CODE2

Cogeneration Observatory and Dissemination Europe

CHP roadmap

Belgium

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Co-funded by the Intelligent Energy Europe Programme of the European Union

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Introduction to CODE2

This roadmap has been developed in the frame of the CODE2 project, which is co-funded by the European Commission (Intelligent Energy Europe – IEE) and is part of an important market consultation for developing 28 National Cogeneration Roadmaps across Europe. These roadmaps are built on the experience of the previous CODE project (www.code-project.eu) and in close interaction with the policy-makers, industry and civil society in each member state through research and workshops.

The project aims to provide a better understanding of key markets and policy interactions around cogeneration and particularly to identify the possibilities for acceleration of cogeneration penetration into industry and SMEs.

Roadmap methodology

This roadmap for CHP in Belgium is written by COGEN Vlaanderen and has been based on a range of studies. It has been developed through a process of discussion and exchanges with experts.

The first draft roadmap has been discussed on an interactive workshop with stakeholders from the three Belgian regions on 12th December 2013. The input from the workshop and any additional input from experts has been used to produce the current version. Although energy and CHP related matters are regional responsibilities and many aspects of this roadmap will show regional differences, the document tries to give a status which is valid for the whole country. However, small differences may still arise between the regions.

For more details and other outcomes of the CODE2 project see: http://www.code2-project.eu/

Summary

In Belgium, CHP has known a steady growth since 2005 and has reached an installed capacity of 2700 MW in 2012. The growth can be attributed to the success of the certificate systems: the Brussels-Capital and Walloon region issue both investment support and Green Certificates, while Flanders has its CHP certificate system.

Due to the long history of cogeneration in Belgium, the level of awareness is high compared to the European average. Economic opportunities are also high for many different types of installations, especially when individual benefits are being maximized. However with the current spark spread the IRR can be too low for positive investment decisions in large industrial companies in this period of crisis. Residential micro-CHP is on average struggling with high investment costs.

This study defined the CHP potential in Belgium, as part of a larger European potential study. Although there are no recent potential studies for CHP in Belgium, existing studies estimate the total potential for Belgium for 2020 to be 3203 MWe. This is an increase of 25% compared to the installed capacity in 2012. For 2030 a doubling of the existing capacity is expected. The highest growth is expected in the market segment of micro CHP, both residential as larger (up to 50 kW). The conservation of the existing installed capacity and the expansion towards the potential are important for Belgium since they can realise a primary energy saving of between 18,7 and 22,9 TWh per year and a CO_2 saving of between 2,3 and 8,1 million tons per year in 2030.

Some important barriers can impede reaching this potential: the lack of (binding) targets for CHP, the low spark spread, especially for large industrial installations, complex and changing policies, limited awareness among certain groups such as SMEs, and general misconceptions about CHP, the slow start of residential micro CHP, the lack of experience with district heating and legal issues for the local use of electricity in common housing.

The scope of this study was to define a number of necessary actions in order to overcome the main barriers. These actions are:

1. Take continuous as well as specific actions at policy level.
2. Expand the operational field of the CHP associations.
3. Provide an efficient, effective and stable financial support system.
4. Improve research and dissemination activities.
5. Develop CHP based district heating.
6. Involve CHP in smart grids, demand response and virtual power plants.
7. Strengthen the position of bio-CHP.
8. Launch residential micro-CHP.
9. Increase the general and specific level of awareness.

This roadmap to 2030 further defines a number of steps to be taken by all stakeholders.

1 Where are we now? Background and situation.

1.1 Current status: Summary of currently installed cogeneration

CHP has known a steady growth in Belgium since the introduction of the certificate systems in 2005 and has reached an installed capacity of 2700 MW in 2012.

Figure 1 shows the **installed capacity** of CHP for the 3 Belgian regions from 2000 to 2012. CHP has known a steady growth especially since 2005, when financial support through CHP and green certificates has been introduced. After a stabilisation in 2009 there was a new increase in 2010 and 2011.

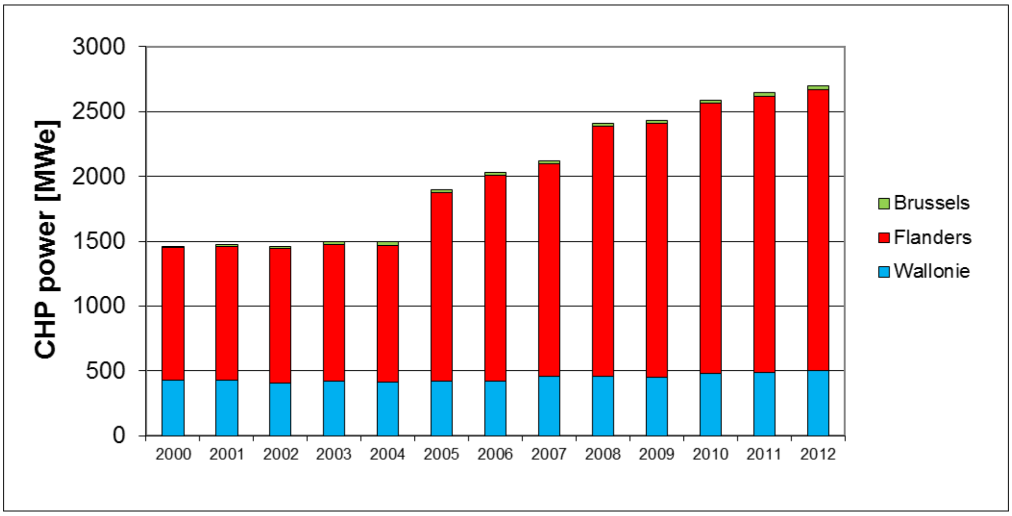


Figure 1: Growth in the CHP sector in Belgium (2000-2012)

The total installed capacity is highest for the combined cycle (Figure 2), although the highest number of installations has an internal combustion engine (260 out of 300 in 2010).

