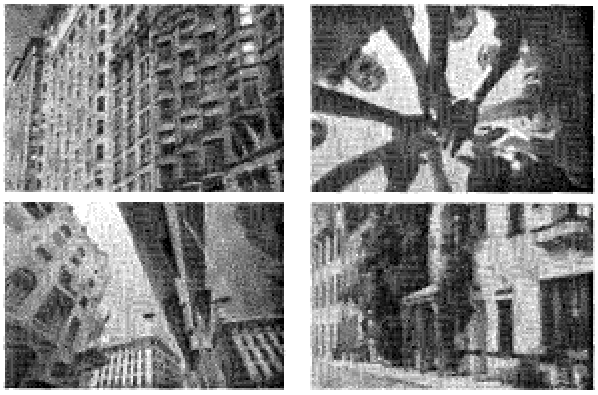
Wallonia Public Service – DGO4

Energy Efficiency Directive 2012/27 – Art. 14 – Strategy for district heating and cooling powered by cogeneration and waste energy



FINAL REPORT – TASKS 1 TO 6
December 2015

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Structure of the document

This report forms part of the transposition of Article 14 of Energy Efficiency Directive 2012/27/EU. In particular, Article 14.1 of the Directive envisages that Member States shall carry out a comprehensive assessment of the potential for applying high-efficiency cogeneration and efficient district heating and cooling, sending it to the Commission by 31 December 2015 at the latest and including the information set out in Appendix VIII. For the purposes of the assessment provided for by Article 14 paragraph 1, Article 14.3 of the Directive envisages that Member States shall carry out a country-level cost-benefit analysis based on climate conditions, economic feasibility and technical suitability in accordance with Section 1 of Appendix IX.

This report contains the results of the six phases of the study entrusted to the consortium made up of PwC, the Institute for Consultancy and Studies in Sustainable Development (*Institut de Conseil et d'Etudes en Développement Durable*, ICEDD) and the Bureau Ph. Deplasse by the Wallonia Public Service (General Operational Directorate - Regional Development, Housing, Heritage and Energy, DGO4) with the aim of responding to the obligation issuing from paragraphs 1 to 4 of Article 14, as well as Appendices VIII and IX, Section 1 of Directive 2012/27/EU and in particular the request to develop a strategy for networks powered by cogeneration and waste energy.

This report is organised into six chapters, each dedicated to one project task. These different tasks are listed below:

- **Task 1**: Heat demand and supply
- **Task 2**: Cooling demand and supply
- **Task 3**: Technical potential
- **Task 4**: Country-level cost-benefit analyses
- **Task 5**: Economic potential
- **Task 6**: Strategy for developing economic potential

Before presenting these different tasks, the introductory chapter sets out the context of energy consumption in Wallonia. This is in the form of a summary of the data from energy balances for 2012. No climate corrections have been made. It should be noted that 2012, with 1915 heating degree days[1] 15/15, was almost a normal year in this regard, a fact which is beneficial for our analysis. The norm was determined using data from the thirty-year period of 1981-2010 as being 1894 degree days 15/15.

[1] *Heating degree days = the difference in degrees centigrade between the average temperature of a given day and the reference temperature (the ICEDD uses 15°C as the reference) (average temperatures higher than the reference temperature were not taken into account. For a given period [month, year], the sum of degree days for the period is calculated). Degree days are used for calculating heating demand.*

Introduction – Context and energy consumption in Wallonia

I. 2012 ENERGY BALANCE

The main source of information is the energy balance for Wallonia carried out by the ICEDD on behalf of the General Operational Directorate 4 (GDO4). It provides final energy consumption for each carrier and sector, as well as the uses by the housing and tertiary sectors. As a preface to the analysis, here is an overview of this balance for 2012 (the most recent year available). In 2012, final consumption in Wallonia stood at 128 TWh split in essence between the industrial (45.464 TWh, 35%), transport (36.984 TWh, 29%), housing (31.101 TWh, 24%), tertiary (13.611 TWh, 11%) and agricultural sectors (1.079 TWh, 1%).

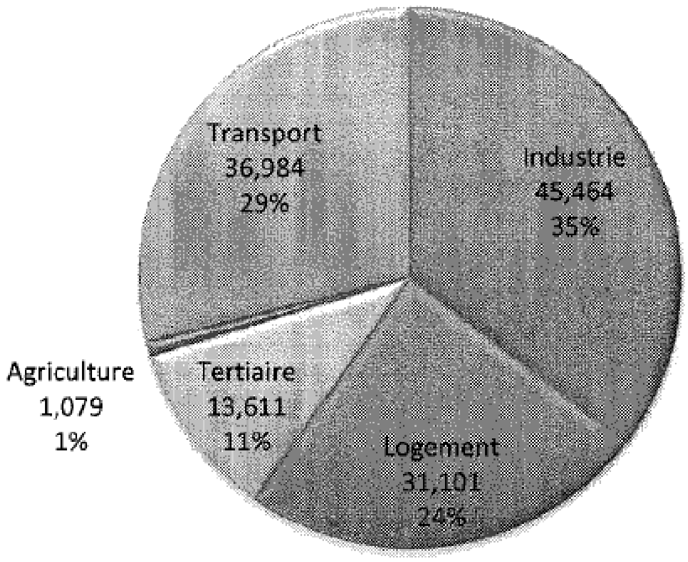


Figure 1 : Répartition de la consommation finale totale énergétique par secteur d'activité 2012

Transport	Transport
Industrie	Industry
Logement	Housing
Tertiaire	Tertiary
Agriculture	Agriculture
Figure 1 : Répartition de la consommation finale totale énergétique par secteur d'activité 2012	Figure 1: Distribution of total final energy consumption by sector of activity in 2012

Wallonia's total final energy consumption in 2012 was 6% lower than the previous year, and 12% lower than in 1990. This is the second lowest level of consumption achieved during the period 1985-2012, after that of 2009.

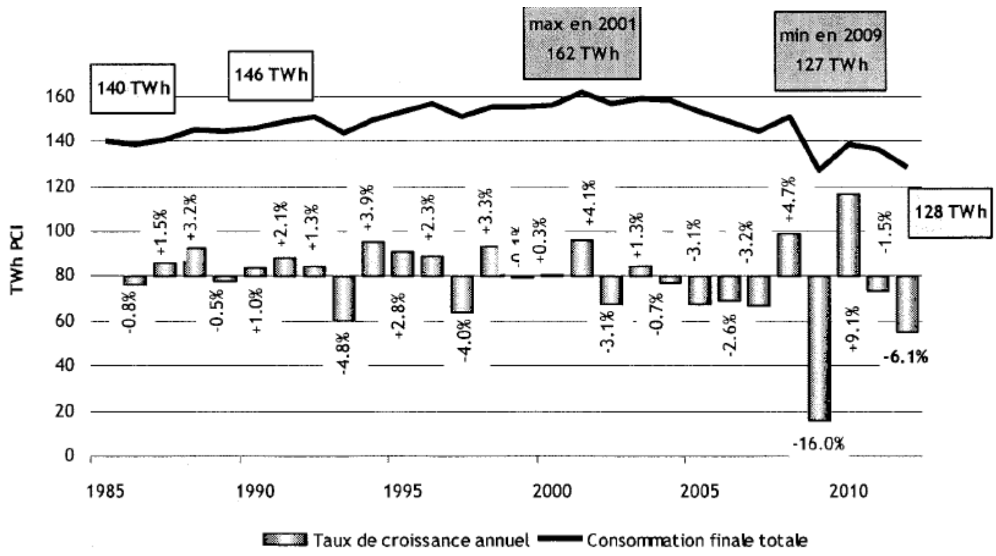
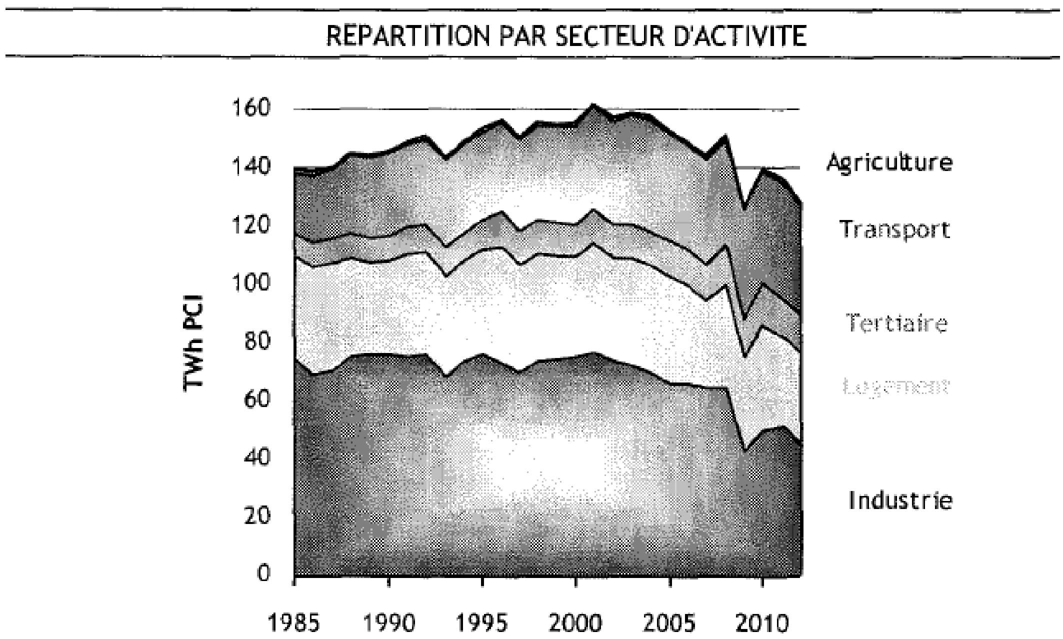


Figure 2 : Evolution de la consommation finale totale en Wallonie (1985-2012)

TWh PCI	TWh Lower Heating Value (LHV)
Max en 2001	Maximum in 2001
Min en 2009	Minimum in 2009
Taux de croissance annuel	Annual growth rate
Consommation finale totale	Total final consumption
Figure 2 : Evolution de la consommation finale total en Wallonie (1985-2012)	Figure 2: Evolution of total final consumption in Wallonia (1985-2012)

The proportion of energy consumed by the industrial sector dropped significantly between 1985 and 2012 (from 53% to 35%). There was also a reduction in the housing sector (from 25% to 24%), while the proportion consumed by both the tertiary and transport sectors increased (6% to 11% and 15% to 29% respectively).



REPARTITION PAR SECTEUR D'ACTIVITE	DISTRIBUTION BY SECTOR OF ACTIVITY
TWh PCI	TWh LHV

Agriculture	Agriculture
Transport	Transport
Tertiaire	Tertiary
Logement	Housing
Industrie	Industry

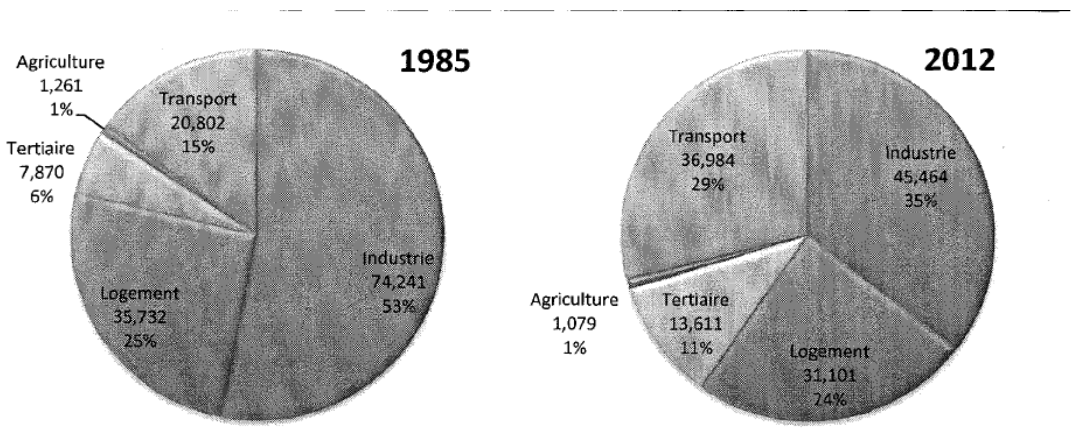


Figure 3 : Evolution de la consommation finale par secteur en TWh (1985-2012)

Agriculture	Agriculture
Tertiaire	Tertiary
Logement	Housing
Industrie	Industry
Transport	Transport
Figure 3 : Evolution de la consommation final par secteur en TWh (1985-2012)	Figure 3 : Changes in final consumption by sector in TWh (1985-2012)

I.1 CHARACTERISTICS OF THE RESIDENTIAL SECTOR (HOUSING)

The total energy consumed by the residential sector was 31.1 TWh LHV in 2012, compared with 32.2 TWh LHV in 1990, which is a decrease of 3.6% over the period in question. It should be noted, however, that this decrease was not linear and in fact varied between 30 and 37 TWh LHV. In 2011, the residential sector's energy consumption was at its lowest at 30 TWh, and 2005 it was at its highest with 36.5 TWh, which can be assumed to be linked to climate conditions.

In 2012, the energy consumed by the residential sector was mainly made up of diesel (37%), natural gas (30%) and electricity (22%). In 2012, energy from renewable sources represented almost 10% of energy consumption in the residential sector.

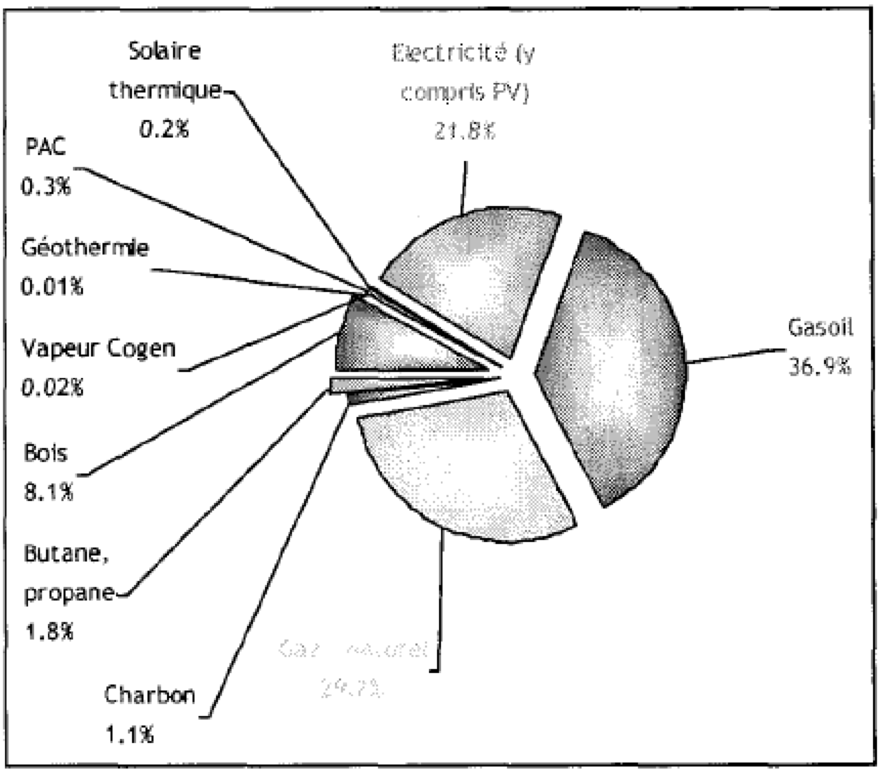


Figure 4 : Répartition de la consommation d'énergie du secteur résidentiel par vecteur (2012)

Solaire thermique	Solar thermal
Electricité (y compris PV)	Electricity (including PV)
Gasoil	Diesel
Gaz naturel	Natural gas
Charbon	Coal
Butane, propane	Butane, propane
Bois	Wood
Vapeur Cogen	Steam cogeneration
Géothermique	Geothermal
PAC	Heat pump
Figure 4 : Répartition de la consommation d'énergie du secteur résidentiel par vecteur (2012)	Figure 4: Distribution of energy consumption in the residential sector by carrier (2012)

Changes to Wallonia's housing stock, both in number and quality (type, size, comfort, facilities, age, etc.) have a decisive effect on energy consumption in the residential sector[2]. According to statistics from the Central Land Registry Office (*Administration Centrale du Cadastre*), Wallonia had 1,615,897 residential buildings on 1 January 2012, in comparison with 1,383,920 on 1 January 1995. The graph below shows that (I) 30.8% of Wallonia's residential buildings are detached properties, (II) 27.8% are terraced properties (III) 22.7% are semi-detached.

Of this housing stock, only a portion is occupied (as a result of works, sales, second homes, etc.), which amounted to around 1,522,000 residential buildings in 2012.

[2] Other factors have also affected energy consumption in the residential sector such as climate conditions, the makeup of households, incomes, energy prices, etc. For more information, see the Energy Balance of the Walloon Region 2012 – Domestic sector and equivalent.

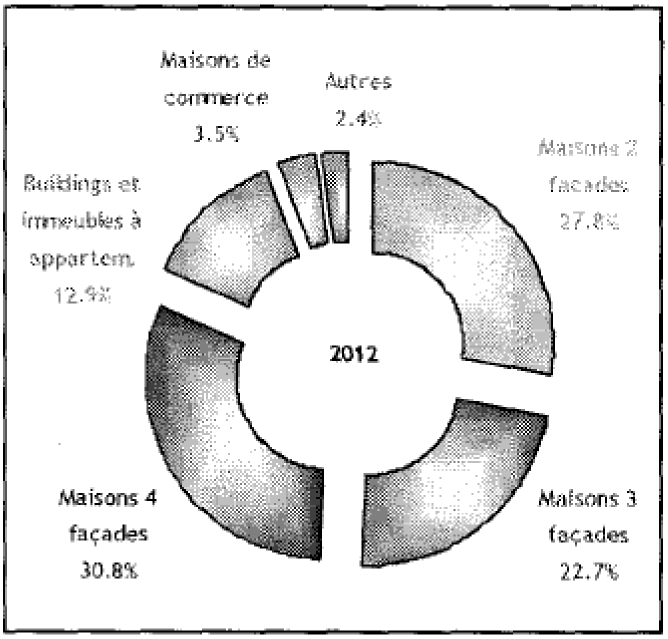


Figure 5 : Répartition du parc de logements wallons bâtis (2012)

Maisons de commerce	Commercial property
Autres	Other
Maisons 2 Façades	Terraced property
Maisons 3 façades	Semi-detached property
Maisons 4 façades	Detached property
Buildings et immeubles à appartem.	Apartment blocks and buildings
Figure 5 : Répartition du parc de logements wallons bâtis (2012)	Figure 5: Distribution of Wallonia's housing stock (2012)

On the subject of the energy consumption of the residential sector, it important to specify that:

- central heating accounts for three quarters of the residential sector's energy consumption (72% in 2012);
- domestic hot water heating represents a little over 10% of the energy consumed by the residential sector (12% in 2012);
- the remainder is used for cooking, and different specific uses of electricity (lighting, electronic household appliances, etc.).

The table below shows the distribution of Wallonia's occupied housing stock in 2012 by type of housing, heating and energy carrier. It shows that diesel is the main energy carrier used for heating. A distinction can nevertheless be made regarding the type of housing in question. For single-family homes, diesel is the main energy carrier used for heating, while in apartments, natural gas is the main carrier.

			Diesel	Natural gas	Coal	Butane, propane	Wood	Steam cogen.	Geothermal	Heat pump	Electricity	Total
In thousands of residences	Appart.	Central heating	91.7	149.6	0.10	1.57	0.4	0.60	0.31	1.84	18.3	264.4
		Decentralised heating	0.6	19.1	1.52	1.57	0.9			0.30	13.2	37.2
		Total heating	92.3	168.7	1.62	3.13	1.3	0.60	0.31	2.14	31.5	301.6
	Single-family homes	Central heating	593.6	324.2	0.84	16.80	12.5	0.04	0.02	3.22	28.9	980.1
		Decentralised heating	78.3	71.3	30.1	2.9	25.8			1.53	30.8	240.8
		Total heating	672	395.5	31.0	19.7	38.3	0.04	0.02	4.75	59.7	1220.9
	Total	Central heating	685.3	473.9	0.94	18.4	12.9	0.64	0.33	5.06	47.2	1244.5
		Decentralised heating	78.9	90.4	31.6	4.5	26.7			1.83	44.0	277.9
		Total heating	764.2	564.3	32.6	22.8	39.6	0.64	0.33	6.89	91.2	1522.5
As a % of the total stock	Appart.	Central heating	34.7%	56.6%	0.0%	0.6%	0.1%	0.2%	0.1%	0.7%	6.9%	100.0%
		Decentralised heating	1.6%	51.3%	4.1%	4.2%	2.4%			0.8%	35.5%	100.0%
		Total heating	30.6%	55.9%	0.5%	1.0%	0.4%	0.2%	0.1%	0.7%	10.4%	100.0%
	Single-family homes	Central heating	60.6%	33.1%	0.1%	1.7%	1.3%	0.0%	0.0%	0.3%	3.0%	100.0%
		Decentralised heating	32.5%	29.6%	12.5%	1.2%	10.7%			0.6%	12.8%	100.0%
		Total heating	55.0%	32.4%	2.5%	1.6%	3.1%	0.0%	0.0%	0.4%	4.9%	100.0%
	Total	Central heating	55.1%	38.1%	0.1%	1.5%	1.0%	0.1%	0.0%	0.4%	3.8%	100.0%
		Decentralised heating	28.4%	32.5%	11.4%	1.6%	9.6%			0.7%	15.8%	100.0%
		Total heating	50.2%	37.1%	2.1%	1.5%	2.6%	0.0%	0.0%	0.5%	6.0%	100.0%

Table 1: Distribution of occupied housing stock in Wallonia in 2012 by type of housing, heating and energy carrier of the main heating

Finally, the housing already supplied by district heating in Wallonia (geothermal or cogeneration) has been identified and accounts for at most 0.03% of the sector’s energy consumption.

I.2 CHARACTERISTICS OF THE TERTIARY SECTOR

In Wallonia, the tertiary sector provides 80% of the region’s jobs and 75% of total value added. In addition, the tertiary sector, along with the construction sector, has most contributed to employment growth in recent years. According to statistics from the Institute of National Accounts (ICN), employment in the tertiary sector grew by 26% in Wallonia from 1995 to 2012, while for the same period, employment in the industrial sector dropped by 3%. During this period, two branches of activity stood out with much higher average annual growth in employment rates than the average for the tertiary sector overall (+1.4%): banks, insurance and services for companies (+3.5%) and health (+2.8%).

Employment statistics for this classification are only available from 1995 onwards, so it is not possible to go back as far as 1990.

	Year	business	transport communications	banks, insurance and bus. servs.	education	health	admin.	others[3]	Tertiary total
In thousands of jobs	1995	192.8	70.2	122.6	109.0	107.7	110.0	65.7	778.1
	2000	191.1	74.2	154.0	103.1	126.1	121.0	70.9	840.3
	2005	195.1	71.4	175.5	108.8	142.5	130.6	75.5	899.3
	2010	197.1	70.1	208.3	116.4	163.4	132.8	73.7	961.9
	2011	200.4	70.1	215.4	119.1	168.0	131.3	74.7	979.0
	2012	199.6	68.4	218.4	119.5	171.3	130.0	74.2	981.4
With 1995 index = 100	1995	100	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2000	99.1	105.8	125.7	94.5	117.0	109.9	107.9	108.0
	2005	101.2	101.8	143.2	99.7	132.2	118.7	114.9	115.6
	2010	102.2	100.0	169.9	106.8	151.6	120.7	112.2	123.6
	2011	103.9	99.9	175.7	109.2	156.0	119.3	113.7	125.8
	2012	103.5	97.5	178.1	109.6	159.0	118.2	113.0	126.1
As % of the tertiary total	1995	24.8%	9.0%	15.8%	14.0%	13.8%	14.1%	8.4%	100.0%
	2000	22.7%	8.8%	18.3%	12.3%	15.0%	14.4%	8.4%	100.0%
	2005	21.7%	7.9%	19.5%	12.1%	15.8%	14.5%	8.4%	100.0%
	2010	20.5%	7.3%	21.7%	12.1%	17.0%	13.8%	7.7%	100.0%
	2011	20.5%	7.2%	22.0%	12.2%	17.2%	13.4%	7.6%	100.0%
	2012	20.3%	7.0%	22.3%	12.2%	17.5%	13.2%	7.6%	100.0%
Change 1995-2012		+3.5%	-2.5%	+78.1%	+9.6%	+59%	+18.2%	+13%	+26.1%
Average annual growth rate		+0.2%	-0.2%	+3.5%	+0.5%	+2.8%	+1%	+0.7%	+1.4%
Change 2011-2012		-0.4%	-2.5%	+1.4%	+0.4%	+2%	-0.9%	-0.6%	+0.3%

Table 2 – Employment (employed and self-employed) in the tertiary sector of Wallonia
Source: ICN regional accounts

[3] Culture and sport, services for people and various

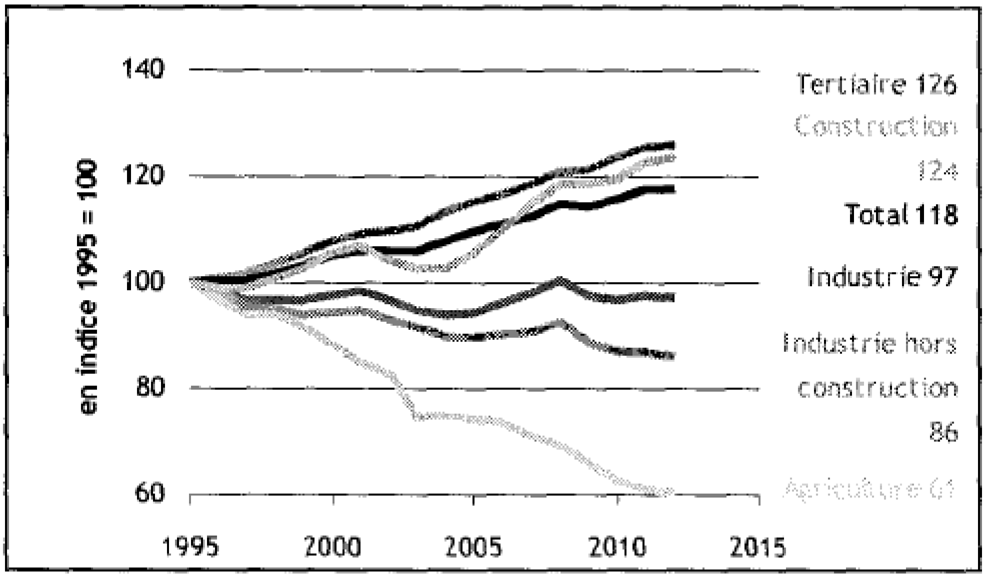


Figure 6 : Evolution de l'emploi en Wallonie

En indice 1995 = 100	As the 1995 index = 100
Tertiaire	Tertiary
Construction	Construction
Total	Total
Industrie	Industry
Industrie hors construction	Industry excluding construction
Agriculture	Agriculture
Figure 6 : Evolution de l'emploi en Wallonie	Figure 6: Changes in employment in Wallonia

Using the data obtained by the energy study carried out each year by the ICEDD and data on domestic employment from the ICN, it is possible to estimate the surface area of the tertiary sector in Wallonia. For 2012, the surface area was estimated at 56 million square metres (which is a 16% increase on 1995). The three main branches of activity in terms of surface area are, in descending order, business (26%), education (18%) and banks, insurance and business services (17%).

Between 1990 and 2012, the total consumption of the tertiary sector increased by 60% to reach 13.611 TWh LHV.

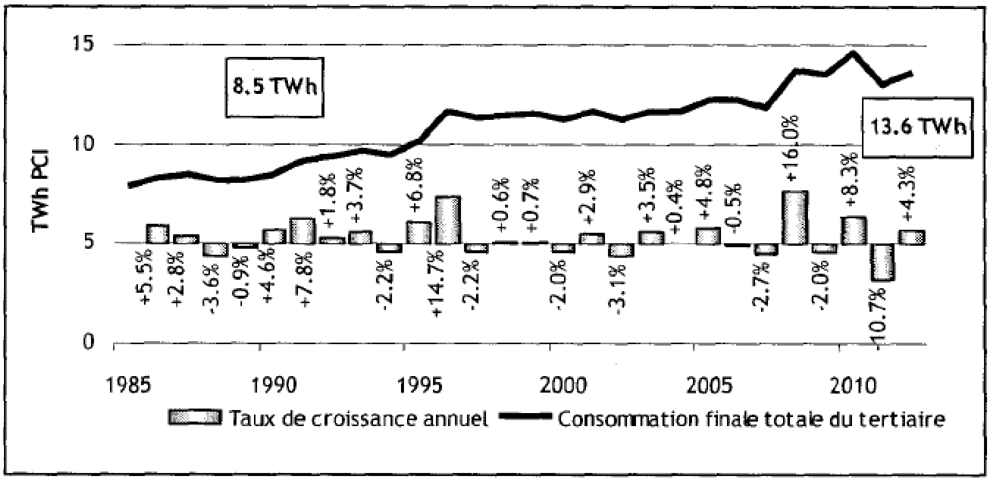


Figure 7 : Evolution de la consommation totale du secteur tertiaire en Wallonie

TWh PCI	TWh LHV
Taux de croissance annuel	Annual growth rate
Consommation finale totale du tertiaire	Total final consumption of the tertiary sector
Figure 7 : Evolution de la consommation totale du secteur tertiaire en Wallonie	Figure 7: Changes in total consumption of the tertiary sector in Wallonia

Within the tertiary sector, four branches of activity share close to three quarters of total energy consumption. In descending order, these are business and arts and crafts (40%), education (12%), care and health (11%) and administration (9%). As shown in the following table, the figure for business has been in growth since 1995, with significant variations between larger retailers and small shops.

	Year	**Electricity**	**Fuels**	**of which oil products**	**of which natural gas**	**of which others**[4]	**Total**
in TWh LHV	1985	2.345	5.516	3.174	2.186	156	7.862
	1990	3.162	5.366	3.208	2.050	108	8.527
	1995	3.922	6.202	3.420	2.636	146	10.124
	2000	4.340	6.939	3.633	3.153	153	11.279
	2005	5.204	7.045	3.797	3.198	49	12.249
	2010	5.984	8.620	3.106	5.376	137	14.603
	2011	5.744	7.301	2.593	4.546	161	13.045
	2012	5.839	7.772	2.540	5.032	200	13.611
as 1990 index = 100	1985	74.2	102.8	98.9	106.6	144.6	92.2
	1990	100	100	100	100	100	100
	1995	124.1	115.6	106.6	128.6	135.3	118.7
	2000	137.3	129.3	113.2	153.8	141.6	132.3

[4] [Translator's note – footnote missing in source text]

	2005	164.6	131.3	118.4	156	45.7	143.6
	2010	189.3	160.6	96.8	262.2	127.4	171.3
	2011	181.7	136.1	80.8	221.8	149.8	153
	2012	184.7	144.8	79.2	245.5	185.7	159.6
as % of the total	1985	29.8%	70.2%	40.4%	27.8%	2.0%	100.0%
	1990	37.1%	62.9%	37.6%	24.0%	1.3%	100.0%
	1995	38.7%	61.3%	33.8%	26.0%	1.4%	100.0%
	2000	38.5%	61.5%	32.2%	28.0%	1.4%	100.0%
	2005	42.5%	57.5%	31.0%	26.1%	0.4%	100.0%
	2010	41.0%	59.0%	21.3%	36.8%	0.9%	100.0%
	2011	44.0%	56.0%	19.9%	34.8%	1.2%	100.0%
	2012	42.9%	57.1%	18.7%	37.0%	1.5%	100.0%
Evolution 1990-2012		+84.7%	+44.8%	-20.8%	+145.5%	+85.7%	+59.6%
Average annual growth rate 1990-2012		+2.8%	+1.7%	-1.1%	+4.2%	+2.9%	+2.1%
Evolution 2011-2012		+1.7%	+6.5%	-2.1%	+10.7%	+23.9%	+4.3%

Figure 8: Changes in the distribution of consumption by carrier in the tertiary sector (1958-2012)

In addition, the final energy balance provides the distribution of the tertiary sectors' consumption by vector, and shows that electricity consumption saw the greatest increase between 1990 and 2012 (+85%), representing over 40% of the total energy consumption of the tertiary sector.

Finally, it should be indicated that the energy balance provides information on the penetration rate of air conditioning systems (by survey) and also refers to a study carried out by the University of Antwerp[5] (STEM) which provides consumption percentages for the main uses of the different branches of tertiary activity. This distribution exists for the use of fuels and electricity in each branch of activity.

Electricity is used primarily (40%) for lighting, around 3% for heating or domestic hot water, 9% for air conditioning and 7% for cold temperature generation in fridges and freezers. This differs between the sector's different branches.

		Lighting	**Heating and domestic hot water**	**Air conditioning**	**Circulation pumps and ventilators[6]**	**Cooling**	**Others[7]**	**Total**
in TWh LHV	Business	0.955	0.051	0.048	0.007	0.379	0.266	0.153
	Transport communications	0.079	0.012	0	0	0	0.031	0.029
	Banks, ins., servs for bus.	0.216	0.012	0	0	0	0.080	0.092
	Education	0.251	0.008	0	0	0.016	0.035	0.039
	Care, health	0.164	0.007	0	0	0	0.043	0.029
	Culture and sport	0.060	0.010	0	0	0	0.024	0.022

[5] *'Bouw en ontwikkeling van SAVER-LEAP ais tool voor scenario-analyses van energiegebruik en emissies: beschrijving van methoden, data en veronderstellingen met een concrete toepassing op de sector handel & diensten in Vlaanderen',* May 2006

[6] For heating and air conditioning

[7] Others include cooking, office equipment and other uses of electricity not mentioned

	Other services	0.030	0.005	0	0	0	0.012	0.011
	Administration	0.131	0.007	0	0	0	0.049	0.056
	Various	0.429	0	0	0	0	0	0
	Total	**2.315**	**0.111**	**0.048**	**0.007**	**0.395**	**0.540**	**0.431**
	as % of the total	**40%**	**3%**	**9%**	**7%**	**7%**	**34%**	**100%**

Table 3: Distribution of tertiary electricity consumption by usage in 2012 (TWh)

The distribution of fuel consumption by usage is listed in the table below. On average, 88% of consumption is destined for heating buildings, and 9% for hot water.

		Heating	**Hot water**	**Other uses**	**Total**
in TWh LHV	Business	2.840	0.228	0.009	3.076
	Transport communications	0.175	0.020	0.008	0.203
	Banks, ins., servs for bus	0.190	0.017	0	0.207
	Education	1.201	0.063	0.016	1.279
	Health care	0.635	0.225	0.143	1.004
	Culture and sport	0.452	0.053	0.021	0.526
	Other services	0.420	0.049	0.020	0.488
	Administration	0.746	0.065	0	0.811
	Water energy	0.153	0.018	0.007	0.178
	Total	**6.812**	**0.737**	**0.223**	**7.772**
as % of the total		88%	9%	3%	100%

Table 4: Distribution of fuel consumption in the tertiary sector by usage in 2012 (TWh)

I.3 CHARACTERISTICS OF THE INDUSTRIAL SECTOR

In Wallonia, the industrial sector contributes over 20% to the creation of value added for retail businesses. The manufacturing industry is the main industrial sector in Wallonia. It includes, in decreasing order of weight, the pharmaceutical industry, metallurgy, the food processing industry and the food industry which make up over 60% of added value created in Wallonia (with 23%, 19%, 12% and 12% respectively).

Overall in 2012, the industrial sector accounted for 45.5 TWh of Wallonia's final energy consumption, whereas in 1990, the figure stood at 76.3 TWh, a decrease of 40% over this period.

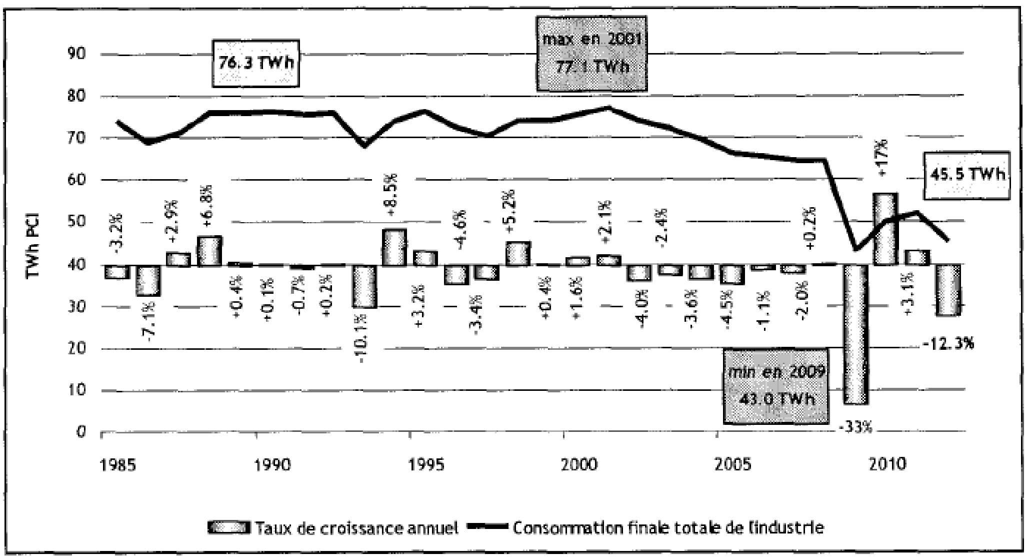


Figure 9 : Evolution de la consommation finale d'énergie de l'industrie (y compris les consommations à usages non énergétiques)

TWh PCI	TWh LHV
Max en 2001	Max in 2001
Max en 2009	Max in 2009
Taux de croissance annuel	Annual growth rate
Consommation finale totale de l'industrie	Total final consumption of the industrial sector
Figure 9 : Evolution de la consommation finale d'énergie de l'industrie (y compris les consommations a usages non énergétiques)	Figure 9: Changes in industry's final energy consumption (including consumption for non-energy usage)

However, this 40% reduction masks changes in consumption among the different branches of Wallonia's industry. For example, the steel industry's consumption fell by 82% during the period 1990-2012, while that of the chemical industry fell by only 3%. The branch of industry in Wallonia that consumed the most energy in 2012 was the non-metallic minerals industry, which represented over a third of the industrial sector's total energy consumption.

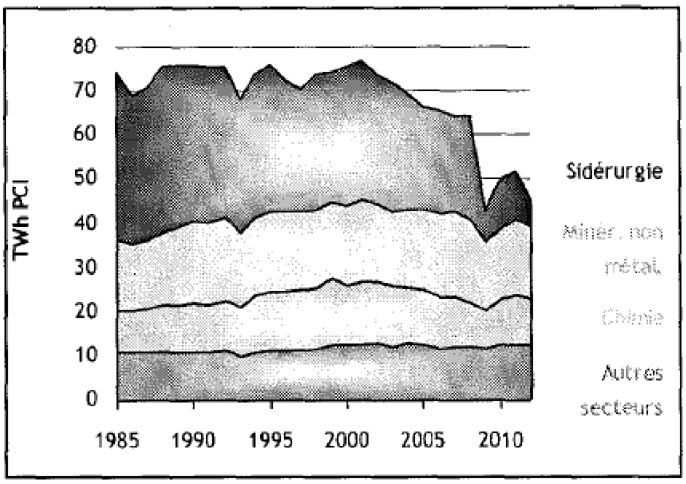


Figure 10 : Evolution de la consommation d'énergie par branche d'activité

Sidérurgie	Steel industry
Miner, non métal	Non-metallic minerals
Chimie	Chemical industry
Autres secteurs	Other sectors
TWh PCI	TWh LHV
Figure 10 : Evolution de la consommation d'énergie par branche d'activité	Figure 10: Changes in energy consumption in each sector of activity

The graph below shows the distribution of the industrial sector's energy consumption by energy carrier. Between 1990 and 2012, the consumption of solid fuels (and derived gas) dropped by 87%, due in large part to the fall in the steel industry's consumption, which in turn was due to the gradual shut-down of all blast furnaces. In 2012, these solid fuels made up only 10% of final energy consumption, whereas in 1990 they had accounted for 43%. In contrast, electricity consumption grew by 13% in the same period, increasing from 12% to 23.6%. In 2012, natural gas (35%) and electricity (23.6%) accounted for almost 60% of the total consumption of Wallonia's industry.

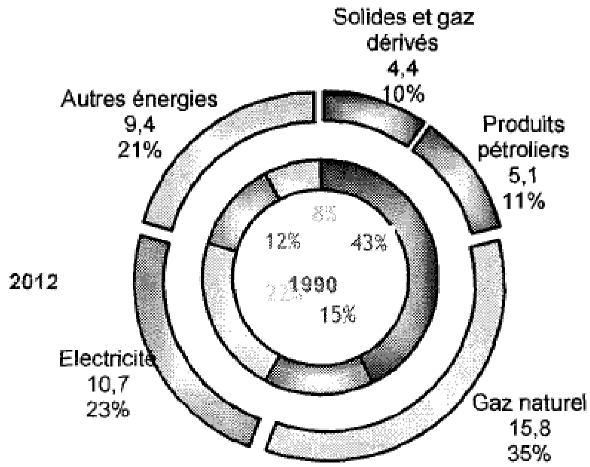


Figure 11 : Répartition de la consommation finale d'énergie de l'industrie par vecteur énergétique (2012)

Solides et gaz dérivés	Solids and derived gas
Produits pétroliers	Oil products
Gaz naturel	Natural gas
Electricité	Electricity
Autres énergies	Other forms of energy
Figure 11 : Répartition de la consommation finale d'énergie de l'industrie par vecteur énergétique (2012)	Figure 11: Distribution of the industrial sector's final energy consumption by energy carrier (2012)

In 2012, the overall heat demand of Wallonia's industrial sector was estimated to be a little under 35 TWh on the basis of its consumption of fuels, excluding electricity. The exact amounts consumed by the largest businesses are available, accounting for almost 90% of the sector's consumption.

The balances do not distinguish between demand for heat at a high temperature (steam) and that which could be powered using district heating networks. In order to make this distinction, assumptions must be applied to each sub-branch as part of the methodology.

For this mission, the ICEDD will rely on expertise acquired from industrialists and their federations during the performance of other missions, such as the distribution of energy information to industrials in Wallonia, cogeneration facilitator and waste heat recovery potential (see ICEDD references).

Chapter 2 – Heat demand and supply

I. ESTIMATED HEAT DEMAND IN 2012

The source of information used to establish Wallonia's heat demand in 2012 was the official energy balance published by the energy division of DGO4 which provides the statistics on energy consumption used for international reporting to meet the requirements of European directives on energy and for regional policy on this subject.

The tenderer will not explain the reporting methods used to draw up these energy balances, as reports on this subject are available from the DGO4.

We have defined two kinds of heat demand.

Firstly, the overall heat demand, which is all the requirements for heat, irrespective of its temperature and constitutes the sum of the heat required for industrial processes, heating, domestic hot water and cooking.

The second kind of demand includes the uses of heat at a lower temperature (50°C to 250°C), which can be supplied by district heating or cogeneration (hot water or steam), which will be referred to as **substitutable heat demand** hereafter. This substitutable demand does not include demand for high-temperature industrial heat or for cooking, as it is difficult to meet such demand using district heating, cogeneration and even waste heat recovery.

The overall and substitutable heat demand of each sector of activity in Wallonia's energy mix (domestic, residential and tertiary and industrial) have been analysed.

The analysis did not include the consumption of agriculture and transport, as they have no demand for heat or cooling. Consequently, 38 TWh were disregarded for the analysis, which amounts to 30% of the final consumption balance. For the industrial sector, only consumption that excludes non-energy purposes is used, which amounts to 41.6 TWh out of 45.5 TWh. These non-energy purposes concern using fuel to manufacture products, such as the use of natural gas to produce fertiliser.

I.1 OVERALL RESULTS

The table below presents a summary of heat demand. Details of each sector are provided in the following paragraphs. The total of 86.342 TWh represents 67.5% of Wallonia's total final consumption (128 TWh).

Sector	Heat process (high temp.)	Heating	Backup heating	Domestic hot water	Cooking	Other uses	TOTAL	Total heat demand	Substitutable heat	Proportion of heat that is substitutable
Tertiary		6.924		0.785	0.007	5.895	13.611	7.716	7.709	56.6%
Housing		20.181	2.246	3.608	0.878	4.187	31.101	26.913	26.035	83.7%
Industry	19.585	11.319				10.726	41.630	30.904	11.319	27.2%
Total	19.585	38.423	2.246	4.393	0.886	20.808	86.342	65.533	45.063	52.2%

Table 5: Summary of Wallonia's heat demand, by usage and sector (TWh).

The overall heat demand (65.533 TWh) represents 76% of these three sectors' total energy consumption, which demonstrates the importance of this demand within the energy balance.

Substitutable heat accounts for over half (52.2%) of the final energy consumption of the three sectors, which is total of 45.063 TWh. Demand from the housing sector accounts for a significant proportion of this total (26.035 TWh, 58%), followed by the industrial sector (11.319 TWh, 25%) and finally the tertiary sector (7.709 TWh, 17%).

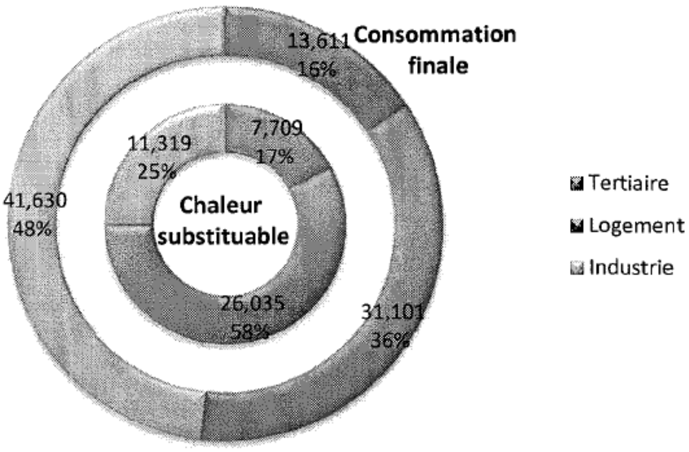


Figure 12 : Répartition de la consommation finale d'énergie et des besoins de chaleur substituable en Wallonie (TWh, 2012)

Consommation finale	Final consumption
Chaleur substitutable	Substitutable heat
Tertiaire	Tertiary
Logement	Housing
Industrie	Industry
Figure 12 : Répartition de la consommation finale d'énergie et des besoins de chaleur substituable en Wallonie (TWh, 2012)	Figure 12 : Distribution of Wallonia's final energy consumption and substitutable heat demand (TWh, 2012)

The outer circle of the figure above represents each sector's proportion of final energy consumption (that of the three sectors). The inner circle represents the proportion of the substitutable heat demand made up by each of the three sectors.

Although industry accounts for almost half of energy consumption (48%), the heat demand that can be supplied by district heating or cogeneration only represents one quarter of total substitutable demand. Conversely, housing, which represents 36% of energy consumption, makes up 58% of substitutable heat demand, making it the sector with the greatest potential for substitution.

I.2 HEAT DEMAND IN THE HOUSING SECTOR

I.2.1 Sources

The DGO4's regional energy balances provide information on consumption by energy carrier and usage in the housing sector for the period from 1990 to 2012, as shown in section I.1 of Chapter I on page 11.

I.2.2 Methods

Energy consumed in the housing sector is used for main central heating (a unit generating and distributing heat in residential rooms or electric storage heaters), main decentralised heating (heaters, stoves, freestanding wood burners in residential rooms), backup heating (additional supply with limited heating time), domestic hot water generation, cooking and various uses of electricity (lighting, fridge, freezer, washing machines, etc.).

The uses are determined by energy carrier: coal, fuel oil, butane-propane, electricity, wood, others (cogeneration, solar, heat pump, etc.).

Overall heat demand includes main heating, backup heating, domestic hot water and cooking.

Substitutable heat demand that could be covered by an external supply linked to district heating or cogeneration does not include heat demand for use in cooking.

I.2.3 Results

According to the methodology above and data from 2012, total consumption is 31.1 TWh, and the housing sector's overall heat demand amounts to 26.913 TWh, or 87% of the total.

For 2012, **substitutable heat demand** (excluding cooking) stands at **26.035 TWh**, which represents **84%** of the sector's total consumption.

This figure therefore represents the maximum potential for substitution for housing in Wallonia.

It was not possible to establish a theoretical substitution potential that takes into account housing location, either how close housing is to a source of waste heat or a location with sufficient housing density to make district heating technically possible, within the timeframe allocated for this mission.

Potential will however be mapped by municipality, as the consumption of housing in each municipality is available. We will apply the same distribution by usage in each municipality as that established on a regional level.

