
WKK LNG terminal	39 500
WKK Primeur	700
Biogas Aspiravi Vuurkruisenlaan Leuven	900
WKK-0106 Inesco	133 000
Zandvliet power	395 000
WKK Agristo	537
WKK-0164 Pafa	1 556
WKK neel Vissers	801
WKK Taminco	6 210
Electrabel Lanxess Canadastraat	55 000
WKK-0275 Syral	50 500
BMS-0073 Horticotrade	695

Biogas-Wkk Unifrost	273.9
IVEB mestvergisting en co-vergisting	1 095
0044 Herman De Langhe Zwijndrecht	2 000
Biofer Guascor (WKK part)	782
Eddy Van De Kerkhof (Kegelslei in OLV Waver) WKK0181	1 400
WKK-0299 ZNA Middelheim	834
WKK-0310 Sunnyland	1 375
WKK Van der Valk Hotel Beveren (WKK 261)	197
WKK Floreac (WKK 0301)	1 006
WKK 370 Belgomilk	772
Eddy De kerkhof wkk 359	2 040
WKK 123 groeikracht Vremde	4 141
TWZ	379
Op de Beeck	2 978
Biopower Tongeren	2 826
Pitoma	2 358
Wittevrongel Eneco Energy	2 830
Nobis	2 358
Vandevelde	1 156
Krikato	1 200
DeWeerdt-Rockele	800
Jozef De Weerdt	800
Eurofreez	250
Duc d'O	140
Quirijnen Energy Farming	3 570
Ampower	8 934
Zwembad Wezenberg	199
Zwembad Iepermann	70
Malve	404
Alcon-couvreur	1 189
Biogas Boeye	2 233
Wim Vertommen Den overkant	2 566
Deltapellets	820
Agrokom	3 938
Desmet (Ardooie)	2 000
Tomaline bvba _after modification	3 898
Van Bulck BVBA _after modification	3 602
Stoffels	6 900
WKK groeikracht broechem (WKK 0040) new	1 817
WKK 0053 Deweerdt Frans	1 129
WKK-0321 Handelskwekerij Vantyghem	70
WKK 0376	732
WKK 0387	220
WKK-0435 + BGS-0110 Digrom Energy (WKK-gedeelte)	495
WKK-0459 Tuinbouwbedrijf Vandewaetere	1 200
WKK 344 Agfa Mortsel	7 510
Kronos Europe	6 270
VC power WKK 219	5 500

BASF D	9 727
WKK 0296 Varico	2 000

ANNEX B

The Flemish Benchmarking Verification Office
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Overview and results of the CHP potential studies in undertakings that have signed up to the Energy Policy Agreement (EPA)

6 October 2015

Geert Reunes – Manager of the Verification Office

1. OVERVIEW of CHP potential studies

The first step in investigating the CHP potential of the undertakings involved was the application process, which offered the undertakings three possible options:

- Option 1: Application for acceptance of an expert to carry out the CHP potential study
- Option 2: Exemption from the obligation to carry out the potential study (subject to meeting one or more conditions – see Section 2.2 of Explanatory Note 05 to the EPA)
- Option 3: Application for acceptance of a study already carried out

At the time this report was produced, 337 undertakings (or establishments) had signed up to the Energy Policy Agreement (EPA). Three establishments have yet to file an application form with the Verification Office (two because they signed up late to the EPA (after 30 June 2015) and one because it has been granted a suspension of its obligations under the EPA due to an emergency). The 334 applications received and processed can be categorised as follows:

- 119 undertakings have carried out a new CHP potential study (Option 1)
- 193 undertakings satisfy one or more conditions for exemption from their obligation to carry out a study (Option 2)
- 22 undertakings were able to call upon a potential study already carried out (Option 3).

In accordance with the above overview, the intention was for the CHP potential of (119 + 22 =) 141 undertakings to be included in the results below. However, there are two undertakings – one late signatory to the EPA and one enterprise that was also hit by a serious emergency in the spring – that have thus far not submitted a CHP potential study for evaluation. Finally, there is one undertaking for which the study submitted has not yet been approved due to the lack of an appropriate (and completed) study in the light of the Verification Office's comments.

The results below thus incorporate (141 – 3 =) 138 potential studies.