Overall, natural gas is the most common **fuel type** (Figure 3) in Belgium, but in Wallonia renewables are the most dominant (Figure 4).

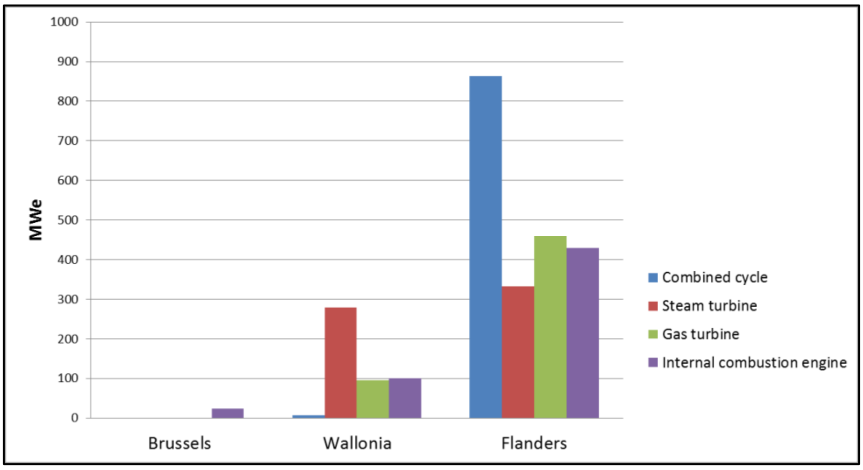


Figure 2: Typology of CHP for Brussels, Wallonia and Flanders (2010).

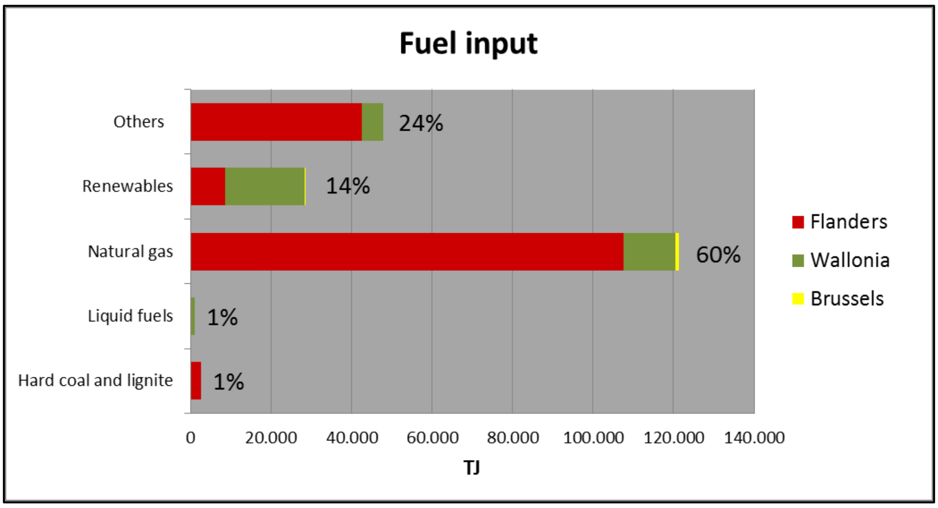


Figure 3: Fuel type of CHP for Flanders, Wallonia and Brussels (2010).

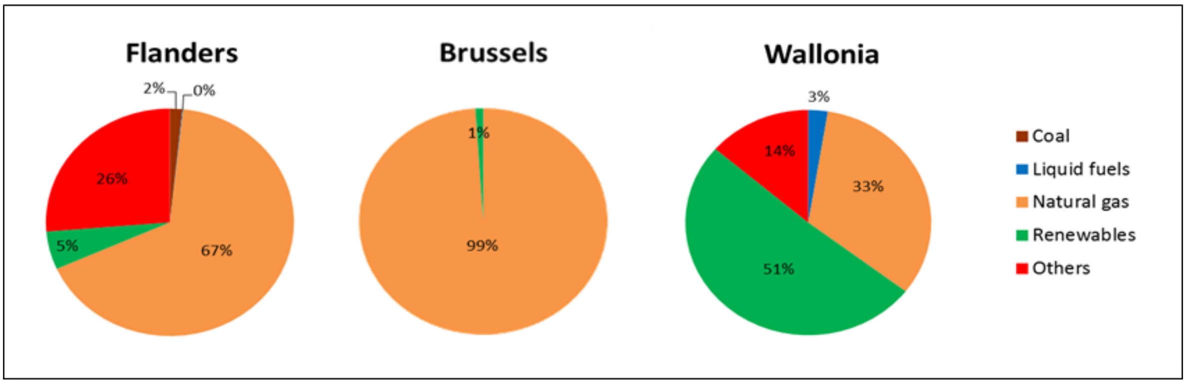


Figure 4: Fuel type of CHP for Flanders, Wallonia and Brussels separately (2010).

The installed capacity is the highest in the sector of the **industry** for Flanders and Wallonia, while in Brussels, CHP is most common in the **tertiary** sector. However in Flanders the highest number of applications and the highest growth was situated in the **agricultural** sector.