The distribution of consumption by the housing sector in each municipality is based on the number and type of residences in each municipality, their level of insulation and the length of the municipality's heating season, which is established using measurements taken at the closest weather station.

The following table provides the details of heating demand by energy carrier, including both the demand that can be substituted and that which cannot.

Type of housing	Usage	Diesel	Natural gas	Coal	Butane propane	Wood	Steam cogen.	Geothermal	Heat pumps	Solar thermal	Electricity	Total
All housing	Specific electricity	0	0	0	0	0	0	0	0	0	4.188	4.188
All housing	Cooking	0	0.211	0.001	0.090	0.006	0	0	0	0	0.572	0.878
All housing	Domestic hot water	0.966	1.317	0.001	0.307	0.021	0.002	0	0	0.075	0.919	3.608
All housing	Backup heating	0	0	0.010	0	1.916	0	0	0	0	0.320	2.246
Sub-total excluding heating	Total excl. heating	0.966	1.528	0.011	0.397	1.943	0.002	0.000	0.000	0.075	5.998	13.920
Flats Main heating	Central heating	0.643	1.186	0.001	0.006	0.004	0.004	0.002	0.018	0	0.105	1.968
Flats Main heating	Decentr. heating	0.004	0.147	0.011	0.006	0.008	0	0	0.003	0	0.074	0.253
Single-family houses Main heating	Central heating	9.102	5.621	0.013	0.133	0.253	0.001	0	0.068	0	0.363	15.554
Single-family houses Main heating	Decentr. heating	0.746	0.768	0.299	0.014	0.318	0.000	0	0.020	0	0.240	2.406
Sub-total Heating	Total heating	10.495	7.722	0.324	0.159	0.583	0.005	0.003	0.109	0	0.783	20.181
Total heating and excl. heating		**11.461**	**9.250**	**0.335**	**0.556**	**2.525**	**0.006**	**0.003**	**0.109**	**0.075**	**6.780**	**31.101**
overall heat demand	Total	11.461	9.250	0.335	0.556	2.525	0.006	0.003	0.109	0.075	2.593	26.913
overall heat demand	As a prop. of total	100%	100%	100%	100%	100%	100%	100%	100%	100%	38%	87%
Substitutable heat	**Total**	11.461	9.040	0.335	0.466	2.520	0.006	0.003	0.109	0.075	2.021	26.035
Substitutable heat	As a prop. of total	100%	98%	100%	84%	100%	100%	100%	100%	100%	30%	84%

Table 6: Distribution of consumption by the housing sector by carrier and usage in 2012, with heating demand (TWh).

I.3 HEAT DEMAND IN THE TERTIARY SECTOR

I.3.1 Sources

The DGO4's regional energy balances provide information on consumption by energy carrier, sub-branch and usage in the tertiary sector for the period 2000 to 2012, as shown in section I.2 of Chapter I on page 16.

I.3.2 Methods

Electricity and fuel usage in the tertiary sector is analysed separately and differentiated by branch of activity (business, care and health, offices, administration, culture, etc.).

Fuels are used for heating demand, domestic hot water generation demand and other usages.

Electricity is used for heating, domestic hot water, cooking, cooling (refrigeration, freezing), air conditioning, office equipment, lighting, circulation pumps and other usages.

Heating demand includes the use of electric heating and fuels, domestic hot water heated by electricity and fuels and cooking. **Substitutable heat demand** that can be met by an external source linked to district heating or cogeneration does not include that used for cooking.

I.3.3 Limits

The distribution by usage dates from the STEM study (see reference on page 17 carried out in 2000 and is not updated by annual surveys. Distribution is done at brand or sub-branch level within the tertiary sector and therefore assumes that all the establishments within the same branch function in a similar manner.

When dimensioning an installation, demand to be met from establishments affected by the project should be established more precisely.

I.3.4 Results

According to the methodology above and data from 2012, total consumption was 13.611 TWh and the tertiary sector's overall heat demand amounted to 7.716 TWh, which represents 56.7% of the total.

In 2012, **substitutable heat demand** (excluding cooking) amounted to **7.709 TWh**, which represents **56.6%** of the sector's total consumption.

This figure is therefore the maximum substitution potential for the tertiary sector in Wallonia.

It was not possible to establish a theoretical substitution potential that takes into account the location of all establishments, either with sufficient proximity to a source of waste heat or a location with sufficient density to make district heating economically viable.

They will however be mapped by municipality, as the consumption of the tertiary sector in each municipality is available. However, as a result of a survey, the individual consumption of close to 2,400 establishments in the tertiary sector is available, and substitutable heat demand has been deduced from this on the basis of their branch of activity. They are geo-localisable and have been mapped. They represent 23% of the total consumed.

The following table provides the details of heating demand by type of energy carrier and usage, both the demand which is substitutable and that which is not.

Fuel uses	**Heating**	**Hot water**	**Other uses**	**Total**	**Sub-total Substitutable heat**	**Prop. Substitutable heat**
Business	2.840	0.228	0.009	3.076	3.068	99.7%
Transport communications	0.175	0.020	0.008	0.203	0.195	69.0%
Banks, ins., servs. for businesses	0.190	0.017	0.000	0.207	0.207	100.0%
Education	1.201	0.063	0.016	1.279	1.263	98.8%
Health care	0.635	0.225	0.143	1.004	0.861	85.8%
Culture and sport	0.452	0.053	0.021	0.526	0.505	96.0%
Other services	0.420	0.049	0.020	0.488	0.468	96.0%
Administration	0.746	0.065	0.000	0.811	0.811	100.0%
Various	0.153	0.018	0.007	0.178	0.171	96.0%
Total	**6.812**	**0.737**	**0.223**	**7.772**	**7.549**	**97.1%**

Electricity uses	Lighting	Heating	Hot water	Cooking	Cooling	Air cond.	Circulation pumps	Office equipment	Others	Total	**Sub-total Substitutable heat**	**Prop. Substitutable heat**
Business	0.955	0.051	0.048	0.007	0.379	0.266	0.153	0	0.565	2.425	0.099	4.1%
Transport communications	0.079	0.012	0	0	0	0.031	0.029	0.007	0.166	0.323	0.012	3.6%
Banks, ins., servs. for businesses	0.216	0.012	0	0	0	0.080	0.092	0.151	0.065	0.616	0.012	2.0%
Education	0.251	0.008	0	0	0.016	0.035	0.039	0.038	0.022	0.408	0.008	1.9%
Health care	0.164	0.007	0	0	0	0.043	0.029	0	0.271	0.514	0.007	1.3%
Culture and sport	0.060	0.010	0	0	0	0.024	0.022	0	0.142	0.257	0.010	3.7%
Other services	0.030	0.005	0	0	0	0.012	0.011	0	0.072	0.131	0.005	3.7%
Administration	0.131	0.007	0	0	0	0.049	0.056	0.092	0.039	0.374	0.007	2.0%
Various	0.429	0.00	0	0	0	0.000	0.000	0.000	0.362	0.792	0.000	0.0%
Total	2.315	0.111	0.048	0.007	0.395	0.540	0.431	0.287	1.704	5.839	0.160	2.7%

Total usage	Heating	Hot water	Cooking	other uses	TOTAL	overall heat demand	Prop. Heat demand	Sub-total Substitutable heat	Prop. Substitutable heat
Business	2.891	0.276	0.01	2.327	5.501	3.174	57.7%	3.167	57.6%
Transport communications	0.186	0.020	0.00	0.319	0.526	0.207	39.3%	0.207	39.3%
Banks, ins., servs. for businesses	0.202	0.017	0.00	0.604	0.823	0.219	26.6%	0.219	26.6%
Education	1.208	0.063	0.00	0.416	1.687	1.271	75.3%	1.271	75.3%
Health care	0.642	0.225	0.00	0.650	1.517	0.867	57.2%	0.867	57.2%
Culture and sport	0.462	0.053	0.00	0.269	0.783	0.515	65.7%	0.515	65.7%
Other services	0.424	0.049	0.00	0.145	0.619	0.473	76.5%	0.473	76.5%
Administration	0.754	0.065	0.00	0.367	1.185	0.819	69.1%	0.819	69.1%
Various	0.153	0.018	0.00	0.799	0.970	0.171	17.6%	0.171	17.6%
Total	6.924	0.785	0.01	5.895	13.611	7.716	56.7%	7.709	56.6%

Table 7: Distribution of the tertiary sector's consumption by branch, type of carrier and usage in 2012, with heating demand (TWh).

I.4 HEAT DEMAND IN THE INDUSTRIAL SECTOR

I.4.1 Sources

The DGO4's regional energy balances provide information on consumption by energy carrier and sub-branch in the industrial sector for the period 1985 to 2012, as shown in section I.3 of Chapter I (page 19). The balances do not include energy usage calculations.

The report *Scénarios de développement de la cogénération en région wallonne* (Scenarios for developing cogeneration in Wallonia) drawn up for the CWaPE (*Commission Wallon pour l'Energie*, Walloon Commission for Energy) in 2005 is a useful source for energy usage. This report defines the proportion of heat for each branch of industrial activity that can be substituted for a cogeneration supply (or district heating).

Finally, the report *Répartition des besoins énergétiques en industrie* (Distribution of energy demand in industry) drawn up in connection with the INFOIND 12 mission on behalf of the DGO4 provides information on electricity usage for several of the main branches of the industrial sector.

I.4.2 Methods

The most common assumption when estimating the industrial sector's heat demand is to consider fuel consumption as a whole. This groups together temperature ranges that vary greatly from branch to branch, with values ranging from around 100°C to above 1500°C. We have used the table below, which is the result of work on cogeneration potential, to calculate the substitutable heat demand of fuel consumption. The total in then calculated per branch.

Sub-branch code	Sub-branch	% substitutable
100	STEEL INDUSTRY	5%
200	NON-FERROUS MINERALS	5%
300	ORGANIC AND INORGANIC CHEMICAL INDUSTRY	72%
300	PARACHEMISTRY (EXCLUDING O2)	71%
300	OXYGEN	90%
300	FERTILISER	77%
300	CHEMICAL INDUSTRY	72%
400	CEMENT	3%
400	LIME, QUARRIES AND DOLOMITE	0%
400	FLAT GLASS	0%
400	OTHER NON-METALLIC MINERALS	20%
500	SUGAR REFINERIES	7%
500	DAIRIES	9%
500	OTHER FOOD	7%
600	TEXTILE	76%
700	PAPER PULP	92%
700	PAPER PRINTING	92%
800	MANUFACTURE OF FABRICATED METAL PRODUCTS	57%
800	ELECTRIC CONSTRUCTIONS	57%
800	TRANSPORT EQUIPMENT	57%
800	METAL MANUFACTURE (NON-SPECIFIC)	57%
900	OTHER INDUSTRIES	53%
900	SAWMILLS AND CONSTRUCTION TIMBER	53%
900	PALLET MANUFACTURE	53%

Table 8: Proportion of substitutable heat in the energy balance by industrial branch.

The study carried out in connection with the INFOIND 12 mission in collaboration with industrial federations provides the following distribution used to determine how the electricity consumed by industrial branches is used.

Federation	**Air conditioning**	**Heating**	**Lighting**	**Cold process**	**HVAC**	**IT**	**Packaging**	**Heat pump**	**Ventilation**	**Others**
FEVIA	2.9%	0.0%	12.0%	21.5%	0.2%	0.1%	2.7%	0.0%	0.6%	60.1%
ESSENSCIA	0.4%	0.8%	9.0%	13.5%	5.8%	0.1%	0.4%	0.0%	0.0%	69.9%
Others	1.0%	0.9%	5.8%	0.5%	0.3%	0.4%	0.9%	0.0%	0.4%	89.7%
FIV-GSV-FEBELCEM-Lime	0.1%	0.0%	2.6%	0.5%	0.0%	0.0%	0.3%	0.0%	0.0%	96.5%
Extractive industry	0.0%	0.8%	2.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	97.1%

FEDUSTRIA- FETRA- AGORIA- FEBELGRA	3.9%	2.4%	15.9%	1.4%	1.2%	1.6%	3.1%	0.0%	1.6%	69.0%

Table 9: Proportion of substitutable heat of the energy balance by branch of industry.

The federations are as follows:

- FEVIA: food sector, food processing, sub-branch code 500;
- ESSENSCIA: chemical industry, parachemistry, sub-branch code 300;
- FIV-GSV-FEBELCEM-Lime: glass sector, steel, cement, lime (non-metallic minerals), sub-branch codes 100 and 400;
- Extractive industry;
- AGORIA-FEDUSTRIA-FETRA-FEBELGRA: technology, textile and wood, paper and printing, sub-branch codes 600, 700, 800 and 900.

I.4.3 Limits

A relatively rapid overall estimate of the industrial sector's heat demand can be calculated using this method, which is a clear advantage.

Companies within one federation or branch of activity can present vastly differing demand. The real substitutable demand may only be established through an exhaustive study that carries out individual surveys. Such a study would exceed the remit of this mission. In addition, this analysis should be done on-site when developing waste heat recovery, district heating or even cogeneration projects.

I.4.4 Results

According to the methodology above and data from 2012, total consumption stood at 41.63 TWh. The industrial sector's overall heat demand amounted to 30.904 TWh, which represents 74% of the total.

For 2012, s**ubstitutable heat demand** (<250°C) amounted to **11.319 TWh**, which represents **27.2%** of the sector's total consumption.

This figure therefore represents the maximum substitution potential for the region's industrial sector.

It was not possible to establish a theoretical substitution potential that takes into account the location of all establishments, either with sufficient proximity to a source of waste heat or a location with sufficient density to make district heating economically viable.

They will however be mapped by municipality, as the consumption of the industrial sector in each municipality is available.

However, as a result of a survey, the individual consumption of close to 540 establishments in the industrial sector is available, and substitutable heat demand has been deduced from this on the basis of their branch of activity. They are geo-localisable and have been mapped. They represent 87% of the total consumed.

The following table provides the details of heating demand, both demand that is substitutable and that which is not, by type of energy carrier, and the total excluding non-energy purposes (NE).

sub-branch code	Sector	Electricity	Fuels	Total (excl. NE)	Substitutable heat	Prop. Substitutable heat	Overall heat demand
100	STEEL INDUSTRY	2.546	3.704	6.250	0.185	3.0%	3.704
200	NON-FERROUS	0.072	0.129	0.201	0.006	3.2%	0.129
300	CHEMICAL INDUSTRY	2.995	5.634	8.629	4.167	48.3%	5.634
400	NON-METALLIC MINERALS	1.905	12.556	14.461	0.314	2.2%	12.556
500	FOOD	1.145	3.554	4.700	2.564	54.6%	3.554
600	TEXTILE	0.150	0.130	0.279	0.098	35.3%	0.130
700	PAPER	0.728	3.057	3.785	2.812	74.3%	3.057
800	METAL MANUFACTURE	0.602	0.929	1.531	0.529	34.6%	0.929
900	OTHER INDUSTRIES	0.583	1.212	1.795	0.642	35.8%	1.212
	INDUSTRY TOTAL	**10.726**	**30.904**	**41.630**	**11.319**	**27.2%**	**30.904**

Table 10: Distribution of industry's consumption by branch and usage in 2012 (TWh).

II. ESTIMATED CHANGES IN HEAT DEMAND

PwC developed a specific approach for each sector (residential, tertiary and industrial) in order to understand how heat demand in Wallonia will change by 2030. These estimates are based on an assessment of the *total heat demand* for 2012, and take into account the prospective evaluation of various key parameters carried out by the *Bureau federal du Plan (*Federal Planning Bureau), or if not, on a historic assessment of certain parameters.

The European Commission indicates that forecasts must take into consideration trends within the main sectors of the economy (EC, 2013):

- This analysis should take into account both probable changes to the demand for heat within **industrial sectors** and any long-term structural changes (deindustrialisation, reindustrialisation, improvements to energy efficiency, the impact of new manufacturing technologies), as well as short-term cyclical changes.
- Changes to the demand for heat in **buildings** should include the impact of improvements to energy efficiency using the calculation method provided in Directive 2010/31/EU (Article 3).

II.1 CHANGES IN HEAT DEMAND IN THE RESIDENTIAL SECTOR

II.1.1 Methodology

The residential sector's heat demand until 2030 has been estimated using projections of annual changes in the residential sector's heat demand in 2012 (the 'g' in equation 1).

Equation 1 : Projection du taux de croissance des besoins de chaleur du secteur résidentiel

$$BC_{t2}^{R} = BC_{t1}^{R} * (1 + g) \rightarrow g = \frac{BC_{t2}^{R}}{BC_{t1}^{R}} - 1$$

$$Avec\ BC = [\frac{BC}{m^2}] * [\frac{m^2}{Log}] * [Log]$$

$$g = \{(1 + \Delta\frac{BC}{m^2}) * (1 + \Delta\frac{m^2}{Log}) * (1 + \Delta\, Log)\} - 1$$

Légende : R = Résidentiel ; BC= besoins de chaleur; g = Evolution annuelle des besoins de chaleur ; Log = Logements

Equation 1 : Projection du taux de croissance des besoins de chaleur du secteur résidentiel	Equation 1: Projection of the growth rate of the residential sector's heat demand
Avec	With
Légende : R = Résidentiel ; BC = besoins de chaleur ; g = Evolution annuelle des besoins de chaleur ; Log = Logements	Key : R = Residential ; BC = heat demand ; g = Annual changes to heat demand ; Log = Housing

On the basis of equation 1 it is apparent that changes in the residential sector's heat demand correlate to changes in building energy performance, changes in the average surface area of housing and changes in the quantity of housing. As a result, annual variations in heat demand per square metre, the average size of housing and the quantity of housing up to 2030 must first be estimated before heat demand until 2030 can be estimated.

1. *Estimate of changes to building energy performance*

We assume that two elements contribute to changes in heat demand per square metre: degree days and improvements in building energy performance[8] (see equation 2).

Equation 2 : Estimation de l'évolution des besoins de chaleur par mètre carré

$$\Delta \frac{BC}{m^2} = \alpha \, \Delta \, dj + \beta \, \Delta \, EE$$

Légende :

- BC = besoins de chaleur
- Log = logements
- dj = degrés-jours
- EE = Performances énergétiques du bâtiment (besoins de chaleur/m²)
- $\alpha = [{}^{contribution\ dj}/_{\Delta\ dj}]$ = 0,04% *(Estimation du Bureau fédéral du Plan)*
- $\beta = \left[{}^{contribution\ EE}/_{\Delta\ EE}\right] = 1 - \alpha$

Equation 2 : Estimation de l'évolution des besoins de chaleur par mètre carre	Equation 2: Estimate of changes in heat demand per square metre
Légende :	Key:
BC = besoins de chaleur	BC = heat demand
Log = logements	Log = housing
Dj = degrés-jours	Dj = degree days
EE = Performances énergétiques du bâtiment (besoins de chaleur/m2)	EE = Building energy performance (heat demand /m^2)
Contribution	Contribution
(Estimation du Bureau fédéral du Plan)	(Estimate from the Federal Planning Bureau)

- ***With regard to changes in degree days until 2030***, we make the same assumption as the Federal Planning Bureau (2014 a), namely that degree days should remain constant at the 2005 level. On the basis of this assumption and the degree day estimate used for the energy balance for the Brussels region (ICEDD, 2014) for 2005, we estimate that degree days will amount to 1828 each year until 2030.[9] Given that we are using a level of degree days until 2030 that remains constant, degree days will consequently make no contribution to changes in heat demand per residence. *It should be specified that this reasoning pertains to the contribution that changes in degree days makes to changes in heat demand, and does not pertain to the contribution that one year's degree days make to the consumption of fuels in that year.* In this case, if we work on the assumption that each year, degree days will amount 1828 until 2030, then changes in degree days will in no way contribute to changes in demand for heat.

[8] It is judged by changes to energy consumption in line with heat demand per square metre.

[9] It should also be indicated that this assumption enables the significant variations in degree days over recent years to be streamlined. They amounted to 2309 in 2010, 1515 in 2011 and 1915 in 2012.

According to estimates produced by the Federal Planning Bureau, the parameter **α** is 0.04%. In other words, an increase of one degree day would lead to a variation of 0.04% in heat demand. Corresponding to the definition of **α**, the parameter **β** has a value of 0.96.

With regard to changes in building energy performance until 2030, we take as a basis:

- The normalised consumption of fuels per square metre (kWh/m^2) recorded in 2012 within the residential sector.[10] This was estimated on the basis of the residential sector's heat demand (26,913 GWh), the total housing surface area (number of residences*average residence surface area) and the normalisation ratio (1828 degree days/1915 degree days). Fuel consumption was normalised so that the impact of variations in degree days on changes to fuel consumption would not be taken into account. As a result, normalised fuel consumption in 2012 amounted to 167.7 kWh/m^2 (see the table below for more information).

	2012
Fuel consumption (GWh)	26,913.05 GWh
Number of residences in Wallonia	1,522,000
Average surface area of residences in Wallonia	100.7
Fuel consumption /square metre (kWh/m^2)	175.7 kWh/m^2
Degree days	1915
Average normalised consumption (Fuel consumption/m^2)	**167.7 kWh/m^2**

Table 11: Consumption of fuels per square metre in 2012

- The entry into force of Regulation (EU) No. 813/2013 of the Commission of 2 August 2013 implementing Directive 2009/125/CE regarding requirements for environmentally responsible design that apply to space heaters and hybrid heating devices. The Directive provides that the majority of equipment should have seasonal efficiency of 86% (Hs, higher heating value).
- The current situation whereby the average annual (seasonal) generation yield does not exceed 70% (Hs, higher heating value).
- The continued existence of an exception to Regulation 813/2013, which applies to 20% of the stock of individual boilers in collective housing.

It can be assumed that, on the basis of this information, 80% of boilers will have reached the seasonal yield of 86% Hs by 2030, while the remaining 20% will remain unchanged in comparison with 2012. *On this basis, we estimate that fuel consumption per square metre will be 142.7 kWh/m^2 in 2030, compared with 167.7 kWh/m^2 in 2012* (an average annual decrease in fuel consumption per m^2 of 0.89%).

[10] The normalised consumption of fuels was obtained using the following formula: 26,913 GWh * 1828 degree days/1915 degree days.

It should be noted that changes in housing energy performance depend solely on changes to the performance of heating equipment. As a result, projections for heat demand in the residential sector should be considered as an upper limit. Factors associated with improvements to building envelopes will lead to a more significant reduction in the residential sector's heat demand.

2. ***Estimated changes in the average surface area of residences***

The following parameters were taken into account when estimating changes in the average surface area of residences:

- Changes in the total surface area of housing, making a distinction between existing and new housing. Projections for the average surface area of new housing were developed using data on the progression of the average surface area of new housing recorded between 2000 and 2012 in Wallonia from the *SPF Economie* (FPS Economy) land registry database. Overall, there was an average decrease of 0.26% per year in the average surface area of new housing between 2000 and 2012.
- Changes in the quantity of housing that is occupied (for more information on this subject, see the next section).

Taking into account changes in the total surface area of housing (existing and new housing) and in the quantity of housing that is occupied, it can be assumed that the average surface area of housing will follow the trend shown in the graph below, falling from an average of 100.7 m^2/residence in 2012 to 100.3 m^2/residence in 2030.

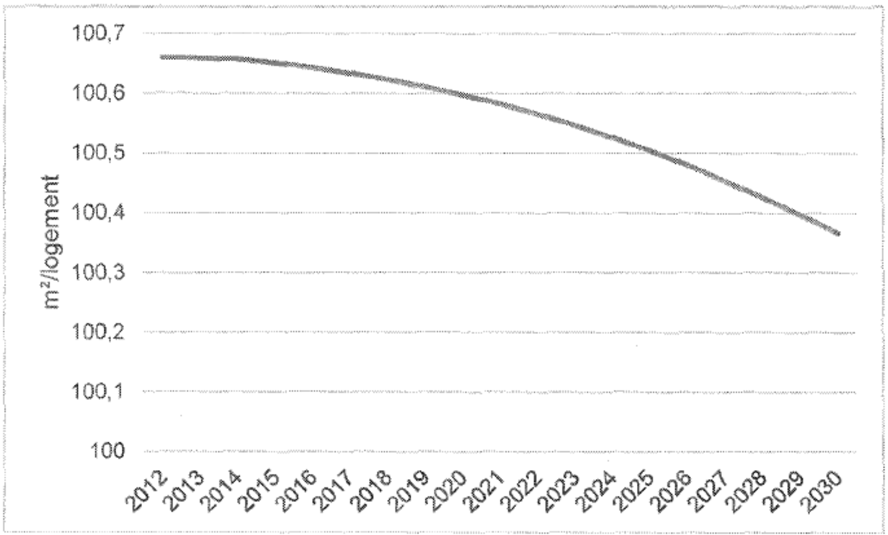


Figure 13 : Evolution de la superficie moyenne des logements (M²/logement)

m^2/logement	m^2/residence
Figure 13 : Evolution de la superficie moyenne des logements (m^2/logement)	Figure 13: Changes in the average surface area of housing (m^2/residence)

3. ***Estimated changes in the number of residences***

We took into consideration the projections produced by the Federal Planning Bureau (BFP, 2014)[11] on the *evolution in the number of households* in Wallonia until 2030 when estimating changes to the number of residences. The BFP believes that the number of households in Wallonia will increase by 13% between 2012 and 2030 (an average annual increase of 0.68%), rising from 1,529,680 in 2012 to 1,728,594. This annual percentage of 0.68% was therefore used to calculate changes to the number of residences in Wallonia.

II.1.2 Results

We estimate that the residential sector's overall heat demand will decrease by an average of 0.23% per year, falling from 26,913 GWh in 2012 to 25,811 GWh in 2030.[12] The main cause of this change is an improvement in energy efficiency (heat demand/m^2) and the anticipated decrease in housing size.

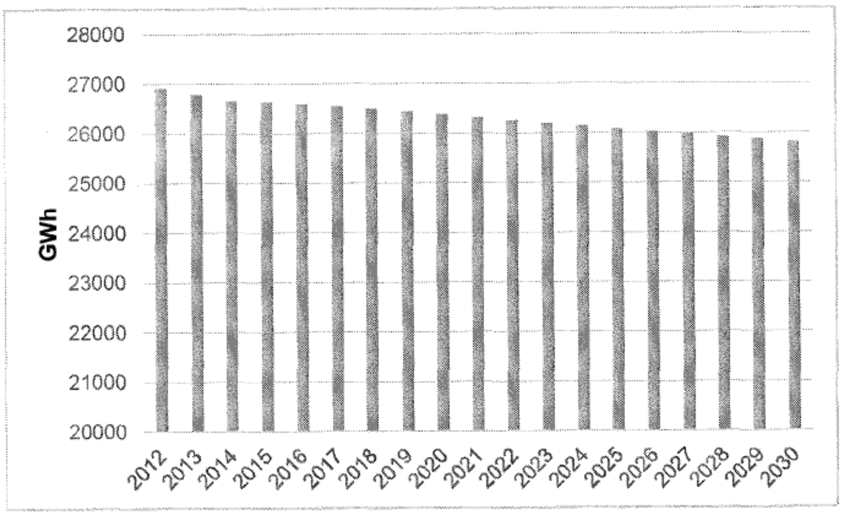


Figure 14 : Projections besoins de chaleur – Résidentiel (GWh)

GWh	GWh
Figure 14 : Projections besoins de chaleur – Résidentiel (GWh)	Figure 14: Heat demand projections – residential sector (GWh)

[11] *Bureau fédéral du Plan* (2014), *'Perspectives démographiques 2013-2060 : Population, ménages et quotients de mortalité prospectifs*', Bruxelles (Demographic perspectives 2013-2060: Population, households and prospective mortality quotients, Brussels).

[12] Heat demand for 2030 is obtained by applying the growth rate 'g' from equation 1. To recap, the growth rate applied results from changes in heat demand per m^2, the average surface area of residences and the number of residences.

II.2 CHANGES IN THE TERTIARY SECTOR'S HEAT DEMAND

II.2.1 Methodology

Projections based on the annual changes to the tertiary sector's heat demand in 2012 (the 'g' in equation 3) were used to estimate the tertiary sector's heat demand until 2030.

Equation 3 : Projection du taux de croissance des besoins de chaleur du secteur tertiaire

$$BC^{T}_{t2} = BC^{T}_{t1} * (1+g) \rightarrow g = \frac{BC^{T}_{t2}}{BC^{T}_{t1}} - 1$$

Avec $BC = \frac{BC}{VA} * VA$:

$$g = \frac{\left(\frac{BC_{t2}}{VA_{t2}}\right) * VA_{t2}}{\left(\frac{BC_{t1}}{VA_{t1}}\right) * VA_{t1}} - 1 = \frac{\left[\left(\frac{BC_{t1}}{VA_{t1}}\right) * \left(1+\Delta\frac{BC}{VA}\right)\right] * \left[(VA_{t1}) * (1+\Delta VA)\right]}{\left(\frac{BC_{t1}}{VA_{t1}}\right) * VA_{t1}} - 1 = \left\{\left(1+\Delta\frac{BC}{VA}\right) * (1+\Delta VA)\right\} - 1$$

$$BC^{T}_{t2} = BC^{T}_{t1} * \left(1 + \left[\left\{\left(1+\Delta\frac{BC}{VA}\right) * (1+\Delta VA)\right\} - 1\right]\right) = BC^{T}_{t1} * \left\{\left(1+\Delta\frac{BC}{VA}\right) * (1+\Delta VA)\right\}$$

Légende :T = Tertiaire ; BC= besoins de chaleur; g = Evolution annuelle des besoins de chaleur ; VA = valeur ajoutée

Equation 3 : Projection du taux de croissance des besoins de chaleur du secteur tertiaire	Equation 3: Projection of the growth rate of the tertiary sector's heat demand
Avec	With
Légende : T = Tertiaire ; BC = besoins de chaleur ; g = Evolution annuelle des besoins de chaleur ; VA = valeur ajoutée	Key : T = Tertiary; BC = Heat demand; g = Annual changes to heat demand; VA = Value added

On the basis of equation 3, it appears that changes to the tertiary sector's heat demand depend on changes to heat demand per unit of value added (energy efficiency) and changes to value added. Consequently, an estimation of annual variations in heat demand per unit of value added and of value added until 2030 were required to be able to estimate heat demand until 2030.

1. ***Estimated changes in heat demand per unit of value added:***

In order to gain an understanding of changes to heat demand per unit of value added in the tertiary sector, we used the projections produced by the BFP (2014 a)[13] on changes to tertiary energy efficiency. Between 2010 and 2030, the BFP believes that energy efficiency in the Belgian tertiary sector will improve by 1.7% per year.

2. ***Estimated changes in value added:***

In order to estimate changes in Wallonia's value added, we referred to the latest regional projections produced by the BFP for each tertiary sector (BFP, 2015)[14]. These projections have been produced up to 2020 for each tertiary sector (business, transport communications, banks, services

[13] Bureau fédéral du Plan (2014 bis), *Le paysage énergétique Belge : perspectives et défis à l'horizon 2050* (The energy landscape in Belgium: perspectives and challenges until 2050),
Brussels.

[14] Bureau fédéral du Plan (2015), *Perspectives économiques régionales* (Regional economic perspectives), Brussels.

for businesses, etc.). As there are no regional projections for the period 2021 to 2030, we have used national projections which make no distinction between the different sectors of the economy. They were drawn up using the same recommended methodology developed for regional projections (BFP, 2014 quater)[15].

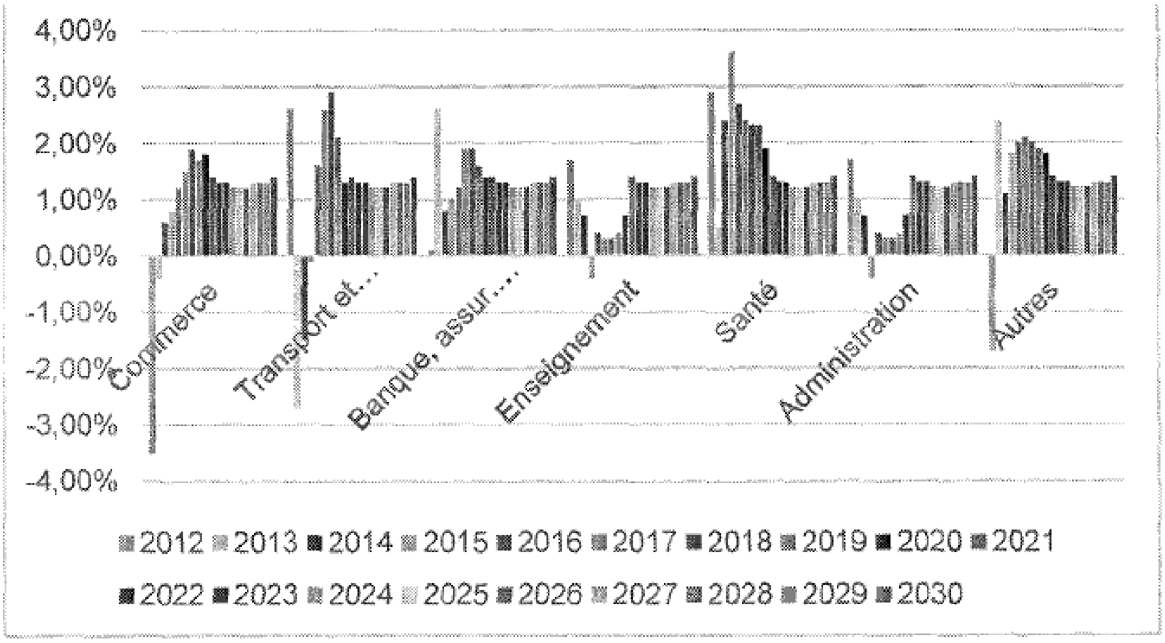


Figure 15 : Projections annuelles du taux de croissance de la valeur ajoutée (2012-2030) -Tertiaire

Commerce	Business
Transport et…	Transport and…
Banque, assur…	Banks, insurance…
Enseignement	Education
Santé	Health
Administration	Administration
Autres	Others
Figure 15 : Projections annuelles du taux de croissance de la valeur ajoutée (2012-2030) -Tertiaire	Figure 15: Annual projections on the rate of growth in value added (2012-2030) – Tertiary sector

II.2.2 Results

We estimate that the tertiary sector's overall heat demand will decrease by an average of 0.47% per year, falling from 7,716 GWh in 2012 to 7,084.9 GWh in 2030. Education and administration will see the *most significant* reduction in demand for heat (-0.81%/year), while healthcare will see the *smallest* reduction (-0.01%/year).

[15] Bureau fédéral du Plan (2014 quater), *Rapport annuel 2014 du Comité d'étude sur le vieillissement* (2014 annual report of the Study Committee on Aging), Brussels.

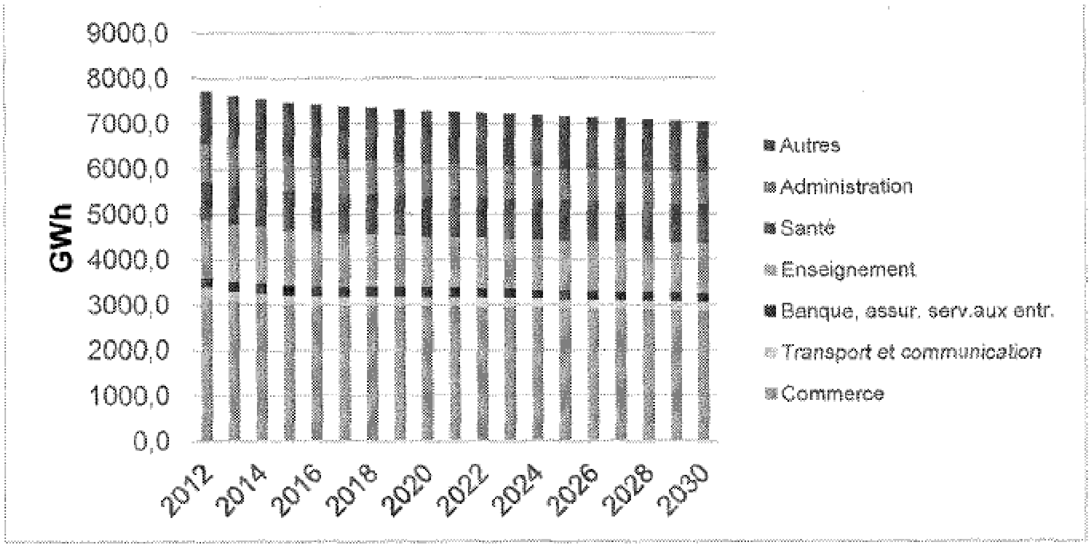


Figure 16 : Projections besoins de chaleur – Tertiaire (GWh)

GWh	GWh
Autres	Others
Administration	Administration
Santé	Health
Enseignement	Education
Banque, assur, serv. Aux entr.	Banks, insurance, services for businesses
Transport et communication	Transport and communication
Commerce	Business
Figure 16 : Projections besoins de chaleur – Tertiaire (GWh)	Figure 16: Heat demand projections – Tertiary sector (GWh)

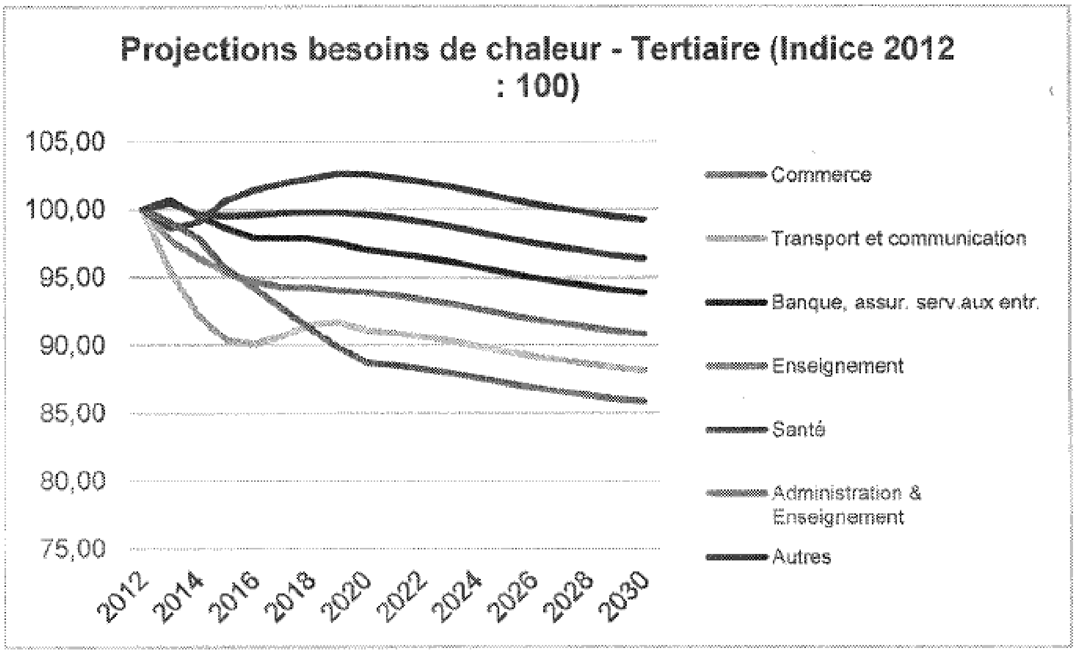


Figure 17 : Projections besoins de chaleur – Tertiaire (Indice 2012 : 100)

Projections besoins de chaleur – Tertiaire (Indice 2012 : 100)	Heat demand projections – Tertiary sector (2012 index: 100)
Commerce	Business
Transport et communication	Transport and communication
Banque, assur. Serv aux entr.	Banks, insurance, services for businesses
Enseignement	Education
Santé	Health
Administration & Enseignement	Administration and education
Autres	Others
Figure 17 : Projections besoins de chaleur – Tertiaire (Indice 2012 : 100)	Figure 17: Heat demand projections – Tertiary sector (2012 index: 100)

II.3 CHANGES IN THE INDUSTRIAL SECTOR'S HEAT DEMAND

II.3.1 Methodology

Projections of annual changes in the industrial sector's heat demand in 2012 (the 'g' in equation 4) have been used to estimate the heat demand of Wallonia's industrial sector until 2030.

Equation 4 : Projection du taux de croissance des besoins de chaleur de l'industrie

$$BC_{t2}^{I} = BC_{t1}^{I} * (1 + g) \rightarrow g = \frac{BC_{t2}^{I}}{BC_{t1}^{I}} - 1$$

Avec $BC = \frac{BC}{VA} * VA$:

$$g = \frac{\left(\frac{BC_{t2}}{VA_{t2}}\right) * VA_{t2}}{\left(\frac{BC_{t1}}{VA_{t1}}\right) * VA_{t1}} - 1 = \frac{\left[\left(\frac{BC_{t1}}{VA_{t1}}\right) * \left(1 + \Delta\frac{BC}{VA}\right)\right] * \left[(VA_{t1}) * (1 + \Delta VA)\right]}{\left(\frac{BC_{t1}}{VA_{t1}}\right) * VA_{t1}} - 1 = \left\{\left(1 + \Delta\frac{BC}{VA}\right) * (1 + \Delta VA)\right\} - 1$$

$$BC_{t2}^{I} = BC_{t1}^{I} * \left(1 + \left[\left\{\left(1 + \Delta\frac{BC}{VA}\right) * (1 + \Delta VA)\right\} - 1\right]\right) = BC_{t1}^{T} * \left\{\left(1 + \Delta\frac{BC}{VA}\right) * (1 + \Delta VA)\right\}$$

Légende : I = Industrie ; BC= besoins de chaleur; g = Evolution annuelle des besoins de chaleur ; VA = valeur ajoutée

Equation 4 : Projection du taux de croissance des besoins de chaleur de l'industrie	Equation 4: Projection of the rate of growth of the industrial sector's heat demand
Avec	With
Légende : I = Industrie ; BC = besoins de chaleur ; g = Evolution annuelle des besoins de chaleur ; VA = valeur ajoutée	Key: I = Industry; BC = Heat demand; g = Annual change to heat demand; VA = value added

On the basis of equation 4, it appears that changes in the industrial sector's heat demand depend on changes to heat demand per unit of value added (energy efficiency) and changes to value added. Consequently, an estimate of annual variations in heat demand per unit of value added and in value added until 2030 were required to be able to estimate heat demand until 2030.

1. ***<u>Estimated changes in heat demand per unit of value added</u>***

To gain an understanding of changes to the industrial sector's heat demand per unit of value added, we have used the projections developed by the BFP (2014 a) on changes to energy efficiency in the different industrial sectors.

Industrial sectors	2010-2030
STEEL INDUSTRY	-1.2%
NON-FERROUS	-1.3%
CHEMICAL INDUSTRY	-2.1%
NON-METALLIC MINERALS	-0.2%
FOOD	-1.1%
TEXTILE	-1.0%
PAPER	-1.6%
METAL MANUFACTURE	-0.8%
OTHER INDUSTRIES	-1.2%

Table 12: Projected changes in energy efficiency in Wallonia's industrial sector (average annual rate of growth)

2. ***Estimated changes in added value***

In order to estimate changes to value added, we refer to the latest regional projections drawn up by the BFP for each industrial sector (BFP, 2015). These sector-level projections have been produced for the period until 2020. As a result of the lack of regional projections for the period 2021 to 2030, we have used national projections that make no distinction between the different sectors of the economy. These do however use the same recommended methodology developed for regional projections (BFP, 2014 quater).

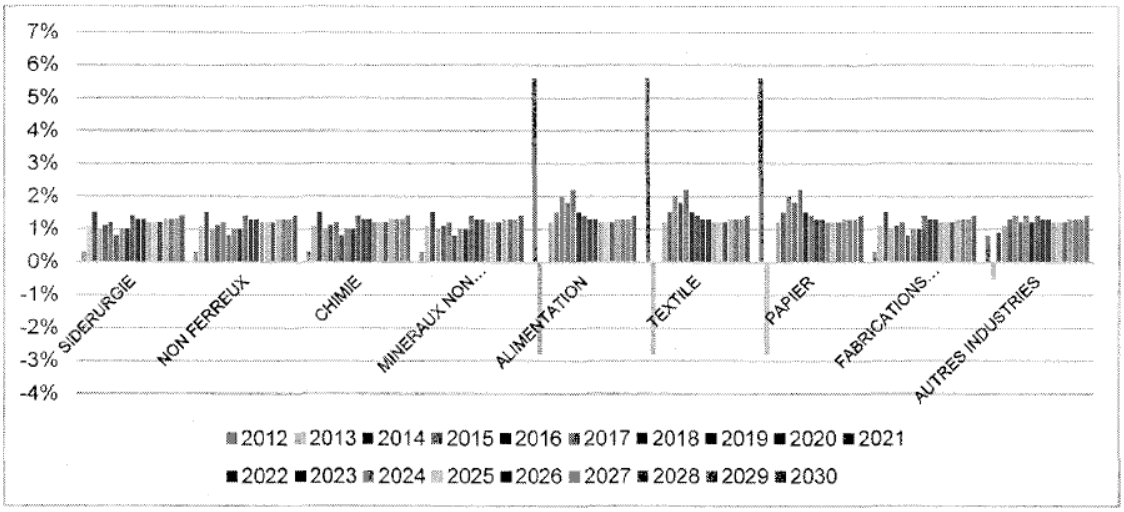


Figure 18 : Projections annuelles du taux de croissance de la valeur ajoutée (2012-2030) - Industrie

SIDERURGIE	STEEL INDUSTRY
NON FERREUX	NON-FERROUS
CHIMIE	CHEMICAL INDUSTRY
MINERAUX NON…	NON-METALLIC MINERALS
ALIMENTATION	FOOD
TEXTILE	TEXTILE
PAPIER	PAPER
FABRICATIONS…	METAL MANUFACTURE
AUTRES INDUSTRIES	OTHER INDUSTRIES
Figure 18 : Projections annuelles du taux de croissance de la valeur ajoutée (2012-2030) - Industrie	Figure 18: Annual projections of the growth rate of value added (2012-2030) – Industrial sector

II.3.2 Results

We estimate that in Wallonia, the industrial sector's overall heat demand will increase slightly by an average of 0.24% per year, rising from 30,904.3 GWh in 2012 to 32,283 GWh in 2030. A distinction must nevertheless be drawn between industrial sectors whose heat demand will increase over the period in question, and those whose heat demand will decrease:

- The following industrial sectors will see a *decrease* in their heat demand between 2012 and 2030 (as a result of a change in economic activity that is smaller than improvements to energy efficiency): the steel industry (-0.01% per year), non-ferrous (-0.12% per year), chemicals (-0.93% per year), paper (-0.50% per year) and other industries (-0.05% per year).
- The following industrial sectors will see an *increase* in their heat demand between 2012 and 2030 (as a result of a change in economic activity that is greater than improvements to energy efficiency): non-metallic minerals (+1% per year), food (+0.01% per year), textiles (+0.11% per year) and metal manufacture (+0.39% per year).