2. RESULTS of CHP potential studies

The 138 approved CHP potential studies provide the following results:

- For 26 undertakings, the study shows that there is no technical potential for high-quality combined heat and power.
- 26 undertakings state that their establishment has an economic potential for high-quality combined heat and power.
- In the remaining 86 undertakings, the study found that there is a technical potential for high-quality combined heat and power but that this potential is currently not viewed as economically viable by the undertakings in question.

a. Enterprises with an economic potential

As stated in Explanatory Note 05 to the EPA, those enterprises with an economic potential are listed in the table below. The 26 enterprises together represent an overall economic potential of approximately 59.5 MW_e.

Establishment	Potential
Enterprise 1	2 MW_e-7 900 h
Enterprise 2	6 MW_e-8 000 h
Enterprise 3	4.4 MW_e-8 000 h
Enterprise 4	4 MW_e-7 500 h
Enterprise 5	1.2 MW_e-8 000 h
Enterprise 6	7.55 MW_e-8 000 h
Enterprise 7	3.85 MW_e-8 000 h
Enterprise 8	2 MW_e-5 400 h
Enterprise 9	0.13 MW_e-8 500 h
Enterprise 10	2 MW_e-8 000 h
Enterprise 11	0.53 MW_e-7 780 h
Enterprise 12	1.6 MW_e-8 200 h
Enterprise 13	0.6 MW_e-8 000 h
Enterprise 14	1.5 MW_e-7 900 h
Enterprise 15	0.14 MW_e-8 200 h
Enterprise 16	0.335 MW_e-4 750 h
Enterprise 17	0.35 MW_e-6 000 h
Enterprise 18	1 MW_e-5 250 h
Enterprise 19	0.8 MW_e-6 200 h
Enterprise 20	1.4 MW_e-7 150 h
Enterprise 21	1.2 MW_e-8 200 h
Enterprise 22	6.3 MW_e-8 000 h
Enterprise 23	0.8 MW_e-7 400 h
Enterprise 24	0.5 MW_e-6 000 h
Enterprise 25	3 MW_e-5 500 h
Enterprise 26	6.3 MW_e-8 100 h
TOTAL	**59.5 MWe**

b. Enterprises with a technical potential

As also stated in Explanatory Note 05, the technical potential of the remaining undertakings is reported in aggregated fashion, whilst stating the reasons why this does not give rise to an economic potential.

The 86 enterprises involved together represent a technical potential of approximately 187 MW_e. The capacity of these CHP plants varies from 0.07 to 15 MW_e; the estimated number of hours of operation is between 4 000 and 8 600.

The table below lists the reasons why the technical potential shown is regarded as economically non-viable.

Establishment	Reason for economic non-viability
Enterprise 1	IRR deemed too low; preference for imported steam from neighbouring enterprise
Enterprise 2	IRR deemed too low; still possibilities for recovery
Enterprise 3	Other priorities for investment (including optimising steam use + heat recovery)
Enterprise 4	IRR deemed too low
Enterprise 5	IRR deemed too low
Enterprise 6	IRR deemed too low
Enterprise 7	Reservation: further study required with regard to the return temperature
Enterprise 8	IRR deemed too low; too much uncertainty with regard to … production
Enterprise 9	IRR deemed too low
Enterprise 10	IRR deemed too low
Enterprise 11	IRR deemed too low
Enterprise 12	IRR deemed too low (with BF 2016; 11.14 % with BF 2015) + in-depth study needed
Enterprise 13	IRR deemed too low
Enterprise 14	IRR deemed too low
Enterprise 15	IRR deemed too low + heat network under construction from neighbouring enterprise
Enterprise 16	IRR deemed too low
Enterprise 17	Enterprise is to get connected to the heat network of a neighbouring enterprise
Enterprise 18	IRR deemed too low
Enterprise 19	IRR deemed too low
Enterprise 20	IRR deemed too low
Enterprise 21	IRR deemed too low
Enterprise 22	IRR deemed too low (with BF 2016 = 0.734)
Enterprise 23	IRR deemed too low (borderline acceptable)
Enterprise 24	IRR deemed too low. Heat demand will continue to fall further due to new projects.
Enterprise 25	The impact and integration of the CHP heat into the current heat recovery system still needs to be worked out in more detail
Enterprise 26	IRR deemed too low. Uncertainty in connection with the contamination of hot water that needs to accept CHP heat
Enterprise 27	IRR deemed too low
Enterprise 28	Investment costs too high (in non-core installations) for an enterprise in full development
Enterprise 29	Investment too large (other large investment recently made)
Enterprise 30	IRR deemed too low
Enterprise 31	Uncertainty about production volumes in forthcoming years
Enterprise 32	IRR deemed too low. Other additional conversion work needed in order to viably utilise hot water
Enterprise 33	Heat recovery options need to be studied in detail first (and implemented)
Enterprise 34	IRR deemed too low + uncertainty with regard to continuing restructure + additional investments needed to use heat from CHP
Enterprise 35	IRR deemed too low
Enterprise 36	IRR deemed too low
Enterprise 37	IRR deemed too low; moreover, additional investments required, which would reduce the IRR still further
Enterprise 38	Uncertainty over the continued existence of the enterprise after entry into use of the new site