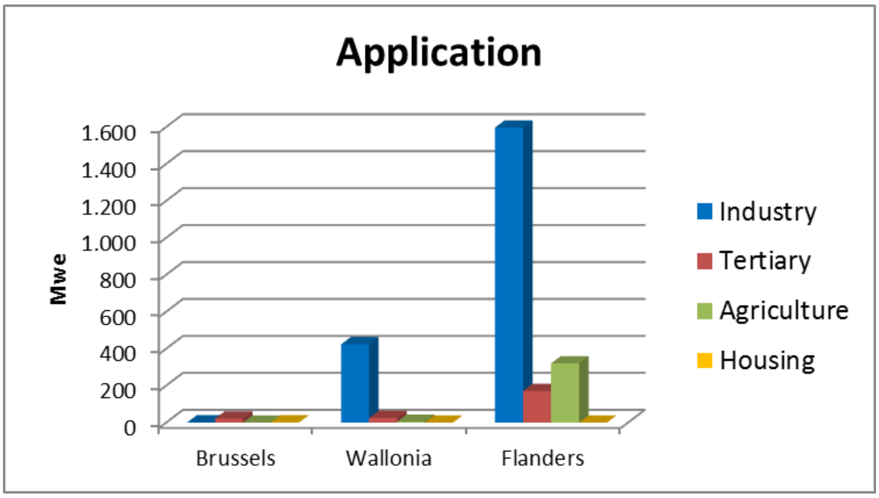


Figure 5: Installed capacity per application (2010).

1.2 The Belgian Energy and Climate Strategy

The Belgian climate strategy is divided between the federal and regional level. Within the framework of the Kyoto Protocol, Belgium is bound to achieve a 15% non-ETS reduction in 2020 compared to 2005. Although this goal has not yet been divided between the Regional Governments, each region has made its own climate action plan.

Belgium is a federal state with political power segregated into three levels: the federal government, the three language communities and the **three regions** (the Flemish Region, the Walloon Region and the Brussels-Capital Region). Since energy is mainly a regional responsibility, many aspects of CHP will be covered at the regional level. However some aspects are also governed on federal or local level.

The division of responsibilities on energy matters over the federal and regional governments is organised as follows.

The Federal Government is responsible for, amongst others:

- the supply of electricity and natural gas;
- the transmission of electricity on the high voltage grid (higher than 70 kV);
- the storage and transportation of natural gas;
- the management of the LNG terminal;
- the classical and nuclear production of electricity;
- the maximum prices for electricity and gas for customers;
- the grid tariffs (until 2014)

This is stipulated in the Federal Electricity Law and Federal Gas Law.

'Plan Wathelet'

In December 2013 a preliminary draft was adopted by the cabinet concerning a mechanism of a 'strategic reserve', initiated by Secretary of state Wathelet. This 'strategic reserve' is a solution to ensure security of supply after the nuclear phase-out and it includes a tender for 800 MW of new gas-fired plants. The cost for these gas plants would cost about 1€ per MWh.

If the CHP sector could prove that it can be equally important in providing this reserve capacity (see total potential, chapter 2.2), it would be much more interesting to invest this budget in additional CHP capacity.

The Regions are responsible for, amongst others:

- the local transmission and distribution of electricity on a voltage lower than or equal to 70 kV;
- the distribution of natural gas;
- the production of electricity from renewable energy sources and cogeneration;
- the environmental aspects (including permits);
- the rational use of energy;
- the social aspects.

This is stipulated in the Regional Electricity and Gas Decrees.

The Belgian climate strategy is also divided between the federal and regional level. Within the framework of the Kyoto Protocol, Belgium was bound to achieve a total emission reduction of 7,5%. In order to reach this goal, in 2001 the three regions signed a cooperation agreement with the federal government in order to have a continuous coordination of policy initiatives. This agreement resulted in the 'National Climate Plan 2009-2012, which provides a detailed overview of all existing measures of the federal and regional authorities.

According to the European Effort Sharing Decision (ESD) Belgian non-ETS sectors have to achieve an

emission reduction in 2020 of 15% compared to the non-ETS emissions in 2005. However, this goals has not yet been divided between the Regional Governments.

On regional level the climate strategy is laid out in regional climate plans.

1.2.1. Brussels-Capital Region:

An **air quality and climate plan** (Plan for the structural improvement of the air quality and the battle against global warming) was made for 2002-2010 (IBGE - BIM, 2002); a new version is currently being made.

The new plan finds its legal basis in the so-called COBRACE (COde BRuxellois de l'Air du Climat et de l'Energie) voted in 2013. Considering the continuous efforts of the Brussels Capital Region for a more efficient use of energy and the integration of more renewable energy sources, cogeneration will be further supported as an innovative technology. This support will materialize in different ways such as e.g. the continued guidance from experts and the exemplarity of public bodies when building new offices/facilities.

1.2.2. Flemish Region

The **Flemish Mitigation Plan** (2013-2020) is part of the Flemish Climate Policy Plan 2013-2020 (LNE, 2013). In the absence of an intra-Belgian division of the non-ETS targets, the present Flemish Mitigation is based on an indicative non-ETS-reduction target of 15% for Flanders. The main efforts will have to be made in the transport and buildings sector. The Mitigation Plan includes some specific aspects related to CHP, for example:

- Action plan micro-CHP (providing good examples, gradual stimulation of the market especially in social housing, research on in situ energy savings, information campaigns
- Grid management in the agricultural sector, e.g. capacity level of the distribution grid when there is a concentration of CHP.