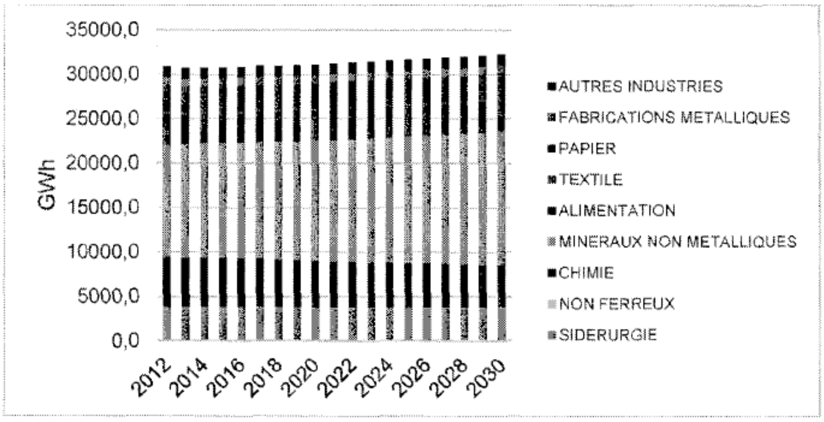


Figure 19 : Projections besoins de chaleur – Industrie (GWh)

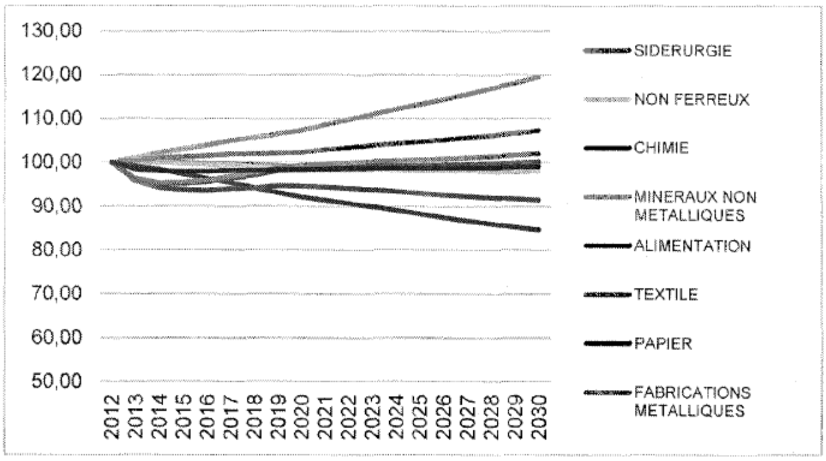


Figure 20 : Projections besoins de chaleur – Industrie (Indice 2012 : 100)

GWh	GWh
AUTRES INDUSTRIES	OTHER INDUSTRIES
PAPIER	PAPER
TEXTILE	TEXTILES
ALIMENTATION	FOOD
MINERAUX NON METALLIQUES	NON-METALLIC MINERALS
CHIMIE	CHEMICAL INDUSTRY
NON FERREUX	NON-FERROUS
SIDERURGIE	STEEL INDUSTRY
FABRICATIONS METALLIQUES	METAL MANUFACTURE
Figure 19 : Projections besoins de chaleur – Industrie (GWh)	Figure 19: Heat demand projections – Industrial sector (GWh)
Figure 20 : Projections besoins de chaleur – Industrie (Indice 2012 : 100)	Figure 20: Heat demand projections – Industrial sector (2012 index: 100)

II.4 SUMMARY

Overall, we estimate that heat demand will slightly decrease in Wallonia by 2030, falling from 65,533 GWh in 2012 to 65,179 GWh in 2030. The tertiary sector will see the greatest reduction in heat demand, falling from 7,716 GWh in 2012 to 7,085 GWh in 2030 (which is a reduction of 0.24% per year). The residential sector will experience a reduction in its heat demand of an average of

0.47% per year, falling from 26,913 GWh in 2012 to 25,811 GWh in 2030. Industry will see a slight average annual increase of 0.24%, rising from 30,904 GWh in 2012 to 32,283 GWh in 2030.

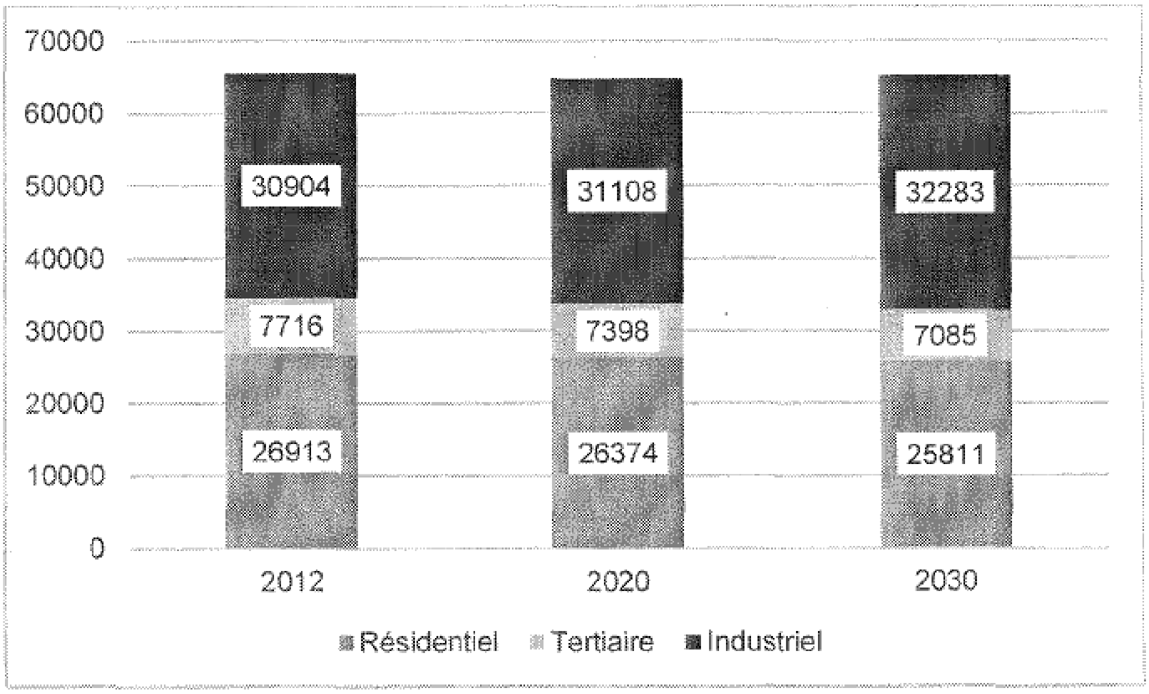


Figure 21 : Projections besoins de chaleur – synthèse (GWh)

Résidentiel	Residential
Tertiaire	Tertiary
Industriel	Industrial
Figure 21: Projections besoins de chaleur – synthèse (GWh)	Figure 21: Heat demand projections – summary (GWh)

III. ESTIMATED HEAT SUPPLIES BASED ON EXISTING INFRASTRUCTURE

III.1 ESTIMATE OF WASTE HEAT SUPPLY WITHIN THE MAIN INDUSTRIES IN 2012

III.1.1 Sources

The main source of information used is the 2012 energy balance published by the DGO4 (see I.3, page 19). It provides information on consumption by energy carrier and sub-branch of activity.

The source of data used for the bottom-up approach (see III.1.2 Methods) is the study carried out in 2013 by the ICEDD on behalf of the DGO4 as part of the *Infoind11* and *Cogeneration Facilitator* missions, which consisted of evaluating the potential for recovering waste heat for generating electricity in Wallonia's industrial sector in 2010.

The sources of data used for the top-down approach (see below) are as follows:

- The study carried out by Maxime Dupont and Eugenio Sapora of EDF R&D, *The Low Temperature Heat Recovery in Industry: Which Potential and How to Access It?*, 2011;
- INSEE (the French national Institute of Statistics and Economic Studies), for data on energy consumption in French industry (ref: Naf_T1).

III.1.2 Methods

Different methodologies were employed to take account of the varying levels of detail provided by the data sources used. Estimating the industrial sector's heat supply from businesses surveyed for the study carried out by the ICEDD in 2013 required the use of the bottom-up approach (see **Bottom-up approach**). The limitations of this study are found in the fact that the heat potential obtained covers only those businesses that use the most energy, with industrial processes that require high temperatures (over 100°C). In other words, the high-temperature waste heat potential is obtained.

But what about the low-temperature waste heat potential (temperatures below 100°C)? To provide an answer to this question given the lack of data available in Wallonia, another source of data had to be used, employing a different methodology. A simplified waste heat potential can therefore be estimated using this **Top-down approach**.

Bottom-up approach

This approach was used to develop the initial evaluation of waste heat recovery potential for electricity generation in Wallonia's industrial sector, produced using data from the 2010 energy balance.

A summary of the methodology used to calculate this potential is provided below (for more information see the *Rapport d'évaluation du potentiel de récupération de chaleur fatale pour la production d'électricité dans l'industrie wallonne* [Report on the evaluation of waste heat recovery potential for electricity generation in Wallonia's industry] produced on behalf of the DGO4 in May 2013).

An inventory of the technologies used to recover waste heat is used as a basis for this methodology. The inventory was firstly compiled though bibliographical research, then through contact with the suppliers of equipment for this market.

Subsequently, the main purpose of the methodology was to attempt to determine the potential in terms of quantity. In order to do so, the companies with the highest levels of consumption and consequently the most significant impact were studied. Smaller companies with lower levels of consumption were deemed to have much less significance when establishing what the quantitative potential is.

A study of the development potential for weaker powers (via heat exchanger, Organic Rankine Cycle, heat pumps) was nonetheless deemed of interest.

This new approach called for a two-pronged analysis of technical potential: firstly qualitative, then quantitative.

The **qualitative potential** was used as the first basis for our work in order to make up for the lack of data available on the smallest companies.

The aim was therefore to determine which sectors and sub-sectors had potential on the basis of direct contact with companies and therefore concrete information on their production processes. As a result of this estimate of qualitative potential, the characteristics of the operations or type of technology can be determined for each sector.

Secondly, the **qualitative potential** was estimated on the basis of information collected for this qualitative analysis.

Companies were considered by branch, which includes just over 160 industrial sites, in order to establish quantitative potential.

Two different cases emerged:

- Sectors that were established as homogenous, with products and process lines which are equatable. In this case, the results for recovery potential (recoverable kW) and for estimated potential for generating energy (heat or electricity) could be used as a basis for direct extrapolating over the whole sector, depending on the recovery technology planned.
- Non-homogenous sectors, which needed to be divided into sub-sectors for both different products and processes.

In each case (homogenous and non-homogenous sectors), data from 2010 on the consumption of fuels (or electricity consumption in the case of electric steel manufacturing) by companies listed in the BADEN energy database (database containing the energy consumption of the main companies of Wallonia's industrial and tertiary sectors) were used for this extrapolation to calculate potential for recovery. Ultimately, out of the 160 initial industrial establishments, 55 were able to provide potential for heat recovery in 2010.

The advantage of the bottom-up approach is that heat supply can be geo-located and mapped (see III.3).

Top-down approach

The study carried out by EDF R&D was the starting point in the process of estimating low-temperature waste heat (temperatures under 100°C) in 2012. This study analyses the technical and economic potential of heat recovery (high and low temperature, 60° - 200°) in the French industrial sector.

The study covers nine branches of activity (NACE Rev.2 code) that consume 70% of industrial heat between 60 and 200°C:

- The production of dairy products (10.5);
- Sugar production (10.81);
- The production of other food and drink products (10+11-10.5-10.81);
- The steel industry (24.1);
- Cement, lime and plaster production (23.5);
- Rubber and plastic product production (22);
- The production of other organic chemical products (20.1+20.2+20.4);
- The production of ground transport equipment (29.1+29.2+29.3+30.2+30.9);
- The paper and cardboard industry (17).

Within these nine branches of activity, six uses of energy that consume 90% of industrial heat between 60 and 200°C were determined:

- Drying;
- Evaporation through concentration and crystallisation;
- Heating liquids and gasses;
- Distillation;
- Thermal processing;
- Chemical reactions.

Theoretical heat potential is estimated using the maximum power of heat pumps (assuming a maximum heating capacity of 5 MW) and heat demand in each branch of activity and by application.

A survey was conducted to gather data enabling a theoretic potential of waste energy to be calculated by sector of industry, application and temperature class.

Theoretic potential was calculated for the following nine temperature classes: 60-69°C, 70-79°C, 80-89°C, 90-99°C, 100-119°C, 120-139°C, 140-159°C, 160-179°C and 180-199°C.

In order to evaluate the theoretical low temperature potential (temperatures under 100°C), only the first four temperature classes were considered (6o-69°C, 70-79°C, 8o-89°C and 90-99°C).

Ratios for each temperature range were estimated based on the French sector's fuel consumption (data from 2012). These ratios were then multiplied by the corresponding fuel consumption of the Walloon sector for 2012 in order to calculate the theoretical potential for Wallonia.

This method does have its limits, however:

- It assumes that heat demand and potential are the same in France and Wallonia;
- It assumes that France and Wallonia's industrial fabric are similar;

- The heat supply obtained cannot be localised.

III.1.3 Results

Results obtained using the bottom-up approach

In 2012, 2.331 TWh of high-temperature waste heat was supplied by 55 industrial sites, in comparison with 2.309 TWh in 2010.

The proportion of high- temperature heat from industrial fuel consumption that could be recovered in 2012 was 7.5%. The table below presents high-temperature waste heat supply by branch of activity.

	in TWh LHV		
Branch of industry	Consumption of fuels	Waste heat supply	Prop. Of heat recovered
STEEL INDUSTRY	3.704	0.246	6.6%
NON-FERROUS	0.129	0.000	0.0%
CHEMICAL INDUSTRY	5.634	0.829	14.7%
NON-METALLIC MINERALS	12.556	1.246	9.9%
FOOD	3.554	0.008	0.2%
TEXTILES	0.130	0.000	0.0%
PAPER	3.057	0.000	0.0%
METAL MANUFACTURE	0.929	0.003	0.3%
OTHER INDUSTRIES	1.212	0.000	0.0%
TOTAL INDUSTRY	**30.904**	**2.331**	**7.5%**

Table 13: High-temperature waste heat supply by branch of activity in 2012

The greatest heat potential is found in **the non-metallic minerals sector** (1.246 TWh). This sector includes:

- Cement manufacturers with 0.571 TWh:

  The exhaust gasses that are issued from cement work kilns contain significant quantities of waste heat, which escapes into the atmosphere. It should be noted that while heat recovery already occurs on exit from the kiln, not all the heat is recovered. Existing recovery varies greatly from one cement works to another. It was not possible to take these variations in recovery into account when extrapolating.

- Glassworks with 0.237 TWh:

It is mainly glass production companies who produce waste heat, rather than glass processing. The exhaust gasses that exit the production kilns contain large quantities of heat which escapes into the atmosphere. There is an exhaust gas purifier that requires a specific temperature and which therefore leaves little freedom regarding the possible delta temperature for recovery.

- Other non-metallic minerals with 0.474 TWh, essentially lime and/or dolomite quarries and brickworks:

  Waste heat is found in exhaust gasses that exit the kilns from chimney stacks. Some of these companies may already have heat recovery at this point for powering dryers, but it is not all used.

For the **chemical industry**, it is companies in the sector that use processes with exothermic reactions that have the potential to recover waste heat for producing electricity. This potential was estimated to be 0.829 TWh in 2012.

In the **steel industry**, the potential is found in exhaust gasses issued from kilns, cooling circuits or very hot water (close to 100°C).

The other sectors have no or almost no high-temperature waste heat potential.

<u>Results obtained using the top-down approach</u>

In 2012, the low-temperature waste heat supply was 0.296 TWh, or 1% in comparison with fuel consumption in Wallonia.

Using the top-down approach, it is possible to obtain heat potential ratios in relation to France's energy consumption for 2012 for each branch of activity and temperature class.

	60-69°C	70-79°C	80-89°C	90-99°C	100-119°C	120-139°C
Organic chemicals	0.19%	0.07%	0.13%	0.07%	0.26%	0.13%
Food processing industry	0.81%	1.54%	0.68%	0.98%	1.18%	0.85%
Steel industry	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Non-metallic minerals	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Paper/cardboard	0.08%	0.00%	0.27%	0.24%	0.37%	0.16%
Others	0.44%	0.24%	0.40%	0.16%	0.20%	0.04%

Table 14: Simplified waste heat potential in relation to the French industrial sector's energy consumption in 2012

The two following tables were obtained by multiplying the ratios obtained in the table above for the four temperature classes that are lower than 100°C by the energy consumption of each branch of activity in Wallonia's industrial sector.

in TWh LHV	60-69°C	70-79°C	80-89°C	90-99°C	**Total <100°C**
Organic chemicals	0.020	0.008	0.014	0.008	**0.050**
Food processing	0.038	0.072	0.032	0.046	**0.188**
Steel industry	0.000	0.000	0.000	0.000	**0.000**
Non-metallic minerals	0.000	0.000	0.000	0.000	**0.000**
Paper/cardboard	0.003	0.000	0.010	0.009	**0.022**
Others	0.017	0.006	0.010	0.004	**0.036**
Total low-temperature heat potential					**0.296**

Table 15: Simplified waste heat potential by branch of activity in Wallonia in 2012

Branch of industry	Fuel consumption	Waste heat supply	Prop. of heat recovered
STEEL INDUSTRY	3.704	0.000	0.0%
NON-FERROUS	0.129	0.000	0.0%
CHEMICAL INDUSTRY	5.634	0.050	0.9%
NON-METALLIC MINERALS	12.556	0.000	0.0%
FOOD	3.554	0.188	5.3%
TEXTILES	0.130	0.000	0.0%
PAPER	3.057	0.022	0.7%
METAL MANUFACTURE	0.929	0.000	0.0%
OTHER INDUSTRIES	1.212	0.036	3.0%
TOTAL INDUSTRY	**30.904**	**0.296**	**1.0%**

Table 16: Low-temperature waste heat supply by branch of activity in 2012

With 0.188 TWh in 2012, the food sector has the greatest potential for low-temperate heat. The (organic) chemical and paper industries follow.

Results obtained from the two approaches

By combining the low- and high-temperature heat supplies, a total potential of 2.628 TWh was obtained for 2012.

	Heat supply in TWh		
Branch of industry	t°>100°C	t°<100°C	Total
STEEL INDUSTRY	0.246	0.000	0.246
NON-FERROUS	0.000	0.000	0.000

CHEMICAL	0.829	0.050	0.879
NON-METALLIC MINERALS	1.246	0.000	1.246
FOOD	0.008	0.188	0.196
TEXTILES	0.000	0.000	0.000
PAPER	0.000	0.022	0.022
METAL MANUFACTURE	0.003	0.000	0.003
OTHER INDUSTRIES	0.000	0.036	0.036
TOTAL INDUSTRY	**2.331**	**0.296**	**2.628**

Table 17: Total waste heat supply by branch of activity in 2012

III.2 ESTIMATED GEOTHERMAL ENERGY SUPPLY

III.2.1 Source

The source of information is the COMPIL-SERV (version 2014-2), which is a database that includes all the installations that generate electricity and/or heat from renewable energy sources and cogeneration that uses fossil fuels. COMPIL-SERV is an integral part of the energy balances, and was developed by the ICEDD for DGO4.

III.2.2 Methods

COMPIL-SERV contains information from 1990 to 2013 on the generation and consumption of deep geothermal heat from the wells at Douvrain and Saint-Ghislain, which are managed by IDEA.

The heat potential is equivalent to the heat recovered, minus any heat sold or used internally.

III.2.3 Results

Heat recovered in 2013 from the two wells in operation amounted to 17.9 GWh, of which 12.2 GWh were sold. The remainder was used internally, and so **there is no heat potential** for these two wells.

The graph below displays the heat from the two wells in operation that was recovered and sold between 1990 and 2013.

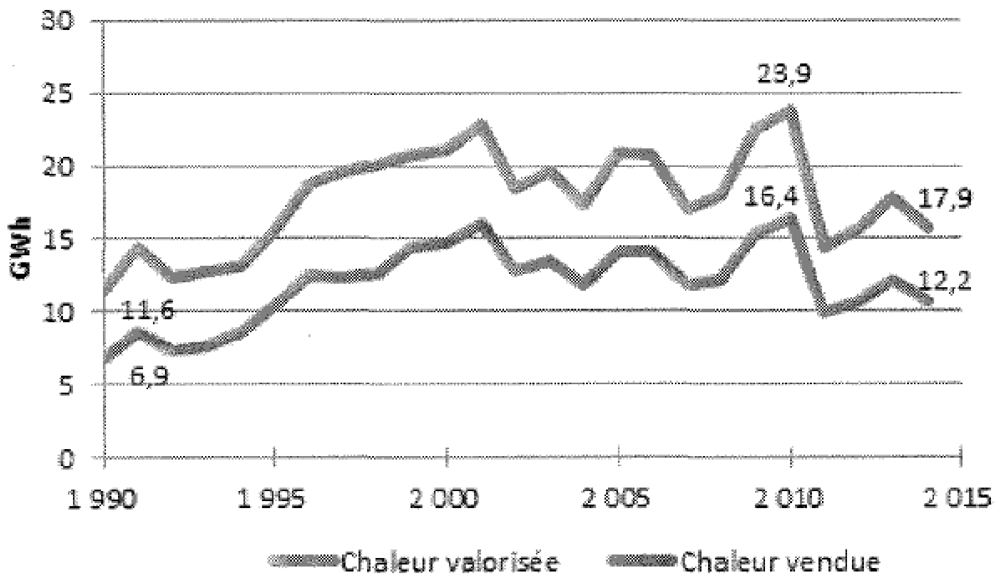


Figure 22 : Evolutions des chaleurs géothermales valorisées et vendues

GWh	GWh
Chaleur valorisée	Heat recovered
Chaleur vendue	Heat sold
Figure 22 : Evolutions des chaleurs géothermales valorisées et vendues	Figure 22: Changes in geothermal heat recovered and sold

A third well has been constructed but is not in operation, due to a lack of customers to purchase the heat. There is no data available on the technical potential of this well. As a result, economic potential has not been estimated for geothermal energy.

III.3 TRANSMISSION OF THE DATA REQUIRED FOR MAPPING

The substitutable heat demand for each sector will be displayed using several maps.

III.3.1 Sources

Municipal energy balances drawn up on behalf of the DGO4 divide up regional energy consumption into municipalities depending on the location of energy consumers, ensuring that the 262 municipalities within Wallonia correspond to the regional balance.

The methods used for this distribution vary from sector to sector.

For the housing sector, municipal consumption was estimated on the basis of the housing stock provided by the land registry, making a distinction between flats, terraced houses, semi-detached houses and detached houses and the year they were built. Using the PEB database, the amount of insulation and energy performance of buildings in the municipality could be added. Finally, distribution by consumption by energy carrier could also be deduced using the PEB data. A final climate correction is applied using degree days (the measure of how cold a year is) provided by the weather station closest to the housing in each municipality. With this method it is possible to compare the energy demand of two identical buildings in different municipalities (for example a 1950s detached house) with an understanding of how much insulation each municipality has and the local 'climate'. The calculation is conducted differently for heating, cooking and hot water demand and electric uses.

The consumption of establishments surveyed in the municipality and a balance of consumption per job not surveyed in the municipality are used municipal distribution for the tertiary and industrial sectors.

III.3.2 Methods

Table 6 on page 26 details the proportion of heat demand that each energy carrier meets in the **housing sector**. For example, 84% of the consumption of butane-propane is used for substitutable heat demand. These carrier percentages were applied to each municipality's consumption by carrier. Each municipality's substitutable heat can be calculated from this.

Table 7 on pages 28-29 provides information on the proportion of heat that is substitutable for each branch of activity in the **tertiary sector**. Municipal balances provide consumption by carrier and municipality, but not for each branch of activity. Each municipality had slightly different heat demands and tertiary activity per branch, and so this distribution by municipality must be estimated as best as possible. Employment per branch of activity per municipality was used for this calculation of distribution by branch. By multiplying the corresponding number of jobs per municipality by the specific average consumption per job for each branch of the tertiary sector at regional level, an estimate of consumption per branch of activity at municipal level is obtained. The proportion of substitutable heat for each branch of activity is then applied to this consumption per branch. Municipal substitutable heat demand was then deduced from this by adding the demand of each branch.

Table 18 presents the values used for this calculation.

branch of activity	**total consumption (in MWh)**	**number of jobs**	**Substitutable heat MWh/job**	**prop. of heat that is substitutable**
Business	5,501,432	185,203	29.70	57.6%
Transport communications	525,640	63,032	8.34	39.3%
Banks, insur., serv. for businesses	823,028	164,478	5.00	26.6%
Education	1,686,974	123,768	13.63	75.3%
Health care	1,517,256	166,196	9.13	57.2%
Culture and sport	783,353	19,334	40.52	65.7%
Other services	618,519	80,797	7.66	76.5%
Administration	1,185,316	127,543	9.29	69.1%
Various	969,797	9,859	98.37	17.6%
Total tertiary	**13,611,315**	**940,209**	**14.48**	**56.6%**

Table 18: Specific consumption per job and the proportion of heat that is substitutable, per tertiary branch.

Five natural classifications will be used for mapping (statistical method), with municipalities colour coded. In addition, the 2400 buildings surveyed provide a precise geo-localised display. This represents 24% of substitutable heat demand.

Of the **industrial sector's** total energy consumption, 78% was obtained by survey, so this consumption is available per building. This surveyed consumption makes it possible to calculate substitutable heat demand per establishment, in line with its branch of activity, and per municipality. The remainder of the sector that was not surveyed was calculated on a municipal basis by subtracting the consumption from the survey from the industrial sector's consumption as found in the municipal energy balances. This remainder is attributed an average substitutable heat demand of 56% (weighted average for the textile, metals and other industrial sectors).

Five natural classifications will be used for the mapping (statistical method), with municipalities colour coded. In addition, the 540 buildings surveyed mean the display can be geo-localised precisely. This represents 62% of substitutable heat demand.

III.3.3 Results

Ten maps are used to display heat demand.

Map 1: Heating demand in the housing sector (GWh, 2012)

The housing sector's substitutable heat demand is divided into municipality, with five natural classifications (statistical method) making up the display and municipalities are colour coded. The two municipalities Liège and Charleroi are part of the group with the highest consumption.

Map 2: Heating demand in the tertiary sector (GWh, 2012)

The tertiary sector's substitutable heat demand divided into municipality, with five natural classifications (statistical method) making up the display and municipalities are colour coded. The three municipalities Namur, Liège and Charleroi are part of the group with the highest consumption.

The map lists 2390 establishments with proportional representation for energy quantity.

Map 3: Heating demand in the industrial sector (GWh, 2012)

The industrial sector's substitutable heat demand is divided into municipality, with five natural classifications (statistical method) making up the display and municipalities are colour coded. The group with the highest consumption includes ten municipalities.

The map lists 540 establishments with proportional representation for energy quantity.

Map 4: Heating demand in Wallonia (GWh, 2012)

This map represents the sum of the substitutable heat demand for the three sectors. There are five natural classifications (statistical method) in the display and municipalities are colour coded. The group with the highest consumption includes two municipalities, logically Liège and Charleroi.

Map 5: Heating demand per residence (MWh/res., 2012)

For each municipality, the housing sector's substitutable heat demand is divided by the number of residences. This representation enables municipalities with the housing that consumes the most energy to be displayed (largest size of housing, detached properties, less insulation, colder climate zone).

The display is divided into five natural classifications.

Map 6: Heating demand per job in the tertiary sector (MWh/job, 2012)

For each municipality, the tertiary sector's substitutable heat demand is divided by the number of tertiary jobs identified in the municipality.

The display is divided into five natural classifications.

Map 7: Heating demand per industrial job (MWh/job, 2012)

For each municipality, the industrial sector's substitutable heat demand is divided by the number of industrial jobs identified in the municipality.

The display is divided into five natural classifications.

Map 8: Housing heating demand by municipal surface area (kWh/m^2)

For each municipality, the housing sector's substitutable heat demand is divided by the municipality's surface area (road areas and buildings). The advantage here is the option of presenting the municipalities with the highest housing density.

The display is divided into five natural classifications.

Map 9: Tertiary sector heating demand by municipal surface area (kWh/m^2)

For each municipality, the tertiary sector's substitutable heat demand is divided by the municipality's surface area (road areas and buildings). The advantage here is the option of presenting the municipalities with the highest tertiary density.

The display is divided into five natural classifications.

Map 10: Industrial heating demand by municipal surface area (kWh/m^2)

For each municipality, the industrial sector's substitutable heat demand is divided by the municipality's surface area (road areas and buildings).The advantage here is the option of presenting the municipalities with the highest industrial density.

The display is divided into five natural classifications.

Chapter 3 – Cooling demand and supply

IV. ESTIMATED COOLING DEMAND IN 2012

The source of information used to establish Wallonia's cooling demand in 2012 was the official energy balance published by the energy department of the DGO4. This balance uses the statistics on energy consumption used for international reports to meet the requirements of European directives on energy and for regional policies on this subject.

The tenderer will not explain the reporting methods that were used to draw up these balances, as there are reports available from the DGO4 on this subject.

We will define two types of demand for cooling.

Firstly, we will look at the **overall demand for cooling**. This includes all requirements for cold temperatures resulting from uses of refrigeration and freezing, and air cooling requirements (air conditioning for premises, HVAC).

The second form of demand include uses of cold temperatures that can be supplied by district cooling. These will be referred to a**s substitutable cooling demand** throughout this document.

Cooling demand, both overall and substitutable, is analysed for each sector of activity within Wallonia's energy landscape (domestic, housing, tertiary and industrial). The agriculture and transport sectors have not been included in the analysis of consumption as they do not require cooling.

I.1 OVERALL RESULTS

A summary of cooling demand is presented below, and details on each sector can be found in the following paragraphs.

Sector	**Air conditioning**	**Refrigeration**	**Other uses**	**TOTAL**	**Total cooling demand**	**Substitutable cooling**	**Prop. of substitutable cooling**
Tertiary	0.540	0.395	12.677	**13.611**	0.935	0.540	4.0%
Housing	0.021	0.794	30.286	**31.100**	0.815	0.021	0.1%
Industrial	0.128	0.702	40.800	**41.630**	0.830	0.128	0.3%
Total	0.688	1.891	83.846	**86.342**	2.496	0.688	0.8%

Table 19: Summary of cooling demand in Wallonia, by usage and by sector (TWh).

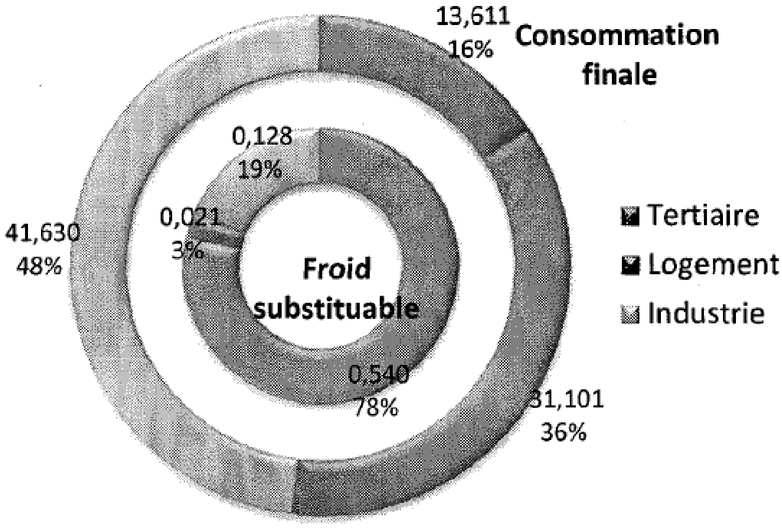


Figure 23 : Répartition de la consommation finale d'énergie et des besoins de froid substituable en Wallonie (2012)

Consommation finale	Final consumption
Tertiaire	Tertiary
Logement	Housing
Industrie	Industry
Froid substituable	Substitutable cooling
Figure 23 : Répartition de la consommation finale d'énergie et des besoins de froid substituable en Wallonie (2012)	Figure 23: Distribution of final energy consumption and substitutable cooling demand in Wallonia (2012)

The outer section of the figure above represents the proportion of total energy consumption made up by each sector. The inner circle represents the proportion of substitutable cold temperatures accounted for by these three sectors.

Although industry accounts for 48% of the final consumption (excluding agriculture and transport), it only represents 19% of substitutable cooling demand. The tertiary sector contributes the most to cooling demand (78%), whereas its contribution to total consumption amounts to only 16%. Finally, the residential sector accounts for 36% of total consumption, but only contributes 3% to cooling demand.

I.2 COOLING DEMAND IN THE RESIDENTIAL SECTOR

I.2.1 Sources

The energy balances provide information on the electricity consumption of refrigerating devices in the housing sector. As such, data on air conditioning demand are not available in the balances as the surveys were too fragmented. The climate is mild in Belgium, and therefore in Wallonia, so there is little need for air conditioning. Heating demand is much greater.

Two sources provide the average surface area of housing in Wallonia. The first is the study *Energy Consumption Survey Belgian Household* (ECS-BH) which was conducted for EUROSTAT and provides the result of 101 m^2 on average per residence. In addition, the average per residence of 101 m^2 was also provided by the study carried out by the CPDT (*Conférence Permanente du Développement Territorial*, Permanent Conference of Territorial Development).

The Study of Housing Quality carried out by the *Centre d'Etude en Habitat Durable* (Centre for Sustainable Housing Studies, CEHD) provides penetration rates for air conditioning systems in 2012-2013.

I.2.2 Methods

Thanks to the availability of the surface area of housing in Wallonia, it is possible to gain at least an approximation of electricity consumption related to cooling demand in the residential sector. The Study of Housing Quality shows that 0.4% of housing has complete air conditioning, while 1.1% has partial air conditioning.

Two complementary assumptions were developed in order to obtain a preliminary estimate of substitutable cooling demand:

1. Firstly, the assumption that housing with only partial air conditioning makes up 50% of the overall surface area that has air conditioning.
2. Secondly, the estimate of a cooling device's average consumption. In the residential sector, air conditioning equipment consumes on average 14.4 KWh of electricity per m^2 in one year.

I.2.3 Results

Considering that an average residence has a surface area of 101 m^2 and that the number of occupied residences in Wallonia amounts to 1,522,000 units, it can be deduced that the annual electricity consumption required to meet air conditioning demand is close to **20.8 GWh**. In comparison with heat demand this is a modest figure, making up only 0.1% of total final consumption.

Cooling demand accounts for an electricity consumption of 794 GWh, which represents 2.6% of the sector's total consumption. This cooling demand is not substitutable.

Given the low estimated values for this sector, we will not map this demand.

I.3 COOLING DEMAND IN THE TERTIARY SECTOR

I.3.1 Sources

The DGO4's regional energy balances provide information on consumption for each energy carrier, sub-branch and usage in the tertiary sector from 2000 to 2012, as shown in Section I.2 on page 16.

I.3.2 Methods

Electricity is used for heating, domestic hot water, cooking, generating cold temperatures (refrigeration, freezing), air conditioning, office equipment, lighting, circulation pumps and other uses.

Cooling is required for producing cold temperatures (refrigeration, freezing) and air conditioning. Substitutable cooling demand, which can be met by an external supply linked to a district cooling network, covers only air conditioning.

I.2.3 Results

Using the methodology described above and data from 2012, it was deduced that the tertiary sector's overall cooling demand amounts to 935 GWh, which represents 7% of the total consumed within the sector.

In 2012, **substitutable cooling demand** (air conditioning) amounted to **540 GWh**, which represents **4%** of the sector's total consumption.

This figure is therefore the maximum substitutable potential for the region's tertiary sector.

Cooling demand could not be displayed in map form for the tertiary sector.

The following table provides details on substitutable and non-substitutable cooling demand per branch of activity.

Usage	Heating	Hot water	Kitchen	Air conditioning	Refrigeration	Others	TOTAL	Total cooling	Proportion of cooling that is substitutable
Business	2.891	0.276	0.007	0.266	0.379	1.682	5.501	0.645	4.8%
Transport communications	0.186	0.020	0	0.031	0	0.288	0.526	0.031	5.9%
Banks, ins.,bus. servs	0.202	0.017	0	0.080	0	0.524	0.823	0.080	9.7%
Education	1.208	0.063	0	0.035	0.016	0.365	1.687	0.051	2.1%
Health care	0.642	0.225	0	0.043	0	0.607	1.517	0.043	2.8%
Culture and sport	0.462	0.053	0	0.024	0	0.0245	0.783	0.024	3.1%
Other services	0.424	0.049	0	0.012	0	0.133	0.619	0.012	2.0%
Administration	0.754	0.065	0	0.049	0	0.318	1.185	0.049	4.1%
Various	0.153	0.018	0	0	0	0.799	0.970	0	0.0%
Total	6.924	0.785	0.007	0.540	0.395	4.961	13.611	0.935	4.0%

Table 20: Distribution of tertiary consumption by branch and usage in 2012 9TWh).

I.4 COOLING DEMAND IN THE INDUSTRIAL SECTOR

I.4.1 Sources

Only the study on electricity usage carried out on industrial federations provides an estimate of cooling demand.

I.4.2 Methods

Table 9 on page 30 presents the results of this study. From it we have deduced the demand for use for refrigeration and air conditioning.

I.4.3 Results

According to the methodology described above and data from 2012, the industrial sector's overall cooling demand amounts to 830 GWh, which is 2% of this sector's total consumption.

In 2012, **substitutable cooling demand** (air conditioning) stood at **128 GWh**, which represents **0.3%** of the sector's total consumption.

This figure is therefore the maximum potential that can be substituted for the industrial sector.

Cooling demand could not be displayed in map form for the industrial sector.

The following table provides details on substitutable and non-substitutable cooling demand per branch of activity.

Sector	Electricity	Fuels	Total (excluding non-energy purposes)	Air conditioning	Refrigeration	Overall cooling	Prop. of cooling that is substitutable
STEEL INDUSTRY	2.546	3.704	6.250	0.001	0.014	0.015	0.0%
NON-FERROUS	0.072	0.129	0.201	0.000	0.000	0.000	0.0%
CHEMICAL INDUSTRY	2.995	5.634	8.629	0.013	0.404	0.417	0.2%
NON-METALLIC MINERALS	1.905	12.556	14.461	0.001	0.010	0.011	0.0%
FOOD	1.145	3.554	4.700	0.033	0.246	0.279	0.7%
TEXTILE	0.150	0.130	0.279	0.006	0.002	0.008	2.1%
PAPER	0.728	3.057	3.785	0.028	0.010	0.038	0.7%
METAL MANUFACTURE	0.602	0.929	1.531	0.023	0.008	0.031	1.5%
OTHER INDUSTRIES	0.583	1.212	1.795	0.022	0.008	0.030	1.3%
TOTAL INDUSTRY	**10.726**	**30.904**	**41.630**	**0.128**	**0.702**	**0.830**	**0.3%**

Table 21: Distribution of cooling demand in industry by branch in 2012 (TWh).

V. ESTIMATED CHANGES IN COOLING DEMAND

II.1 CHANGES IN COOLING DEMAND IN THE RESIDENTIAL SECTOR

II.1.1 Methodology

Due to insufficient data on cooling demand in Wallonia for the residential sector, we are unable to estimate changes in cooling demand until 2030.

II.1.1 Results

For the residential sector, we can however assume that the proportion of households that have air conditioning systems will remain similar to the figures for 2014, which is 1%, as determined by the study carried out by *SPF Environnement* (Scenarios for a low carbon transition).

This is supported by several realistic observations:

1. The low replacement rate in residential property stock means that it is unlikely that efficient refrigeration will be installed on a large scale. This is compounded by limited energy performance in old buildings and investment constraints linked to upgrading the refrigeration in these buildings.
2. The climate which reduces refrigeration demand. Belgium is a temperate country that experiences few extreme temperature events. When such temperatures do occur they are generally short lived.
3. When temperatures do soar temporarily, older buildings which generally have limited heating performance in fact offer the advantage of significant thermal inertia. Everything else being equal, this means it is possible to make passive use of free/night cooling.
4. Finally, the area covered makes it difficult to meet the objectives of this study. Cold temperature generation using co/tri-generation units involves the use of heating/cooling thermal loads simultaneously, unless an absorption cycle could be established that consumes all the heat produced by the cogeneration during the refrigeration period. Although this is possible in theory, it is difficult in practice due to issues of dimensioning because of the difference between the demands for heating and cooling in different seasons.

Taking all this into account, a cautious approach has been adopted in assessing changes in cooling demand in Wallonia.

II.2 CHANGES IN COOLING DEMAND IN THE TERTIARY SECTOR

II.2.1 Methodology

The approach used is the same as that for estimating changes to heat demand above.

II.2.2 Results

We estimate that total cooling demand in the tertiary sector should decrease slightly in Wallonia by 2030, falling from 934.4 GWh in 2012 to 856.1 GWh in 2030. This translates into an average annual decrease of 0.49%. This change results largely from the reduction in the cooling demand of the business sector, which had the highest demand in 2012. Between 2012 and 2030, we believe that business's total cooling demand will decrease by 0.5% on average per year, due in large part to improvements in energy efficiency.

The following figure depicts this trend and the respective proportions of the sectors involved.

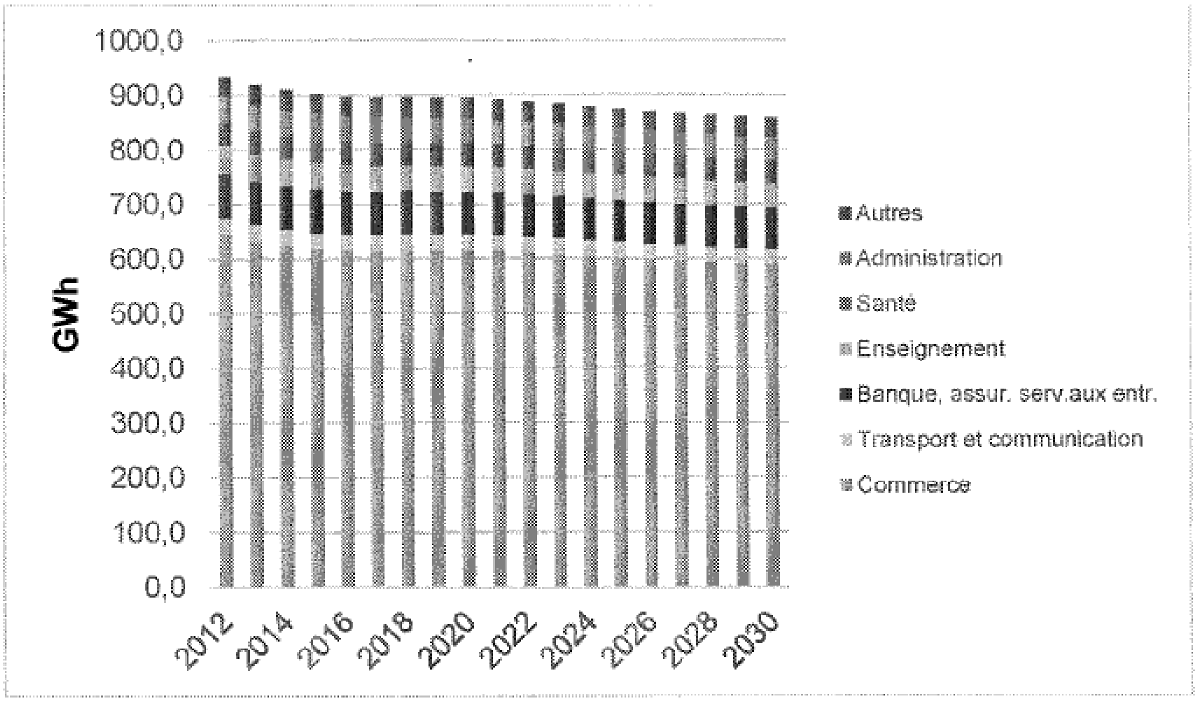


Figure 24 : Projections des besoins de froid – Tertiaire (GWh)

GWh	GWh
Autres	Others
Administration	Administration
Sante	Health
Enseignement	Education
Banque, assur. Serv. Aux. Entr.	Bank, insur., services for businesses
Transport et communication	Transport and communication
Commerce	Business
Figure 24 : Projections des besoins de froid – Tertiaire (GWh)	Figure 24: Cooling demand projections – Tertiary sector (GWh)

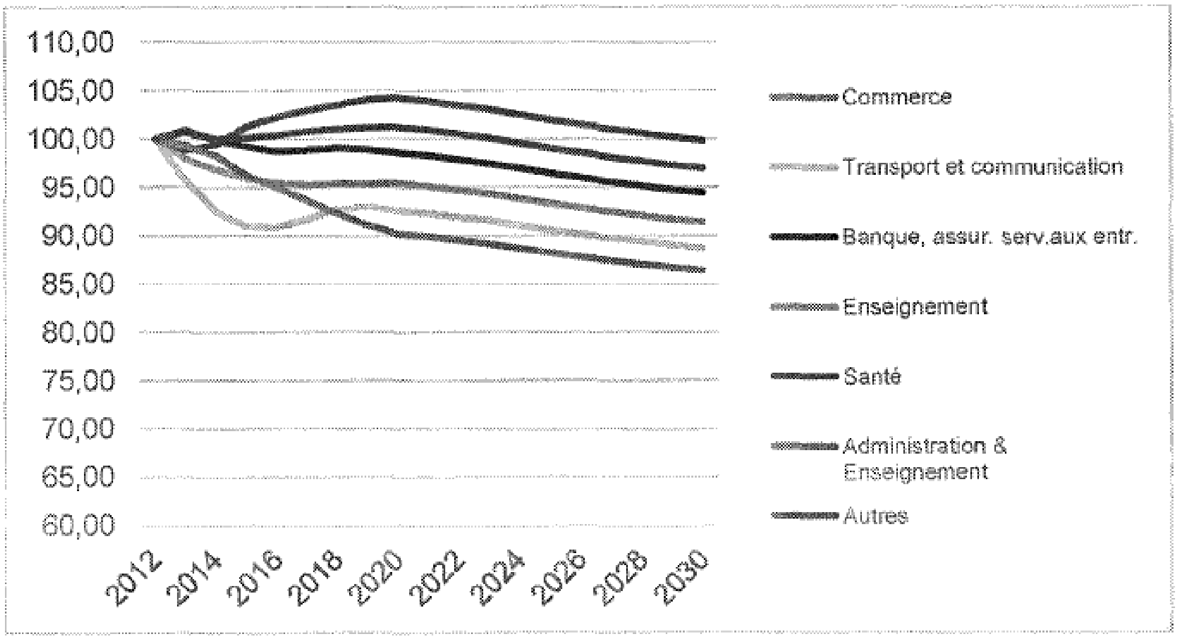


Figure 25 : Projections besoins de chaleur – Tertiaire (Indice 2012 : 100)

Commerce	Business
Transport et communication	Transport and communication
Banque, assur. Serv. Aux. Entr.	Bank, insur., services for businesses
Enseignement	Education
Sante	Health
Administration & Enseignement	Administration and education
Autres	Others
Figure 25 : Projections besoins de chaleur – Tertiaire (Indice 2012 : 100)	Figure 25: Heat demand projections – Tertiary sector (2012 index: 100)

II.3 CHANGES IN COOLING DEMAND IN THE INDUSTRIAL SECTOR

II.3.1 Methodology

The approach used is the same as that for estimating changes in heat demand above.

II.3.2 Results

We estimate that total cooling demand in the industrial sector should decrease slightly in Wallonia by 2030, falling from 830.3 GWh in 2012 to 767.6 GWh in 2030. This translates into an average annual decrease of 0.44%. This change is attributable in large part to the chemical industry, the industrial sector which had the highest total cooling demand in 2012. Between 2012 and 2030, we believe that the chemical industry's total cooling demand will decrease by 0.93% on average per year, due in large part to improvements in energy efficiency.

The following figure depicts this trend and the respective proportions of the sectors involved.

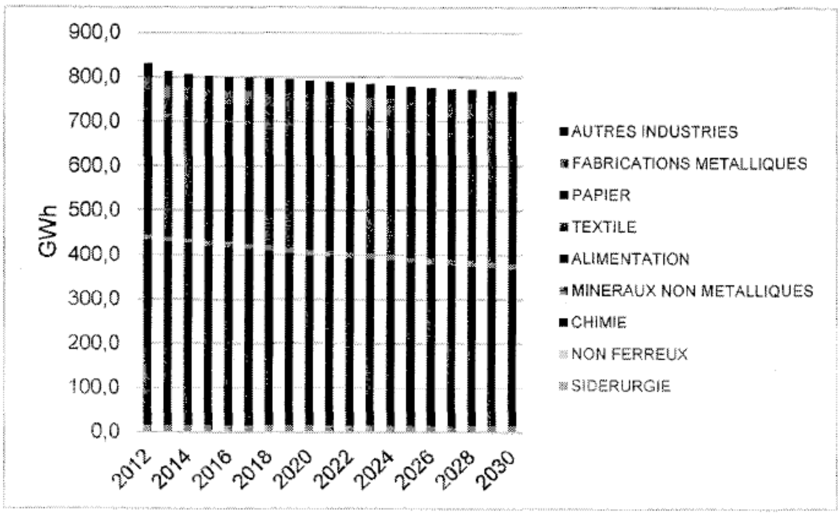


Figure 26 : Projections des besoins de froid– Industrie (GWh)

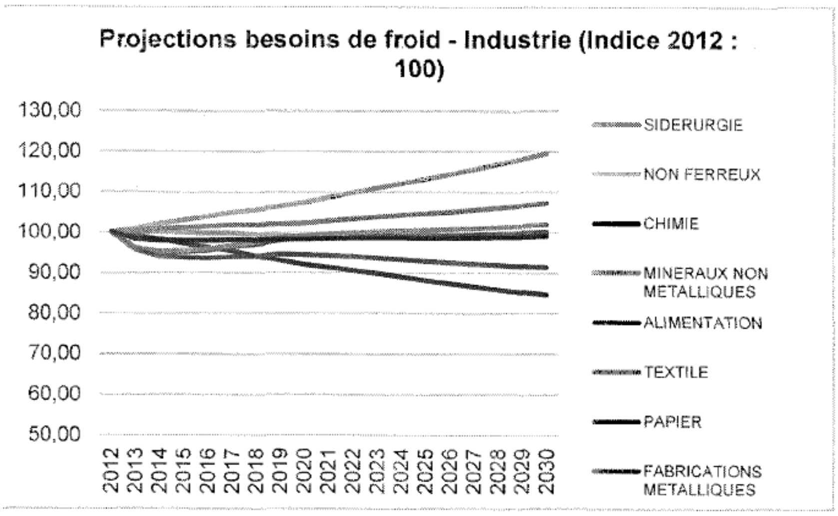


Figure 27 : Projections besoins de froid – Industrie (Indice 2012 : 100)

AUTRES INDUSTRIES	OTHER INDUSTRIES
FABRICATIONS METALLIQUES	METAL MANUFACTURE
PAPIER	PAPER
TEXTILE	TEXTILE
ALIMENTATION	FOOD
MINERAUX NON METALLIQUES	NON-METALLIC MINERALS
CHIMIE	CHEMICAL INDUSTRY
NON FERREUX	NON-FERROUS
SIDERURGIE	STEEL INDUSTRY
Figure 26 : Projections des besoins de froid – Industrie (GWh)	Figure 26: Cooling demand projections – Industrial sector (GWh)
Projections besoins de froid – Industrie (Indice 2012 : 100)	Cooling demand projections – Industrial sector (2012 index: 100)
Figure 27 : Projections besoins de froid – Industrie (Indice 2012 : 100)	Figure 27: Cooling demand projections – Industrial sector (2012 index: 100)

VI. ESTIMATED COOLING SUPPLIES FROM EXISTING INFRASTRUCTURE

According to our information, there are no installations in Wallonia that are capable of producing cold temperatures that can be recovered in a distribution system or that can be consumed on site. The chemical and food industries are the only sectors with potential in terms of cooling.