Enterprise 39	IRR deemed too low; moreover, too much uncertainty with regard to certificates (BF)
Enterprise 40	IRR deemed too low; the investment threshold for the group is a payback period of no more than 3 years
Enterprise 41	Too much uncertainty about the hot water consumers
Enterprise 42	Awaiting results of EPA plan + production (and product mix) master plan being drawn up
Enterprise 43	IRR deemed too low; moreover, there is uncertainty about future volumes
Enterprise 44	IRR deemed too low
Enterprise 45	IRR deemed too low
Enterprise 46	IRR deemed too low
Enterprise 47	IRR deemed too low
Enterprise 48	Investment budget used for other resources
Enterprise 49	IRR deemed too low
Enterprise 50	Hot water cannot be viably utilised in the current situation (and requires additional conversion work and investment costs)
Enterprise 51	Awaiting final results of EPA plan (possibilities for heat recovery)
Enterprise 52	IRR deemed too low. Also, uncertainty about heat use in a network.
Enterprise 53	No budget at present due to new strategic cap. study + awaiting EPA audit
Enterprise 54	Too much uncertainty in respect of future production
Enterprise 55	Uncertainty in respect of investment costs for the viable utilisation of hot water from CHP
Enterprise 56	IRR deemed too low + major uncertainty about the degree of use of the powder area
Enterprise 57	IRR deemed too low + evaluate new situation (thermal oxidiser) first
Enterprise 58	IRR deemed too low + recent investment in new boilers
Enterprise 59	IRR deemed too low + recent steam and TO installation + thermal oxidiser with heat recovery
Enterprise 60	IRR deemed too low + option of 3 MW – 7 200 h also regarded as too risky for the process
Enterprise 61	IRR deemed too low
Enterprise 62	IRR deemed too low + more efficient steam consumption in new mode with a single thermal oxidiser
Enterprise 63	IRR deemed too low
Enterprise 64	IRR deemed too low
Enterprise 65	IRR deemed too low
Enterprise 66	IRR deemed too low (due to low price of electricity)
Enterprise 67	IRR deemed too low + uncertainty over use of … area
Enterprise 68	IRR deemed too low + evaluate after conversion …hall
Enterprise 69	IRR deemed too low for investment in non-core activities
Enterprise 70	IRR deemed too low
Enterprise 71	Cost of investment too high in the short term
Enterprise 72	No approval from HQ
Enterprise 73	IRR deemed too low
Enterprise 74	IRR deemed too low
Enterprise 75	Will only be considered once processes have been optimised (and there is clarity about the demand for and supply of heat)
Enterprise 76	Will only be considered once processes have been optimised (and there is clarity about the demand for and supply of heat)
Enterprise 77	IRR deemed too low
Enterprise 78	Will only be considered once processes have been optimised (and there is clarity about the demand for and supply of heat)

Enterprise 79	Awaiting results of internal heat recovery + strategic project
Enterprise 80	Will complete ongoing energy optimisations first in order to get a better overview of remaining heat needs
Enterprise 81	Will only be considered once processes have been optimised (and there is clarity about the demand for and supply of heat)
Enterprise 82	Will only be considered once processes have been optimised (and there is clarity about the demand for and supply of heat)
Enterprise 83	IRR deemed too low
Enterprise 84	IRR deemed too low
Enterprise 85	IRR deemed too low
Enterprise 86	IRR deemed too low + future plans have a negative impact on the viability of the CHP