1.2.3. Walloon Region

The Walloon Region has implemented its air and climate objectives with the '**Air and Climate Plan**' (Région Wallonne, 2007). CHP plays a role in some of the action steps in the plan:

- Promoting the use of renewables and CHP in the industrial sector, through certificates and investment support and support for energy audits; and through the encouragement of research, development and demonstration projects.
- Supporting sustainable urban development projects such as district heating based on CHP.
- Promoting energy audits for buildings in the public and tertiary sector.
- Supporting investments for CHP in the private sector.
- Improving the operation of the facilitators: private or associated experts in specific fields of competence, who have the task to advise any institution, company, investor… wanting to improve the energy performance of their facilities. There are facilitators for different renewables as well as CHP.

1.3 CHP Policy development

CHP in Belgium is mainly supported at the regional level through different regional Decrees. The Brussels-Capital and Walloon region issue both investment support and Green Certificates. Flanders has its CHP certificate system.

The Cogeneration Directive (2004/08/EC) has been fully implemented in Belgium.

Within the Belgian legislation, CHP is supported for the following reasons:

- to account for European 20-20-20 goals, in a cost efficient way without compromising the economy.
- to reduce greenhouse gas and other emissions.
- to be less dependent on fossil fuels.
- to promote economic growth, technology innovations and green jobs.

On the federal level, **financial support for investments** in CHP is given through a reduction of the taxable profits (see Table 4).

All federal and regional incentives are summarised in Table 4. The next paragraphs further explain the CHP policies in the three regions. In all regions a certificate based support system is operational, although the practical implementation differs between the regions.

1.3.1. Brussels-Capital Region

In Brussels one type of certificate is used for both natural gas CHP and renewable energy sources: the **Green Certificate** (GC).

The Ordinance of 19/07/2001 on the organization of the electricity market in the Brussels-Capital Region lays the foundation of the system of Green Certificates and the system of quota.

Several subsequent Decrees and Decisions regulate the practical procedures, the calculations and the awarding procedures for Green certificates.

Principle of the certificate systems in Belgium

A CHP certificate is a tradable product that proves that an installation realized an amount of primary energy or CO_2 savings by using CHP, compared to a reference installation. The owner of an qualitative CHP installation receives every month a number of certificates from the local energy regulator. He can then sell them to the electricity suppliers for a price determined by the free market. In order to maintain the market, electricity suppliers have to buy a number of certificates, regulated by quota. The owner also has the choice to sell his certificates to the grid regulators for a minimum price.

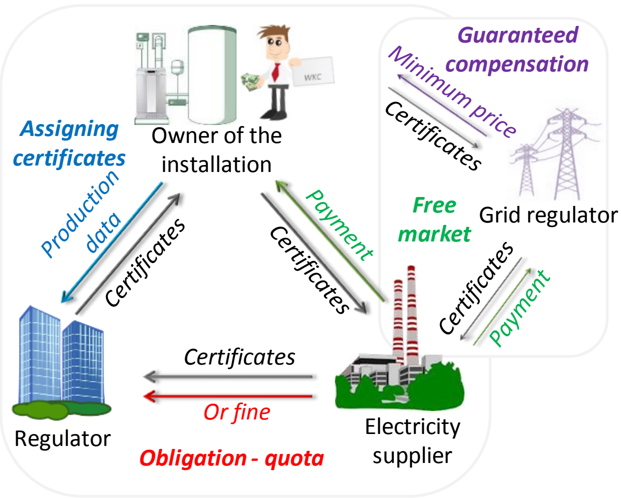


Figure 6: Principle of the market for CHP certificates.

The general principle of certificates is explained in the text box. In Brussels the energy regulator is BRUGEL. The amount of Green Certificates equals the number of kg avoided CO_2, divided by 217. The avoided CO_2 equals: {Pel (MWh)/0,55) x 217 + Pth (MWh) /0,9 x 217} - {fuel consumption (MWh) x CO_2 emission coefficient of the fuel}. The CO_2 emission coefficient of natural gas is 217 kg/MWh; for rapeseed oil it is 70 kg/MWh, and for biogas it ranges between 1 and 5 kg/MWh (calculated for each individual case). The value of the certificates has been very stable since the beginning. The actual market value for one certificate is 80-85 €.

In the Decree of 26/05/2011 a multiplication coefficient was introduced for gas fired CHP in **collective housing** buildings. To compensate the lack of financial benefit from local use of electricity (see further: barriers to CHP) an extra support was given : twice more certificates for CHP <50 KW and 1,5 times more for CHP >50 KW.

Electricity suppliers have the obligation to buy a number of green certificates (quota) from green electricity producers, as regulated by several Decrees. The last Decree of 29/11/2012 regulates the quota from 2013 to 2025 (see

Table 1), which give long term perspectives to the sector. In the same Decree a mechanism allows the minister to increase the quota for the next years if the number of granted green certificates is higher than 5% of the quota for the last 4 trimesters. The increase is equal to the surplus quantity. This gives a strong stability to the green certificates market in Brussels.

Year	Obligation
2013	3,5%
2014	3,8%
2015	4,5%
2016	5,1%
…	%
2025	12,0%

Table 1: CHP and green electricity quota for the Brussels-Capital Region

Brussels also issues an **investment support** of 3500 to 4500 €, depending on the income category, and with a maximum of 30% of the relevant/eligible parts of the expenses. For the basic income this accounts for $3500€ \times \sqrt{P_{elec}(kW)}$. More details are given in Table 4.