Contact was made with the corresponding federations, Essenscia and Fevia, and they confirmed that there are currently no existing installations that could generate recoverable cold temperatures.

VII. TRANSMISSION OF THE DATA REQIRED FOR MAPPING

Given the lack of information on the distribution of cooling demand and the relatively low level of substitutable cooling demand in Wallonia, no maps have been drawn up on this subject.

Chapter 4 – Technical potential

VIII. TECHNOLGICAL STATE OF THE ART

I.1 DEFINITIONS FROM DIRECTIVE 2012/27/EU ON COGENERATION AND DISTRICT HEATING NETWORKS

Directive 2012/27/EU on energy efficiency introduces binding measures in order to meet the target of improving energy efficiency by 20% by 2020. This target is one of the EU's more general aims concerning energy and climate, which in particular envisages reducing greenhouse gas emission by 20%, and making renewable energies account for 20% of the EU's energy mix.

It defines the notions of:

- **high-efficiency cogeneration**, which must meet the following criteria:
  - Production through cogeneration using cogeneration units must provide primary energy savings, calculated in accordance with Point b) of Appendix 2 of the EE Directive, of at least 10% in comparison with reference data on the separate production of heat and electricity;
  - Production using small-scale cogeneration units (<1 MW_e) and micro-cogeneration units (<50 kW_e) that provides primary energy savings can be considered to be high-efficiency cogeneration.

- **efficient district heating and cooling**, a district heating or cooling network using at least 50% renewable energy, 50% waste heat, 75% cogenerated heat or 50% of a combination of such energy and heat;

- **efficient heating and cooling**, a heating and cooling option that, compared to a baseline scenario reflecting a business-as-usual situation, measurably reduces the input of primary energy needed to supply one unit of delivered energy within a relevant system boundary in a cost-effective way, as assessed in the cost-benefit analysis referred to in this Directive, taking into account the energy required for extraction, conversion, transport and distribution.

I.2 LISTING AND CHARACTERISTICS OF EXISTING TECHNOLOGY

I.2.1 Condensing boilers

This technology both consumes a significantly smaller quantity of fuels and produces less pollution than a conventional boiler.

Nevertheless, there are **constraints**:

- Optimum operation occurs at low temperatures.
- The technology requires a flue that is waterproof.

Using natural gas means:

- An improved yield (HR TOP seal of approval) is obtained;
- The local impact on the environment is reduced;
- No need to store fuel;

- The installation costs are lower.

Applicability in Wallonia:

- 85% of the market of new boilers;
- For all sizes of projects;
- Works for existing buildings, but preferable for new buildings and deep renovations.

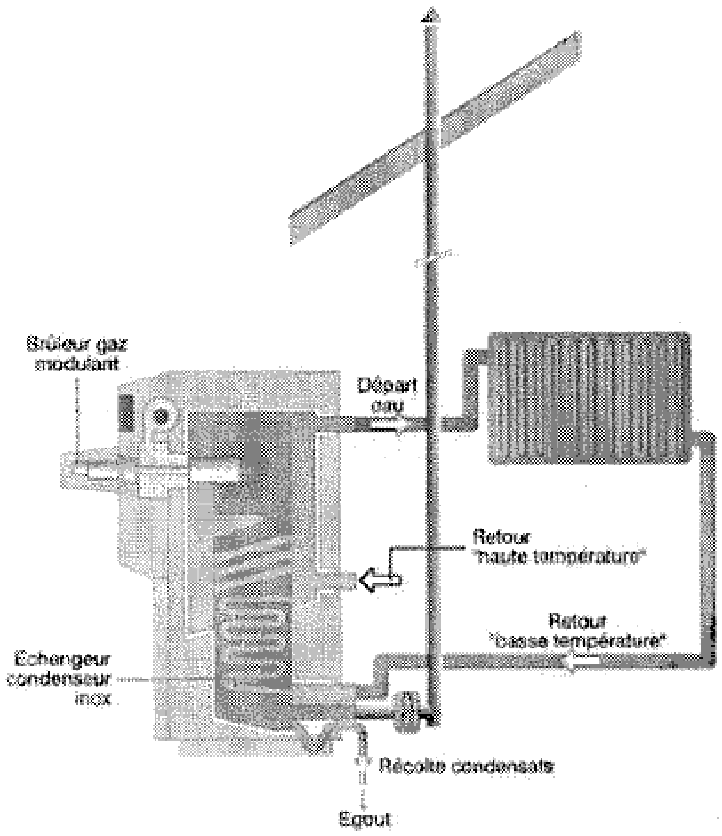


Figure 28 : Schéma d'une chaudière à condensation)

Bruleur gaz modulant	Adjustable gas burner
Départ eau	Hot water to radiators
Retour 'haute température'	Hot air return
Retour 'basse température'	Cold air return
Récolte condensats	Condensate trap
Egout	Condensation drain
Echangeur condenseur inox	Stainless steel condensing heat exchanger
Figure 28 : Schéma d'une chaudière à condensation)	Figure 28: Diagram of a condensing boiler

I.2.2 High-efficiency cogeneration

This technology is **more energy efficient** than the equivalent separate production of heat and electricity.

The **constraints** include:

- Higher investment costs (€3000 per kW_e installed);
- A shorter life span (50,000 and 60,000 hours);
- A profitability threshold that depends on how the installation operates (heat and electricity demand) and is optimum at over 4500 hours of operation;
- Bulky and creates noise pollution;
- The non-profitable price of rapeseed oil for biomass cogeneration;
- The overly high cost of the Stirling engine for domestic micro-cogeneration.

Applicability in Wallonia:

Green certificates encourage high-efficiency cogeneration, or at least high-quality cogeneration with the required reductions in CO^2 emissions.

I.2.3 Industrial solutions

There are currently four solutions:

- Central systems with a boiler and radiators;
- **Waste heat recovery**;
- Infrared heating;
- Heating using hot air.

Waste heat recovery is the most viable option, but requires the use of heat internally or externally using a network through a heat exchanger or heat pump, or by producing electricity using an **ORC engine** (see details below).

Applicability in Wallonia:

This is an interesting option, although it depends on the existing potential for waste heat.

ORC technology

ORC technology (Organic Rankine Cycle) was developed to recover waste heat produced at low temperatures.

Organic Rankine cycles are based on the classic Rankine cycle, using instead an organic working fluid.

This means that it is therefore easier to work at lower temperatures.

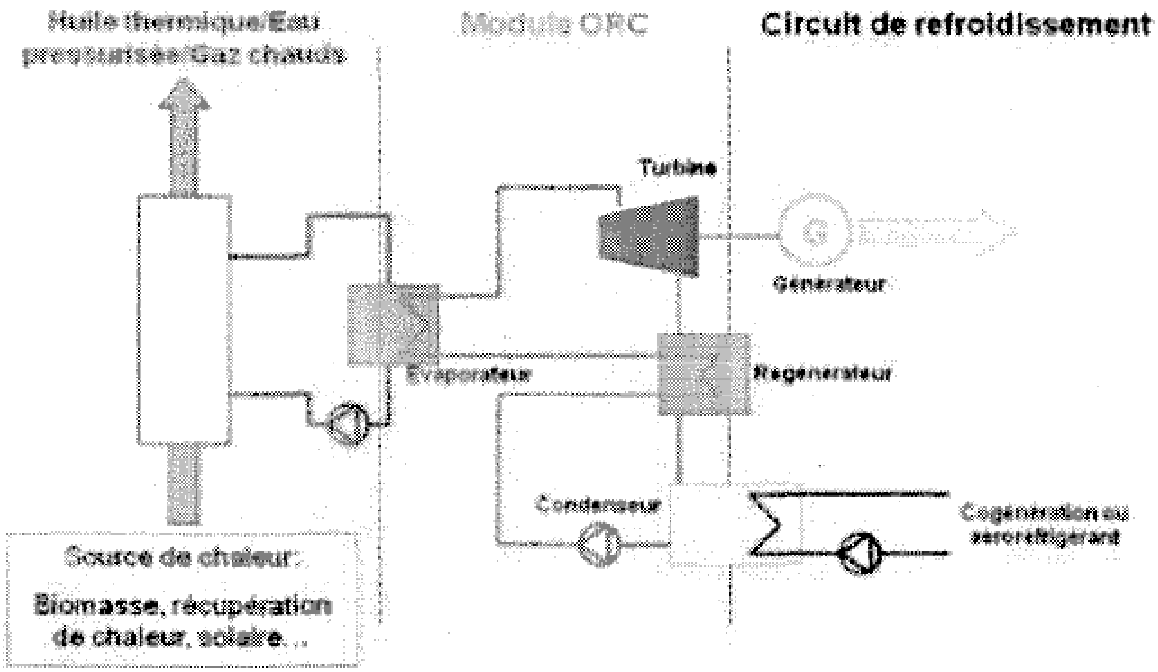


Figure 29 : ORC (source Enertime)

Huile thermique/Eau pressurisée/Gaz chauds	Hot thermal oil/Pressurised water/Hot gasses
Source de chaleur	Heat source
Biomasse, récupération de chaleur, solaire…	Biomass, heat recovery, solar…
Evaporateur	Evaporator
Condenseur	Condenser
Turbine	Turbine
Module ORC	ORC unit
Circuit de refroidissement	Cooling circuit
Générateur	Generator
Régénérateur	Regenerator
Cogénération ou aéroréfrigérant	Cogeneration or air cooled heat exchanger
Figure 29 : ORC (source Enertime)	Figure 29: ORC (Source: Enertime)

An Organic Rankine cycle is composed of three loops, whichever heat source is used:

<u>The thermal loop:</u> A heat source heats a thermal fluid, normally mineral or synthetic oil. The benefit of this oil is that it remains in liquid form at high temperatures and under low pressures. This circuit transfers thermal energy from the heat source to the ORC unit's evaporator. For some uses, the oil can be replaced with water. In some cases (see the previous paragraph), this intermediary heat transport system can be bypassed, leading to a direct exchange between the ORC unit's evaporator and heat source.

<u>ORC unit:</u> The organic vapour produced in the evaporator is held in the turbine to produce to thermal electricity. The organic fluid then remains in vapour form, as there is no condensation in the ORC turbine and the fluids used have a drying property. This stops droplets forming that could erode the ORC turbine and therefore reduces maintenance costs. Moreover, some of the thermal energy from this vapour can be recovered, therefore increasing the cycle's yield by preheating the organic

fluid from the condenser though a heat exchanger called a recuperator. On exiting the recuperator, the vapour then passes into a condenser. The organic fluid, now in liquid state, is compressed to finish the circuit.

Cooling circuit: A cooling circuit is required to condense the organic fluid in an ORC unit. The temperature of the cooling circuit is critical for the installation's efficiency: the lower it is, the better the yield. The cooling technology used is also an important element, with an air-cooled condensation system (dry circuit) consuming more electricity than a system that uses water (wet circuit or open cooling water circuit). When choosing the type of cooling system, it is also important to consider the availability of water at the site.

I.2.4 District heating networks

The advantages of district heating are:

- Diverse sources of energy;
- Flexibility to change energy source;
- Reduced costs, in particular for maintenance;
- Reduced inconvenience due to the centralisation of the production unit.

This option also has **drawbacks**:

- It requires significant initial investment;
- Heat is lost in the network (5% to 20%);
- The profitability threshold is directly linked to energy density (2000 kWh/m^3);
- It is complex to operate (several stakeholders involved);
- Urban constraints (earthworks in areas containing roads), long-term commitment, etc.

IX. TECHNICAL POTENTIAL OF COGENERATION

II.1 SOURCES

The source of data for 2012 for establishments is the database of the annual energy study (BADEN) carried out on behalf of the DGO4 in connection with regional energy balances.

The methodology used was developed in 2005 for the CWaPE and IBGE (*Institut bruxellois pour la gestion de l'environnement*, Brussels Institute for Environmental Management) as a tool for dimensioning and expertise for estimating cogeneration potential in Wallonia and the Brussels region. The tool is designed to enable updates to be applied to the technical and economic parameters of installations, profiles and consumption and to introduce or not introduce certain limiting parameters described later on in the methodology.

The technical and economic parameters that apply to cogeneration installations are updated by the cogeneration facilitator who monitors such information daily.

II.2 METHOD

A dual approach, both bottom-up and top-down, was used to estimate cogeneration potential. The bottom-up approach starts with the individual situation of a number of tertiary and industrial establishments made available by energy surveys carried out each year by the ICEDD on behalf of Wallonia and divided into sectors of activity. The top-down approach analyses the industrial and tertiary sectors in their entirety. The main crux of the work carried out by the ICEDD focusses on the bottom-up approach.

The first stage consists of creating an inventory of the establishments for which individual consumption is available. This includes over 2600 establishments in the tertiary sector in Wallonia (public and private) and around 580 industrial establishments. The data on energy, fuels (solids, liquids and gasses) and electricity used for the study date from 2012. If data is not available for 2012, data from 2011 were used. For large companies, data from 2010 were used if data from 2011 were not available either.

Own-energy generation is not included in the energy data. In other words, it does not include the quantity of fuel already used by decentralised generation units (including cogeneration) or the quantity of electricity already generated by the establishment. Moreover, for the tertiary sector, only companies connected at high voltages have been listed. In the rare instances where a company has reported consumption of both high and low voltages, we have taken the sum of the two consumptions into account.

The second stage consists of carrying out an initial dimensioning of a cogeneration unit on the basis of each establishment's energy data. Using the fuel consumption, the net annual heat demand was estimated taking into account the installation's thermal yield, the proportion of the heat that could be cogenerated and an efficient use of energy factor (or Demand Side Management). This net annual heat demand was then time distributed, hour by hour, depending on which of the 13 heat profiles defined for this study of potential was chosen. The descending classification of the chronological heat demand curve that was obtained in this way provides the monotonic heat curve.

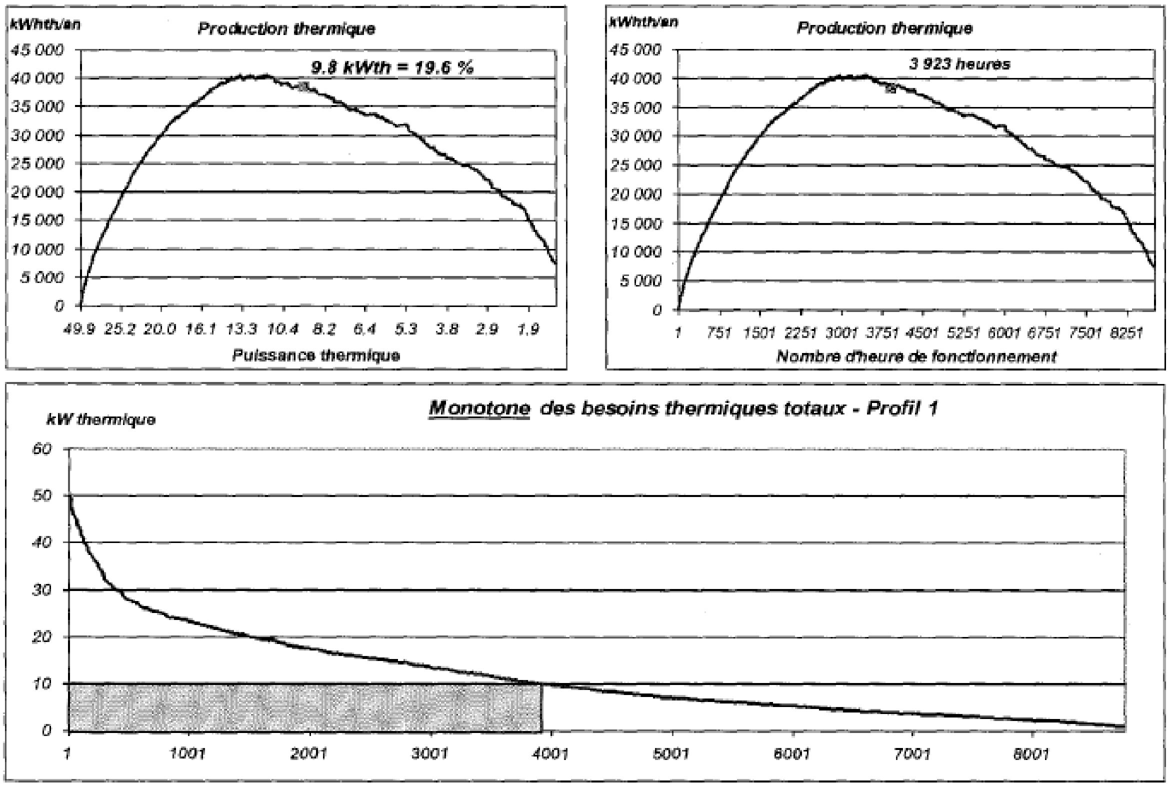
The dimensioning rule maximises thermal energy generation, and therefore the number of green certificates each installation has. In other words, the rectangle that has the largest area under the monotonic heat curve should be chosen (the base that corresponds to the number of cogeneration operating hours and the upper limit of its thermal power). This is therefore dimensioning using a purely energy-based criterion.

It must be noted that this is a rather conservative dimensioning method. Choosing a rectangle underneath the monotonic heat curve implies operation at full load for a certain number of hours. In practice, cogeneration units can operate at up to a partial load of 80% without a significant loss of yield, and therefore increase their operating time. Additionally, we have not considered the option of using several small-scale cogeneration units operating in sequence instead of one large unit, even though this option would not just lead to increased energy generation, but also make electricity generation more reliable in order to reduce the negative impact of the high tariff for backup or emergency electricity.

Next, visual optimisation was carried out in order to take into account a more economic criterion for dimensioning. This entails choosing a rectangle close to that with the maximum area, but with a higher number of operating hours and lower powers, as illustrated below. In effect, in some cases choosing a lower power enables the proportion of surplus electricity in relation to electric power required by the establishment to be reduced or eliminated, and therefore also reduces or eliminates instances of resale to the network at a less than attractive rate. This dual recommendation is the result of the ICEDD's extensive experience in cogeneration.

Numerical example: **Profile 1: Daytime – 5 days/7 – offices, schools, services for people**

The peak power required is 49.9 kW_{th}, which for annual consumption of 100 MWh is a theoretical U_Q duration of 2,005 hours. By determining an operating power of 9.8kWth, a U_{cogen} cogeneration operating duration of 3,923 hours is obtained. The proportion that can be cogenerated is therefore 9.8/49.9, or 19.6%.



(heures de fonctionnement)

kWhth/an	kWhth/year
Production thermique	Heat generated
Heures	Hours
kW thermique	Thermal kW
Puissance thermique	Thermal power
Nombre d'heure de fonctionnement	Number of operating hours
Monotone des besoins thermiques totaux – Profil 1	Monotonic of total thermal demand – Profile 1
(heures de fonctionnement)	(hours of operation)

II.2.1 Simplified assumptions

It is important to note that the potentials established using both the bottom-up and top-down approaches do not take time into account. The software is limited to estimating what is potentially achievable under current market conditions.

No future expansions of the natural gas networks have been taken into account either. Consequently, the software considers that companies who currently consume no natural gas cannot be connected to this fuel. The software therefore considers that these companies can only be equipped with cogeneration that uses light fuel oil.

Potential economies of scale in terms of investment or maintenance costs that could result from installing several engines of the same power have not been taken into account. Such economies of scale have been considered marginal, and of little influence on the model's overall results.

II.2.2 Modelling the tertiary and industrial sectors

II.2.2.1 Model thermal profiles

The bottom-up approach requires that the energy behaviour of companies in different sectors be modelled. In order to do so, it is assumed that all of the establishments in each tertiary or industrial sector considered have the same heat consumption profile. All of the more than 3000 establishments taken into account are therefore divided into a set of sub-sectors of activity. The profiles for the different sectors taken into account are listed in Table 22.

	Profile	**U cogen**	**Cogen proportion**
Model 1	Tertiary daytime, 5 days per week (offices, schools, services for people)	3923	0.196
Model 2	Tertiary daytime, 6 days per week (businesses, culture)	4213	0.209
Model 3	Tertiary daytime, 7 days per week (sports centres)	4679	0.440
Model 4	Tertiary continuous, 7 days per week (care, horeca)	5419	0.239
Model 5	Tertiary daytime, 5 days per week (SMEs, laundry, dry cleaners, regular consumption)	2893	0.464
Model 6	Tertiary daytime, 7 days per week (collective housing)	4718	0.306
Model 7	Industry 1: 7 days per week, 3 breaks; 10 months/year (steel industry, lime, MNF)	8016	0.467
Model 8	Industry 2: chemical industry profile, (PRAYON model) + construction timber drying	8014	0.612
Model 9	Industry 3: parachemistry profile (L'OREAL model)	4581	0.180
Model 10	Industry 4: sugar refinery profile (WANZE model)	2184	0.889
Model 11	Industry 5: other food profile (KRAFTFOODS model)	8050	0.429
Model 12	Industry: Wood drying, pallet	5109	0.274
Model	Paper industry	6264	0.679

13			

Table 22: List of tertiary and industrial sectors taken into account

II.2.2.2 Segmentation of the industrial and tertiary sectors

Table 23 shows the branch of activity and sub-branch code that enables the software's users to select one single sub-sector of activity, the type of thermal profile (see Table 22), the percentage of heat that can be cogenerated and the best available technology (BAT) assumed for each sub-branch of activity.

For industrial sectors, the ratios of heat that can be cogenerated are taken from a study carried out by the ICEDD in 1996.[16] It was not possible to contact a sample of companies again given the time constraints of this study, which would have enabled us to update the values obtained by survey.

In some cases, another value was taken into account. For the **steel industry** (sub-branch code 120), we only considered a balance of the quantity of heat already generated in own-generation (hot water and oil heating) as cogenerable. This value was arbitrarily set at 10% of the quantity of heat actually cogenerated. In fact, it seems obvious that the residual cogeneration potential in the steel industry is very low given that this technology has been used traditionally by steelworkers in Wallonia. Due to a lack of information, we have considered that the non-ferrous mineral sector (sub-branch code 200) has the same characteristics as the steel industry.

The bottom-up approach was also used to determine which technology could theoretically be used for each sector concerned. This choice is based on the establishment's heat demand and any characteristics of the sector.

Consequently, we have assumed that sub-sectors 120 to 440 and 600 to 720 should have gas turbines (when natural gas is available) with vapour generation, but without a post-combustion system. Nevertheless, if the thermal power of the cogeneration installation to be installed is lower than 500 kW_{th}, the software will require the establishment in question to have a natural gas or diesel engine depending on whether the company is able to consume natural gas.

We chose biogas engines for sectors 510 to 530 (food processing) given the expected availability of biomass that can be recovered for energy. It must be noted here that we have assumed that only 10% of the heat that can be cogenerated by companies in this sector can be provided by using biomethanated biomass.

We chose wood gasification technology followed by an internal combustion engine for sawmills and pallet manufacture (sectors 901 and 902). For these two sectors, we set a lower limit of 138 kW_{th}. Below this limit, the software chooses a natural gas or diesel engine. As with biogas engines, we have not limited cogenerable heat, given that the production of ancillary sawmill products is estimated by Valbiom to be 250,000 m^3 of bark, 190,000 m^3 of sawdust and 800,000 m^3 of woodchips.

It was assumed that by definition, the entire tertiary sector was unable to use natural gas or diesel engines. In effect, it is supposed that heat demand in the tertiary sector is for low temperatures

[16] *Demande de chaleur techniquement cogénérable pour la Région wallonne et la Région de Bruxelles-Capitale*, Heat demand that can be cogenerated on a technical basis for the region of Wallonia and Brussels – Final report of 18 December 1996, ICEDD, page 47.

which can be provided by hot water. On the other hand however, the characteristic size of companies in the tertiary sector makes it more likely to use engines powered by fossil fuels (diesel or natural gas), although in some rare cases gas turbines could be justified (large hospitals, industrial laundries).

BRANCHES	**SUB-BRANCH CODE**	**SUB-BRANCH**	**Type**	**% cogen**	**Best Available Technology**
INDUSTRY	120	STEEL INDUSTRY	7	0.05	Gas turbine - vapour - without post-combustion
	200	NON-FERROUS MINERALS	7	0.05	Gas turbine - vapour - without post-combustion
	310	ORGANIC AND INORGANIC CHEMCAL INDUSTRY	8	0.72	Gas turbine - vapour - without post-combustion
	320	PARACHEMISTRY (EXCLUDING O2)	9	0.71	Gas turbine - vapour - without post-combustion
	330	OXYGEN	1	0.90	Gas turbine - vapour - without post-combustion
	340	FERTILISER	8	0.77	Gas turbine - vapour - without post-combustion
	399	CHEMICAL INDUSTRY	9	0.72	Gas turbine - vapour - without post-combustion
	410	CEMENT	7	0.03	Gas turbine - vapour - without post-combustion
	420	LIME, QUARRIES AND DOLOMITE	7	0.00	Gas turbine - vapour - without post-combustion
	431	FLAT GLASS	7	0.00	Gas turbine - vapour - without post-combustion
	440	OTHER NON-METALLIC MINERALS	7	0.20	Gas turbine - vapour - without post-combustion
	510	SUGAR REFINERIES	10	0.73	Biogas engine
	520	DAIRIES	11	0.86	Biogas engine
	530	OTHER FOOD	11	0.70	Biogas engine
	600	TEXTILES	5	0.76	Gas turbine - vapour - without post-combustion
	710	PULP	13	0.92	Gas turbine - vapour - without post-combustion
	720	PAPER PRINTING	13	0.92	Gas turbine - vapour - without post-combustion
	810	MANUFACTURE OF FABRICATED METAL PRODUCTS	1	0.57	Fossil fuel engines
	820	ELECTRIC CONSTRUCTIONS	1	0.57	Fossil fuel engines
	830	TRANSPORT EQUIPMENT	1	0.57	Fossil fuel engines
	899	METAL MANUFACTURE (NON-SPECIFIC)	1	0.57	Fossil fuel engines
	900	OTHER INDUSTRIES	5	0.53	Fossil fuel engines
	901	SAWMILLS AND LUMBER	8	0.53	Cogen wood gasification
	902	PALLET MANUFACTURE	12	0.53	Cogen wood gasification
BUSINESS	1110	Wholesale and middlemen	2	0.98	Fossil fuel engines
	1120	Retail trade (excl. supermarkets)	2	0.98	Fossil fuel engines

	1130	Supermarkets	2	0.98	Fossil fuel engines
	1140	Horeca	4	0.90	Fossil fuel engines
	1199	Non-defined business	2	0.98	Fossil fuel engines
TRANSPORT AND COMMUNICATION	1210	Railways (SNCB)	1	1.00	Fossil fuel engines
	1220	Public transport (excl. SNCB)	1	1.00	Fossil fuel engines
	1230	Private transport and activities related to transport	1	1.00	Fossil fuel engines
	1240	Belgacom, post office	1	1.00	Fossil fuel engines
BANKS, INSURANCE AND SERVICES FOR BUSINESSES	1310	Banks and insurance	1	1.00	Fossil fuel engines
	1320	Estate agents	2	1.00	Fossil fuel engines
	1321	Housing	6	0.98	Fossil fuel engines
	1330	Services for businesses	1	1.00	Fossil fuel engines
EDUCATION	1410	Education at community level	1	1.00	Fossil fuel engines
	1420	Education at province and municipality level	1	1.00	Fossil fuel engines
	1430	Free, private an international education	1	1.00	Fossil fuel engines
	1440	University and research	1	1.00	Fossil fuel engines
	1499	Non-specified education	1	1.00	Fossil fuel engines
CARE AND HEALTH	1510	Hospitals	4	0.90	Fossil fuel engines
	1520	Private general hospital, laboratories	1	0.90	Fossil fuel engines
	1530	Crèches, social housing	1	0.90	Fossil fuel engines
	1540	Retirements homes	4	0.90	Fossil fuel engines
	1599	Non-specified health and care	1	0.90	Fossil fuel engines
CULTURE AND SPORT	1610	Swimming pools	3	1.00	Fossil fuel engines
	1620	Libraries, archives, museums	2	1.00	Fossil fuel engines
	1630	Other sporting or cultural services	3	1.00	Fossil fuel engines
	1640	Tourism	2	1.00	Fossil fuel engines
OTHER SERVICES	1710	Laundries and dry cleaners	5	0.90	Fossil fuel engines
	1720	Repair shops and garages	1	0.98	Fossil fuel engines
	1730	Other services for people	1	1.00	Fossil fuel engines
	1740	Other collective services	1	1.00	Fossil fuel engines
PUBLIC AND INTERNAT. ADMINISTRATION	1810	State and regional administration	1	1.00	Fossil fuel engines
	1820	Municipal and province administration, CPAS[17], local authority	1	1.00	Fossil fuel engines
	1830	National defence	1	1.00	Fossil fuel engines
	1840	International bodies and armed forces	1	1.00	Fossil fuel engines
	1850	Mandatory social security	1	1.00	Fossil fuel engines
	1910	Water: catchment, transport, distribution	1	1.00	Fossil fuel engines
	1930	Waste treatment	5	1.00	Fossil fuel engines
UNDETERMINED	9999	Non-specified tertiary	1	0.90	Fossil fuel engines

Table 23: List of sectors and technologies taken into account

[17] CPAS = Public Centre for Social Welfare

II.3 RESULTS

The following table provides a summary of the dimensioning results for cogeneration in the tertiary and industrial sectors. It presents the total number of establishments studied, as well as those that have energy potential, which represents 78% of the total for the tertiary sector and 68% of the industrial total.

Potential thermal power is 529 $MW_{th.}$ The industrial sector accounts for 76% of this, with corresponding heat generation estimated at 3,172 GWh. Potential electric power is 428 MWe, with the industrial sector accounting for 81%, and a corresponding electricity generation of 2,621 GWh.

	TERTIARY	INDUSTRY	TOTAL
Total number of establishments	2,636	579	3,215
Number with energy potential	2,056	391	2,447
Proportion of the total	78%	68%	76%
Max. electric power (MW)	3.652	40.874	44.526
Total thermal power (MWth)	127.120	401.922	529.042
Total electric power (MWe)	80.427	347.976	428.402
Cogenerated heat generation GWh	552.448	2,619.125	3,171.573
Cogenerated electricity generation GWh	350.296	2,271.555	2,621.851

Table 24: The technical potential of cogeneration in Wallonia

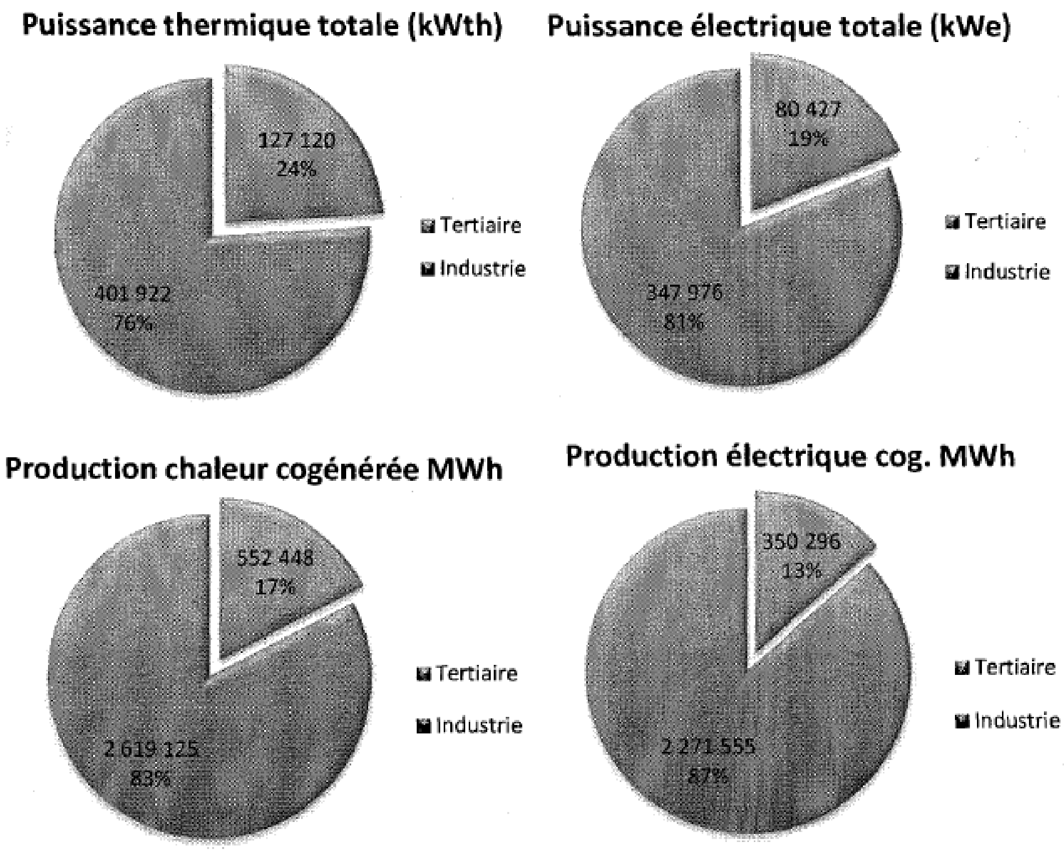


Figure 30 : Potentiel de la cogénération du tertiaire et de l'industrie (2012)

Puissance thermique total (kWth)	Total thermal power (kW_{th})
Tertiaire	Tertiary
Industrie	Industry
Puissance électrique total (kWe)	Total electric power (kW_e)
Production chaleur cogénérée MWh	Cogenerated heat generation, MWh
Production électrique cog. MWh	Cogenerated electricity generation, MWh
Figure 30 : Potentiel de la cogénération du tertiaire et de l'industrie (2012)	Figure 30: Cogeneration potential of the tertiary and industrial sectors (2012)

X. TECHNICAL POTENTIAL OF WASTE ENERGIES

III.1 SOURCES

The same sources of data were used for calculating heat supply (see section III.1.1 of Chapter 1).

III.2 METHODS

In order to estimate the technical potential of waste energies until 2030, the total estimated waste heat supply for 2012 (including low and high temperatures, see Table 17 on page 51) was used to develop six scenarios.

The first scenario entitled 'Business as usual' is based on the assumption that the situation in Wallonia's industrial sector will be the same in 2030 as it was in 2012. In other words, it assumes that energy consumption and waste heat potential will be the same in 2012 and 2030. This may seem optimistic, but is a useful starting point for assessing economic potential (see Chapter 6, Economic potential).

For the '-30%' scenario, it is assumed that the economic crisis affecting Wallonia's industrial sector will continue into 2030, and so energy consumption and the resulting heat potential will consequently decrease by 30% in comparison with 2012. The heat potential for 2020 is obtained by applying a regressive factor of 0.7 to the potential obtained for 2012.

For the '+30%' scenario, it is assumed that between now and 2030, Wallonia's industrial sector will boom, and consequently that energy consumption and the resulting heat potential will increase by 30% in comparison with 2012. This scenario may seem unrealistic, but is a useful tool for assessing maximum heat potential in 2030.

The last three scenarios are more complex. Given that we have energy consumption for each branch of industrial activity since 1990, a progressive trend can be applied to consumption dating from 2013 to 2030, using three periods of time before 2013 as a reference in order to calculate three separate scenarios depending on the time period selected (1990-2012, 2000-2012 and 2010-2012). For example, for the 2000-2012 trend scenario, the energy consumption of each branch of activity between 2000 and 2012 was used as a basis and projected for 2030. In this way a theoretical consumption for each branch of activity can be obtained for 2030. These theoretical consumptions can then be used as a basis for calculating 2030/2012 consumption ratios for each branch of activity. The table below shows the results.

	1990-2012 trend scenario	**2000-2012 trend scenario**	**2010-2012 trend scenario**
STEEL INDUSTRY	0%	0%	0%
NON-FERROUS	0%	0%	0%
CHEMICAL INDUSTRY	121%	73%	89%
NON-METALLIC MINERALS	92%	71%	84%
FOOD	115%	129%	28%
TEXTILES	0%	0%	77%
PAPER	144%	111%	154%
METAL MANUFACTURE	65%	65%	11%
OTHER INDUSTRIES	149%	116%	91%

Table 25: 2030/2012 energy consumption ratios for each branch of activity

Finally, we obtained each branch of activity's heat potential by multiplying the ratios by the heat supply of 2012.

in TWh	1990-2012 trend scenario	2000-2012 trend scenario	2010-2012 trend scenario
STEEL INDUSTRY	0.000	0.000	0.000
NON-FERROUS	0.000	0.000	0.000
CHEMICAL INDUSTRY	1.060	0.639	0.780
NON-METALLIC MINERALS	1.151	0.883	1.052
FOOD	0.226	0.253	0.055
TEXTILES	0.000	0.000	0.000
PAPER	0.032	0.025	0.034
METAL MANUFACTURE	0.002	0.002	0.000
OTHER INDUSTRIES	0.054	0.042	0.033
TOTAL INDUSTRY	**2.525**	**1.844**	**1.954**

Table 26: Three trend scenarios for the technical potential of waste energy in 2030

III.3 RESULTS

The table below shows the estimated technical potential for 2030 for each branch of activity and for six scenarios, classed from left to right in order of least favourable to most favourable. To recap, the business as usual scenario corresponds to the waste heat supply of 2012.

in TWh	-30% scenario	2000-2012 trend scenario	2010-2012 trend scenario	1990-2012 trend scenario	business as usual scenario	+30% scenario
STEEL INDUSTRY	0.172	0.000	0.000	0.000	0.246	0.320
NON-FERROUS	0.000	0.000	0.000	0.000	0.000	0.000
CHEMICAL INDUSTRY	0.615	0.639	0.780	1.060	0.879	1.142
NON-METALLIC MINERALS	0.872	0.883	1.052	1.151	1.246	1.619
FOOD	0.137	0.253	0.055	0.226	0.196	0.254
TEXTILES	0.000	0.000	0.000	0.000	0.000	0.000
PAPER	0.015	0.025	0.034	0.032	0.022	0.029
METAL MANUFACTURE	0.002	0.002	0.000	0.002	0.003	0.004
OTHER INDUSTRIES	0.026	0.042	0.033	0.054	0.036	0.047
TOTAL INDUSTRY	**1.839**	**1.844**	**1.954**	**2.525**	**2.628**	**3.416**
Pro rata evolution in comparison to business as usual	**70%**	**70%**	**74%**	**96%**	**100%**	**130%**

Table 27: Recap of the scenarios for the technical potential of waste energy in 2030

The 2000-2012 trend scenario is one of the least favourable scenarios, as it was in this period that Wallonia's industry was most affected by the economic crisis of 2009. Conversely, the 1990-2012 trend scenario is one of the most favourable and is very close to the business as usual scenario.

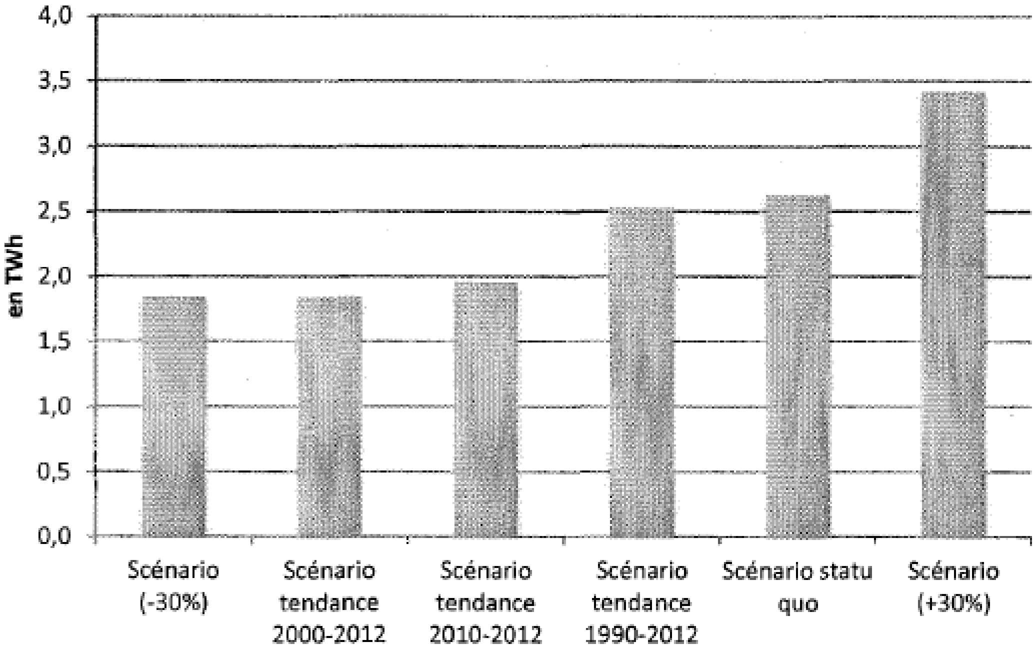


Figure 31 : Potentiel technique total selon les 6 scénarios

En TWh	In TWh
Scénario	Scenario
Scénario tendance	Trend scenario
Scénario statu quo	Business as usual scenario
Figure 31 : Potentiel technique total selon les 6 scenarios	Figure 31: Technical potential according to the six scenarios

The figure below displays technical potential for each branch of activity using the four most realistic scenarios, namely the business as usual scenario and the three scenarios based on the trends of changes in consumption.

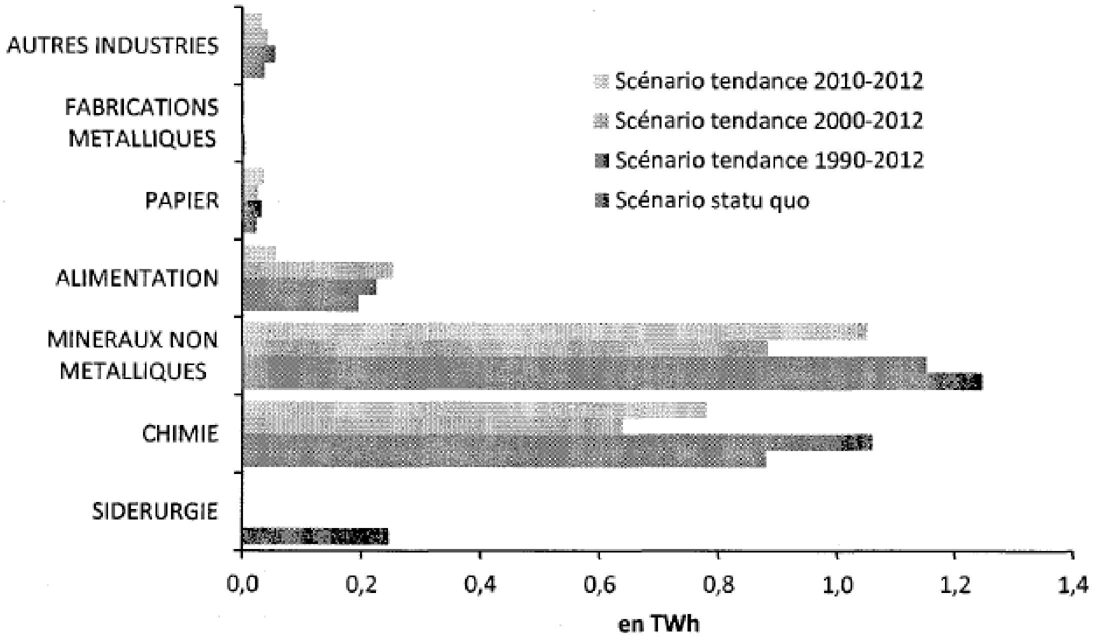


Figure 32 : Potentiel technique par branche d'activité selon 4 scénarios

AUTRES INDUSTRIES	OTHER INDUSTRIES
FABRICATIONS METALLIQUES	METAL MANUFACTURE
PAPIER	PAPER
ALIMENTATION	FOOD
MINERAUX NON METALLIQUES	NON-METALLIC MINERALS
CHIMIE	CHEMICAL INDUSTRY
SIDERURGIE	STEEL INDUSTRY
En TWh	In TWh
Scenario tendance	Trend scenario
Scenario statu quo	Business as usual scenario
Figure 32 : Potentiel technique par branche d'activité selon 4 scenarios	Figure 32: Technical potential for each branch of activity using four scenarios

It can be observed that only the business as usual scenario produces potential for the steel industry in 2030. For the other branches of activity using all the scenarios, it is non-metallic minerals, the chemical industry and, to a lesser extent, the food industry that provide most of the technical potential.

The most favourable scenario for the chemical industry is the 1990-2012 trend scenario (+21% in comparison with business as usual). For non-metallic minerals, the business as usual scenario is the most advantageous. For the food industry, the 2000-2012 trend scenario is the most favourable (+29% in comparison with business as usual), whereas the 2010-2012 trend scenario is the least favourable (-72%).

XI. TECHNICAL POTENTIAL OF DISTRICT HEATING AND COOLING

IV.1 TECHNICAL POTENTIAL OF DISTRICT COOLING

Wallonia currently has no district cooling networks. The main reason for this is that given Belgium's temperate maritime climate, demand for cooling residential and tertiary buildings is too low to make the costs associated with installing district cooling viable (CAPEX and OPEX). In terms of the industrial sector, cooling demand varies greatly from one sub-sector to another, are relatively specific to each industry and are difficult to substitute.

Consequently, stage 4.3 focuses on the technical potential of district heating.

IV.2 TECHNICAL POTENTIAL OF DISTRICT HEATING

In order to approach the technical potential of district heating, we have developed four scenarios that could be applied to Wallonia, on the basis of parameters that are favourable for installing district heating systems, coupled with high-efficiency generation systems or renewable energy generation. The scenarios are as follows:

1. **Increasing the density** of existing district heating networks by increasing connections between buildings located in immediate proximity to the existing district systems;
2. **Extending** existing district heating networks in order to supply buildings located under 1,000 metres away;
3. **Improving** existing district heating network (excluding extending and increasing density);
4. **Creating** new district heating networks.

In order to gain a better understanding of the condition of existing district heating, we believe it would be useful to draw up an inventory of the existing district systems in Wallonia.

IV.2.1 Inventory of existing district heating networks

This table presents an inventory of existing district heating. It is not exhaustive, but presents the data from projects that could be collected.