1.3.2. Flemish Region

The **Energy Decree** (Vlaanderen, 2009) coordinates and replaces all previous energy related decrees, among which the former Electricity Decree and the Natural Gas Decree.

The Energy Decree regulates several CHP related topics, it:

- defines high efficiency CHP in Flanders,
- regulates the general principles of CHP and Green electricity certificates as well as guarantees of origin,
- regulates the responsibilities of the electricity suppliers and grid operators regarding priority to the grid, costs for grid connection and the responsibility in the stimulation of rational energy use,
- defines the reporting obligations of the Flemish Government, including an energy balance with the production of electricity and heat by CHP per subsector and energy source.

The last major change to the decree was made on 13th July 2012. This completely changed the working of the certificate system. The Energy Resolution (Vlaanderen, 2010) arranges the implementation of the Decree. The implementation of the certificate system was also changed in 2012.

Since 2005, **CHP certificates** have been used in Flanders**.** The support system used to allow for the granting of CHP certificates per MWh primary energy savings, and one green certificate for each MWh green electricity. The support system was so effective that it resulted in an overshoot of ca. 252% of the obligation for CHP in 2012 and as a result, many certificates were sold at the bottom price of €27, whereas the market price was €41 until 2009.

In order to address this oversupply, the Flemish authorities increased the obligations on the power retailers so that they have to redeem a higher number of certificates for the same quantity of power delivered before. On the other hand however, a substantial part of the power delivered to the energy intensive industry is exempt from this obligation, reducing the net effect of the obligation increase (Cornelis, 2013).

Added to that, Flanders' CHP support scheme has been **drastically reformed** after questions were raised about the support levels to some renewable power technologies in the green certificate scheme. In order to avoid over-subsidy, support levels are now no longer proportional to the renewable energy produced, or the primary energy saved for CHP. Instead it is also dependent on the economic feasibility of the technology used (Cornelis, 2013). The amount of financial support is now more adapted to the real needs of the technology, and it is limited in time. Less viable types of technologies can be issued more than one CHP certificate per MWh primary energy saved, although a maximum is set at 1.25 . In 2013, this maximum was even lowered to 1. The idea is that the government cannot spend most of its funds on, for example, new technologies that are still expensive and would need a high amount of support to become financially profitable.

The calculations showed that almost all CHP categories needed an amount of support that was higher than 1 certificate per MWh primary energy saved. Because they only received the maximum of 1 certificate, this amount of support will not be enough to be economically feasible in the current market conditions, for an average installation of that category.

Moreover it has become a very complex system which will be permanently evaluated and adapted, creating more insecurity for the investors.

Year	Obligation
2013	8,6%
2014	9,8%
2015	10,5%
2016	11,2%
2017	11,2%
2018	11,2%
2019	11,2%
2020	9,3%
2021 and after	7,0%

Table 2: CHP quota for the Flemish Region

How big is the support then for a CHP owner?

This is calculated by multiplying the number of certificates with the value of the certificates. The minimum amount of support for one certificate is 31€[1], while the fine for the electricity suppliers (if they don't reach their quota) is 41€.

In theory the **market value of the certificates** will be between these two, however in reality it depends on a number of other factors, such as long term contracts and the existing oversupply of certificates in the market. The number of certificates assigned for every 1000 kWh primary energy savings is defined as one, multiplied by the so called 'Banding factor', which is a number representing the amount of support needed to make the installation financially profitable. As mentioned before, this factor is limited to a maximum which is currently set at 1. Therefore, in reality, most (but not all) CHP installations receive one certificate for every 1000 kWh primary energy savings. Every year, the banding factor and the set maximum are calculated and published.

A similar systems of certificates exists In Flanders for renewable energy, where **Green Electricity Certificates** are traded. A CHP running on renewable energy can obtain both CHP and Green Electricity certificates.

Some **investment grants** in Flanders have been omitted (e.g ecology grant, investment support for micro-CHP). Recently (October 2013) a budget was approved for demonstration projects with micro-CHP in the social housing sector.

Non-financial incentives include priority access to the grid improving the ability of new plants to start dispatching power, however, there is no priority dispatch for any generator in Flanders and this applies equally to CHP.

Difference between quota and targets

In the 3 Belgian regions quota are used to support the market for CHP certificates (in Flanders) and Green certificates (in Brussels and Wallonia). A (binding) target for CHP, which would have more connection with the potential, is nonexistent.

The quota are set for a limited time period, and therefore don't represent a long term vision. Moreover, quota of one year can be reached with the energy production of previous years. As a result a large surplus of certificates impedes the growth in the sector, because the quota can be easily reached.

Quota are also relative to the amount of electricity production. When the electricity production slows down, e.g. in times of crisis, the amount of certificates to be bought by electricity suppliers also goes down, and thus also the stimulus.

In Brussels and Wallonia, there is only one type of certificates for CHP and green electricity, so the quota don't represent specific goals for CHP only.

While quota are necessary and useful to support the markets of certificates, long term (binding) targets for CHP are useful to represent the long term vision, to stimulate growth and to reach the potential.

1.3.3. Walloon Region

CHP is covered by two regulations:

- Decree of 12 April 2001 on the organization of the regional electricity market: sets out the guidelines for the green certificates.
- Decree of 11 March 2004 on incentives intended to promote environmental protection and sustainable energy use: regulates other investment support.

The Walloon Region issues **Green Certificates** for both renewable energy and CHP. This is regulated by the CWaPE (Walloon Commission for Energy), who is also responsible for determining the quota.

[1] Currently certificates are being sold for less than 27€.

The granting is proportional to the electricity production of the installation and the amount of CO_2 reduction compared to a reference installation:

1 Green Certificate = 1 MWh CO_{deman}-free electricity (with respect to a reference electricity production)

With: CO_2-emission of a CCGT power station for the production of 1 MWh electricity with natural gas (efficiency of 55%; CO_2-emission factor of natural gas: 251 kg CO_2/MWhp) = 251 kg CO_2 / 0,55 = 456 kg CO_2

→ 1 Green Certificate for 456 kg CO_2 savings

Thus, one green certificate is awarded for 456 kg CO_2 avoided. The amount of CO_2 reduction will be higher if a renewable energy source is used, because the emission factor will be lower. In that case more certificates will be granted. The total saving is capped at 200%. The fine for not achieving the quota is 100€ per missing certificate, while the minimum price is 65€ per certificate.

Year	Obligation
2013	19,40%
2014	23,10%
2015	26,70%
2016	30,40%
2017	32,80%
2018	34,15%
2019	36,03%
2020	37,90%

Table 3: CHP and green electricity quota for the Walloon Region

The quota for the Green Certificates are considered to be realistic and are a means of realizing the target for 2020 of 3 TWh of electricity produced by high efficient cogeneration. The quota for 2013-2016 and 2020 were approved in 2012, and for the other quota an indication is given (Table 3) (CWaPE, 2012).

CWaPE believes that achieving their goals will depend on a rapid stabilization of the legal framework. However at this moment is it possible that the support system will be reviewed, although it is not known when or how this will happen.

Other support systems include support for feasibility studies, compensation for injected electricity and different types of investment support. These are summarized in Table 4 (situation end of 2013).

Table 4: Certificate systems in Belgium (Federal and Regional)

Where	Type	Name	Target group	Amount	Terms and conditions
Federal (Belgium)	Investment support	Reduction of the taxable profits for energy saving measures	- Companies	14,5% of the investment (2013)	- not applicable to active used for rent - amortization > 3y taxation period - grant introduction max 3 months after end of taxation period
Flemish Region	Investment support	CHP certificates	- Private persons - Companies	- # CHP certificates / MWh PES = 1 x Banding Factor - # support = # CHP certificates x market value of CHP certificates - Minimum value CHP certificates = 31€ - Banding Factor ≤ 1,25	- installation located in Flanders - it is a high efficient CHP installation
		Green energy certificates	- Private persons - Companies	- # GE certificates / MWh green electricity = 1 x Banding Factor - # support = # GE certificates x market value of GE certificates - Minimum value GE certificates = 93 € - Banding Factor ≤ 1,25	- installation located in Flanders - electricity is produced from renewable sources, limited to a list of technologies
	Operational support for energy production	Compensation principle for injected electricity	- Private persons - Companies - NGO and public entities	- electricity meter counts backwards when injecting electricity on the grid (→ value electricity injected is same as value electricity consumed) - No compensation for surplus production of electricity on yearly basis	- < 10 kW - Owner can choose between compensation principle or separate measuring of electricity consumption and injection
Brussels-Capital Region	Supports for feasibility studies	- Premium A2 for feasibility study on energy performance of buildings and feasibility studies for CHP. - Investment premium E2	- Companies - Private persons - NGO and public entities	- 50% of the amount	-

	Operational support for energy production	Green certificates	- Private persons - Companies - NGO and public entities	- price depends on market - ± 80€ /GC	- 1 GC = 217 kg CO_2 avoided (reference for electricity is gas turbine 55% efficiency and for heat a boiler with 90% efficiency), taking into account the CO_2 emission coefficient of the fuel - time limit 10 years - for collective residential sector you get 1,5 (if CHP > 50 kWe) or 2 GCS (if CHP < 50 kWe) for 217 kg CO_2 reduction - it is a high efficient CHP installation
		Compensation principle for injected electricity	- Private persons - Companies - NGO and public entities	- value electricity injected is same as value electricity consumed.	- CHP < 5 kVA
	Investment support	Premium E2 for CHP installations with min 5% CO_2 reduction	- Private persons - Companies - NGO and public entities	- Basic category : 3 500 € * √(Pelectric in kW) - Middle income : 4 000 € * √(Pelectric in kW) - Low income : 4 500 € * √(Pelectric in kW) - Limited to max 30 % of the investment	- Study on energy performance of buildings is necessary if CHP > 5 kVA (see premium A2) - CHP has min 5% CO_2 reduction
		Energy premium C1b: extra investment support if you do a complete renovation of the boiler house	- Private persons - Companies - NGO and public entities	- 20% extra premium on the cumulative premiums	- The total renovation must include condensing boiler, CHP, temperature regulation and frequency based circulation pumps. - See also other specific conditions.
Walloon Region	Support for feasibility studies	Audit énergétique (UREBA): for studies on energy performance on buildings	- NGO and public entities	50% of the amount	- 25% if other grant for the same study - done by authorized expert, grant introduction max 6 months after payment
		Etude de pré-faisabilité (UREBA): support for pre-feasibility studies	- NGO and public entities	50% of the amount	- 25% if other grant for the same study - done by authorized expert, grant introduction max 6 months after payment
		Etude de faisabilité d'une installation de production d'énergie à partir d'énergies renouvelables: for feasibility studies of renewable energy plants	- Companies - NGO end public entities (non-UREBA)	50% of the amount	- max 2500 € (bio-methanization project)