Name	Location	Energy source	Technology	Generation (kWh/year)	Network length (m)
La surizée	Surice	wet biomass	biomethanation and cogeneration	900,000	400
Bois del Terre	Limelette	natural gas	cogeneration - internal combustion engine	75,000.00	100
Enerwood	Dison	dry biomass	steam turbine	8,000,000	1,430
Ottignies network	Ottignies	vegetable oil	cogeneration - internal combustion engine	900,000.00	100
UCL	Louvain-la-Neuve	natural gas	cogeneration - internal combustion engine + boiler	70,000,000.00	3,800
Ulg - Sart- Tilman	Sart-Tilman, ANGLEUR	dry biomass	steam turbine	60,528,571.43	12,000
Chatelet, Régie des chauffage Urbains	CHATELET	industrial waste heat	recovery of industrial waste heat - exchanger and boiler	4,000,000.00	3,000
Gedinne	GEDINNE	dry biomass	wood gasification + internal combustion engine	1,300,000.00	1,300
Spaque	Anton	biogas	cogeneration	2,400,000.00	800
Biogaz Haut Geer	Geer	wet biomass	biomethanation and cogeneration	800,000.00	1,700
Renogen	Amel	dry biomass and vegetable oil	steam turbine	102,000,000.00	unknown
Recybois	Virton	dry biomass	steam turbine	62,800,000.00	unknown
St ghislain	St ghislain	geothermal	geothermal	11,000.00	6,000
Hotton	Hotton	dry biomass	wood boiler	unknown	440
Baelen	Baelen	dry biomass	wood boiler	675,000	100
Tournai	Tournai	wet biomass	biomethanation and cogeneration	3,100,000	200
Philippeville	Philippeville	dry biomass	wood boiler	unknown	210
Chimay	Chimay	dry biomass	wood cogeneration	unknown	unknown
St Vith	St Vith	unknown	unknown	unknown	unknown
Nassogne	Nassogne	unknown	unknown	unknown	unknown
Tenneville	Tenneville	dry biomass	wood boiler	unknown	unknown
Libin	Libin	dry biomass	wood boiler	unknown	715
Visé	Visé	dry biomass and solar	wood boiler and solar	2,600,000	5,000

Socageth	Charleroi	unknown	unknown	unknown	unknown
Minerve	Gosserlies	unknown	unknown	unknown	unknown
Verviers	Verviers	unknown	unknown	unknown	unknown
Colruyt	unknown	unknown	unknown	unknown	unknown
Greenwatt	Nivelles	unknown	unknown	unknown	unknown
Ateliers du Monceau	unknown	unknown	unknown	unknown	unknown
Ateliers de beauraing	Beauraing	unknown	unknown	unknown	unknown
Radadesh	unknown	unknown	unknown	unknown	unknown
Menuiseries Gonay	Dürler	unknown	unknown	unknown	unknown
Synergies Fleurus	Fleurus	unknown	biomethanation	unknown	1,500

Table 28: Inventory of existing district heating networks

IV.2.2 Increasing the density of existing district heating

As a general rule, the denser district heating is, the more profitable it is. This is linked to losses in the distribution network, which are proportional to the density of the network. The thermal density of district heating is defined as the ratio between the quantity of energy distributed by the network (kWh) and the length of the network (m). The figure below illustrates this decrease in the cost of district heating in line with its density.

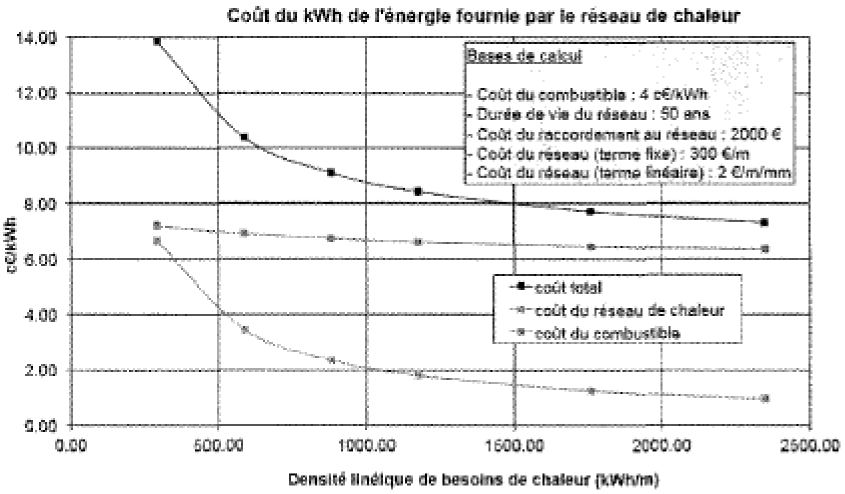


Figure 33 : Coût du kWh en fonction de la densité du réseau (Source : Climat-Air-Energie, Rhônes-Alpes)

Cout du kWh de l'énergie fournie par le réseau de chaleur	kWh cost of energy supplied by the district heating network
c€/kWh	Euro cent/kWh
Bases de calcul	Calculation basis
Cout du fuel : 4 c€/kWh	Fuel cost: 4 euro cents/kWh
Durée de vie du réseau : 50 ans	Lifetime of the network: 50 years
Cout du raccordement au réseau : 2000 €	Cost of connecting to the district heating: €2000
Cout du réseau (terme fixe) : 300 €/m	Network cost (fixed term): €300/m
Cout du réseau (terme linéaire) : 2 €/m/mm	Network cost (linear term): €2/m/mm

Cout total	Total cost
Cout du réseau de chaleur	Cost of district heating
Cout du fuel	Fuel cost
Densité linéique de besoins de chaleur (kWh/m)	Heat demand linear density (kWh/m)
Figure 33 : Cout du kWh en fonction de la densité du réseau (Source : Climat-Air-Energie, Rhône-Alpes)	Figure 33: kWh cost in line with network density (Source: Climat-Air-Energie, Rhône-Alpes)

In order to set an order of magnitude, a thermal density of around 2000 kWh per year and per metre of length created in the network is normally used as the key value in evaluating how economically feasible a district heating project is. As a result, it seems judicious to increase the density of an existing network in order to increase its profitability. However, there are some impediments to doing so, which are explained below.

Buildings that are close to a network but are not yet connected to this network are existing buildings that generate heating and hot water independently. If we wish to integrate these buildings into a network, we will need to be able to offer them an alternative that is more financially advantageous (CAPEX and OPEX).

In addition, the network must be able to generate greater quantities of heat. In concrete terms, the network must have variable delivery with reserve power in order to be able to supply this increased density.

By definition, an existing network is one that has been in place for several years. Consequently, it can be assumed that its maintenance costs (OPEX) will increase over time. In some extreme cases (a dilapidated network), it is sometimes better to stop the network operating (for example, the Verviers network. A company doctor could not be found to recover the existing network). Moreover, if an existing network used to be linked to a waste heat source and this source disappeared, this could endanger the continued existence of the network (the Châtelet network, for example). It is clear that many factors influence the longevity of district heating networks, and all of them must be taken into account when determining whether the density of an existing network can be increased.

Finally, it is also possible to increase network density by disconnecting any buildings that are deemed to be located too far away.

IV.2.3 Extending existing networks

The factors that influence whether it is possible to extend a network are similar to those pertaining to increasing network density. It must be determined whether:

- extending the network will critically decrease network density
- the network in place will require repair costs that are too high
- network capacity is sufficient to supply new buildings. For example, the Charleroi network uses 10 MW out of a potential 48 MW, as some buildings are disconnected. This network therefore has potential for increased density or extension, as it has available reserve power.
- the alternative proposed for new buildings will be competitive compared with their current supply (for existing buildings) or compared with the market price (for new buildings).

As a result, the circumstances surrounding the installation of a new network will have an effect on the potential for extending it. Logically, the more expensive the installation is (ease of access for digging the trenches, obstacles to be overcome in increasing the network size, etc.), the less potential there will be for extension. Generally speaking, when determining an order of magnitude, it is estimated that installing a new network costs between €1000 and €3000 excluding VAT per linear metre (pipes, civil engineering, sub-station and running). The body investing in extending the network (distributor, public authority, etc.) will have to integrate the cost of extending it into the cost of heat sold to the entire network. If the extension costs are too high, the project will not be viable.

IV.2.4 Improving existing networks

Listed below are the different options for improving existing networks.

1. <u>Automating substations with the aim of matching supply to demand more accurately.</u>

Most of the older district heating networks provide constant delivery. In such networks, the delivery does not vary to match demand from the different buildings, but remains constant throughout the year. There are two modifications that can be made to transform such a network into one that provides an adaptable delivery:

- Placing two-way valves at the input to each connected unit so they can be isolated within the network when there is no demand from that building.
- Placing circulator pumps with variable outputs within the primary network.

The benefits of such modifications are twofold:

- Electricity consumption is reduced due to the variable output pumps
- The return temperature of the network is reduced, which aids condensation and increases the network generation yield.

2. <u>Reducing distribution losses.</u>

One of the disadvantages of district heating is the thermal loss that occurs in the network. As a result, these losses should be reduced as far as possible.

The following formula is used to calculate the online losses of a network:

*Thermal losses = length of heating time * Network length * Pipe loss coefficient *Difference in average water and atmosphere temperatures*

We therefore propose two measures that will reduce distribution losses from the primary network: (over-) insulating the network (improving the pipe loss coefficient) or reducing the network's water temperature (reducing the temperature difference).

- (Over-) insulating the network:

The profitability of such a measure depends greatly on how easy it is to access the network. If it is buried underground, the cost of implementing this measure increases significantly, as earthworks must be performed, thus reducing cost effectiveness.

It is easier to access overhead pipes, making the operation more profitable.

- Reducing the temperature of the water distributed:

As losses are proportionate to the difference between the average temperature of the water that runs through the network and the average atmospheric temperature, reducing the network's water temperature will have a direct impact.

However, there is limited scope for reducing the temperature if the network produces both heating and hot water given the risk of Legionnaire's disease.

Before reducing network temperature, it is therefore crucial to determine how it is used in the buildings served.

3. Increasing the yield of existing boilers (maintenance/refurbishment)

In general, the heat generated by existing networks has already been optimised, given the importance of this yield for the consumption of all the buildings served. Nevertheless, there are several possibilities for improving the generation yield of district heating:

- Heat exchange between combustion exhaust gasses and combustion air (heat pipe) to increase the temperature of the air that feeds the burner and reduce losses through exhaust gasses. This technology can be used with higher powers, and is therefore ideal for district heating.
- For conventional boilers (not condensing boilers), an external condenser can be added to increase seasonal yield. Again, this investment becomes more cost-effective the greater the power of the boiler.
- Managing burners on the basis of the oxygen levels in the exhaust gasses by installing a stack probe with an oxygen level setpoint (for example, 3%). The equipment cost is high and requires significant generating power to make the investment profitable.

4. Maintenance of the network generation unit

Unit maintenance is crucial given the amount of heat generated. It should take place frequently and be sufficient to maintain a significant generation yield. Additional monitoring of the maintenance may be required to ensure the yield remains high.

5. Reorganising an existing network

Some current district heating networks are sometimes connected to units that reduce the network's profitability, for historic reasons that are no longer relevant (reducing network density because of a remote unit). In this case, this unit should be made independent in order to increase network density and consequently increase profitability.

IV.2.5 Creating new networks

There are two scenarios to consider in relation to creating new networks:

- Creating a new network as part of a new project or an in-depth renovation of a building's envelope
- Creating a new network as part of technical renovations to an existing building.

The main difference between these two scenarios is the energy performance of the buildings' envelopes and therefore their heat demand. When planning to create district heating, the key value to achieve is heat demand of 1 MW.

Given the energy performance requirements for new projects and in-depth renovations to an envelope (for example, heat demand of new housing <K35), district heating can only be included in large-scale single-use projects, or projects with mixed uses (housing + offices/nurseries/homes/hospitals, etc.) to increase the heat demand met by the future network. In the latter case, the presence of difference uses also serves to smooth out the curve of daily heat demand, which is ideal when operating district heating.

- E.g. The Bella Vita project at Waterloo (new construction)
    - 87 houses, 182 flats, 1 nursery, 1 grocer's shop, 1 restaurant, 1 serviced flat, 1 nursing home, 1 medical centre, 1 swimming pool and 1 gym
    - District heating powered by biomass

New district heating networks should have a variable output and be set up in a star-like configuration (networks) with an extra heat supply planned (a new generation unit at a point within the network) to enable future extension or compensate for any future reduction in the amount of waste heat that was available when the network was created. Networks can therefore be developed in the future in line with any changes to circumstances.

It should be noted that in Scandinavia, district heating networks that measure several tens of kilometres in length that supply entire districts are commonplace, powered by generation plants that use cogeneration. This is the result of a comprehensive energy policy that has been in place for many years that saw networks created when districts were built. It would be difficult to apply this approach to the existing stock in Wallonia as a result. Indeed, there are a great many barriers related to the current stock in Wallonia that would make putting a very large-scale district heating network in place difficult (the requirement for a regional strategic policy, the cost-effectiveness of the project in an environment that is already constructed, etc.). In addition, Scandinavia has a harsher climate than Belgium, which requires much greater fuel consumption, everything else being equal. This model of a district heating network that services a whole district is seemingly more realistic when new districts are being created (see the example of Bella Vita).

There are several criteria to be considered when assessing the cost-effectiveness of a district heating project, which are detailed below.

1. <u>Ease of installation and the number of underground utilities</u>

The cost of the network is one of the most important aspects of a district heating project. Consequently, how easy it is to install has a direct impact on how cost effective the project will be. Clearly, constructing a network on grassland is cheaper than if the route must cross one or several existing roads, or a mineralised surface.

In addition, the cost of the network for both existing and new projects will be affected by the number of utilities in the ground, their position and whether or not there are maps available that detail their location.

In order to set a target value, a general range of €1000 to €3000 excluding VAT per linear metre of the network is used. Note that this calculation does not include the supply and return channels; only the linear metres of the trenches are accounted for. In practice, the supply and return pipes are generally located in the same trench.

2. The number of stakeholders

In the event of carrying out renovations to the technology of a group of existing buildings, a district heating project is generally more successful the lower the number of stakeholders involved. If there are multiple owners/decision makers, the free rider phenomenon, under which a decision maker favours a decision that benefits himself and hinders a decision that benefits the group as a whole if it has a negative impact on that decision maker, serves to complicate the collective decision making process. As a result, the most favourable scenario is one where there is building stock with one owner or decision maker (social housing, office stock with one owner, a school with several buildings, etc.).

The issue of multiple stakeholders affected new projects too, but in a different manner. In such a project, a dialogue upstream of the project must be conducted and an agreement concluded between the four key stakeholders:

- The town/municipality
- The local authority
- The developer
- The heat generator/supplier

It is difficult for a project to move forward without this dialogue and the agreement of these different partners, given the issues related to a network that may have to cross over roads (existing or to be constructed) and that needs to be created at the same time as other utilities (drains, gas, water, electricity, etc.).

When it is possible for the network to be installed with other utilities, an attempt should be made to place the network deeper underground. In principle, this network will be buried underground and should require no intervention for the entirety of its life span, in contrast with other utilities (gas, water, internet, drains, etc.). Burying the network as deep as possible in this way:

- provides better insulation for the network, given the higher ground temperature at lower depths.
- prevents work on other utilities damaging the network.

3. Network density

As previously seen, a network's cost effectiveness is proportional to its density. Connecting new or existing buildings that are relatively close to one another will improve the project's chances of success.

4. Renewable energy

District heating can even out heat demand through a scaling effect. In the case of a single-use complex, this smoothing of demand is obtained statistically, given the increased number of users. For sites with multiple uses, this effect is also reinforced by the diverse nature of the demand that characterises each use. For example, a residential building will see greater demand during the morning and evening and at the weekend, while for an office building this will occur at weekday daytimes. By combining these two uses, demand is better distributed temporally than the two buildings taken in isolation.

This smoothed heat demand curve works particularly well with cogeneration, which becomes more cost effective the longer it operates. Consequently, district heating can be seen as a tool for achieving a situation that favours cogeneration. New district heating networks are therefore often coupled with cogeneration in order to take advantage of green certificates and increase the profitability of the project.

5. Waste heat

District heating becomes still more profitable when it can make use of a waste heat source. In that situation a duplicate form of generation should be put in place to continue to provide a heat supply when the industrial activity is not in operation (either temporarily or definitively).

Chapter 5 – Cost-benefit analysis by territory

1. DEFINING SCENARIOS

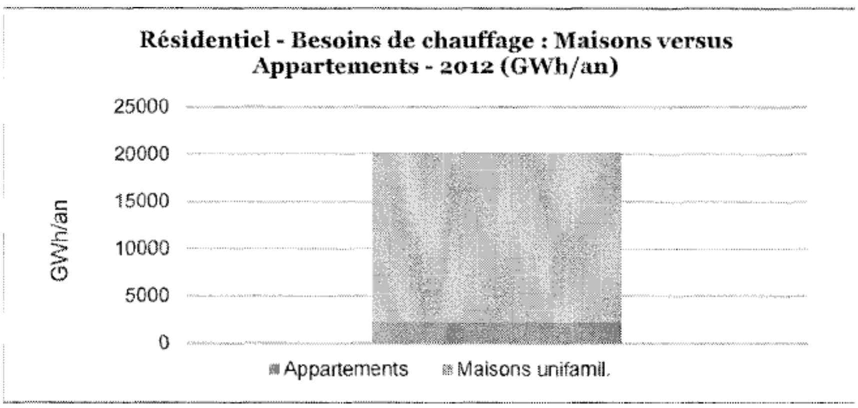
I.1 METHODOLOGY

The aim of this fourth chapter is to provide a **cost-benefit analysis** as required by Directive 2012/27/EU in order to calculate the cost differential between the alternative scenarios and the reference scenarios.

In this respect, a baseline scenario and alternative scenarios for the residential, tertiary and industrial sectors have been defined. As recommended by the European Commission, the baseline scenario should outline the most likely technological advancement for satisfying the heating and cooling demand in each of the sectors to be supplied. Alternative scenarios are based on conventional and unconventional solutions but are always likely to deliver an effective and appropriate response to Wallonia's energy demand. The choice of alternative (non) or less conventional production methods is warranted by market developments and, more importantly, by the situation in Wallonia. Pursuant to the provisions of Directive 2012/27/EU, the following solutions were chosen for alternative scenarios: cogeneration, efficient heating and cooling networks, efficient individual heating and cooling systems.

The scenarios were considered in the context of Walloon's residential, tertiary and industrial sectors both for heating and cooling demand.

In the **residential sector**, the scenarios were first considered for a group of 20 houses (terraced or equivalent) as the heating demand was primarily for single family homes (17,960 GWh versus 2,221 GWh against for apartments).

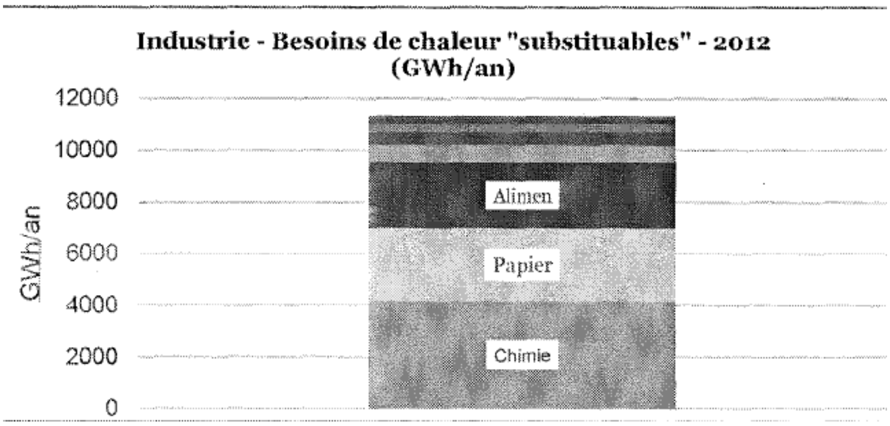


Résidentiel – Besoins de chauffage: Maisons versus Appartements – 2012 (GWh/an)	Residential – Heating demand: Houses vs. Apartments – 2012 (GWh/year)
Appartements	**Apartments**
Maisons unifamil.	**1-family houses**

For apartment buildings, an approach was taken on the basis of a representative sample of a large part of the market in urban centres (e.g. social landlord), i.e. a group of several apartment buildings housing around sixty apartments each. This typology allows us to consider a scenario "on a large scale", *a priori* favorable to cogeneration and heating networks, by the density of housing present on the same site.

Regarding the **tertiary sector**, the scenarios were developed for a homogeneous group of six office buildings. In this regard, it should be noted that the heating and cooling demands of businesses were similar to those of offices (hours of operation, typology, etc.).

Regarding **industry**, the scenarios were considered separately for the three sectors in which the "replaceable" heating demand is the most important, namely chemicals, paper and food.



Industrie – Besoins de chaleur “substituables” – 2012 (GWh/an)	Industry – Substitutable heating demand – 2012 (GWh/year)
Alimen	**Food**
Papier	**Paper**
Chimie	**Chemicals**

I.2 DEFINING SCENARIOS

I.2.1 Defining scenarios for heating demand

Preliminary remark

The scenarios were chosen based on their ability to be reproduced in a real life situation, taking account of the existing constraints in either a physical, geographical, mobility or social environment.

1/ Residential sector (new district)

- Baseline scenario: Decentralised condensing boilers per building
    - Alternative scenario 1.1: Centralised gas cogen + heating network + auxiliary gas boiler
    - Alternative scenario 1.2: Centralised solid biomass boiler + heating network
    - Alternative scenario 1.3: Heating network with waste heat injection

2/ Residential sector (existing apartments)

- Baseline scenario 2: Decentralised condensing boilers per building
- Alternative scenario 2.1: Centralised gas cogen + heating network + auxiliary gas boiler
- Alternative scenario 2.2: Centralised solid biomass boiler + network

Note: fatal heat was not considered in this scenario, given the lack of resources in reasonable proximity to existing entities of this kind.

3/ Tertiary sector (new)

- Baseline scenario 3: Decentralised condensing gas boilers
- Alternative scenario 3.1: Centralised gas cogen + heating network (auxiliary gas boiler)
- Alternative Scenario 3.2: Centralised solid biomass boiler + heating network
- Alternative scenario 3.3: Heating network with waste heat injection

4/ Industrial sector (existing)

The scenarios related to the industrial sector refer to the three industrial sectors identified as having the greatest substitutable heat potential, i.e.:

- the chemical industry,
- the paper industry,
- the food industry

For each industry, we considered a baseline scenario with a centralised traditional boiler, *an alternative scenario* with a centralised (on-site) gas cogeneration installation. Baseline scenario 4.1 relates to the chemical industry, baseline scenario 4.2 relates to the paper industry and baseline scenario 4.3 relates to the food industry.

  - Baseline scenarios 4.1, 4.2, 4.3: Traditional decentralised boilers
- Alternative scenarios 4.1, 4.2, 4.3 Cogen centralised gas (+ auxiliary gas boiler

We then simulated a heating network connecting these three industrial sites. It is worth noting that, in practice, it is unlikely that there will be several industrial sites within close proximity to each other.

3. Baseline scenario 4.4: Centralised gas cogen with network connecting three industrial sites (+ auxiliary gas boilers)

5/ Common remarks on various scenarios

4. Scenarios 1.3 and 2.3 – Waste heat

In the scenarios related to waste heat, it was considered that this type of heat was valued at 90% of the price of the baseline scenario by the suppliers thereof, via the intermediary of an operator. This assumption is justified by the need to offer users an alternative solution that is financially attractive compared to the existing situation so that the project is feasible.

Therefore, the calculation of profitability to be analysed is that of the supplier who, on the one hand promotes the use of waste heat which would have otherwise been lost and, on the other, must bear the investment costs involved in promoting this type of heat.

We also take account of (i) the costs in connection with the network needed to transport heat into buildings, and (ii) the network charges for connecting buildings to the industrial site.

5. Scenarios 1.2 and 2.2 – Solid Biomass

In the interest of reproducibility, only solid biomass was considered because it does not require specific equipment such as, for example, a digester (biogas). This technology requires no auxiliary boiler, from a technical perspective.

6. Scenarios 1.1, 2.1 and 3.2 – Backup

In the scenarios using cogeneration, technical backup is essential given that cogeneration does not have the capacity to meet all of the requirements.

I.2.2 DEFINING SCENARIOS FOR COOLING DEMAND

1/ Residential sector

No scenarios were considered for the cooling demand in the residential sector as it is minimal in Wallonia.

2/ Industrial sector

No scenarios were considered for the cooling demand in the industrial sector as it needs to be specific to each process and are difficult to replace.

3/For cooling demand in office buildings and shops:

7. Baseline scenario 5 = traditional chiller

3. Alternative scenario 5.1 = gas cogen supplied to an absorption cycle
4. Alternative scenario 5.2 = small cooling network supplied by a chiller

XII. STUDY OF SCENARIOS FROM A TECHNICAL AND ECONOMIC PERSPECTIVE

For the different scenarios defined above, this chapter provides a technical and economic analysis of the proposed technological solutions for ensuring an effective response to the heating and cooling demand in Wallonia.

Both for the single-family residential sector and the tertiary sector, the analysis was carried out for "new but non-passive construction projects" while for the industrial sector and collective dwellings the analysis was carried out on existing situations.

For new projects, we simulated a building envelope with walls that met BEP standards, which are shown in the table below:

Walls with protected volume	U Value [W/m^{2}K]
Roof and ceilings	0.24
Windows	1.8
Window panes	1.1
Walls	0.24
Flooring	0.3

II.1 DETAILED DESCRIPTION OF TECHNICAL CHOICES USED IN DEFINING SCENARIOS

II.1.1 Scenarios for district heating demand

Architecture

Scenario 1
20 ‘2 by 2’ terraced houses (2 floors)
Size of façade = 7m, depth = 9m, -> 63m^2 ground/2 floors
Heated air = 2520 m^2

Consumption

Q heat = 66 kWh/m^{2}y
Nom. Cap. Heat. 20 x 4.5 = 90 kW
Q DHW = 20 x 900 kWh/y[35]
Q total (heating + DHW) = 20 x 9247 kWh
Q. el. = 20 x 2100 kWh/y[36]

[35] The user profile in the study was 2 adults and 2 children per house
[36] 60 % of currently published average consumption (technological development)

Applied Technology

Scenario	SB1	SA 1.1	SA 1.2	SA 1.3
Systems	Individual heating	Cogen network gas + indiv. gas source	Network solid biomass	Heating network with waste heat injection
Technical information of the systems	Gas condensation heater, 24 kW with modulating burner	Cogen 18 kW th – 4760 h + source, as SB1	Pellet boiler, 90 kW not increased for DHW	CAPEX of network taken over by a dealer – energy price = 90 % SB1 price
Production output	Seasonal η = 93 % (Hs)	Seas. η th(Hs) = CG 55 %, source 93 %	Seas. η th = 75 % (Hs)	
Length of network		240m	240m	3240m[37]
Network losses	-	4 %[38]	6 %[39]	76 %[40]

II.1.2 Scenarios for heating demand in apartment buildings (existing)

This example of multi-storey apartment blocks is based on a real case representative of housing stock in the 1970s.

Architecture

Scenario 2
8 blocks, 15 floors
450 flats, 85m^2

Consumption

Q heat = 124 kWh/m^{2}y
Nom. Cap. Heat. Approx. 5.3 kW/flat

[37] The network is longer to take into account a 'reasonable' distance between an industrial site and a residential area

[38] 240m network, avg. regime 55/30 [˚C], DN pipes 20, insulation 75 mm PU, avg. temperature 12 ˚C, shutdown during summer given the individual source serving the DHW

[39] 240m network, continuous start 65 ˚C, avg. return 35 ˚C, DN pipes 20, insulation 75 mm PU, avg. temperature 12 ˚C, no shutdown during summer given the provision of DHW

[40] 3240m network, continuous start 65 ˚C, avg. return 35 ˚C, DN pipes 20, insulation 75 mm PU, avg. temperature 12 ˚C, no shutdown during summer given the provision of DHW

Q DHW = 837,750 kWh/y[41]
Q. el. = 1,000,000 kWh/y[42]

Applied Technology

Scenario	SB2	SA 2.1	SA 2.2
Systems	Collective heating per block	Cogen network gas + indiv. gas source	Collective network solid biomass
Technical information of the systems	Gas condensation heater, 8 x 400 kW with modulating burner	CG 600 kH th – 4760 h + source, total 3000 kW	Biomass boiler (with mobile grate) 3 MW
Production output	Seasonal η = 93 % (Hs)	Seas. η th(Hs) = CG 44 %, source 91 %	Seas. η th = 75 % (Hs)
Length of network	-	800m	800m
Network losses[43]	-	4 %	4 %

II.1.3 Scenarios for heating demand in office buildings and shops

Preliminary note: the scenarios related to heating demand in office buildings and shops because of their behavioural similarities (needs, supplies, average hours, structural characteristics), are representative of the market and non-market sectors listed below: office buildings, businesses, schools, public sector, etc. Other sectors such as health care may fall under collective buildings in the previous scenarios.

Architecture

Scenario 3
6 office buildings, R+1 in a business park
400m² ground/floor – surface 800m²/building – total surface 4800m²

[41] 15 % of the total consumed based on real measurements from similar cases
[42] Basis see II.1.1 + general collective consumption
[43] 800m network, continuous start 65 ˚C, avg. return 35 ˚C, DN pipes 200, insulation 37 mm PU, avg. temperature 12 ˚C, no shutdown during summer

Consumption

Q heat = 51 kWh/m^{2}y
Nom. Cap. Heat. 6 x 24.5 kW = 147 kW (5000 operating hours per year)
Q DHW = 0 kWh/y
Q heating = 6 x 40,787 kWh/y
Q. el. = 360,000 kWh/y

Applied Technology

Scenario	SB3	SA 3.1	SA 3.2	SA 3.3
Systems	**Decentralised gas condensation boilers**	**Cogen centralised network gas + gas source**	**Network + solid biomass**	**Heating network with waste heat injection**
Technical information of the systems	**Gas condensation heater with modulating burner 6 X 24 kW**	**Cogen 31 kW th – 4022 h + heating source, as SB3 P total 150 kW**	**Biomass boiler (with mobile grate) 150 kW**	**CAPEX of network taken over by a dealer – energy price = 90 % SB2 price**
Production output	**Seasonal η = 93 % (Hs)**	**Seas. η th(Hs) = CG th = 54 %, source 93 %**	**Seas. η th = 75 % (Hs)**	
Length of network	**-**	**200m**	**200m**	**3200m[44]**
Network losses	**-**	**5 %[45]**	**5 %[46]**	**64 %[47]**

II.1.4 Scenarios for industrial heating demand

General consideration

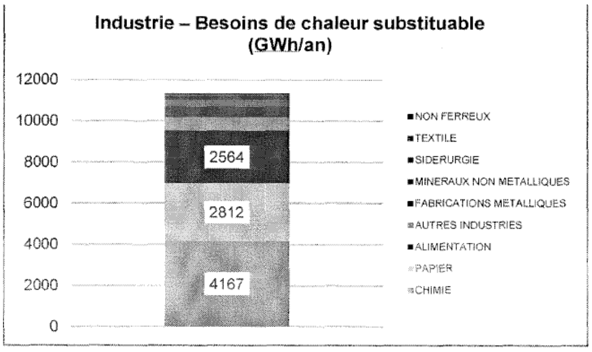
84% of substitutable heat is concentrated in three industrial sectors, namely chemicals (37%), paper (25%) and food (23%).

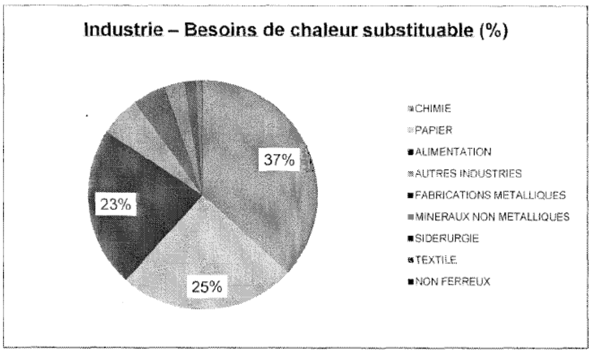
[44] The network is longer to take into account a 'reasonable' distance between an industrial site and a residential area

[45] 200m network, avg. regime 55/30 [˚C], DN pipes 20, insulation 75 mm PU, avg. temperature 12 ˚C, shutdown during summer given the absence of DHW

[46] 200m network, avg. regime 55/30 [˚C], DN pipes 20, insulation 75 mm PU, avg. temperature 12 ˚C, shutdown during summer given the absence of DHW

[47] 3200m network, continuous start 55 ˚C, avg. return 30 ˚C, DN pipes 20, insulation 75 mm PU, avg. temperature 12 ˚C, shutdown during summer given the absence of DHW

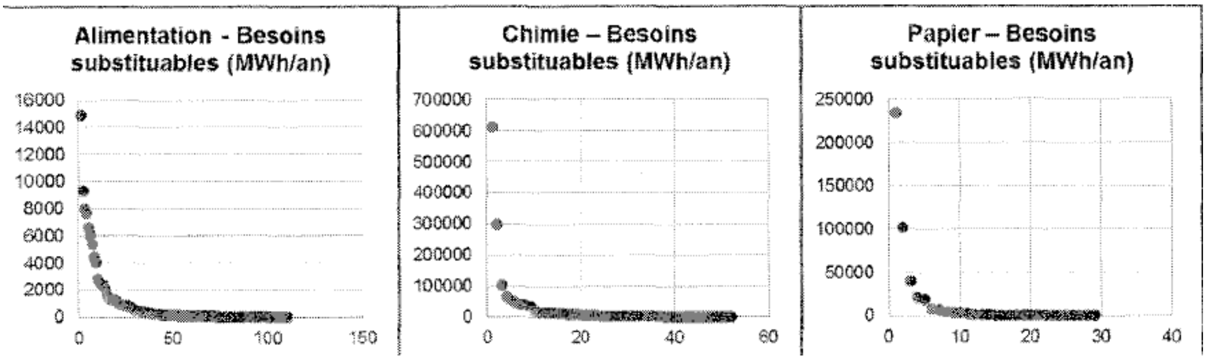




1

Industrie – Besoins de chaleur substituable (GWh/an)	Industry – Substitutable heating demand (GWh/year)
NON FERREUX	NON-FERROUS METALS
TEXTILE	TEXTILES
SIDERURGIE	STEEL INDUSTRY
MINERAUX NON METALLIQUES	NON-METALLIC MINERALS
FABRICATIONS METALLIQUES	METALLIC MANUFACTURING
AUTRES INDUSTRIES	OTHER INDUSTRIES
ALIMENTATION	FOOD
PAPIER	PAPER
CHIMIE	CHEMICALS

In these industries, there is a large disparity in the distribution of substitutable heating demand. Given the need for a consistent approach, it seems important not to consider an average, which would not be representative of the sector, but rather a **median**. In this respect, the substitutable heating demands are 3,467 MWh/year in the chemicals industry, 698 MWh/year in the paper industry and 1,070 MWh in the food industry. Before considering alternatives to cogeneration and heating networks, the assumption will consider all of the substitutable heating demands, i.e., the requirements necessary for supplying heat to buildings and for part of the process (the part of which heat can be supplied by means of water in a liquid state).



2

Alimentation – Besoins substituables (MWH/an)	**Food – substitutable demand (MWh/year)**
Chimie – Besoins substituables (MWh/an)	**Chemicals– substitutable demand (MWh/year)**
Papier – Besoins substituables (MWh/an)	**Paper – substitutable demand (MWh/year)**

Chemical sector		
Scenario	SB 4.1	SA 4.1
System	Traditional gas boiler	Cogeneration gas with gas source
Nom. Cap.	1560 kW	CG 280 Kwth + source 1560 kW
Production output	88 %	CG: 46 % source: 88 %
Duration of operation of CG		4581 h

Paper sector		
Scenario	SB 4.2	SA 4.2
System	Traditional gas boiler	Cogeneration gas with gas source
Nom. Cap.	130 kW	CG 86 Kwth + source 130 kW
Production output	88 %	CG: 55 % source: 88 %
Duration of operation of CG		6264 h

Food sector		
Scenario	SB 4.3	SA 4.3
System	Traditional gas boiler	Cogeneration gas with gas source
Nom. Cap.	185 kW	CG 80 Kwth + source 185 kW
Production output	88 %	CG: 455 % source: 88 %
Duration of operation of CG		8050 h

Scenario 4.4: Chemical + Paper + Food	
System	**Cogeneration network gas + traditional gas source boilers**
Nom. Cap.	**CG 446 Kwth + source total 1875 kW**
Production output (/Hs)	**CG:55 % source: 88 %**
Duration of operation of CG	**1702 h**
Network length	**3000 m**
Network losses	**10 %**

II.1.5 Scenarios for cooling demand in office buildings and shops

Preliminary note: the scenarios of this part comprise, because of their behavioural similarities (needs, supplies, average hours, structural characteristics) market sectors including: offices, shops. Schools, public sector, etc., are either not included or given very little weight (computer room). The other sectors (such as health care) correspond to a consumption per m^2 similar to that of offices[48].

Architecture

Scenario 5
Park with 6 office buildings on 2 levels (R+1)
±façade 28m X depth = 14m = 400m2 ground, - total surface 4800 m2
Air conditioned air = 4800 m2 (int. temp. 24˚C/ext. 30 ˚C)

Consumption

50 Wac/m2
Q ac 6 x 40 kWac = 240 kW ac
Q. el. 360,000 kWh/y

Applied Technology

Scenario	**SB5**	**SA 5.1**	**SA 5.2**
System	**Individual air conditioning each building**		**Common cooler on network**
Composition	**6 monoblock coolers with air refrigerated condensers**	**6 x NG cogeneration installations joined to absorption CAP**[49]	**Monoblock coolers with refrigerated air serving a network to the buildings**
Nom. Cap	**6 x 40 kWac**	**CG 6 x 50 kWth**[50]	**1 x 240 kWac**
Production output	**-**	**-**	**200m**
Network loss	**-**	**-**	**1 %**[51]

II.2 TECHNICAL-ECONOMIC ASSUMPTIONS OF THE SCENARIOS

II.2.1 Technical assumptions

The model supports the technical assumptions as follows:

[48] http://www.ifdd.francophonie.org/docs/prisme/Fi-ME%20en%20ESante.pdf
[49] Gross cost of all machines is ± EUR100,000.00/building
[50] Cogeneration installation: ηth 45% η elec. 25% (Hs)
[51] L=2x210m DN 100 13mm PU avg. t. + 13˚, ground t. 10˚C

- The model identifies three energy loads: heating demand, cooling demand and electricity demand. The demands are globalised annually and simulations are performed in static mode (no transient stages; see below).
- Two additional means of energy production are considered in the calculation: firstly the primary source covering the basic demand and second the secondary source responsible for the backup. Technologies may differ depending on the case.
- Natural gas is used since Wallonia has access to the right size of distribution network and it is relatively environmentally friendly. It is also worth highlighting that, apart from network supplies, alternative options such as biomass gas are also considered because of the profile of the Walloon Region.
- The heating and electrical demands of consumers are the basis of the assessment. The heating demand must be covered 100% independently with the primary source and, in general, the additional backup supply. In the case of electricity demand, there are several scenarios to consider depending on whether:

- The electricity demand is provided through cogeneration (theoretical case).
- The electricity demand is lower than the energy produced through cogeneration: in this case the consumption gap is purchased and imported by the network.
- The electricity demand is higher than the energy produced through cogeneration: in this case the surplus is sold to the grid.
- The production system does not include cogeneration and any energy requested by the customer is charged separately on the network. This is the case for compression refrigeration cycles. It is also, by default, the situation in the baseline scenarios based on the use of conventional boilers.

- Savings in on-farm consumption and energy yield sold on the network come net of costs/cash flow in the defined scenario (profits).
- The design of the installation is considered separately from the annual estimated energy demand. It is dependent on the peak demand for heat production, all combined functions (heating and hot water[52]). The electrical capacity depends on the production system and the excess/surplus is imported/exported by the network.

II.2.2 Economic assumptions

The model supports the economic assumptions as follows:

- The benefits of alternative options were established on the basis of cost. Each option is compared to the costs of the baseline scenario. The costs considered are the net balances resulting from the aggregation of overall production costs after the possible deduction of revenue generated by the sale of electricity produced in the case of cogeneration (see above). The subsidies allocated are also deducted from the production and operating costs, when that is the case[53].

[52] Understood unless otherwise indicated in the secondary production (source).
[53] Hypothesis is not taken into account in the analyses made within this report.

- Since cogeneration is designed to produce both heat and electricity at the same time, the comparison bases include consumer demand expressed in both forms and valued in monetary units (see above).

- The operating time is the physical depreciation of equipment (technical obsolescence). It is treated parametrically and varies according to the common technology used for all installations (primary and secondary sources). This is justified by the fact that both production systems are integrated and therefore share the same service life. Only the heating network when in use is the subject of a specific depreciation (longer).

- Since the duration of the physical depreciation of equipment may vary, current values are *a priori* not comparable. The bases of comparison are restored by taking account of the current annual values (CAV/year). The actuarial calculations are based on monetary data therefore inflated expressed in current EUR and therefore inflated. The results obtained therefore include the speculative effect generated by the change in prices.

- The cash flows of costs include both CAPEX[54] and OPEX[55]:

- CAPEX or *capital expenditure*, take into account the cost of equipment and installation works (infrastructure)

- OPEX or operating costs, cover servicing and maintenance. Fuel charges are handled separately in the model.

- Divestment fees are also supported when they are identifiable. They cover primary and secondary production installations but not heating networks since their service life is longer.

- Cash flows are defined before taxes. This is explained by the fact that the tax system differs widely depending on the status and position of consumers. For example, the deduction possibilities for natural persons are influenced by the level of income. The applicable conditions are different for commercial and/or industrial uses.

- Due to the heterogeneity of the proposed production methods, the expression of gains/losses as a result of the implementation of new technology has little meaning in itself if it is reported in kWh. Indeed, methodological difficulties then need to be addressed: should the gains/losses be attributed to the production of heat or electricity? Consequently, these variables will not be calculated. However, comparisons between the baseline scenario and the proposed alternatives are analysed in terms of the contribution of each component, or group of variables, to the final updated result.

- Capital expenditure depends on whether the project is new or is part of an existing construction. Both options are considered depending on the configuration that can be realistically considered in the context of the RW. Refurbishment applies to industrial scenarios and new corresponds to other scenarios. This assessment focuses on:

[54] CAPitalEXpenditures
[55] OPerationalEXpenditures

3. *Technical* considerations: economies of scale, availability of sufficiently reliable material on the market, performance (such as network distribution losses), etc.
4. *Urban design* considerations: concentration/distribution of residential areas, built-in installations, disturbances (noise, civil engineering works, etc.).

II.2.3 Baseline information

Entries are generally grouped as follows for all of the scenarios:

1. Information relating to the *economic and financial framework*. Such information shows variables such as interest rate, the rates applicable to the purchase and sales of energy on the network, the cost of fuel (natural gas), inflation, subsidies, etc.

2. Information on *heating and electricity charges* for consumers (or groups of consumers). Such information shall be treated as net, i.e. before any additional charges that may apply in the activation of heating or cooling production equipment (such as heat pumps).

3. Information outlining the solutions proposed for the *baseline production*: the amounts for equipment investment (CAPEX), other installation costs such as set-up costs, the installation of chimneys for condensing boilers (expressed as a percentage of CAPEX), costs for the servicing and maintenance of equipment, service life, amounts used for end-of-service-life dismantling purposes, heat rates (in the case of boilers, cogeneration) and electricity rates (in the case of cogeneration), the performance coefficient (compression and absorption cycles), annual production and installation capacity. The baseline production may be centralised or decentralised, e.g. an apartment building or an office building. The network usage is optional (see below) and only concerns the transportation of cooling liquids to outside suppliers or between company buildings.

4. Comparable information on *backup production*. The latter concerns both heating and hot water demand. The backup production can cover a significant part of consumer demand if the primary source is limited by the constraints on the load curve.

5. Information on *network transports*. Such information essentially includes capital expenditure, servicing costs and losses. The network is defined as a system for transporting energy between buildings. Internal networks, such as those used within the same building for the transportation of cooling water and heating water for feeding into induction units are not integrated into the network at this stage.

Data on capital and operational expenditure are reduced to physical units: the installation capacity. The unit consumptions are therefore processed separately from OPEX. They depend on the output or the performance coefficient. The underlying assumption is the lack of economy of scale, which is acceptable in practice if sufficiently narrow ranges of power output are proposed.

In the scenarios concerned, the use of a network is only proposed in a few of the cases: two for heating and one for cooling. The selected cases relate *a priori* to technical solutions. The simulations are based on a common set of economic and financial data outlined below.

Actuarial rate	**%/y**	**3.50%**

Cost of fuel (natural gas)	**EUR/kWh**	**0.05**
Cost of fuel (biomass)	**EUR/kWh**	**0.041**
Cost of fuel (waste heat)	**EUR/kWh**	**0.045**
Fuel inflation (natural gas)	**%/y**	**1.00%**
Electricity tariff LV sale/output	**EUR/kWh**	**0.15**
Electricity tariff LV purchase/output	**EUR/kWh**	**0.05**
Electricity inflation	**%/y**	**2.00%**[56]
CAPEX inflation (equipment)	**%/y**	**1.00%**
OPEX inflation (use)	**%/y**	**1.50%**
CAPEX subsidies (primary source)	**EUR**	**Not foreseen**
OPEX subsidies (primary source)	**EUR/y**	**Not foreseen**

The rates used correspond to reduced low voltage tariffs. This is to show how they compare with decentralised installations for the residential sector. However, some solutions are eligible for a medium voltage tariff. The working assumption is therefore conservative.

The capital expenditure, operating expenditure and fuel charges are shown without VAT (see above).

The table below shows the common data on consumer demands in the five scenarios employed. The data are duplicated in the case of industrial applications as many sectors are examined on the assumption they will undergo renovation. But in both scenarios, the buildings are similar.

DATA	**(scenarios)**	**SB1**	**SB2**	**SB3**	**SB4.1**	**SB4.2**	**SB4.3**	**SB4.4**	**SB5**
Heat load, hot	**kWhth**	**184,940**	**5,585,000**	**244,721**	**3,467,000**	**698,000**	**1,070,000**	**5,235,000**	**-**
Heat load, cold	**kWhth**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**154,560**
Electronic load	**kWh el.**	**42,000**	**1,000,000**	**360,000**	**7,003,947**	**1,403,644**	**4,624,731**	**13,032,322**	**360,000**

The difference between the heating loads of buildings in each of the baseline scenarios is significant.

[56] Average rate taken for a long period (2030). It takes into account, particularly, surcharges brought on by development of renewable energy and the start of decommission nuclear plants.

It should be recalled that, if a primary source (centralised or decentralised) is used in all scenarios and especially in baseline scenarios, the use of a secondary source is only expected in the following cases:

5. Alternative scenario SA 1.1: residential sector; cogeneration, auxiliary boiler, heating network.

6. Alternative scenario SA 2.1: residential sector (collective dwellings); cogeneration, auxiliary boiler, heating network.

7. Alternative scenario SA 3.1: tertiary sector; cogeneration, auxiliary boiler, heating network.

8. Alternative scenario SA 4.1: industrial sector; cogeneration, auxiliary boiler.
9.

Moreover, the distribution network is used in the following options:

- Alternative scenario SA 1.1: residential sector; cogeneration, auxiliary boiler, heating network.
- Alternative scenario SA 1.2: residential sector; common centralised solid biomass boiler, heating network.
- Alternative scenario SA 1.3: residential sector; waste heat, heating network (property of the waste heat supplier[57]).
- Alternative scenario SA 2.1: residential sector (collective dwellings); cogeneration, auxiliary boiler, heating network.
- Alternative scenario SA 2.2: residential sector (collective dwellings); biomass boiler, heating system.
- Alternative scenario SA 3.1: tertiary sector; cogeneration, auxiliary gas boiler, heating network.
- Alternative scenario SA 3.2: tertiary sector; centralised biomass boiler, heating network.
- Alternative scenario SA 3.3[58]: tertiary sector; injection of waste heat; heating network (property of the waste heat supplier).
- Alternative scenario SA 4.4: industrial sector; cogeneration; heating network.
- Alternative Scenario SA 5.2: "chiller" reversible on water loops, small cooling network.

Natural gas is the only fuel used except in the cases where biomass is specified and in the case of electrical compression cooling cycles.

Finally, as regards environmental load and subsidies, the working assumptions are summarised as follows:

a) In order not to distort the results of economic calculation, investment subsidies and/or operating subsidies are not accounted for[59].

[57] Therefore not taken into account in CAPEX relating to the installations.
[58] As above.
[59] Entered as zero in the calculation model.

b) C02 emissions, however, are taken into account. The C02 emission coefficients taken into account in the calculation are 395kg C02/MWh for electricity and 217kg C02/MWh (HHV[60]) for natural gas, respectively. A rate of EUR 10 per tonne of CO2 is applied which is a high assumption in the context of the current market where the prices are nearly 50% lower[61].

II.3 MAIN RESULTS

The results are presented according to each groups of scenarios (baseline scenario and alternative scenarios) to achieve direct comparisons. The first three scenarios deal with meeting the heating demands of collective and individual housing and the tertiary sector. The fourth scenario covers industrial applications divided into three sub-sections: chemical, paper and agribusiness. It is combined with a mixed scenario (three combined sub-sections all including cogeneration). The fifth scenario, however, deals with cooling in the tertiary sector.

II.3.1.1 Scenario # 1: District heating demand

In the first scenario to be analysed, each building's collective decentralised condensing boiler is compared respectively:

a) to the heating network powered by means of cogeneration and auxiliary natural gas boilers (SA 1.1);

b) to the heating network with a common centralised solid biomass boiler (SA 1.2);

c) to the heating network powered by waste heat (SA 1.3).

As shown in the graph below, the comparison between the baseline scenario and the alternative options shows the latter are more expensive in terms of cost except in the case of waste heat for **new buildings**.

[60] High Heat Value.
[61] The current situation is around EUR 5/t.