	Operational support for energy production	Green certificates	- Private persons - Companies - NGOs and public entities	- price depends on market: currently less than 60€ - price warranty of 65€ by the Region	- 1 GC = 456 kg CO_2 avoided (reference is gas turbine) - More CO_2 avoided and more certificates when using renewable energy sources - The total saving is capped at 200%. - time limit 10 or 15 years - reduction factor applied on plants > 10 years old - it is a high efficient CHP installation!
		Compensation principle for injected electricity	- Private persons - Companies - NGO and public entities	- value electricity injected is same as value electricity consumed	- CHP < 10 kVA
	Investment support	UREBA: improving energy performance of buildings	- NGO and public entities	30 % of the investment	- investment of minimum 2500 € - only for high efficient CHP - min 10% CO2 emission reduction - limited to an amount of 15% if other support systems are used for the same investment
		URE: Rational energy use premium	- Private persons - Companies - NGO and public entities (non-UREBA)	- 20 % of the invoice - maximum 15000 €	- investment in 2013 - if District Heat (DH): 100 €/m of pipe with max 50% of the invoice and 100000 per DH - only for high efficient CHP
		URE: support for the installation of a biomass boiler with automatic feeding	- Private persons - Companies - NGO and public entities (non-UREBA)	- 1750 € if < 50 kW - 1750 euros + 35 €/kW if 50- 100 kW - 3500 € + 18 €/kW if 100 - 500 kW - 10700 € + 8 €/kW if > 500 kW	- investment in 2013 - max 50% of invoice, max 15000 per installation - if DH: 100 €/m of pipe with max 50% of the invoice and 100000 per DH
		UDE: support for companies making an investment (e.g. high efficient cogeneration) to improve their energy and environmental footprints.	- Companies	- Between 20% (BC) and 50% (SME) of the additional cost of the installation compared to the reference technology	- min investment: 25000 € - Excluded: legal entities, NGO, financial institutions, large retailers, healthcare, schools, large energy production, CHP > 1MWe, …

1.4 Awareness

Due to the long history of cogeneration in Belgium, the level of awareness is high compared to the European average. The main sector that still needs to be addressed are the SMEs and the households, where CHP still has a high potential but where the market is not well developed.

1.4.1. Key role of awareness and know-how on CHP

Sales of cogeneration to customers rely on a commercial proposition and a **functioning market** for the application of cogeneration. The policy intervention of the European Union to support cogeneration and assist the removal of market barriers is an important element of creating a good commercial proposition however in itself it will not be sufficient to grow sales of cogeneration if the customers are unaware or misinformed and lacking support within influencing groups or, and if the supply chain of skills and suppliers does not exist.

A final buying decision by a customer is the result of a set of complex interactions, involving the supplier, the supply chain and the customer. External conditions influence the process as do the market structure and the policy structure. A mature market for a product is characterized by a high degree of awareness among all the relevant players in the market and ongoing buying and selling activity.

1.4.2. Cogeneration Awareness assessment in pilot Member States: Method

An assessment of awareness of cogeneration among key market actors has been developed. Using qualitative interview techniques with experts and market participants four groups of the socio-economic actors for cogeneration were assessed. The four groups and their subsectors are below. The list is not exhaustive but contains all the most relevant players.

- Customers: utilities (& DH), industry, potential users;
- Market and supply chain: installation companies, planners, energy consultants, architects, technology and equipment providers, banks/leasing, energy agencies;
- Policy structure: energy and climate legislators and all levels of government;
- Influencers: media, general public, academics, environment NGOs, associations.

With: ■ Poor - ■ Low - ■ Early awareness - ■ Interest - ■ Active market

Figure 7 lists the possible actors under each of the groups in the socio-economic model. The level of awareness was assessed for each of the groups and rated 1-5, as below. The detailed comments on each group are described in Annex 1 (p.52).

1.4.3. Role of key actors

Among the **customer group**, CHP is especially well known among industry and utilities. Awareness is growing among commercial premises and in certain sectors. For example among greenhouses, CHP is common practice and owners are supported by their own sector organisation.

Although the potential for (micro-)CHP for SMEs is very high, these companies are not always aware of opportunities and the support mechanisms for CHP. Experience has shown that it is very difficult to reach this group of people, whose core business is often very distinct from energy. Not only initial awareness is important in this group, but also guidance during the implementation and operation of the CHP plant.

Residential micro-CHP is becoming slightly more known. However due to the slow start of the introduction of the technology in Belgium and some negative experiences with manufacturers have resulted in a negative connotation of the household micro-CHP, not only among potential customers but also among potential investors and government. Although the general public is slowly becoming aware of micro CHP, through building fairs and publications in general and specialised press, they are often not aware of the true benefits and the optimum siting and sizing.

The **market and supply chain** for industrial or large CHP are well developed and awareness is high among all players. The awareness for micro CHP (< 50 KW) is increasing the last 2-3 years. Only for residential micro-CHP (1 kW) the market is not yet well developed, only one producer is currently operational, which limits also the development (no competition in the market, and no investment support because of this).