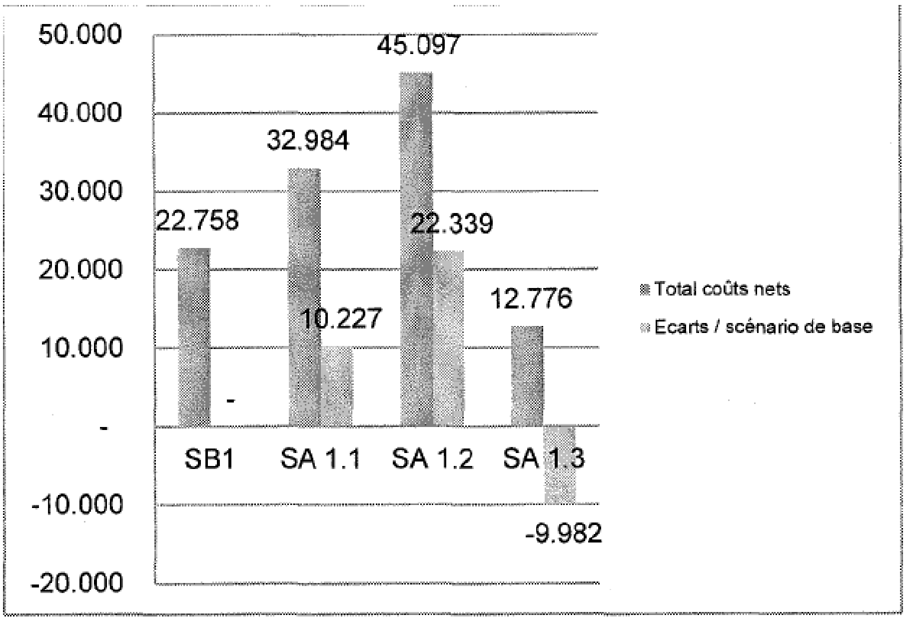


Figure 34 : Coût total (neuf ; EUR/an)

Total coûts nets	**Total net costs**
Ecarts / scenario de base	**Contrast/base scenario**
Figure 34: Coût total (neuf ; EUR/an)	**Figure 34: Total cost (new, EUR/year)**

The contrast is unfavorable for heating networks powered by cogeneration (SA 1.1) and in particular biomass (SA 1.2), while favorable for homes heated through a supplier that recovers waste heat at 90% of the price of fuel in the case of the baseline scenario, all other things being equal.

It is worth bearing in mind that, in the latter case, the CAPEX relating to the heating network serving the buildings and connecting them to the industrial site are covered by the heating supplier, which has an impact on the corresponding charges affecting its selling price. In this respect, it is therefore important to consider whether the operation is profitable for the supplier. While this alternative might have its advantages, it will never be implemented if it is not profitable as no supplier will take it on. First, we consider below whether the project is profitable for the defined typology and secondly we assess the critical mass that would be required for it to become a profitable project for the supplier.

Profitability of the project as defined in our typology

- Network cost for the supplier: 3,240m x EUR 1,500/m = EUR 4,860,000
- Revenue from the sale of waste heat: 50 years[62] x 0.9 x 184,940kWh/year x EUR 0.05/kWh = EUR 416,115

It is clear that such a project is not at all profitable on such a small scale. Therefore, it seems worthwhile to model the situation in order to see how many dwellings it would take to offset these investments.

Critical mass required to reach a profitable project for the supplier: the waste heat solution will be worth considering if the annual cost price of the network per household corresponds as closely as possible to the cost price per household in the baseline scenario:

- Cost price per household in the baseline scenario:
  - Annual consumption per household: 9,247 kWh/0.93*EUR 0.05/kWh = EUR 497
  - Cost of boiler: EUR 203/year[63]
  - Total investment cost + consumption = **EUR 700/year**

- Annual cost price of the network per household[64]
  - Cost of "district – industry" connection (3,000m x EUR[65] 1,500/m)/50 years = EUR 90,000/n[66]
  - Cost of "intra-district" connection per household: (12m[67] x EUR 1,100[68]/m)/50 years = EUR 360

[62] Lifespan of the network = 50 years
[63] 203 EUR/y = 3045 EUR/15 years, including the purchase price and triennial inspections
[64] Lifespan of the network, 50 years
[65] This cost includes supply units
[66] N=number of houses to obtain
[67] Assumed distance between 2 houses
[68] Linear cost of the intra-district network is less than that of the network to connect the industrial district, in light of the obstacles to overcome (roadways, other underground service networks, etc.)

o Total cost of network per household: EUR 90,000/n + EUR 360

These two prices will balance out for a district with a minimum of 265 dwellings. Therefore, the project shall only be profitable for the supplier when it reaches this scale. The prospects of using waste heat shall therefore only apply to new districts of a certain size.

It is worth noting that the net costs in the different graphs are calculated net of the benefits arising from the generation of electricity when it is present, whether it is used to reduce personal energy demands or, in the case of net surplus, the net surplus is resold.

As shown in the graph describing the value chains below, CAPEX and OPEX (excluding fuel) have a negative impact on the heating network powered by cogeneration (SA 1.1). Higher OPEX costs (excluding fuels) and, to a lesser extent, CAPEX costs, have a significant impact on the biomass option. Waste heat is a cheaper alternative because of the savings on fuel costs, despite the relatively high sales price applied thereto (SA 1.3).

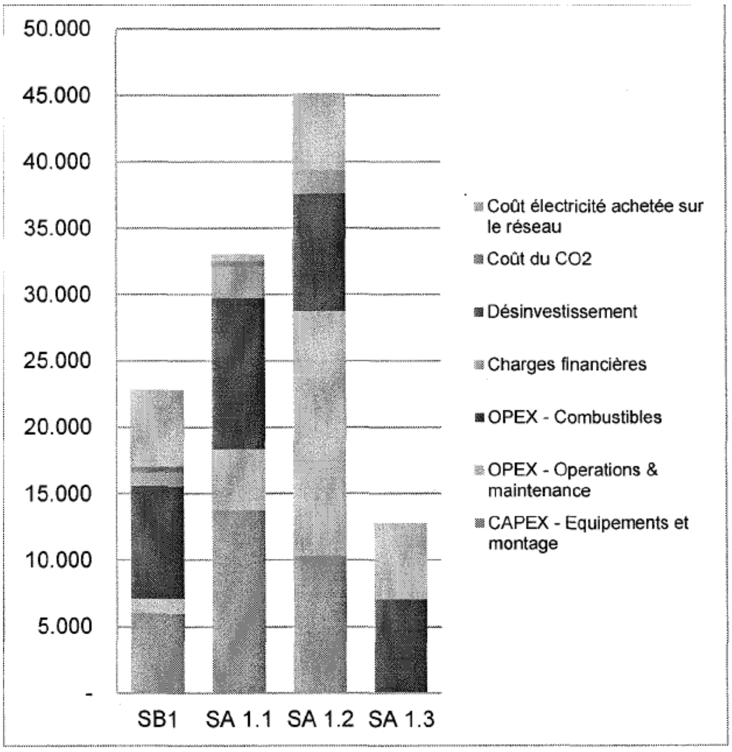


Figure 35:Structure des coûts (existant ; EUR/an)

Coût électricité achetée sur le réseau	**Cost of electricity purchased on the grid**
Coût du CO2	**Cost of CO_2**
Désinvestissement	**Divestment**
Charges financières	**Financial costs**
OPEX – Combustibles	**OPEX – Fuels**
OPEX – Operations & maintenance	**OPEX – Operations & maintenance**
CAPEX – Equipements et montage	**CAPEX – Equipment and assembly**

Figure 35: Structure des couts (existant ; EUR/an)	**Figure 35: Cost structure (current, EUR/year)**

II.3.1.2 Scenario #2: Heating demand in apartment buildings

The second case to be analysed involves multiple dwellings of 8 units. In this second scenario to be analysed, the condensing boilers per building (SB 2) are compared respectively:

a) to a cogeneration option supplemented by auxiliary boilers and a heating network (S2.1);

b) to biomass boilers (SA 2.2).

As indicated in the following graph on **existing buildings**, the cogeneration option is marginally less competitive than the baseline scenario (SA 2.1). The second option (biomass boilers; SA 2.2) is much more expensive than the baseline scenario (SB2).
The following graph shows that the main area responsible for the higher price of the latter option (individual boilers; SA 2.2) is "other net costs" such as CAPEX, OPEX, financial expenses, etc. for **existing buildings**, especially financial costs and operating costs combined.

The purchase of electricity is lower in the case of cogeneration (SA 2.1a) but CAPEX and OPEX costs are significantly higher because of fuel costs, and cannot be offset completely by the savings on electricity.

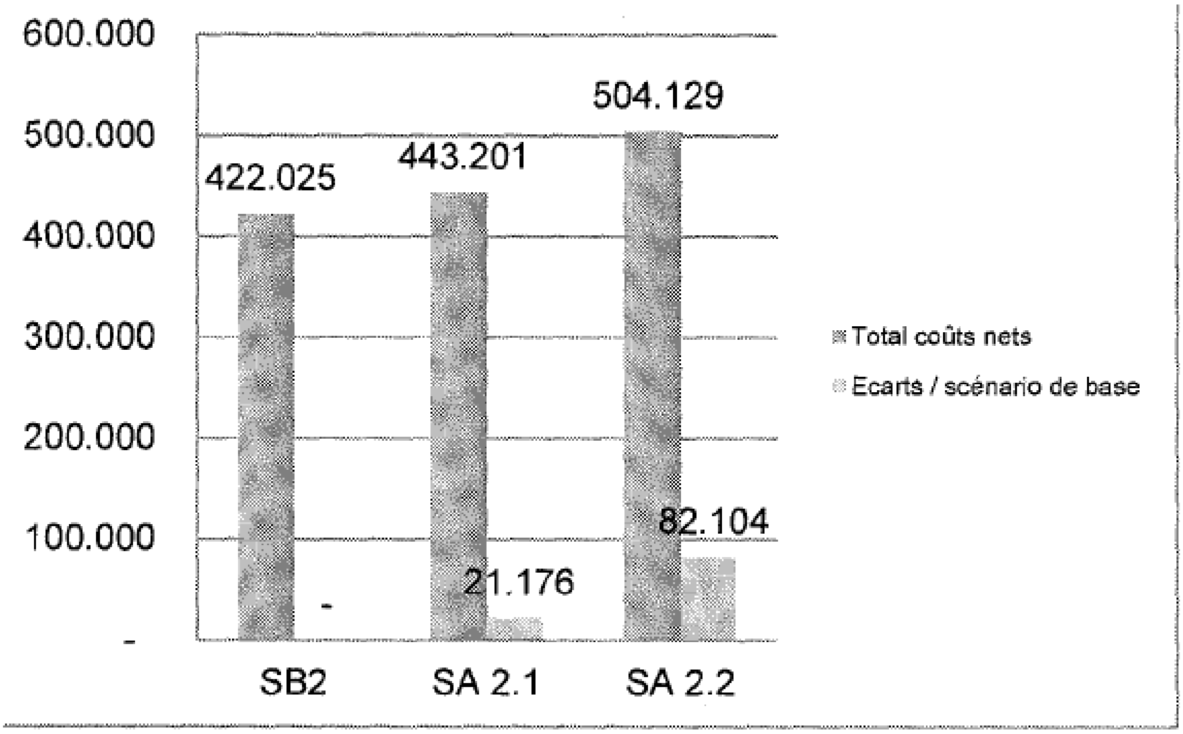


Figure 36: Coût total (neuf ; EUR/an)

Total coûts nets	**Total net costs**
Ecarts / scenario de base	**Contrast/base scenario**
Figure 34: Coût total (neuf ; EUR/an)	**Figure 36: Total cost (new, EUR/year)**

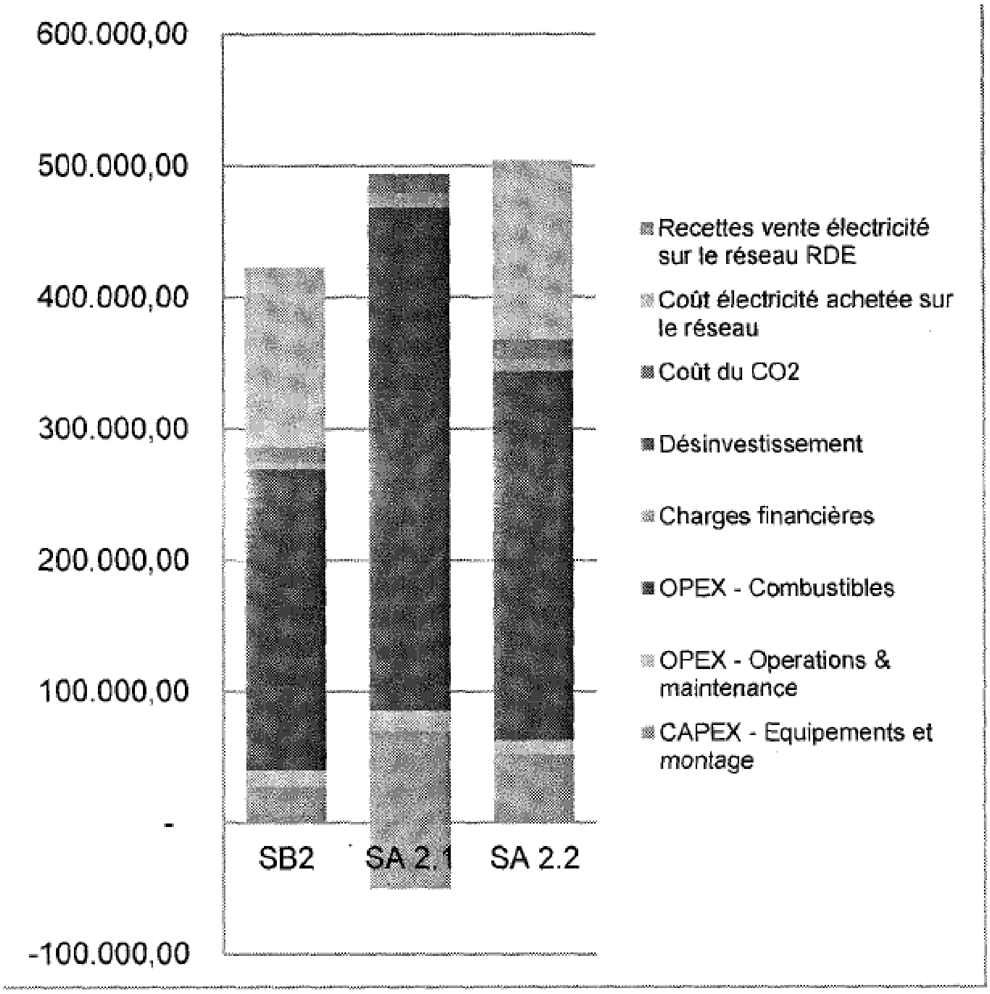


Figure 37: Structure des coûts (neuf; EUR/an)

Recettes vente électricité sur le réseau RDE	**Income from sales of electricity on the RDE grid**
Cout électricité achetée sur le réseau	**Cost of electricity purchased on the grid**
Cout du CO2	**Cost of CO_2**
Désinvestissement	**Divestment**
Charges financières	**Financial costs**
OPEX – Combustibles	**OPEX – Fuels**
OPEX – Operations & maintenance	**OPEX – Operations & maintenance**
CAPEX – Equipements et montage	**CAPEX – Equipment and assembly**
Figure 37: Structure des couts (neufs ; EUR/an)	**Figure 37: Cost structure (new, EUR/year)**

II.3.1.3 Scenario #3: Heating demand in office buildings and shops

The baseline scenario relates to decentralised boilers (SB 3). The three options considered are:

c) cogeneration supplemented by an auxiliary boiler and a network (SA 3.1).

d) a centralised solid biomass boiler with a heating network (SA 3.2).

e) a heating network powered by waste heat (SA 3.3),

respectively.

The baseline scenario for the **new buildings** shown in the graph below is less competitive than the heating network powered by waste heat (SA 3.3). The option of cogeneration with an auxiliary boiler and network (SA 3.1), and, in particular, the option of a solid biomass boiler (SA 3.2), are, however, more expensive than collective boilers (SB 3).

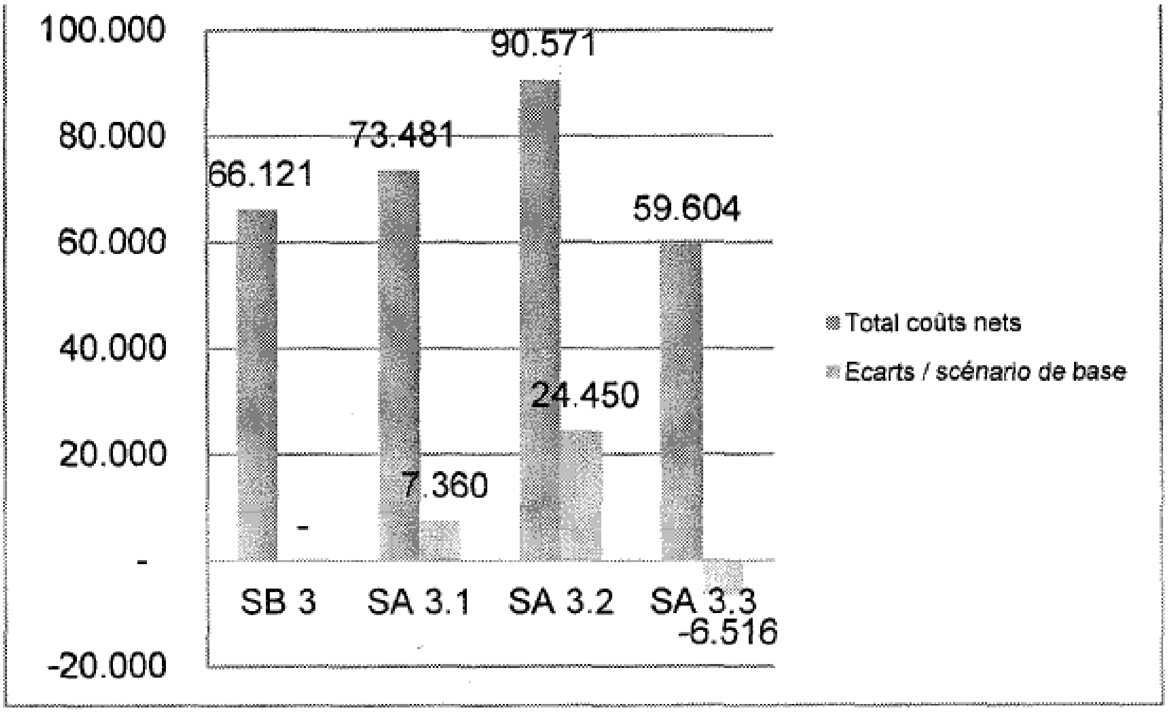


Figure 38 : Coût total (neuf; EUR/an)

Total couts nets	**Total net costs**
Ecarts / scenario de base	**Contrast/base scenario**
Figure 38: Cout total (neuf ; EUR/an)	**Figure 38: Total cost (new, EUR/year)**

It is worth remembering that in the latter case (SA 3.3), the CAPEX costs for the heating network serving the buildings and connecting them to the industrial site are covered by the heating supplier and reflected in the selling price.

The question then is to what extent the operation is profitable for the supplier While this alternative might have its advantages, it will never be implemented if it is not profitable as no supplier will take it on.

Profitability of the project as defined in our typology

- Costs to be borne by the supplier: 3,200m x EUR 1,500/m = EUR 4,800,000
- Revenue from the sale of waste heat: 50 years x 0.9 x 244,721kWh/year x EUR 0.05/kWh = EUR 550,622

It is clear that such a project is not at all profitable for the supplier on such a small scale. Therefore, it seems worthwhile to model the situation in order to see how many office buildings it would take to offset these investments.

Critical mass required to reach a profitable project for the supplier

Cost price per building in the baseline scenario:

o Annual consumption per building: 40786 kWh/0.93*EUR 0.05/kWh = EUR 2,192/year
o Cost of boiler: EUR 216/year[69]
o Total investment cost + consumption = **EUR 2,408/year**

- Annual cost price of network per household[70]

o Cost of "district – industry" connection (3,000m x EUR 1,500[71]/m)/50 years = EUR 90,000/n[72]
o Cost of "on-site" connection per building: (40m[73] x EUR[74] 1,100/m)/50 years = EUR 880
o Total cost of network per household: EUR 90,000/n + EUR 880

These two prices will balance out for a district with a minimum of 59 office buildings. Therefore, the project shall only be profitable for the supplier when it reaches this scale. The prospects of using waste heat shall therefore only apply to new districts of a certain size.

A future alternative might be to supply a business park/housing in order to reach the required size.

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[69] 3240 EUR/15 years, including the purchase price and triennial inspections
[70] Lifespan of the network, 50 years
[71] Cost includes supply units
[72] N= number of houses to obtain
[73] Assumed distance between 2 houses
[74] Linear cost of the intra-district network is less than that of the network to connect the industrial district, in light of the obstacles to overcome (roadways, other underground service networks, etc.)

For **new constructions**, the three scenarios are characterised by high electricity bills; the first component of the cost chain (see graph below). Other cost factors are, respectively, fuel in each case, and OPEX and CAPEX in the case of cogeneration (SA 3.1 and SA 3.2).

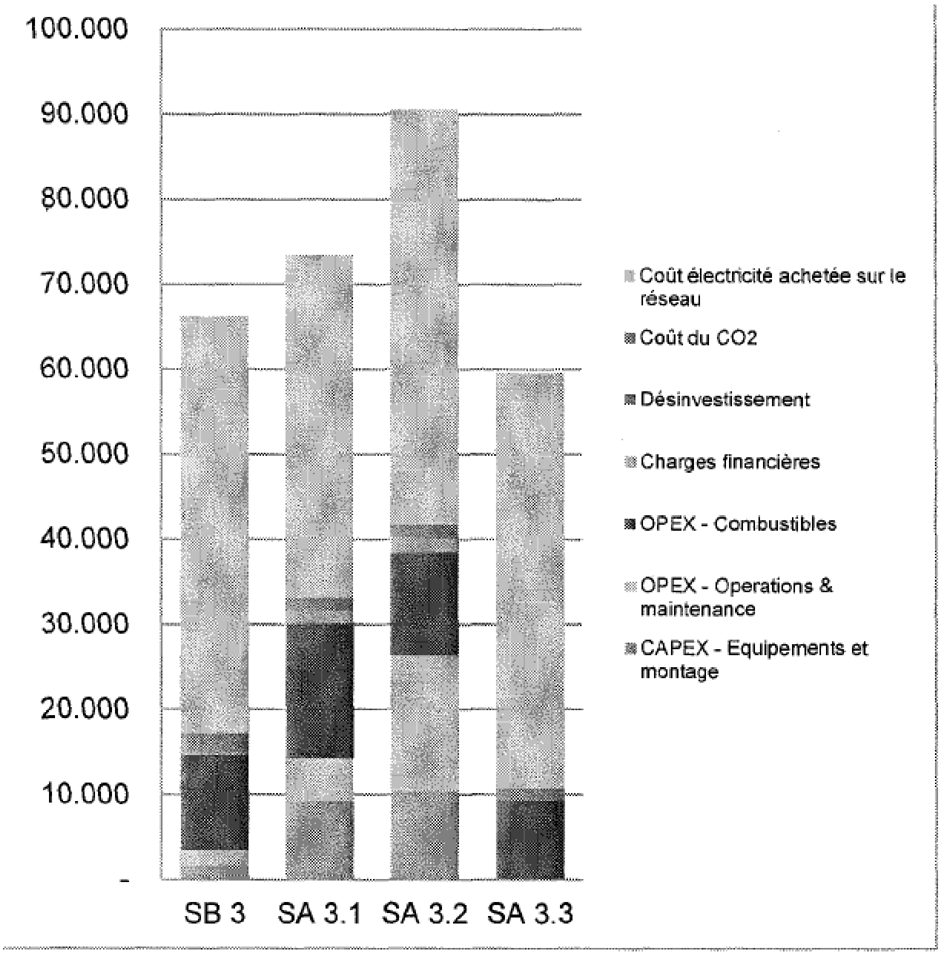


Figure 39: Structure des coûts (neuf; EUR/an)

Cout électricité achetée sur le réseau	**Cost of electricity purchased on the grid**
Cout du CO2	**Cost of CO_2**
Désinvestissement	**Divestment**
Charges financières	**Financial costs**
OPEX – Combustibles	**OPEX – Fuels**
OPEX – Operations & maintenance	**OPEX – Operations & maintenance**
CAPEX – Equipements et montage	**CAPEX – Equipment and assembly**
Figure 39: Structure des couts (neuf ; EUR/an)	**Figure 39: Cost structure (new, EUR/year)**

II 3.1.4 Scenario #4: heating demand in the industrial sector

Three sectors characterised by different load profiles are compared then combined. They are analysed successively thereafter.

Unlike the examples discussed in the residential and tertiary sectors, scenarios proposed for the industrial sector include all **renovation projects**.

II.3.1.4.1 Chemical sector

The baseline scenario in the chemical sector includes traditional boilers (SB 4.1). It is compared to the alternative scenario which involves cogeneration supplemented by auxiliary boilers powered by natural gas (SA 4.1).

In this case, the cogeneration option (SA 4.1) is slightly more competitive than the baseline version (SB 4.1).

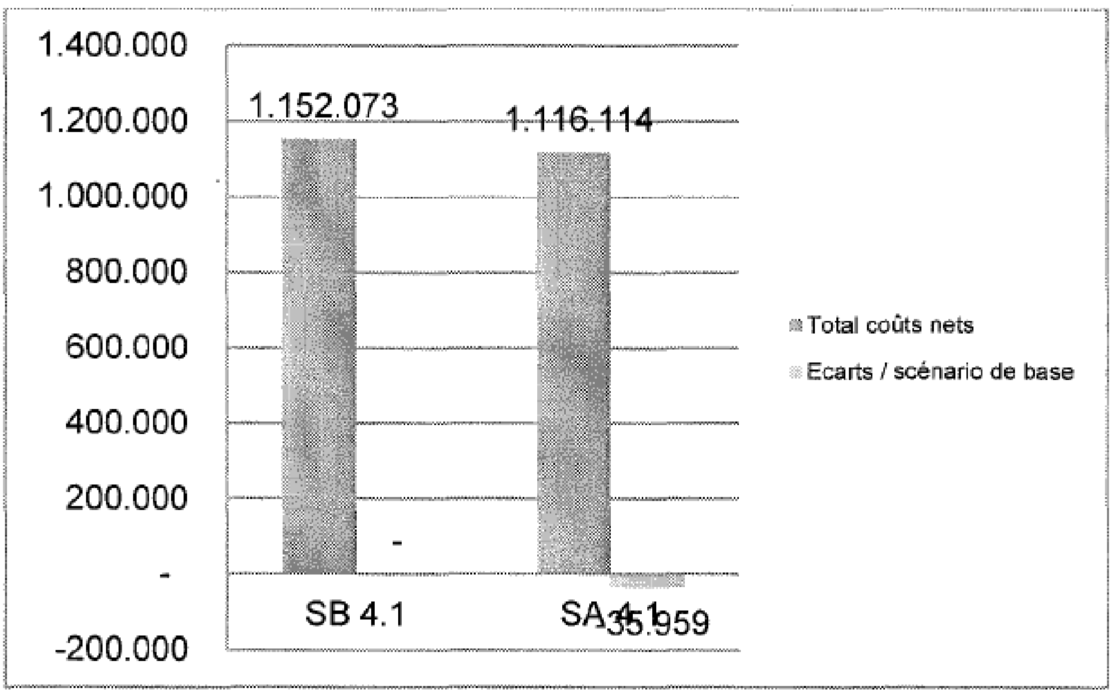


Figure 40 : Coût total (rénové ; EUR/an)

Total couts nets	**Total net costs**
Ecarts / scenario de base	**Contrast/base scenario**
Figure 40: Cout total (rénové ; EUR/an)	**Figure 40: Total cost (renovated, EUR/year)**

This can be explained, as indicated in the following figure, bu the positive impact of production of cogenerated electricity on the cost chain (SA 4.1)

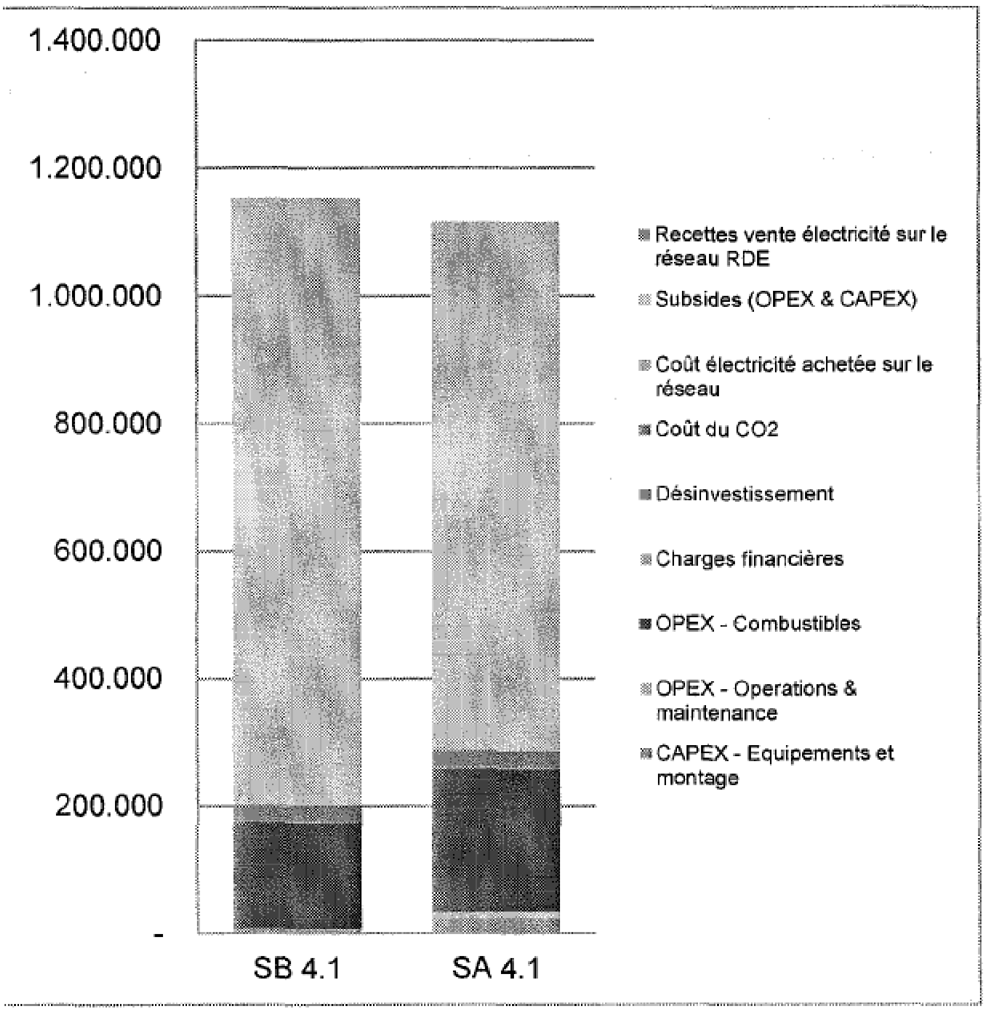


Figure 41 : Structure des coûts (rénové; EUR/an)

Recettes vente électricité sur le réseau RDE	**Income from sales of electricity on the RDE grid**
Subsides (OPEX & CAPEX)	**Subsidies (OPEX & CAPEX)**
Cout électricité achetée sur le réseau	**Cost of electricity purchased on the grid**
Cout du CO2	**Cost of CO_2**
Désinvestissement	**Divestment**
Charges financières	**Financial costs**
OPEX - Combustibles	**OPEX – Fuels**
OPEX – Operations & maintenance	**OPEX – Operations & maintenance**
CAPEX – Equipements et montage	**CAPEX – Equipment and assembly**
Figure 41: Structure des couts (rénové ; EUR/an)	**Figure 41: Cost structure (renovated, EUR/year)**

II.3.1.4.2 Paper sector

The baseline scenario in the paper sector also includes traditional boilers (SB 4.2). It is also compared to the alternative scenario which involves cogeneration supplemented by auxiliary boilers powered by natural gas (SA 4.2).

In this case, the cogeneration option has a competitive advantage as shown in the following graph.

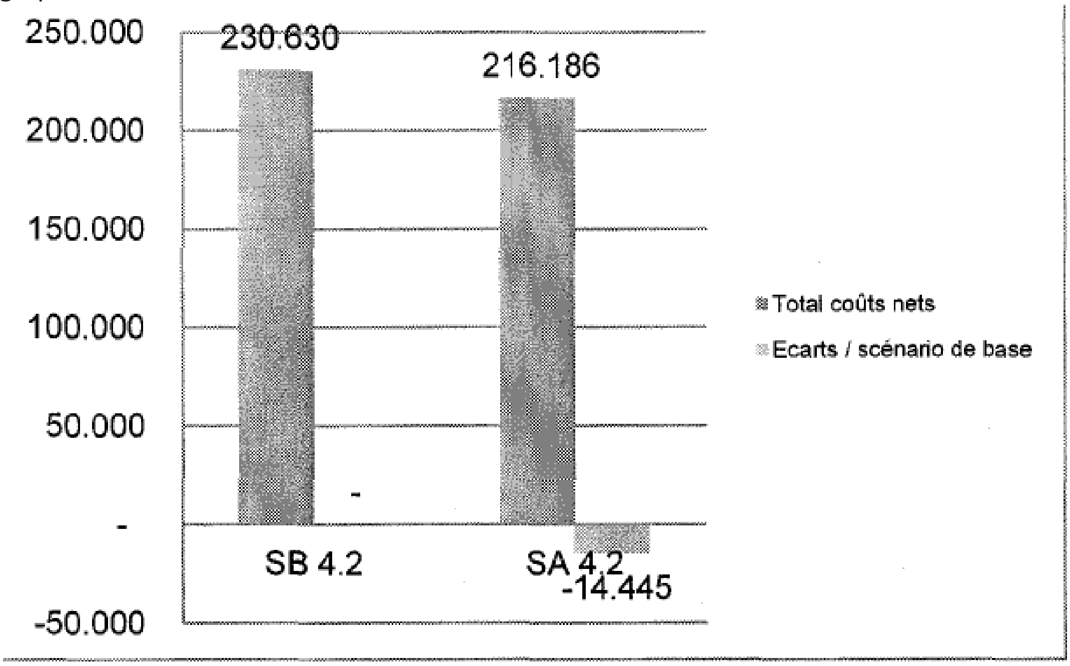


Figure 42 : Coût total (rénové; EUR/an)

Total couts nets	**Total net costs**
Ecarts / scenario de base	**Contrast/base scenario**
Figure 42: Cout total (rénové ; EUR/an)	**Figure 42: Total cost (renovated, EUR/year)**

It is observed in the value chain that the cost of electricity is the most expensive (figure below). Cogeneration is a significantly cheaper option and offsets the additional costs of CAPEX OPEX.

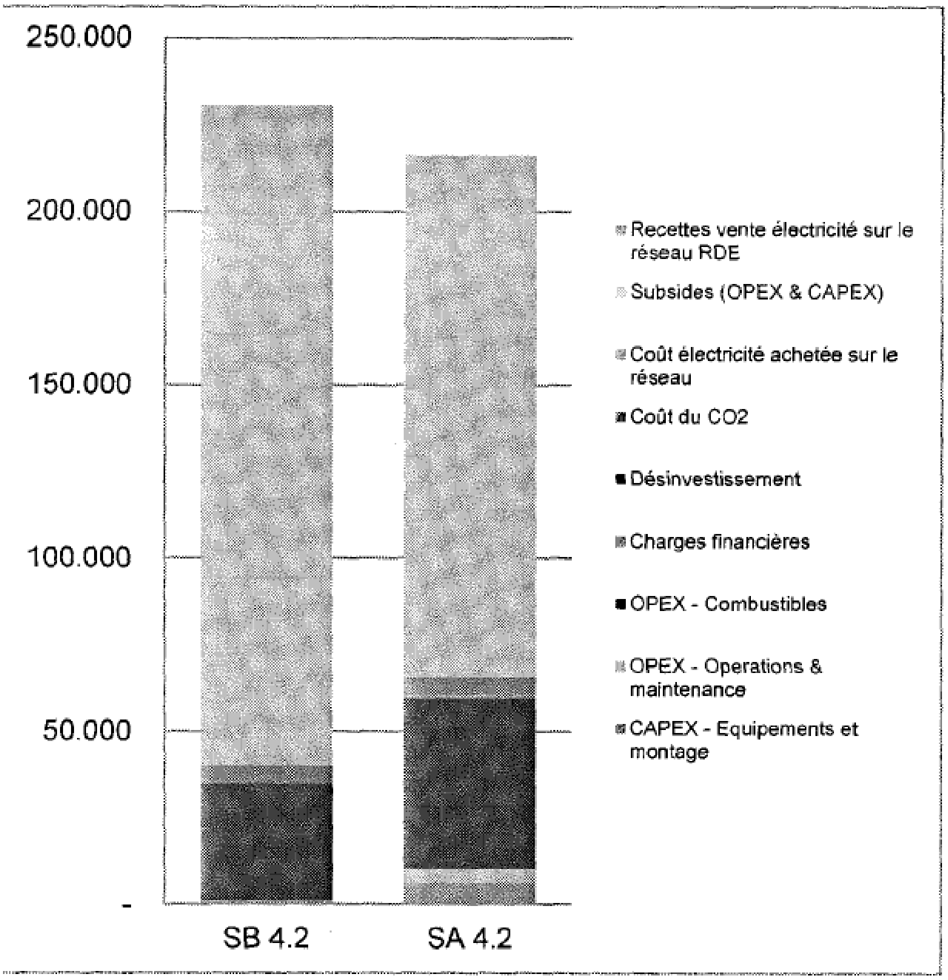


Figure 43 : Structure des coûts (rénové; EUR/an)

Recettes vente électricité sur le réseau RDE	**Income from sales of electricity on the RDE grid**
Subsides (OPEX & CAPEX)	**Subsidies (OPEX & CAPEX)**
Cout électricité achetée sur le réseau	**Cost of electricity purchased on the grid**
Cout du CO2	**Cost of CO_2**
Désinvestissement	**Divestment**
Charges financières	**Financial costs**
OPEX – Combustibles	**OPEX – Fuels**
OPEX – Operations & maintenance	**OPEX – Operations & maintenance**
CAPEX – Equipements et montage	**CAPEX – Equipment and assembly**
Figure 43: Structure des couts (rénové ; EUR/an)	**Figure 43: Cost structure (renovated, EUR/year)**

II. 3.1.4.3 Food sector

The baseline scenario in the food sector also includes traditional boilers (SB 4.3). It is also compared to the alternative scenario which includes cogeneration supplemented by auxiliary boilers powered by natural gas (SA 4.3).

Unlike the case above, cogeneration does not have a competitive advantage (figure below). The difference in cost, however, remains low compared to the traditional solution (SB4.3). In both the baseline scenario and the alternative scenario, the main cost factor is electricity.

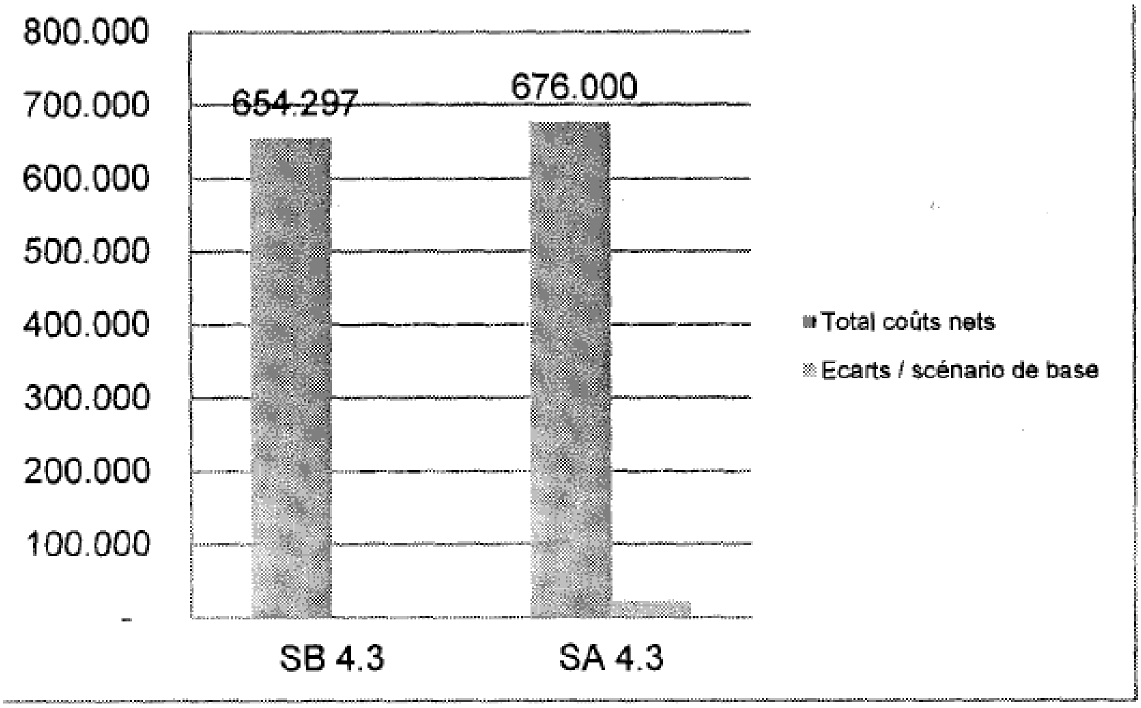


Figure 44: Coût total (rénove; EUR/an)

Total couts nets	**Total net costs**
Ecarts / scenario de base	**Contrast/base scenario**
Figure 44: Cout total (rénové ; EUR/an)	**Figure 44: Total cost (renovated, EUR/year)**

In both the baseline scenario and the alternative scenario, the main cost factor is electricity. The positive difference concerning the purchases of electricity means that the additional costs of CAPEX and OPEX associated with cogeneration cannot be offset.

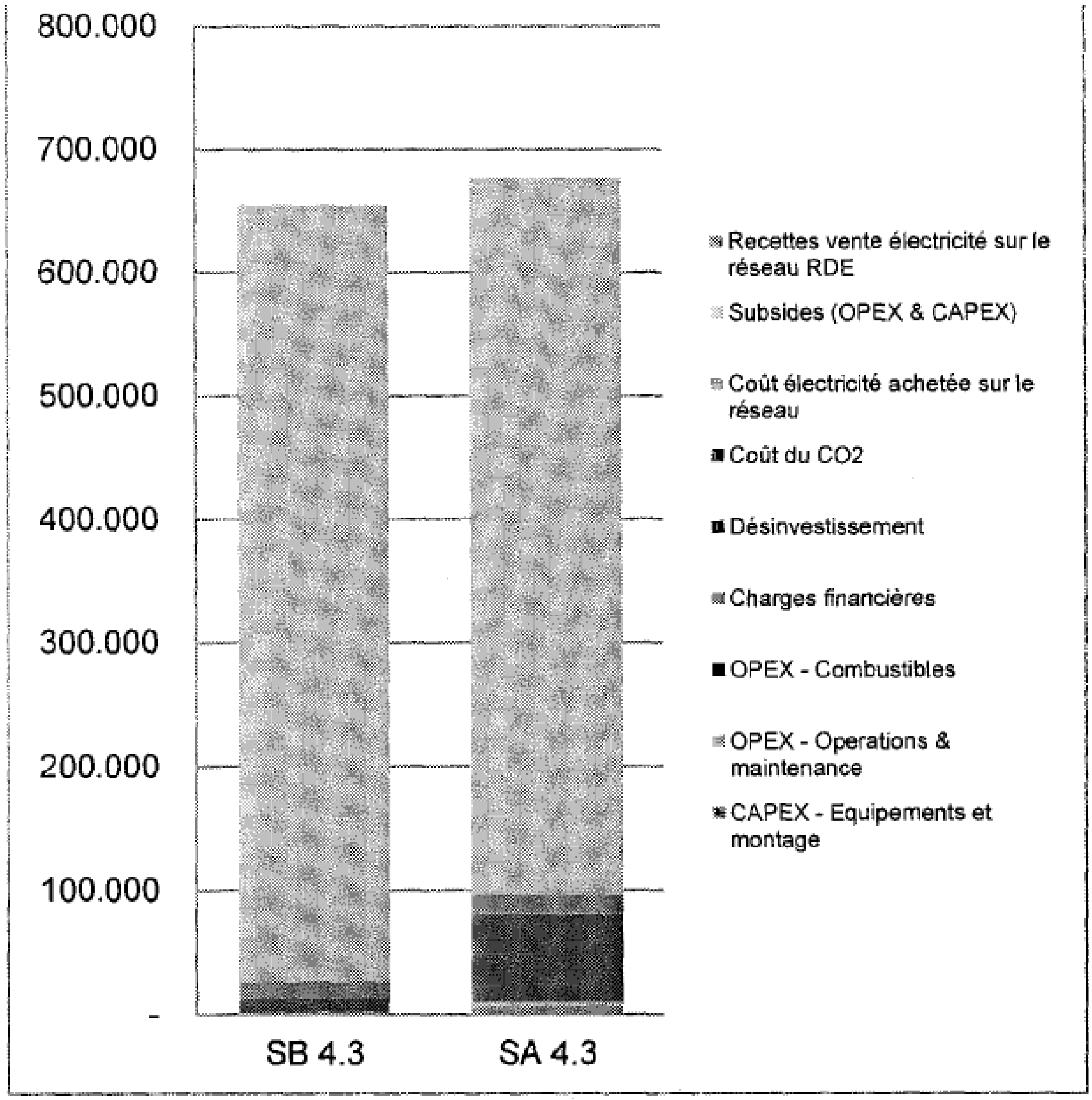


Figure 45 : Structure des coûts (rénové ; EUR/an)

Recettes vente électricité sur le réseau RDE	**Income from sales of electricity on the RDE grid**
Subsides (OPEX & CAPEX)	**Subsidies (OPEX & CAPEX)**
Cout électricité achetée sur le réseau	**Cost of electricity purchased on the grid**
Cout du CO2	**Cost of CO_2**
Désinvestissement	**Divestment**
Charges financières	**Financial costs**
OPEX – Combustibles	**OPEX – Fuels**
OPEX – Operations & maintenance	**OPEX – Operations & maintenance**
CAPEX – Equipements et montage	**CAPEX – Equipment and assembly**
Figure 45: Structure des couts (rénové ; EUR/an)	**Figure 45: Cost structure (renovated, EUR/year)**

II.3.1.4.4 Combined industrial sectors

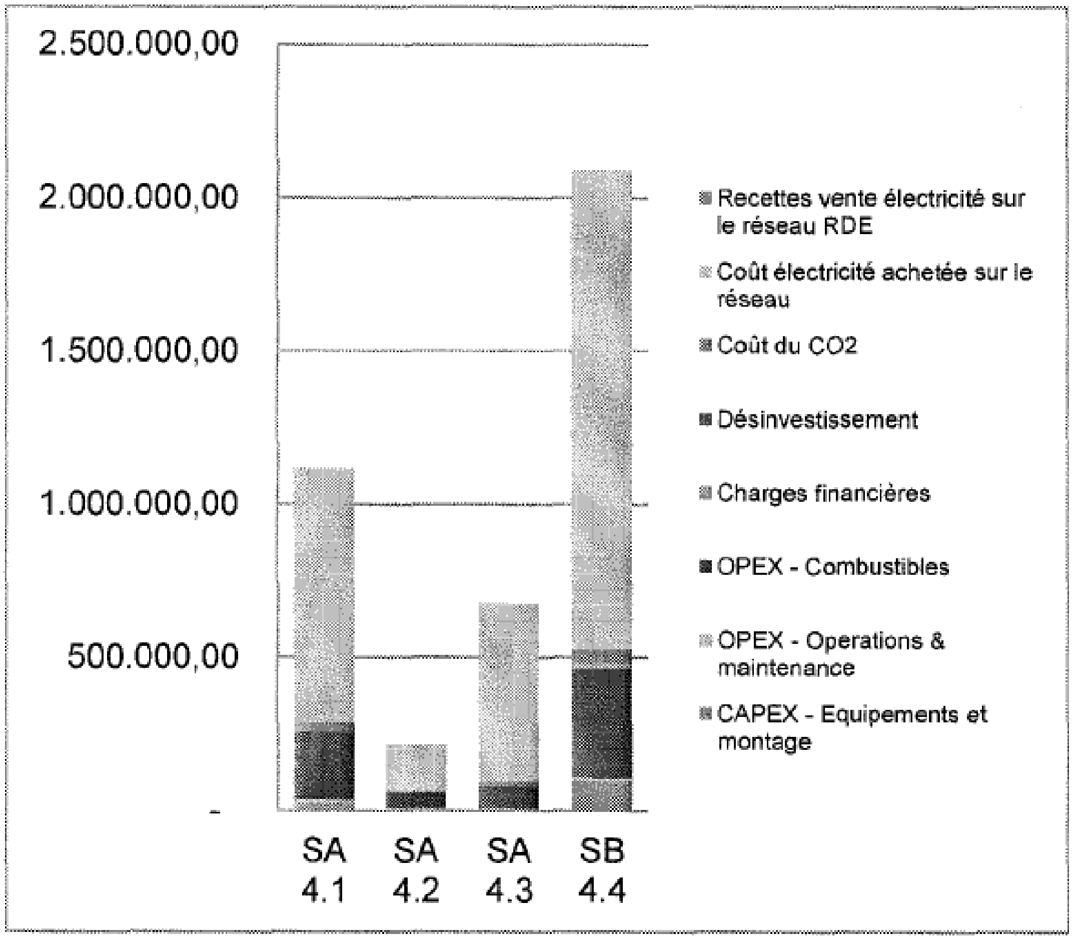


Figure 46 : Structure des coûts (rénové; EUR/an)

Recettes vente électricité sur le réseau RDE	**Income from sales of electricity on the RDE grid**
Subsides (OPEX & CAPEX)	**Subsidies (OPEX & CAPEX)**
Cout électricité achetée sur le réseau	**Cost of electricity purchased on the grid**
Cout du CO2	**Cost of CO_2**
Désinvestissement	**Divestment**
Charges financières	**Financial costs**
OPEX – Combustibles	**OPEX – Fuels**
OPEX – Operations & maintenance	**OPEX – Operations & maintenance**
CAPEX – Equipements et montage	**CAPEX – Equipment and assembly**
Figure 46: Structure des couts (rénové ; EUR/an)	**Figure 46: Cost structure (renovated, EUR/year)**

The combined scenario includes the cogeneration options listed above (SB 4.4). As is the case with the other industrial scenarios, it is still in the **stages of renovation**.

The summary of results is provided for guidance on the two graphs below in which the combined scenario is compared to similar scenarios using cogeneration in the industrial sectors discussed above. These graphs confirm the importance of the "electricity" component.

The first graph is expressed in absolute terms in order to show the relative importance of each sector in the combined scenario.

The same graph is then expressed in relative terms. The horizontal bar lines show the relative weight of each cost item in the corresponding value chain. It mainly includes the component related to the purchases of electricity.

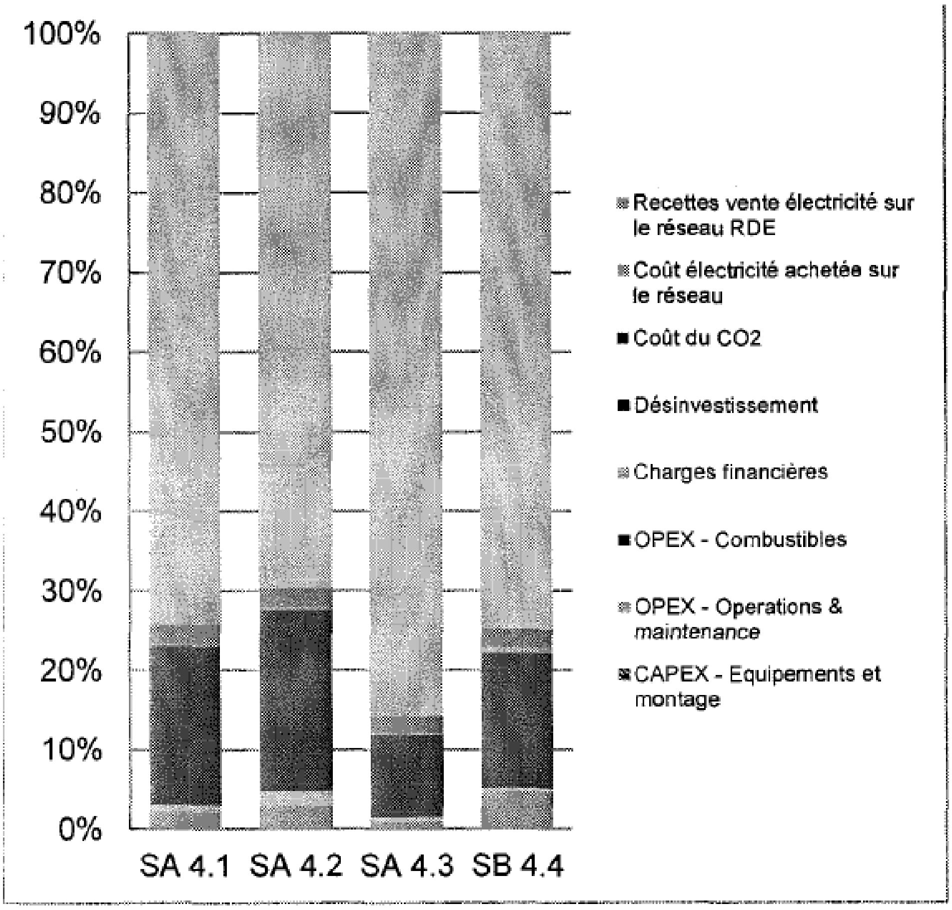


Figure 47 : Structure des coûts (rénové ; EUR/an)

Recettes vente électricité sur le réseau RDE	**Income from sales of electricity on the RDE grid**
Subsides (OPEX & CAPEX)	**Subsidies (OPEX & CAPEX)**
Cout électricité achetée sur le réseau	**Cost of electricity purchased on the grid**
Cout du CO2	**Cost of CO_2**
Désinvestissement	**Divestment**
Charges financières	**Financial costs**
OPEX – Combustibles	**OPEX – Fuels**

OPEX – Operations & maintenance	**OPEX – Operations & maintenance**
CAPEX – Equipements et montage	**CAPEX – Equipment and assembly**
Figure 47: Structure des couts (rénové ; EUR/an)	**Figure 47: Cost structure (renovated, EUR/year)**

II.3.1.5 Scenario # 5: Cooling demand in office buildings and shops

The last baseline scenario consists in using traditional chillers for office buildings and shops (SB 5). It covers significant cooling demand and is compared with two alternative options:

i. first, gas cogeneration supporting an absorption cycle (SA 5.1);

ii. secondly, a common chiller on the network (SA 5.2).

For **new buildings,** the baseline scenario is the most competitive (SB 5). The option of cogeneration with an absorption cycle is much more expensive than the cooling network combined with heat pumps (see graph below), the latter being only slightly less competitive when compared to the baseline scenario.

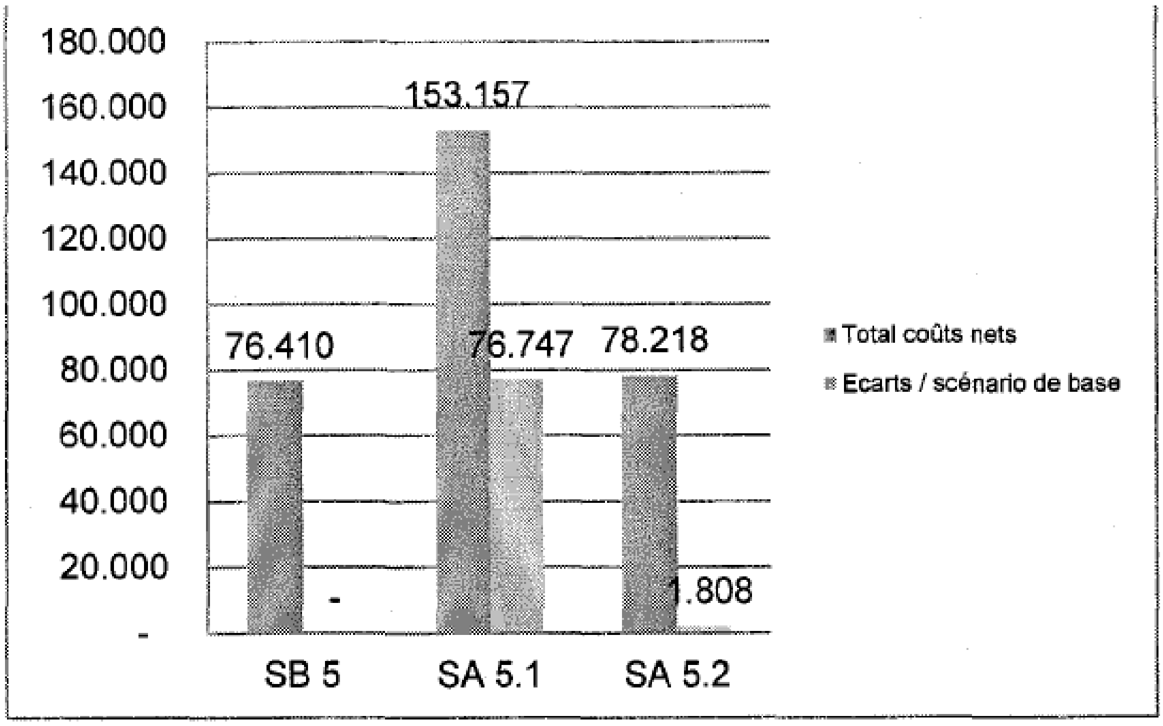


Figure 48: Coût total (neuf; EUR/an)

2

Total couts nets	**Total net costs**
Ecarts / scenario de base	**Contrast/base scenario**
Figure 48: Cout total (neuf ; EUR/an)	**Figure 48: Total cost (new, EUR/year)**

The main area responsible for higher prices is "other net costs", such as CAPEX, OPEX, financial expenses, etc. As in the previous scenarios, it mainly includes investments. Cogeneration absorption cycles (SA 5.1) are cost effective in terms of electricity purchases but these savings cannot offset "other net costs" consisting of the other identified components.

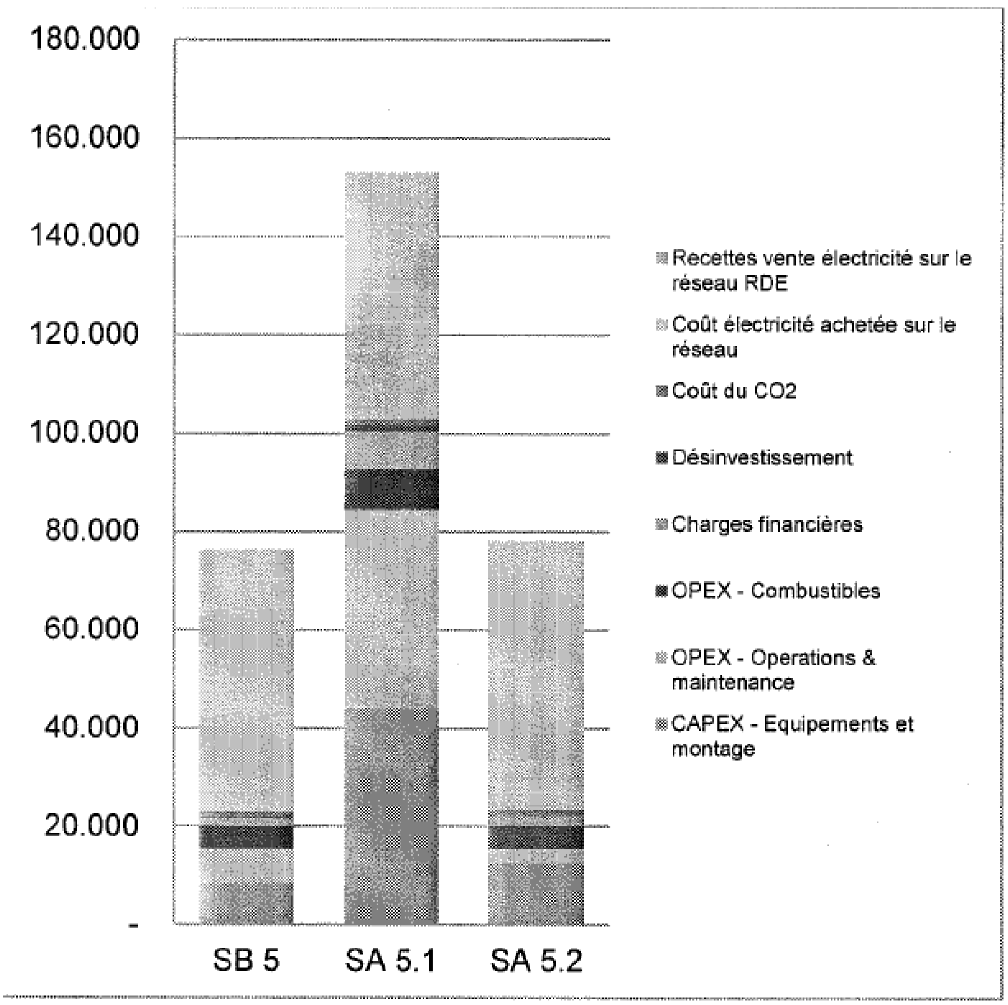


Figure 49 : Structure des coûts (neuf; EUR/an)

3

Recettes vente électricité sur le réseau RDE	**Income from sales of electricity on the RDE grid**
Subsides (OPEX & CAPEX)	**Subsidies (OPEX & CAPEX)**
Cout électricité achetée sur le réseau	**Cost of electricity purchased on the grid**
Cout du CO2	**Cost of CO_2**
Désinvestissement	**Divestment**
Charges financières	**Financial costs**
OPEX – Combustibles	**OPEX – Fuels**
OPEX – Operations & maintenance	**OPEX – Operations & maintenance**

CAPEX – Equipements et montage	CAPEX – Equipment and assembly
Figure 49: Structure des couts (neuf ; EUR/an)	**Figure 49: Cost structure (new, EUR/year)**

II.3.2 Sensitivity analysis

A sensitivity analysis has been carried out for the main variables causing some uncertainty for the longer-term development (see below). The following graphs contain the results for all the scenarios concerned.

This analysis has been carried out for:

1) Fuel inflation rates: natural gas, biomass and/or waste heat;

2) The inflation rate of electricity;

3) The rate of growth of operational expenditure (excluding fuel);

4) The cost of capital or discount rates.

The underlying assumption is that these variables rely on forecasts for which there is a fairly high probability of deviation by 2030. This will particularly affect the financing conditions and the market for primary energy materials which both have a strong cyclical factor, but will also affect electricity tariffs which will remain subject to the prices of traditional primary sources, changes in the energy mix and, ultimately, although to a lesser extent, operational expenses.

Each analysis was conducted with a standard modification of the considered rates to ensure findings were comparable, i.e. a common difference of **+ 50%** compared to the reference rates in the baseline scenarios.

The following two graphs are on fuel and electricity. It is clear that the profiles and orders of magnitude of both inflation variables applied to energy products (gas and electricity) differ considerably. In general, the sensitivity of the results is lower than the range of variation imposed on the baseline data. Indeed, the results are generally under the 50% mark with one exception (SA 2.1). In fact, they are often much lower as is the case for gas in scenarios 3, 4 and 5 and for electricity in scenarios 1 and 2.

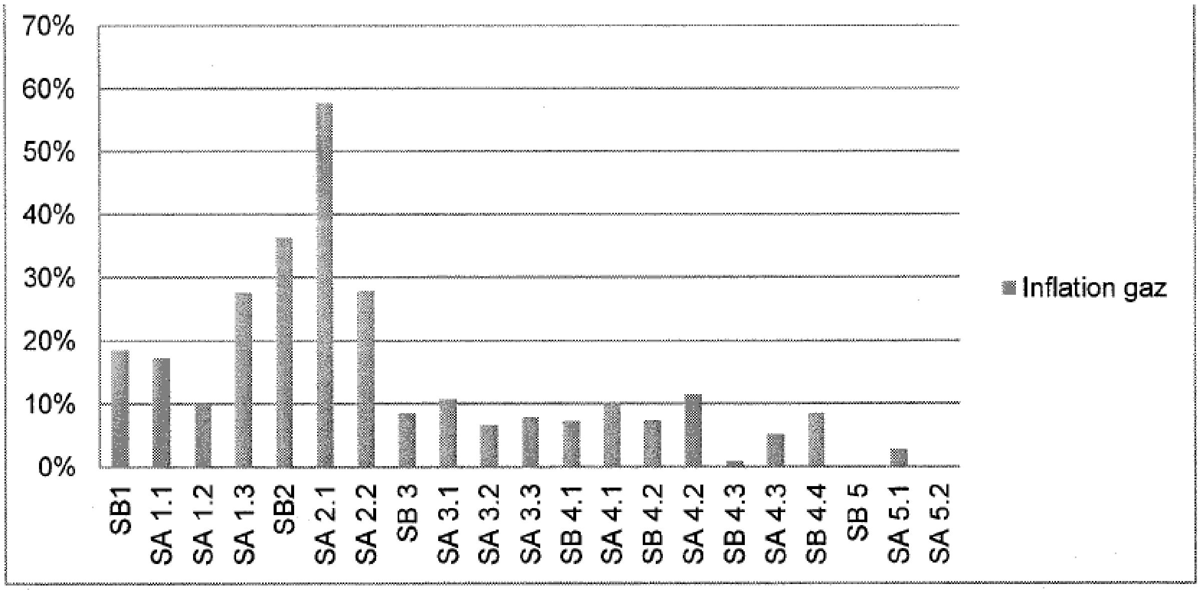


Figure 50 : Analyse de sensibilité (inflation gaz)

Inflation gaz	**Gas price inflation**
Figure 50: Analyse de sensibilité (inflation gaz)	**Figure 50: Sensitivity analysis (gas price inflation)**

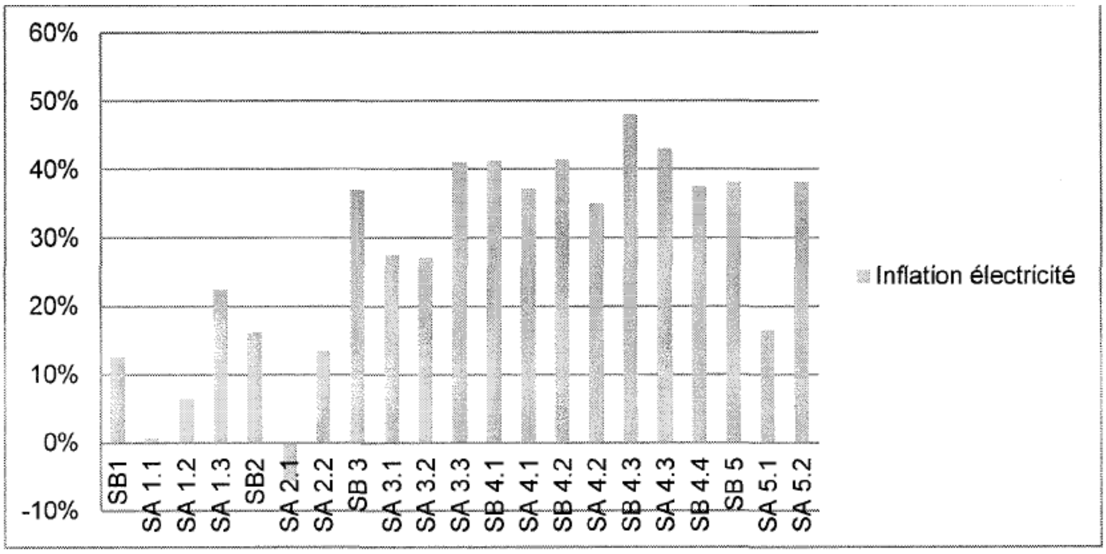


Figure 51 : Analyse de sensibilité (inflation électricité)

Inflation gaz	**Electricity price inflation**
Figure 50: Analyse de sensibilité (inflation gaz)	**Figure 51: Sensitivity analysis (electricity price inflation)**

The stark difference in the results is due to the negative impact inflation may have on energy prices, for example, when cogeneration drives electricity purchase costs down, when they would otherwise be potentially more expensive, but also facilitates a significant amount of surplus energy to be exported onto the network (SA2.1).

The variation in OPEX prices and the cost of capital[75] occurs when the range of reverse trends is broader (see graph below). Overall, the increase in the cost of capital tends to reduce future expenditure through the actuarial method, so the cost approach. The opposite is the case for OPEX. In both cases, the impact is much less significant in relative terms than the changes imposed on the variables tested (+ 50%; see above).

The OPEX results vary widely depending on the scenario. They also fluctuate within a small range (0% to 3%).

As in the case of new buildings, the impact of the cost of capital is higher for commercial scenarios (SB3) than it is for [text missing] and cooling (SB 4).

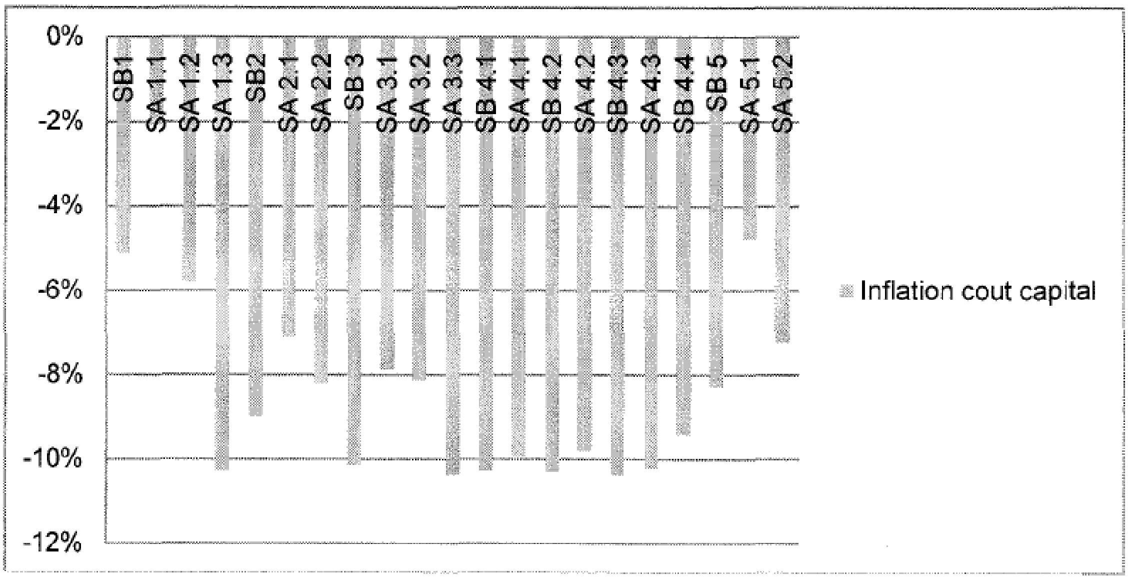


Figure 52 : Analyse de sensibilité (inflation coût du capital)

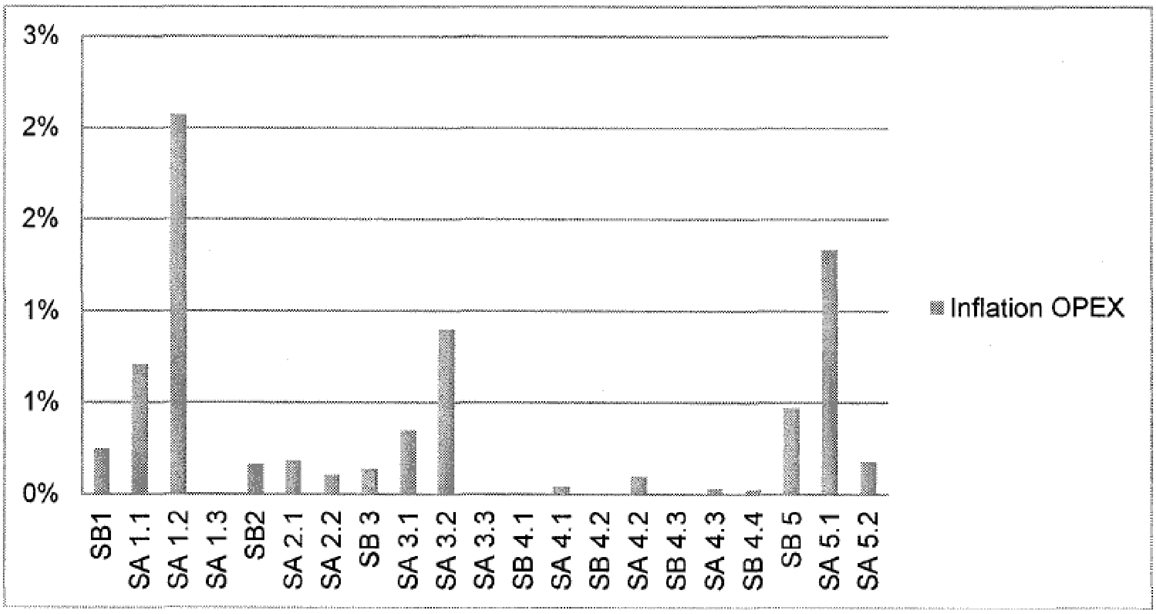


Figure 53: Analyse de sensibilité (inflation OPEX)

[75] The discount rate.

Inflation cout capital	**Capital cost inflation**
Figure 52: Analyse de sensibilité (inflation cout du capital)	**Figure 51: Sensitivity analysis (capital cost inflation)**
Inflation OPEX	**OPEX inflation**
Figure 53: Analyse de sensibilité (inflation OPEX)	**Figure 51: Sensitivity analysis (OPEXinflation)**

II.3.3 Conclusions

The five baseline scenarios assessed have contrasting energy load profiles. Comparability is guaranteed for each baseline scenario and its alternatives through the uniformity of energy demand. The results must finally be considered in the context of Wallonia, which has a limited urban planning framework and targeted needs particularly in the industrial sector. The following conclusions cannot therefore be applied to different environments, even in configurations where usage profiles differ substantially from the scenarios discussed. Based on the results of the different simulations carried out, it appears that the baseline options are generally very competitive. The option of cogeneration, however, has an economic advantage in the chemical industry and the paper industry. The competitive advantage, however, is very weak.

When cogeneration is used, the additional costs related to distribution networks can be partially offset. Therefore, the combined solution (cogeneration + network) has an advantage over a network powered by a single boiler from an energy perspective at least.

The benefits of the network are apparent in the recovery of waste heat, provided that a certain project size is reached to offset the costs incurred by the network connecting the area to be served to the place of origin of the heat to be recovered.

In addition to the scenarios involving cogeneration and/or a network, the traditional options using condensing boilers are competitive, especially in the case of collective installations by building (without network) and in the tertiary sector. This is due mainly to their performance and, in the latter scope, economies of scale offered by the installation.

The differences between the costs of the baseline scenarios and the alternatives are sometimes significant. In general, "other net costs" plays an important role in the competitiveness imbalances of the alternative scenarios discussed. A component with a significant potential impact is the cost of capital.

The results must be assessed without taking account of taxation (including VAT).

Chapter 6 – Economic potential

1. ECONOMIC POTENTIAL OF COGENERATION

To recap, the cogeneration potential is calculated on the basis of the bottom-up approach, which begins with the individual circumstances of a series of commercial and industrial establishments identified through energy surveys conducted annually by the ICEDD on behalf of the DGO4 and grouped according to industry sector.

I.1.1 Method

The first two steps, to determine the technical potential, are explained in section 2 of chapter 4 "technical potential".

The **third step** is to calculate the profitability of the cogeneration project. As both the operating time and scale of cogeneration is known for each establishment, project profitability can be calculated.

The **savings** through cogeneration are of the following order:

- The first is related to the electricity bill. It is assumed that the electricity produced by cogeneration will no longer be purchased at the average current sales price (more specifically in 2013). The potential surplus is resold on the network, at a price fixed by the model.
- The second is related to heating. It is assumed that the heat produced by cogeneration will be provided by the existing heating system at the average current sales price (more specifically in 2013).
- The third is related to the fuel costs after cogeneration. It is assumed that the fuel consumption increase in the establishment compared to the scenario in which cogeneration is not used allows for a better fuel tariff to be negotiated for the entire establishment, as is shown by the degressive curve below calculated on the basis of costs in 2013.

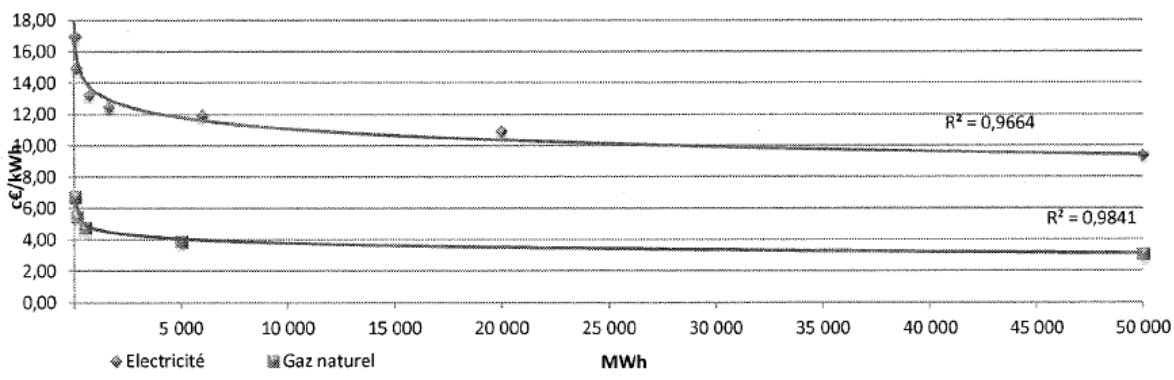


Figure 54 : Courbe des prix du gaz et de l'électricité en Wallonie en 2013 (source CWaPE)

•

Electricité	**Electricity**
Gaz naturel	**Natural gas**
MWh	**MWh**

c€/kWh	Eurocents per kWh
Figure 54: Courbe des prix du gaz et de l'électricité en Wallonie en 2013 (source CWaPE)	**Figure 54: Price curve for gas and electricity prices in Wallonia in 2013 (source: CWaPE)**

- A fourth is in connection with the sale of green certificates. In accordance with the task that was to be carried out, the green certificate was valued at EUR 0 for the purposes of calculating profitability before the deduction of grants or regional state aid. In the simulation, however, it is possible to adjust the price of green certificates to assess the impact on the final profitability of projects.

The **expenses** associated with cogeneration that can then be deducted are of the following order:

- The first expense relates to the purchase of fuel for cogeneration, depending on the type of technology used. This was calculated based on a lower purchase price if the fuel used was the same as the one used before cogeneration, in accordance with the degressive curve shown in figure 54. However, the average costs for the year 2013 were used for the other types of fuel (wood, vegetable oils, etc.).

- The second expense relates to the auxiliary fuel surcharge when other fuels are used in cogeneration (renewable, for example).

- The third expense relates to the surcharge for the additional supply of electricity. This was calculated based on an average purchase price corresponding to an amount of electricity purchased on the cheaper network after cogeneration, in accordance with the degressive curve shown above.

- Finally, the fourth expense relates to the costs of the servicing and maintenance of the cogeneration unit, which varies from one type of installation to another.

The difference between the amount of earnings and expenditure totals the annual net profit of the project.

The simple payback period (SPP) of the cogeneration project is calculated by dividing the net investment, minus any subsidies received, by the annual net profit.

The fourth stage is to determine the economic potential which only includes projects whose simple payback period is less than a previously defined maximum duration. The simple payback period must be less than **two years** for the industrial sector and less than **five years**.

An assessment of the impact of the simple payback return period on the economic potential is carried out.

It should be noted that the potential is based on the 2012 energy consumption of today's businesses. It does not take into account new sources of heating demand such as central sewage drudge drying plants or wood drying, where the practice is no longer carried out on site, for example, nor does it take account of energy derived from various types of organic waste (forest residue, etc.), which is not currently processed by means of cogeneration.

I.1.1.1 Economic parameters

The impact of **green certificates is not considered** in the economic analysis. A simulation, however, shows the impact of these green certificates on profitability and thus on the economic potential of projects.

The price of the **resale of electricity** to the network, in the case of overproduction, is fixed at EUR **0.2.5/kWh**, which corresponds to the lower end of the average price of different offers received by the ICEDD for three different projects of very different sizes (5 kilowatts, 200 kilowatts and 1,400 kilowatts).

It was decided that the realistic potential would be based on **2030 energy prices staying the same as their current values**[76]. Indeed, it seems logical to consider that a company's investment decisions are often carried out based on the energy prices in place at the time the decision is made. It is worth bearing in mind that this realistic potential is calculated on an economic potential including all **industrial enterprise** projects with a **simple payback period (SPP) of less than two years** and all **commercial establishments with an SPP of less than five years**.

The price of natural gas and electricity decrease in relation to quantity and are taken from consumption data and bills from Walloon establishments in 2013, published by CWaPE and provided in Figure 54.

The expected developments in energy prices were fixed according to all probabilities. The annual **increases** in the price of heating **fuels** and cogeneration installations were assumed to be equal to **1%/year**, while that of **electricity** was assumed to be equal to **2%/year.** Considering an increase in the fuel bill for cogeneration, this increase would be much higher than that on the gains from heating, which lead to reduction of the annual net gain year after year.

The development of the **CAPEX** (investment) price was fixed at **1%/year** and the development of the **OPEX** (use and maintenance) cost was fixed at **1.5%/year.**

The price of renewable fuels and diesel is based on the most recent data, these are considered fixed regardless of quantities.

Energy	In c. EUR/kWh
Pure vegetable oil	8.5
Recycled vegetable oil	7.0
Biodiesel	9.0
Wood gasification	1.2
Biogas	1.0
diesel	8.1

Table 29: energy prices

The simulation does not take into account the potential investment subsidies, which would increase the profitability of installations.

[76] More precisely, the 2013 value since these are the values used in the model

The price per **tonne of CO2** is fixed at **EUR 10**[77].

[77] This concerns the same reference as the one made within the cost-benefit analysis

I.1.2 Results

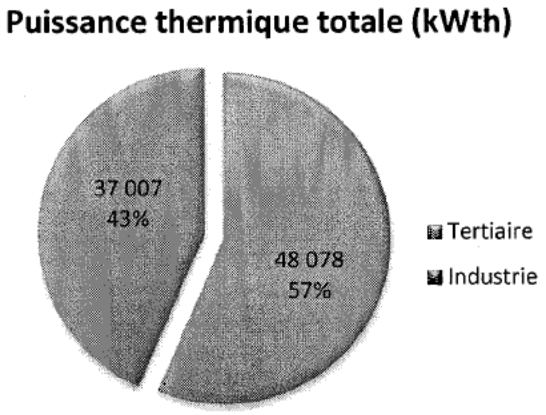
The table below summarises the results of the **calculated cogeneration potential** in the tertiary and industrial sectors. The total number of establishments included in the study is shown, as well as those that have an economic potential, i.e. 8% of the total in the tertiary sector and 4% of the total in the industrial sector.

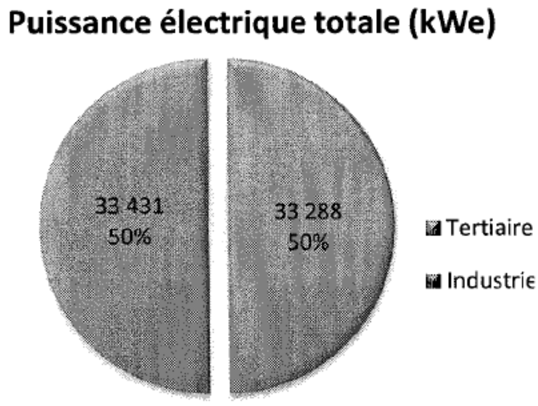
The technical potential is covered in chapter 4. In short, the potential heating power is 529 MWh, 76% of which is used in the industrial sector, and the corresponding heat production is calculated at 3,172 GWh. The potential electrical output is 428 MWe, 81% of which is used in the industrial sector, and the corresponding power generation is 2,621 GWh.

The table below contains the results of the economic potential, according to the criteria used. The economic potential of heating power is 85 MWh, 44% of which is used in the industrial sector, and the corresponding heat production is calculated at 458 GWh. The economic potential of the electrical output is 67 MWe, 50% of which is used in the industrial sector, and the corresponding power generation is 361 GWh.

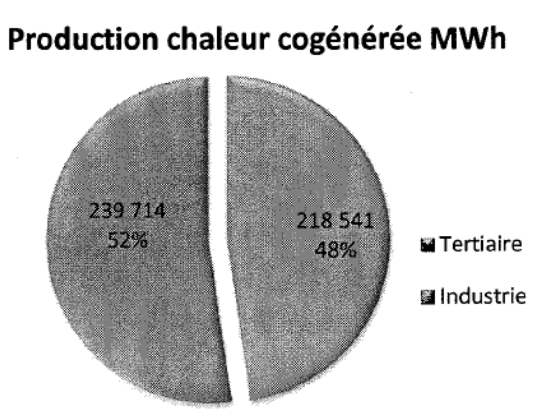
	TERTIARY	**INDUSTRY**	**TOTAL**	**Part of technical pot.**
Total number of establishments	**2636**	**579**	**3215**	
Number with economic potential	**210**	**24**	**234**	**9.6%**
Part of total	**8%**	**4%**	**7%**	
Total thermal power (kWth)	**48,078**	**37,007**	**85,086**	**16.1%**
Total electric power (kWe)	**33,288**	**33,431**	**66,719**	**15.6%**
Cogenerated heat production MWh	**218,541**	**239,714**	**458,255**	**14.4%**
Cog. Electric production MWh	**150,989**	**210,797**	**361,085**	**13.8%**

Table 30: Economic potential of cogeneration in Wallonia





Puissance thermique totale (kWth)	**Total thermal power (kWth)**
Tertiaire	**Tertiary**
Industrie	**Industry**
Puissance electrique totale (kWe)	**Total electrical power (kWe)**
Tertiaire	**Tertiary**
Industrie	**Industry**



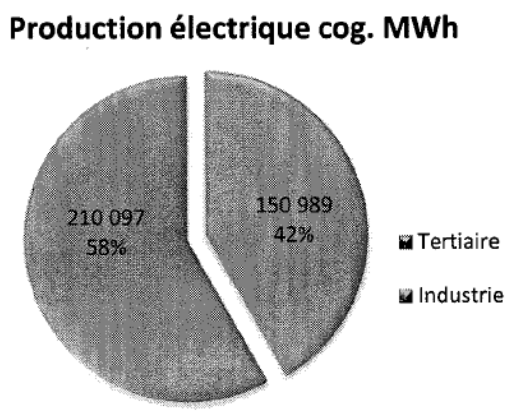


Figure 55 : Potentiel économique de la cogénération du tertiaire et de l'industrie (2012)

Production chaleur cogénérée MWh	**Cogenerated heat power (MWh)**
Production électrique cog. MWh	**Cogenerated electrical power (MWh)**
Tertiaire	**Tertiary**
Industrie	**Industry**
Figure 55: Potentiel économique de la cogénération du tertiaire et de l'industrie (2012)	**Figure 55: Economic potential for cogeneration in the tertiary and industrial sectors (2012)**

As the following graph perfectly illustrates, the economic potential, with a payback period of two years for the industrial sector and five years for the tertiary sector, not supported by a green certificate, is only around 15% of the technical potential, which is very low by comparison.

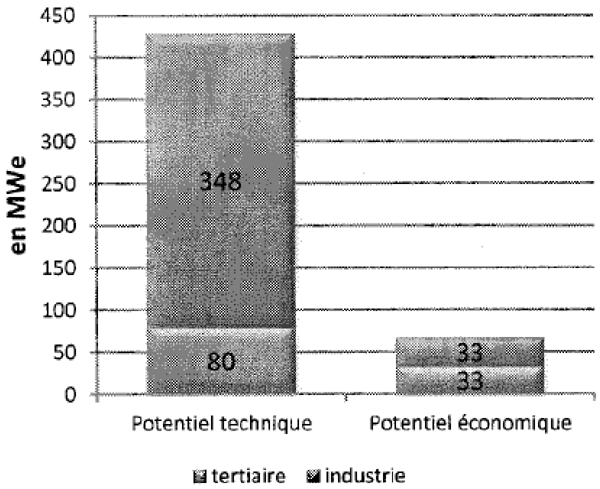


Figure 56 : Potentiel technique et économique de la puissance électrique des cogénérations du tertiaire et de l'industrie (2012)

En MWe	**In MWe**
Potentiel technique	**Technical potenital**
Potentiel économique	**Economic potential**
Tertiaire	**Tertiary**
Industrie	**Industrial**
Figure 56: Potentiel technique et économique de la puissance électrique des cogénérations du tertiaire et de l'industrie (2012)	**Figure 56: Technical and economic potential for electrical power from cogeneration in the tertiary and industrial sectors (2012)**

I.1.2.1 Influence of parameters

The price per tonne of CO2 restricts the potential for cogeneration because there is a surcharge for the installation in relation to the previous situation, despite the decline in CO2 for separate heat and power production systems on a global scale.

The expenses related to the EUR 10 price per tonne of CO2 reduce the economic potential of the installed electrical output by 50%.

The situation included in the calculated economic potential is highlighted in green (no green certificates, SPP two years for the industrial sector and five years for the tertiary sector).

Price per tonne of CO2	kWe	Part of tech. pot.	MWhe	CO2 avoided

0	**213,053**	**31.9%**	**870,154**	**125,091**
5	**199,861**	**28.9%**	**807,031**	**116,131**
10	**160,200**	**15.6%**	**361,085**	**89,176**
15	**153,715**	**14.8%**	**345,423**	**86,820**
20	**84,627**	**13.7%**	**317,701**	**82,658**
25	**73,056**	**10.9%**	**245,850**	**71,787**
30	**62,025**	**9.7%**	**219,637**	**67,775**
40	**44,768**	**7.4%**	**163,483**	**59,253**
50	**34,746**	**5.9%**	**127,634**	**53,860**
Technical pot.	**428,402**	**100%**	**2,621,851**	**289,392**

Table 31: Development of the economic potential of cogeneration in Wallonia in relation to price support per tonne of CO2.

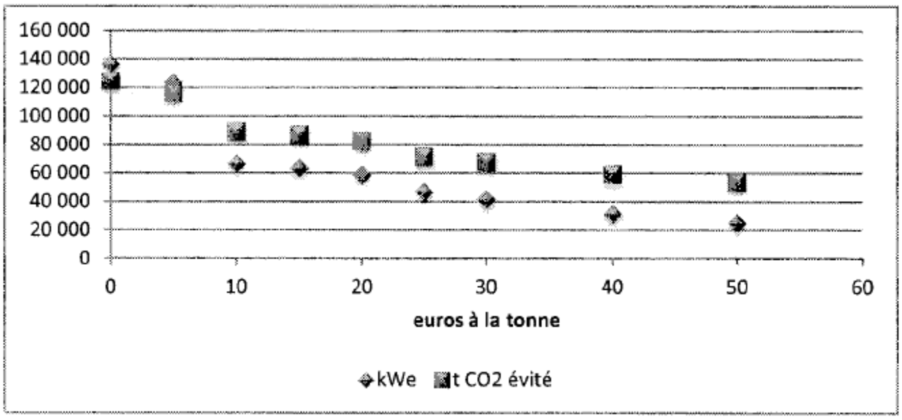


Figure 57 : impact du coût du CO_2 sur le potentiel économique de la puissance électrique et des émissions de CO_2 évitées (2012)

Euros à la tonne	**EUR/tonne**
kWe	**kWe**
T CO2 évité	**Tons of CO_2 avoided**
Figure 57: impact du cout du CO2 sur le potentiel économique de la puissance électrique et des émissions de CO2 évitées (2012)	**Figure 57: Impact of the cost of CO_2 on the technical and economic potenital of electrical power, and reduced CO_2 emissions.**

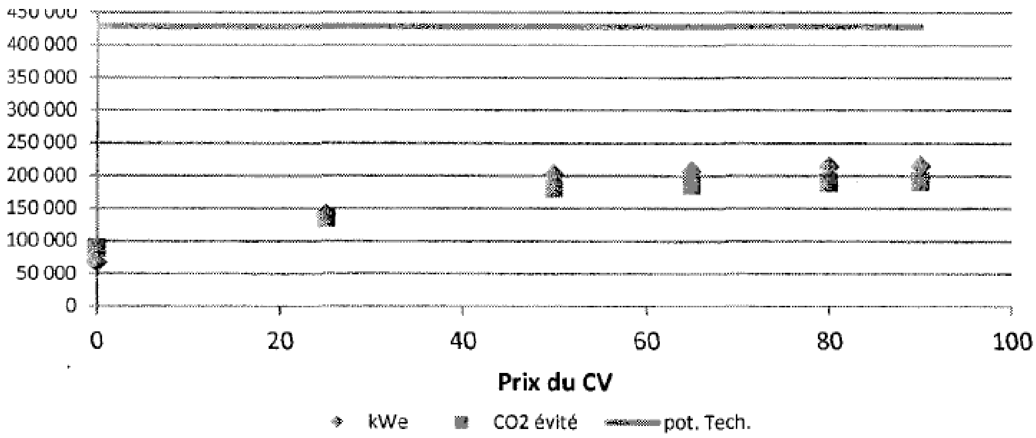
Not taking account of the advantage of a **green certificate** also heavily restricts the economic potential of cogeneration.

A green certificate, valued at the guaranteed price of EUR 65 increased the economic potential from 16% to 48% of the technical potential, i.e. a three-fold increase.

The situation included in the calculated economic potential is highlighted in green (CO_2 = EUR 10/tonne, SPP two years for the industrial sector and five years for the tertiary sector).

Price of GC	kWe	Part of tech. pot.	MWhe	CO2 avoided
0	66,719	15.6%	361,085	89,176
25	140,004	32.7%	883,590	134,137
50	200,935	46.9%	1,219,306	180,426
65	206,708	48.3%	1,246,114	185,283
80	213,332	49.8%	1,279,712	190,005
90	215,255	50.2%	1,288,577	191,361
Technical pot.	428,402	100%	2,621,851	289,392

Table 32: Development of the economic potential of cogeneration in Wallonia in relation to green certificate support.



Prix du CV	Price of GC
kWe	kWe
CO2 evite	CO_2 avoided
Pot. Tech.	Technical potenital
Figure 58: Impact du soutien des CV sur le potentiel économique de la puissance électrique et des émissions de CO2 évitées (2012)	Figure 58: Impact of the support of GC on the economic potential of electrical power and reduced CO_2 emissions (2012)

The **choice of the payback period (SPP)** also influences the outcome of the economic potential. Two simulations were carried out on the payback period for the industrial sector and the tertiary sector.

Industrial sector:

For the industrial sector, the payback period of two years restricts to less than 10% of the technical potential for installed electrical power.

Extending the payback period to three years increases the economic potential to 47% of the technical potential, i.e. almost five-fold compared to an SPP of two years.

The economic potential peaks at around 85% of the technical potential with a payback period of 5.5 years. There is no notable progression in terms of the economic potential after 5.5 years.

If, moreover, the added benefit of a green certificate valued at EUR 65 is taken into account, the potential with a CPP of two years is the same as that calculated with a CPP of three years without the added benefit of a green certificate.

The situation included in the calculated economic potential is highlighted in green (CO2 EUR 10/tonne, no green certificate).

Payback period (years)	kWe	Part of Tech. pot.	MWhe	CO2 avoided	kWe with GC at EUR 65
1	0	0.0%	0	0	24,339
2	33,431	9.6%	210,097	66,151	158,570
3	164,373	47.2%	1,067,792	139,165	220,422
4	212,941	61.2%	1,319,442	171,427	297,085
5	228,682	65.7%	1,408,742	181,563	329,337
6	293,041	84.2%	1,910,396	203,642	332,282
7	297,507	85.5%	1,934,001	206,454	334,012
8	299,107	86.0%	1,941,017	207,497	334,589
10	303,373	87.2%	1,960,063	208,929	339,712
Technical pot.	347,976	100%	2,271,555	239,688	

Table 33: Development of economic potential of industrial cogeneration in relation to SPP

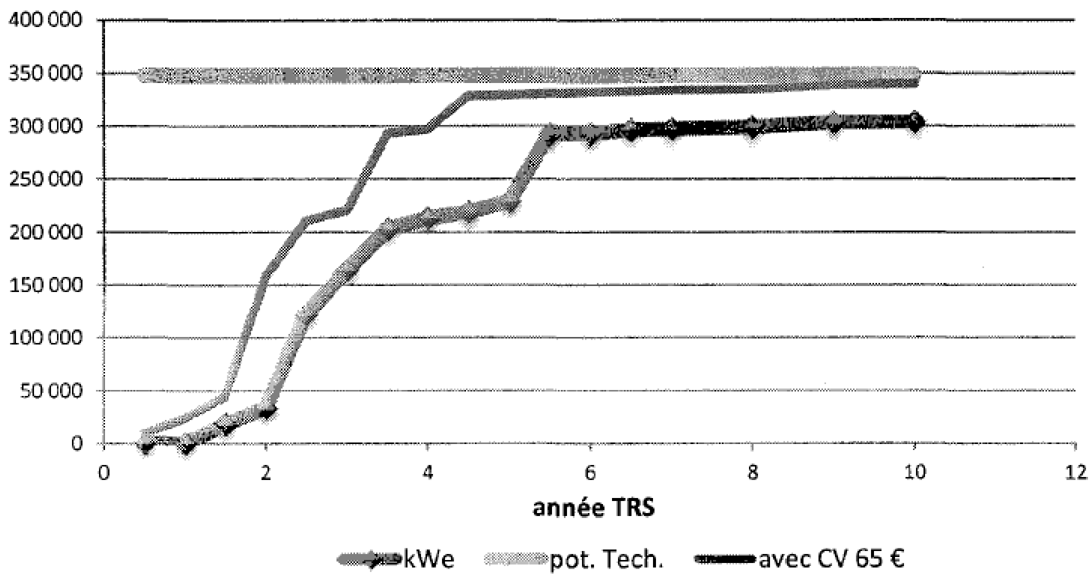


Figure 59 : Evolution du potentiel économique de la puissance électrique avec et sans CV pour l'industrie (2012)

kWe	kWe

Pot. Tech.	Technical potential
Avec CV 65 €	With GC EUR 65
Année TRS	SPP years
Figure 59: Evolution du potentiel économique de la puissance électrique avec et sans CV pour l'industrie (2012)	Figure 59 : Trend in economic potential of electrical power with and without GC in industry (2012)

Tertiary sector:

For the tertiary sector, the payback period of five years restricts the economic potential to 41% of the technical potential for installed electrical power.

Extending the payback period to seven years increases the economic potential to 60% of the technical potential, i.e. an increase of 50% compared to a CPP of five years.

The economic potential peaks at around 85% of the technical potential with a payback period of 12 years. There is no notable progression in terms of the economic potential after 12 years.

If, moreover, the added benefit of a green certificate valued at EUR 65 is taken into account, the potential with a CPP of five years is the same as that calculated with a CPP of seven years without the added benefit of a green certificate.

The situation included in the calculated economic potential is highlighted in green (CO2 EUR 10/tonne, no green certificate).

Payback period (years)	kWe	Part of Tech. pot.	MWhe	CO2 avoided	kWe with GC at EUR 65
1	0	0.0%	0	0	0
2	1663	2.1%	9010	1341	7997
3	10,165	12.6%	47,375	7101	21,016
4	22,647	28.2%	105,008	15,935	38,488
5	33,288	41.4%	150,989	23,025	48,138
6	41,857	52.0%	188,021	28,696	54,081
7	48,693	60.5%	217,419	32,941	59,984
8	54,384	66.4%	237,551	35,630	63,603
10	60,251	74.9%	266,402	39,526	67,486
15	67,403	83.8%	295,946	43,299	70,877
Technical pot.	80,427	100%	350,296	49,705	

Table 34: Development of economic potential of tertiary cogeneration in relation to SPP

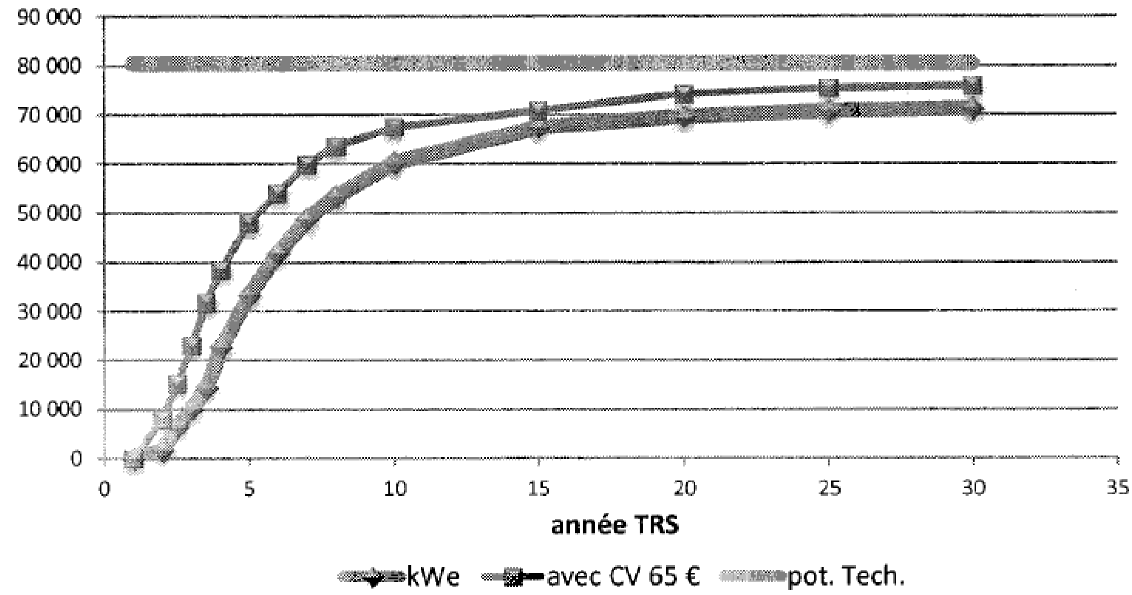


Figure 60 : Evolution du potentiel économique de la puissance électrique avec et sans CV pour le tertiaire (2012)

kWe	**kWe**
Pot. Tech.	**Technical potential**
Avec CV 65 €	**With GC EUR 65**
Année TRS	**SPP Years**
Figure 59: Evolution du potentiel économique de la puissance électrique avec et sans CV pour l'industrie (2012)	**Figure 59 : Trend in economic potential of electrical power with and without GC in industry (2012)**

XIII. ECONOMIC POTENTIAL OF WASTE HEAT

II.1.1 Economic potential of high-temperature waste energy

II.1.1.1 Sources

The basis for calculating the economic potential of high-temperature energy is the supply of high-temperature waste heat, which is calculated on the basis of infrastructure existing in 2012. The information sources are identical to those used for the estimated supply (see bottom-up approach in chapter 1).

It is worth noting that the main source of information is the 2012 energy report published by the DGO4 and the other information source is the study conducted in 2013 by the ICEDD for the DGO4 through the training and information for industries "INFOIND11" project and the "Facilitator in cogeneration" project.

II.1.1.2 Method

The economic potential of high-temperature waste energy estimated for 2030 is based on
the so-called bottom-up approach: each of the 55 sites included in the "INFOIND11" project is assessed on an individual basis.

The first step is to look at the **technical potential** (or the supply of recoverable heat) in 2012 for each of the 55 sites included in the study. |The high-temperature heat potential for 2012 is achieved by adding up the technical potential of each field of activity.

To calculate the high-temperature technical potential for 2030, the same methodology used
in chapter 4 is applied upon which six scenarios based on the potential of 55 companies are founded. The different scenarios are explained in this chapter.

The results achieved are outlined below:

In GWh	Scenario (-30%)	Trend scenario 2000-2012	Trend scenario 2010-2012	Trend scenario 1990-2012	Status quo scenario	Scenario (+30%
STEEL	172.2	0.0	0.0	0.0	246.0	319.8
NON FERROUS	0.0	0.0	0.0	0.0	0.0	0.0
CHEMICAL	580.0	602.9	735.3	1000.0	828.5	1142.1
NON-METALLIC MINERALS	872.0	883.0	1051.7	1150.9	1245.7	1619.4
FOOD	5.5	10.1	2.2	9.0	7.8	254.2
TEXTILES	0.0	0.0	0.0	0.0	0.0	0.0
PAPER	0.0	0.0	0.0	0.0	0.0	28.8
METAL MANUFACTURING	2.2	2.0	0.3	2.0	3.1	4.1
OTHER INDUSTRIES	0.0	0.0	0.0	0.0	0.0	47.4

TOTAL INDUSTRY	**1631.9**	**1489.1**	**1789.5**	**2161.9**	**2331.2**	**3415.8**
Development comp. to status quo	**70%**	**64%**	**77%**	**93%**	**100%**	**147%**

Table 35: Overview of scenarios on the technical potential of high temperature waste energy in 2030

As the bottom-up approach is required for assessing the economic potential of high-temperature energy, the first stage is to look at the technical potential achieved in the "Status quo" scenario.

The calculations for assessing the economic potential are based on the assumption that the industrial situation in Wallonia will be the same in 2030 compared to 2012. However, the information contained in other scenarios, particularly "trend" scenarios, are interesting in more ways than one. For example, according to these scenarios, the technical potential for the steel industry would be zero in 2030.

The second stage is to move from the technical potential to the **economic potential per site**. In order to achieve this, **the earnings and costs resulting from the technology** in place to transform the recoverable heat into electricity (combined heat and power). Currently, only the Organic Rankine Cycle (ORC) technology can be used for this purpose.

The technical characteristics of ORC technology are described in chapter 4 on the latest developments in technology.

The general **economic characteristics** of ORC technology are:

- **The investment costs** of ORC for the recovery of waste heat are vary substantially and highly depend on the applications concerned.
- The quality and amount of energy available will largely determine the size and therefore **the cost of the recovery exchangers**: the specific costs vary from EUR 1,000/kW for installations of several megawatts to EUR 3,000/kw for those of a few hundred kW.
- **Installation costs** represent, *a priori*, 50% of the cost of ORC (percentage from the bibliography). Note, however, that, in practice, installation costs can be significantly larger because they highly depend on the civil engineering site, hydraulic and electrical connections, etc.

Finally, the **specific cost** of an ORC (installation fee included) is in the range of EUR 1,500/kW to EUR 4,500/kW.

In order to determine whether an ORC installation is viable economically, the following technical data must be known for each of the 55 sites concerned:

A. recoverable heat;

B. viable electrical output;

C. total operating hours;

D. electricity production: calculated by B*C.

This up-to-date information is obtained directly or indirectly from the "INFOIND11" project.

This technical information is necessary for calculating the economic indicators **based on the following assumptions**:

- Discount rate = 0%
- Subsidy rate = 0%
- Cost of green certificate EUR 0
- Inflation = 0%
- SPP (Simple Payback Period) < or = two years

The economic viability of a site is based on the following economic indicators:

1) The cost of installing the ORC

On the basis of the electrical output, the cost per kWe is calculated (EUR excl. VAT/kWe) using the following formula:

Cost per kWe (EUR excl. VAT/kWe) = 10,155*electrical output (-0.177)

For example, if the electrical output is equal to 250 kWel, the cost per kWel is equal to EUR 3,821.50 excl. VAT/kWe

(10,155*250^ (-0. 177) = 3 ,821.50).
The figure below shows a curve with the trend of the cost per kWe (EUR excl. VAT/kWe).

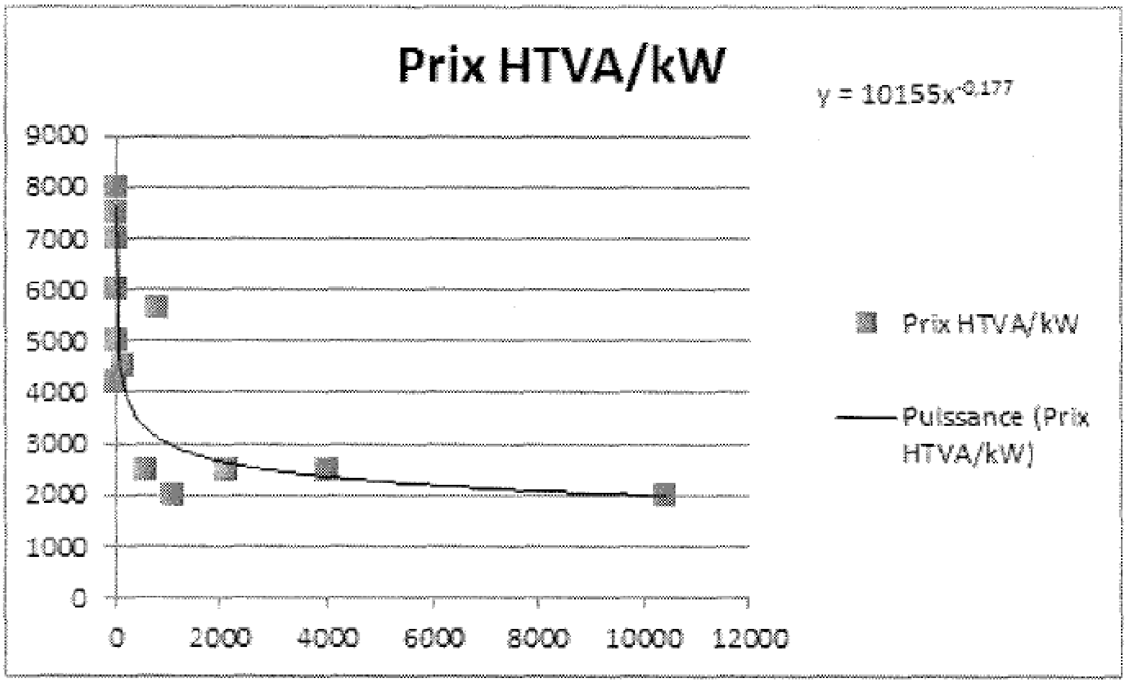


Figure 61 : Courbe de tendance du coût au kWél de la technologie ORC

Prix HTVA/kW	**Price excl. VAT per kW**
Puissance (Prix HTVA/kW)	**Power (Price excl. VAT per kW)**

Figure 61: Courbe de tendance du cout au kWel de la technologie ORC	Figure 61 : Curve showing trend in cost of kWel of ORC technology

The total cost of the installation is obtained by multiplying the electrical power by the cost per kWe, or in
our example EUR 955,358 excl. VAT (250 * 3821.50 = 955,358).

2) Cash flow

The cash flow in the case of an ORC is equal to the difference between the **annual savings on the electricity bill** and the **annual operating expenses (OPEX)**.

The savings on the invoice are calculated by multiplying the price of electricity by the amount of electricity produced. The advantage of a green certificate is not considered because it is not applicable for an ORC.

For operating expenses, it is assumed that the OPEX is 4% of the installation cost.

3) The SPP (Simple Payback Period)

In order to calculate the SPP of each of the sites, only the cost of installation and the cash flow need to be known.

SPP (in years) = (cost of investment-subsidies)/cash flow

In order to calculate the SPP, it is assumed that the subsidies are zero and the cash flow is positive.

A negative cash flow or a cash flow equal to zero means that the OPEX is greater than or equal to the earnings generated. That is the case when the viable electrical output is too weak, which, on one hand, results in very high installation and operating costs and, on the other, a very small saving on the electricity bill.

Out of the 55 sites included in the study, 13 CROs have a negative cash flow: investing is therefore not profitable and is consequently rejected.

II.1.1.3 Results

Based on the methodology and assumptions outlined in the previous chapter (see §11.1.1.2), the graph below shows the CPP based on the total high-temperature potential and the total high-temperature technical potential combined.

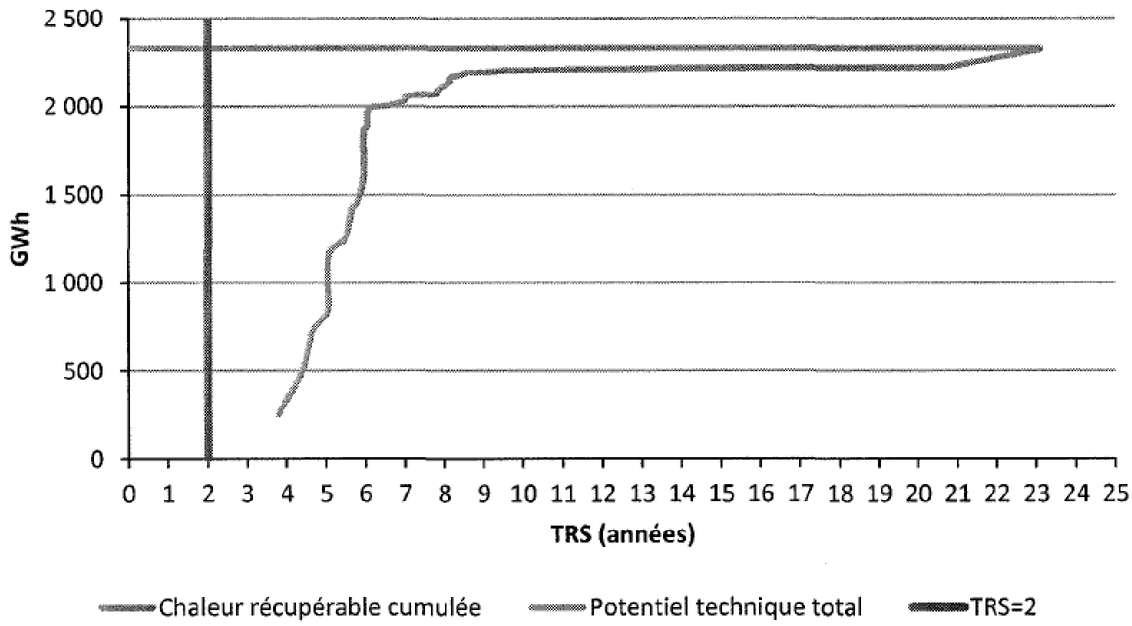


Figure 62 : Potentiel technique et économique des énergies à haute température

GWh	**GWh**
TRS (années)	**SPP (years)**
Chaleur récupérable cumulée	**Cumulated recoverable heat**
Potentiel technique total	**Total technical potential**
TRS = 2	**OEE = 2**
Figure 62: Potentiel technique et économique des énergies à haute température	**Figure 62 : Technical and economic potential of energy at high temperature**

If an **SPP is less than or equal to two years**, **the economic potential is zero**. The shortest SPP is 3.8 years for an establishment in the chemical sector with a technical potential of 256 GWh (11% of the overall potential).

<u>**Conclusion**</u>

The payback period is currently very long for the recovery of waste heat. Based on current energy prices and since there is no element of subsidy, the ORC sector is not profitable. Moreover, given that the crisis in the sectors discussed is considered to be a priority in this instance (i.e. chemicals and non-metallic minerals), investing in this sector is not a priority.

II.1.2 Economic potential of low-temperature waste heat

II.1.2.1 Sources

The information sources used are:

- the study conducted by Maxime Dupont and Eugenio Sapora of EDF R&D: "The Low Temperature Heat Recovery in Industry: Which Potential and How to Access It?", 2011;

- DECC, The potential for recovering and using surplus heat from industry, 2014
- IEA Heat Pump Programme, Annex 35: Application of Industrial Heat Pumps, 2014
- L'INSEE for energy consumption in French industry (ref: Naf_Ti);
- Walloon Energy Report (DGO4);
- Eurostat for the price of electricity for industrial consumers (ref: nrg_pc_205).

II.1.2.2 Method

In calculating the technical potential of low-temperature waste energy (i.e., heat-heat applications), a "bottom-up" approach would be far beyond the resources and deadline for this project. Indeed, this approach requires a fairly detailed knowledge of possible heat pump applications (the technology used for heat recovery at low temperatures). Given the number of industrial processes and industrial sectors that could be affected, a survey would need to be conducted in order to achieve this, which is beyond the scope of this study. For that reason, the economic potential of low-temperature waste energy was calculated using a "top-down" approach starting with the technical potential (i.e., the supply of low-temperature waste heat, see §III.3) and based on the existing literature on this subject.

The first study (EDF R&D) was used as reference for calculating the economically viable part of the technical potential (i.e., the supply of low-temperature waste heat) based on infrastructure existing in 2012 (see "Results based on the top-down approach", §1.3.1 3). The other two studies were used to evaluate the results in light of the latest information on possible heat pump applications (International Energy Agency study) and in light of a different approach to calculating the technical/economic potential such as that of the Department of Energy and Climate Change study.

In the EDF study, a technical potential and an economic potential for the recovery of waste energy based on the temperature of residual heat is calculated for the French industrial sectors. The study covers the following sectors (NACE codes in brackets): production of milk products (10.53), sugar (10.813), other food and drink products (10 + 11-10.5-10.813), iron, steel and iron alloys (24.13), cement, lime and plaster (23.53), plastic and rubber products (223), other organic chemicals (20.1 + 20.2 + 20.43), land transport equipment (29.1 + 29.2 + 29.3 + 30.2 + 30.93), paper products. In terms of the energy sector, the following are also included: "Drying", "Evaporation", "Crystallisation", "LPG heating", "Distillation", "Heat treatment" and "Chemical reaction".

Information for the study was collected through a survey that was used to calculate a theoretical potential for waste heat for each industry, application and temperature. A technical potential was then calculated based on the maximum power of the heat pumps that could be installed and on the basis of the heating demand for each sector and application. Finally, an economic potential was calculated as the number of installations that could be used taking account of investment costs, operational costs and energy savings.

The results of the EDF study can be found in the table below:

Activity sector	60-69˚C	70-79˚C	80-89˚C	90-99˚C
Organic chemistry	**130**	**20**	**80**	**10**

Agriculture-food	**110**	**310**	**150**	**180**
Steel	**0**	**0**	**0**	**0**
Not-metallic materials	**0**	**0**	**0**	**0**
Paper-cardboard	**20**	**0**	**40**	**70**
Other	**0**	**0**	**60**	**30**
Total	**260**	**330**	**330**	**290**

Table 36: Economic potential of waste heat recovery by sector and by temperature in France (GWh/y)

The relationship between the technical potential and the economic potential is calculated based on the profitability of investment. Only installations with a simple payback period of less than two years were selected.

In order to calculate Wallonia's economic potential, we first looked at the "status quo" scenario of the technical potential. We calculated a ratio for the economic potential/fuel consumption of each of the industrial sectors (French) included in the EDF study. We then multiplied these ratios by the consumption totals for each of the corresponding sectors in Wallonia included in the "status quo" scenario.

This calculation was based on the following assumptions:

- same low-temperature heat recovery applications in France and Wallonia;
- homogeneity of industrial sectors between France and Belgium, i.e. the same kind of production methods and similar procedures were used for each industrial sector;
- same costs for investments, installations and maintenance in France and Wallonia.

The results were then analysed to reflect the price differences between gas and electricity in France and Belgium. To do this, we first compared the Eurostat information on gas prices and electricity prices for industrial consumers in France and Belgium.

The price differences for the years 2010 and 2011 (the reference years used in the EDF study) are clearly positive for electricity (most expensive in Belgium) and more moderate for natural gas (cheaper in Belgium but only for some consumers). We have therefore chosen to modify the results of the EDF study by only taking into account a price difference for electricity of 21%. To do this, we used the results of the sensitivity analysis from the EDF study and, more specifically, the case where electricity was priced at more than 21% of the baseline price of the study. According to the sensitivity analysis, the two sectors most impacted by cheaper electricity are the cardboard and food sectors, for which the economic potential is reduced by 45% and 5% respectively.

II.1.2.3 Results

The results of our analysis of the economic potential of the recovery of low-temperature waste heat by sector and by temperature range in Wallonia are presented in the table below.

The **total economic potential is 93.12 GWh/year, equivalent to 31% of the total technical potential** of the sectors discussed.

Activity sector	**60-69˚C**	**70-79˚C**	**80-89˚C**	**90-99˚C**	**Total**

Organic chemistry	**13.00**	**2.00**	**8.00**	**1.00**	**24**
Agriculture-food	**8.28**	**23.33**	**11.29**	**13.55**	**56.44**
Steel	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Not-metallic materials	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Paper-cardboard	**1.11**	**0.00**	**2.21**	**3.87**	**7.19**
Other	**0.00**	**0.00**	**3.66**	**1,83**	**5.40**

Table 37: Economic potential of waste heat recovery by sector and by temperature in Wallonia (GWh/y)

The figure below shows the results of Table 37 and, for each sector, shows the part of the technical potential that would be economically viable.

XIV. ECONOMIC POTENTIAL OF HEATING NETWORKS

III.1 INTRODUCTION

The calculation of the economic potential of heating networks is based on the results of a 2012 study by the University of Liège whose objective was to determine the potential of the heating network in Belgium[78].

In calculating this potential, the heating demand is the baseline data used for installing a heating network. It goes without saying that the higher the demand is in an area the more energy can be sold for the same investment. However, the network length for connecting buildings must be considered given that the further apart consumers are from each other, the higher the investment costs will be. Therefore, in calculating the economic potential of the networks, the length of the network as well as the heating demand must be given due consideration.

The network potential is therefore calculated on the basis of the heating demand of the residential buildings and commercial buildings in each municipality, as well as of each statistical sector[79] within each municipality and the size of the road networks[80] of these areas, to determine the areas in which the heat density per linear metre of network are variable.

It is worth noting, however, that industrial functions have not been considered by the ULG as part of their study because their energy needs depend greatly on the equipment installed such as ovens, dryers, etc., which would require specific research. Nevertheless, the heating network potential of industrial buildings can be related to the potential of waste energy.

The outcome of the calculation of the technical potential revealed that the economic profitability of a heating network was guaranteed if the linear density of the heating network was greater than 2000 kWh/m/yr. Therefore, areas with a density lower than this value do not contribute to the heating network potential.

Calculating the heating network potential in each of the municipalities provides an insight into the global potential on a fairly large scale. The risk of operating on such a large scale can lead to implausible conclusions.

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[78] Evaluation of need for cogeneration in Belgium in the 2020-2030 plans, H. Pacot Pierre-Emmanuel, 2012

[79] 'The statistical sector is the basic territorial unit resulting from the subdivision of territory of the municipalities and former municipalities by the National Statistics Institute to distribute its statistics at a more refined level than the communal level. It was created for the 1970 Population and Housing Census and redesigned for the 1981 census based on structural characteristics of society, economy, urbanism and morphology. It was edited for the 2001 Socio-economic Survey to add modifications of municipality boundaries and to integrate large modifications of ground use.' Statbel, 2011.

[80] To get closer to the potential of heating networks, the road network is used in place of length of future networks.

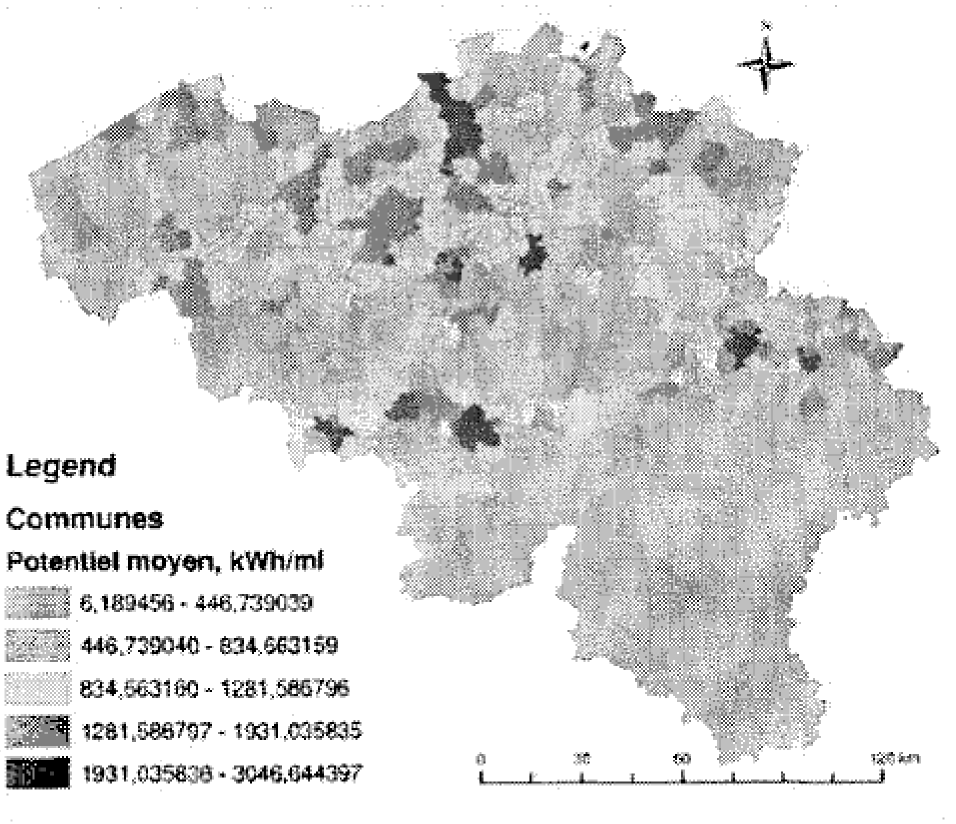

Figure 63 : Potentiel économique des réseaux de chaleur par commune

Legend	Key
Communes	**Municipalities**
Potentiel moyen, kWh/ml	**Average power, kWh/m**
Figure 63: Potentiel économique des réseaux de chaleur par commue	**Figure 63 : Economic potential of heat networks by municipality**

This approach helped to identify 19 Belgian municipalities, including seven municipalities in Wallonia, with a heating demand per linear meter above 2000 kWh/yr/m. The numerical values of these 19 municipalities are shown in the table below.

Name of municipality	Area of municipality, km2	Number of buildings	Total needs GWh	Potential for heating network, kWh/km	Density of streets, km/km2
JETTE	**5.20**	**7789**	**492.99**	**3046.64**	**31.13**
ST-JOSSE-TEN-NOODE	**1.16**	**3511**	**189.82**	**3001.68**	**54.46**
ST-GILLES	**2.51**	**7598**	**322.95**	**2967.12**	**43.33**
SAINT-NICOLAS	**6.88**	**9736**	**201.90**	**2896.71**	**10.13**

COLFONTAINE	**13.78**	**10986**	**239.37**	**2577.03**	**6.74**
FRAMERIES	**26.12**	**10847**	**303.93**	**2570.15**	**4.53**
IXELLES	**6.42**	**14766**	**558.59**	**2539.17**	**34.27**
MORTSEL	**7.78**	**8856**	**228.97**	**2406.78**	**12.23**
SCHAARBEEK	**7.92**	**19567**	**752.43**	**2358.11**	**40.29**
ETTERBEEK	**3.19**	**8048**	**336.45**	**2332.07**	**45.17**
ANTWERP	**203.84**	**125849**	**4199.25**	**2298.36**	**8.96**
NIEL	**5.31**	**4138**	**77.79**	**2251.00**	**6.51**
CHARLEROI	**102.97**	**89569**	**2320.32**	**2240.53**	**10.06**
LIEGE	**68.61**	**65470**	**1829.56**	**2181.61**	**12.22**
LEUVEN	**57.61**	**35743**	**1189.75**	**2154.83**	**9.58**
BOUSSU	**20.08**	**10311**	**254.71**	**2153.78**	**5.89**
LIEDEKERKE	**10.09**	**6109**	**127.45**	**2133.22**	**5.92**
HEMIKSEM	**5.52**	**4262**	**79.59**	**2095.92**	**6.88**
BERCHEM-STE-AGATHE	**2.97**	**4879**	**163.15**	**2079.31**	**26.37**
LA LOUVIERE	**64.25**	**36781**	**910.41**	**2011.28**	**7.04**

Figure 64: Belgian municipalities with potential for a heating network

The same approach was performed on the statistical sectors within each municipality. Such a precise breakdown in this respect facilitated the accurate calculation of the economic potential of heating networks. Indeed, the smaller the breakdown, the more accurate the analysis. The economic potential of the entire region is based on the total demand of these different qualifying areas.

The figure below contains information on the qualifying statistical sectors for the municipality of Liège.

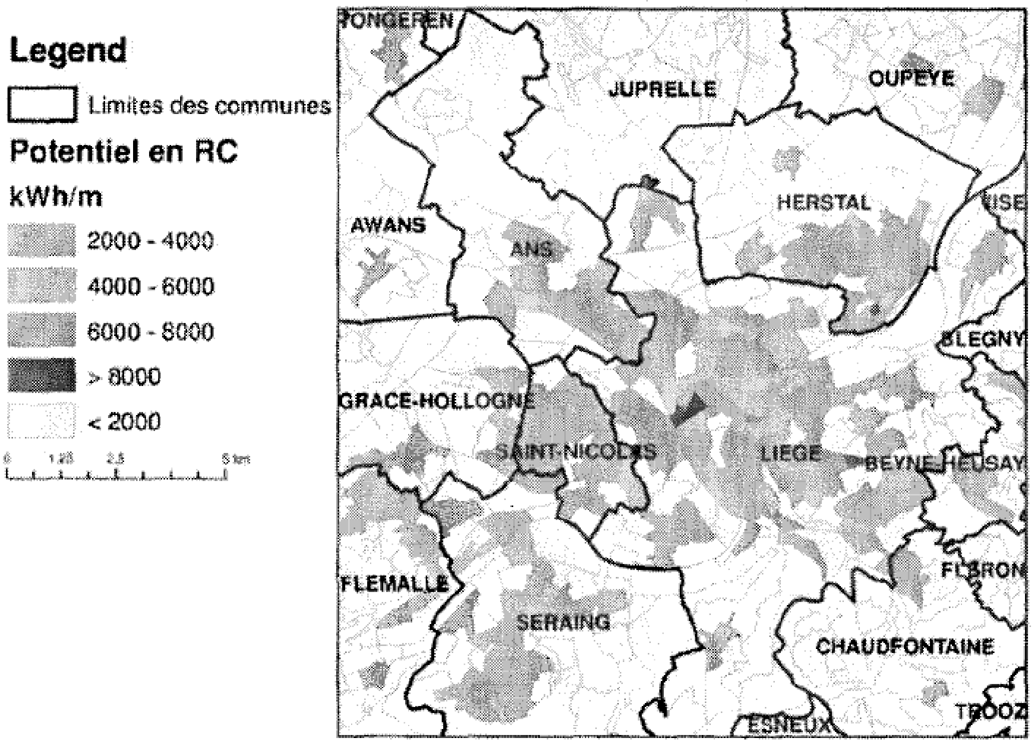

Figure 65 : Potentiel des réseaux de chaleur aux alentours de la commune de Liège

6

Legend	**Key**
Limites des communes	**Municipality borders**
Potentiel en RC	**Heat network power**
kWh/m	**kWh/m**
Figure 65: Potentiel des réseaux de chaleur aux alentours de la commune de Liège	**Figure 65 : Power of heat networks around the municipality of Liege.**

In conclusion, the Walloon region has **940 statistical sectors** with a linear demand higher than 2,000 kWh/yr/m, which is an energy potential of **13,733 GWh**. The potential is of course concentrated around the most densely populated areas.

The 940 statistical sectors were made up of 399,549 residential buildings and 47,286 commercial buildings. The residential buildings therefore represent 89% of this potential, compared with 11% for the tertiary sector.

It is worth noting that following the renovation of building stock (renovations and new constructions), this theoretical potential will decrease over the years, given the increased energy performance of the stock.

50% of the qualifying statistical sectors are grouped into nine municipalities, as shown in the table below:

Name of municipality	Number of sectors	Potential in HN, GWh	Cumulative potential, GWh	Relative cumulative

				potential
Liege	100	1811	1811	13.2%
Charleroi	121	1690	3501	25.5%
La Louviere	52	739	4240	30.9%
Mons	43	681	4921	35.8%
Namur	36	538	5458	39.7%
Mouscron	21	489	5948	43.3%
Seraing	28	435	6383	46.5%
Verviers	22	378	6761	49.2%
Herstal	25	295	7056	51.4%
Total in Wallonia	940	13,733	-	-

Figure 66: Potential for heating networks of the 9 municipalities with the most statistical sectors

III.2 CONCLUSIONS

Heating networks can have a long-term economic interest but the investment decision
must be considered on a case-by-case basis, depending on cluster, technical and decision-making configurations.

Cluster configuration:

- The case studies clearly indicate the heating demand needs to be around 1 MW for a heating network to be considered.
- The heating demand in existing buildings is relatively high because of low-performance thermal insulation.
- Low heating demand in new buildings triggers the need for large-scale projects or mixed use projects so that the critical rated output threshold that justifies the need for a distribution network is met.

(E.g.: Bella Vita in Waterloo: 87 houses/182 apartments/1 creche/1 grocery store/1 restaurant/1 retirement village/1 nursing home/1 medical centre/1 pool/1 gymnasium)

Technical configuration: A network will be even more profitable if it is dense and easy to install, in terms of the underground network (loose soil, non-mineralised, synergies with other underground networks).

Decision-making configuration:

5. A network will be even easier to develop if the number of decision-makers is low, or if a preliminary project has been carried out from a technical and financial perspective.
6. One of the observed parameters involves a technical operator acting as an investor in this type of scenario, who will be compensated by billing users for heating.
7. In the case of a new project, requiring the granting of a concession or a right of way on public land, it is essential that an agreement is reached among the various key players before the project commences:

    o The competent administrative body (town/municipality)

- Distribution Network Administrator
- The Promoter
- Heating supplier and manufacturer

Chapter 7 – Strategy for developing economic potentials

1. SWOT ANALYSES

The various aspects of the techno-economic situation in Wallonia for and/or against the development of cogeneration (table 1), heating networks (table 2) and the supply of waste energy (table 3) are included in this section under each SWOT analysis[81].

TABLE 1: SWOT ANALYSIS FOR COGENERATION

STRENGTHS	WEAKNESSES
<u>Economic axis:</u> **- Green certificate mechanism: major support mechanism for cogeneration allowing a 10% reduction of CO2 emissions.** **- Investment aid mechanism put in place by the public authorities in the Walloon Region (branch agreements for the industrial sector, UREBA[82] in the public sector, AMURE[83], as well as SEU aid[84]**	<u>Economic axis:</u> **- Increased CAPEX & OPEX** **-Price of micro-cogeneration: Although micro-cogeneration is a technology that is available to meet particular residential needs, it is relatively expensive in terms of the KWh price.** **- Cogeneration represents an additional investment compared to traditional heating since it can't replace it (need for a backup).** **-Since the technology is more complex than a simple heater, it requires monitoring and higher usage costs.** **- The problem of reselling electricity: There are many administrative and legal complexities relating to the impossibility of distributing produced electricity to other neighbouring establishments without having to meet a series of administrative and technical obligations, such as the obligation to go through the distribution network.** **-The need for a financial support mechanism to activate technical potential: With an economic constraint from the payback period of 2 years for industry and 5 years for the tertiary sector, without the support of green certificates the economic potential of cogeneration is very weak compared to the technical potential, around 15%. However, we should note that it is higher for the tertiary sector (41%) than for industry (9%).**
<u>Technical axis:</u> **Decentralised electricity production: cogeneration installations are located/distributed at the heart of the transport/distribution network. They therefore help reduce transport/distribution losses and, if well coordinated, contribute to the reliability of the electronic network or parts thereof.**	<u>Technical axis:</u> **Complexity: To function at its best, a cogeneration installation requires careful integration into an existing circuit, almost daily monitoring and regular maintenance. A cogeneration installation is not controlled by a 'central dispatch' and therefore its connection must be made in accordance with the**

[81] It should be noted that there are no SWOT analyses that were made for technology responding to the need for cooling in Wallonia given that these are much lower than heating needs. For more on this subject see chapter 1.

[82] UREBA subsidies are intended to support entities that want to reduce energy consumption in their buildings.

[83] The Walloon Public Service grants a subsidy to companies to carry out energy audits and studies.

[84] Specific investment aid for Sustainable Energy Use.

-Proven technology: Cogeneration technology has particularly mastered the large powers existing in the Walloon Region. The small power sector and, more specifically, domestic machines (micro-cogeneration) are, however, just starting out. **- Autonomy of heat and electricity production – decreased energy dependence.** **-Possibility to promote renewable fuels.**	**law to ensure the safety of the equipment and people.** **-Administrative difficulties related to the project: The complexity of the various administrative steps (permit request, certification procedure, etc.) impacts the development of cogeneration.** **-Emission of fumes: Technical surcharges for evaluation of fumes (these are not traditional chimneys).** **-Installation constraints: The need to provide a boiler room to install the cogeneration installation (difficulties for the residential sector in high-density urban areas).** **- Difficulty optimising synchronisation of the heat and electricity needs.**

OPPORTUNITIES	**THREATS**
Economic axis: **- The upwards development of the price of electricity and gas could prove an advantage for the development of cogeneration (decentralised production) in the Walloon Region.** **-Meeting heat and electricity needs of new neighbourhoods, collective buildings or groups of existing buildings or tertiary sector buildings which have significant and constant heat and electricity needs (e.g. residential care homes, hospitals, hotels, etc.). In light of this, it should be noted that the ratio between the demand for heat and for electricity would be better for cogeneration installations in the tertiary sector than residential.** **-Accrued economic profitability if dimensioning on the basis of electricity is possible, but it is necessary to find a flexible system for heat production.** **Technical axis:** **-Emergence and mainstreaming of new technologies, mainly relating to biofuels being encouraged by the European and Walloon regulatory framework.** **-Development of design requirements of buildings towards NZEB with access to 'nearby renewable sources' that could foster heating networks in a neighbourhood, supplied by biomass cogeneration.**	**Economic axis:** **-Energy price volatility: investing in a cogeneration installation requires a technological and economical feasibility study, the results of which will depend strongly on predictions of energy prices for the next ten years.** **-Limited development potential and few large-scale projects to make cogeneration desirable in Wallonia without a prediction on the dimensioning by heat needs of buildings.** **Technical axis:** **-Improvement of energy performances of envelopes in the Walloon Region, consequently limiting the heat needs of buildings, which leads to decreased economic potential of cogeneration.** **-Eco-design directive.**

TABLE 2: SWOT ANALYSIS OF HEATING NETWORKS

STRENGTHS	WEAKNESSES
Economic axis: **-Pooling of investment allowing for economies of scale.** **-Decrease of surcharges related to flexibility and availability through pooling and therefore levelling of needs (reduction in over-dimensioning).** **Technical axis:** **- Allows for meeting the heating needs of many households and/or companies from a centralised unit (e.g. cogeneration). The user will therefore be free of maintenance and fuel supply constraints.** **- Allows for promoting renewable fuels (on a large scale) and for new technology to take over (e.g. cogeneration, heat pumps), or waste heat.** **- Decrease in usage constraints through centralisation of the production unit.**	**Economic axis:** **-The economic relevance is not obvious: investment surcharge. However, a distinction should be made between new-build projects and renovations and we should point out the probable competition between individual and collective solutions (mainly in the case of Wallonia where there is competition with the natural gas network already in place in high density urban areas).** **-Difficulties motivating a neighbourhood or all of a local collective to take part in a project and difficulties making joint decisions in the case of multiple decision-makers.** **-Long return on investment time. Investors prefer a shorter period of return on investment mainly when the project depends on external variables such as subsidies, which are not guaranteed to reoccur in the longer term.** **-Collective dependence on the network (in the event of breakdowns the repercussions will affect a much larger number of individuals and/or companies).** **-Difficulty of promoting Demand Side Management in the framework of a centralised distribution unit. The network should remain at a permanent temperature, unlike decentralised heating for which the ranges of use can be tuned to the needs of a specific user. This is the case for both heating and sanitary water.** **Technical axis:** **-Lack of understanding of heating networks (impact on users? Installers, etc.).** **-Heat loss during transport (currently no charge on the level of insulation of networks) which negatively affects, sometimes significantly, the energy performance of the networks. It should, however, be noted that distribution losses of good quality heating networks are relatively small when the pipes, valves and hot water distribution header are well insulated.** **-Difficulty in implementing a legal and contractual framework (use rights, ownership, transfer, subscription contract, etc.).** **-Difficulty, even impossibility, of implementation in an existing building (particularly relating to underground service network problems).**

OPPORTUNITIES	THREATS
Economic axis: **- Interest in developing heating networks to meet significant heat needs (new neighbourhoods, office buildings, hospitals, retirement homes, pools, etc.) connected to cogeneration. A target value to plan creation of a new heating network is to reach a heat need of 1 MW.** **-Densification of the networks makes it possible to improve profitability. To establish an order of magnitude, a heat density of 3000 kWh per year and per linear metre of network created tends to be held as the 'key' value for evaluating the economic feasibility of a heating network project.** **- Development of networks will be even more beneficial for an estate of buildings held by the same property manager or decision-maker (social housing, office park with one owner, school complex with multiple buildings, etc.)** **-Heating networks can be profitable if they are paired with waste energy sources or local renewable sources such as geothermal, biomass, solar, etc.** **Technical axis:** **-A heating network theoretically makes it possible to smooth out heating needs through a scale effect. This, however, requires diversity of user profiles (e.g. housing + offices/nurseries/homes/hospitals, etc.)** **-Development of design requirements of buildings toward NZEB with access to nearby renewable sources. This development could help heating networks in neighbourhoods that are supplied by biomass cogeneration or any other renewable system (e.g. heat pump).**	**Economic axis:** **-One of the most important items in a heating network project is cost of the network. Therefore the ease of establishing a network will have a direct impact on the profitability of the project. It is obvious that if a network has to be made on grassland or ground with no previous underground service networks, its cost will be less than if it has to cross one or more existing roads or even a paved surface.** **Technical axis:** **-Improvement of energy performance of buildings limits the technical potential of heating networks in the Walloon Region.**

TABLE 3: SWOT ANALYSIS OF THE WASTE ENERGY OFFER

STRENGTHS	WEAKNESSES
Economic axis: **Local production: Self-supply generally assured since surplus heat is generated when the process occurs, contribution to reducing transport and distribution losses and therefore reduction in associated costs.** **-Availability and lack of cost of energy** **-Promotion of a resource that would otherwise be lost**	**Economic axis:** **-The costs of the study and implementation are still high.** **-Economic potential of recoverable heat relies on the following factors:** **-With an SPP of 2 years, there is zero economic potential for high temperature waste heat. Consequently, the payback periods on investments**

<u>Technical axis:</u> **Many technologies available: 'traditional' steam cycle, ORC and steam engine. These technologies, particularly thanks to the technical development of ORC, now make it possible to cover an increasingly large power range.**	**are very long to value high temperature waste heat.** **-The total economic potential of 'low temperature' waste heat recovery is still very high. It is equivalent to 31% of the total technical potential of the studied sectors.** **-Does not meet the needs of the industrial sector, is not part of its 'core business'.** **<u>Technical axis:</u>** **-Necessity of precise knowledge of the heat source and the upstream process.** **-Variability of the source: certain sources can be relatively variable over time, both in terms of quality and quantity.**
<u>OPPORTUNITIES</u>	**<u>THREATS</u>**
<u>Economic axis:</u> **-The upwards development of the price of electricity and gas could prove an advantage for the development of waste heat projects.** **-Projects that should particularly be considered for construction of new neighbourhoods: the results of chapter 5 showed that the alternative scenario 'Heating network with waste heat injection' both in the residential and tertiary sectors presented a lower total cost than the technology considered in the reference scenario.** **-Possibility to develop a new 'heat supplier' market.** **<u>Technical axis:</u>** **-The heating networks are a great way to promote waste heat: connected to installations releasing significant quantities of waste heat.**	**<u>Economic axis:</u>** **-Limited development potential and few large-scale projects to make waste heat desirable in Wallonia.** **-Lack of support from public authorities and inadequate green certificate mechanism.** **<u>Technical axis:</u>** **- Lack of understanding among the large sectors concerned** **- Waste heat generally has industrial origins, which makes it difficult to combine with residential demands (not much housing in close proximity to industrial areas).**

XV. DEFINITION OF APPROACHES

The approaches for promoting the development of cogeneration, heating networks and waste energy in Wallonia can be found below for the projects that have been approved in terms of their technical feasibility and economic profitability.

II.1 ECONOMIC AND FINANCIAL APPROACHES

- Maintaining the current financial support for cogeneration (including green certificates) is essential given the investments to be made by the project leaders with respect to the reference solutions;

- Awarding green certificates by applying a multiplication coefficient to projects combining cogeneration installations with heating networks that have been approved in terms of their technical feasibility and economic profitability.

- Providing support mechanisms for new and existing building projects (e.g. new neighborhoods) using a heating system powered by waste energy that have been approved in terms of their technical feasibility and economic profitability.

6. Promoting investment through third party financing for cogeneration projects and/or heating networks. Third-party financing has many benefits for project developers: no immediate investment of capital, no requirements for technical skills, no obligation to carry out maintenance labour, etc.

II.2 LEGAL APPROACHES

7. Facilitating access to the electricity grid and promoting the local recovery of electricity produced particularly for the residential sector;

8. Providing a simple and effective framework for ensuring the correct size of cogeneration installation is set up for collective dwellings.

II.3 TECHNICAL APPROACHES

9. Improving and stepping up training on cogeneration technology and the management/maintenance thereof and potentially introducing additional modules within the framework of existing accreditations (liquid and/or gas fuels).

10. Providing training on the installation & maintenance of heating networks.

II.4 OTHER APPROACHES

11. Providing individuals/companies with information on the steps involved in setting up a cogeneration installation for each of the possible scenarios.

12. Organising training sessions/information sessions for construction professionals to make them aware of the advantages of cogeneration.

13. Lifting all restrictions preventing the producers of low-voltage cogeneration from accessing the energy market for the resale of surplus heat: price transparency, metering, Grid Code, load-shedding obligations in the event of constraints.