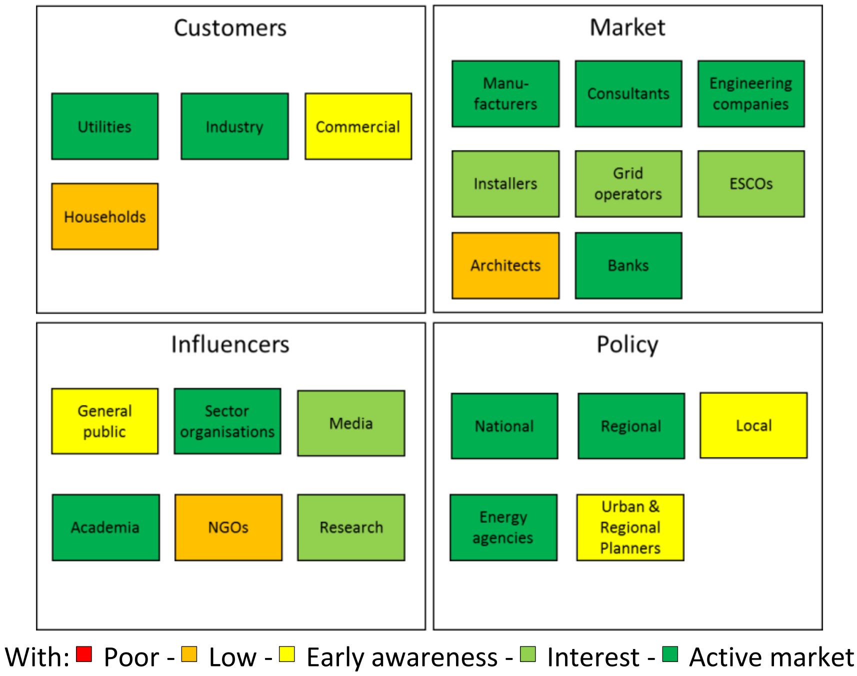


Figure 7: Level of awareness among key actors under the 4 socio-economic groups

Federal and regional **governments** are aware of CHP and specific legislation is implemented. Energy agencies are very well aware of CHP and cooperate well with the government. However since energy is mainly a regional matter, legislation is different in the three regions, which complicated awareness of the legislation for the stakeholders who are operational in the three regions, and which also complicates awareness of and implementation of new European legislation such as the EED. Although some cities or communities have signed the Covenant of Mayors or are adopting Sustainable Energy Action Plans, the role CHP could play within these plans is generally not so well understood.

Among **influencers,** CHP is relatively well known. CHP is covered in academia, articles, research. An important link is the role of the CHP sector organisations. They are the knowledge centres for CHP and organise the consultations between all stakeholders and government. This cooperation assures a fluent information stream and mutual understanding of specific problems or needs, enabling the government to anticipate adequately and to translate these needs into a coherent and supportive legislation. However, while the organisation is still operational in Flanders, it is replaced in Wallonia and Brussels with a 'CHP facilitator': specialists who can give advice on CHP related matters, therefore a true coalition doesn't exist here.

1.5 The economics of CHP

Economic opportunities are high for many different types of installations, especially when individual benefits are being maximized. However with the current spark spread the IRR can be too low for positive investment decisions in large industrial companies in this period of crisis. Residential micro-CHP is on average struggling with high investment costs.

1.5.1. General remarks

To estimate the economic attraction of cogeneration in each member state CODE II has established a standard set of cases to be evaluated in each member states. (**Error! Reference source not found.**: **Error! Reference source not found.**).

Following factors are important in estimating the viability of a CHP project:

- investment or capital cost,
- other fixed costs,
- fuel cost,
- value of the electricity used on site,
- value of the electricity sold to the grid,
- value of the heat produced,
- operational costs,
- investment support,
- tax exemptions,
- in case of large CHP participating in the emission trading system (ETS), the CO_2 prices.

These factors will be further discussed below and several examples will be given. However, two important aspects have to be kept in mind. First, investments are being made in the **long term**, especially for larger installations (e.g. district heating). Therefore people should not only consider current variable costs such as energy prices. Second, it should be taken into account that energy is in most cases **not the core business** for companies. These parties not only need a sufficient return on investment, but also (and equally important) sufficient stability and security.

1.5.2. Spark spread

The most important factor influencing CHP viability at this moment in Belgium is the spark spread, i.e. the difference between the power price and the natural gas price, the dominant fuel for CHP installations.

Due to the massive investment in renewable electricity in Belgium, as well as in its surrounding countries, wind turbines became the marginal production unit instead of gas-fired power plants. At this moment we are also facing very low CO_2 prices and a slightly decreasing demand for electricity. Moreover the price for coal is very low (dumping of American coal because of cheap shale gas). As a result the **value of electricity** on the energy markets are historically low.

An important part of the electricity price and therefore of the economic case for CHP consists of the **transmission and distribution tariffs**. Requirements for the grid and the grid operators have been increasing due to the impact of decentralised production units on balancing and safety aspects of the grid. Not only have tariffs been increasing, but the regulatory framework has been changing several times in the past and is still prone to change in the future, e.g. when the responsibility will be transferred from the federal to the regional regulator in 2015. Changing tariffs and insecurity have a negative impact on the CHP sector. On the other hand we expect that the positive impact of CHP on grid balancing and grid stability will be more validated in the future, and that this will have a positive impact on these tariffs and electricity prices for CHP.

On the other hand **fuel costs** (especially gas for fossil CHP) are increasing. This results in a structural over capacity and in a declining or even negative spark spread. The operating hours of both gas-fuelled conventional power plants and gas-fuelled CHP installations are therefore now being reduced.

Following graph gives the spark spread based on the spot prices for the last 4 years.

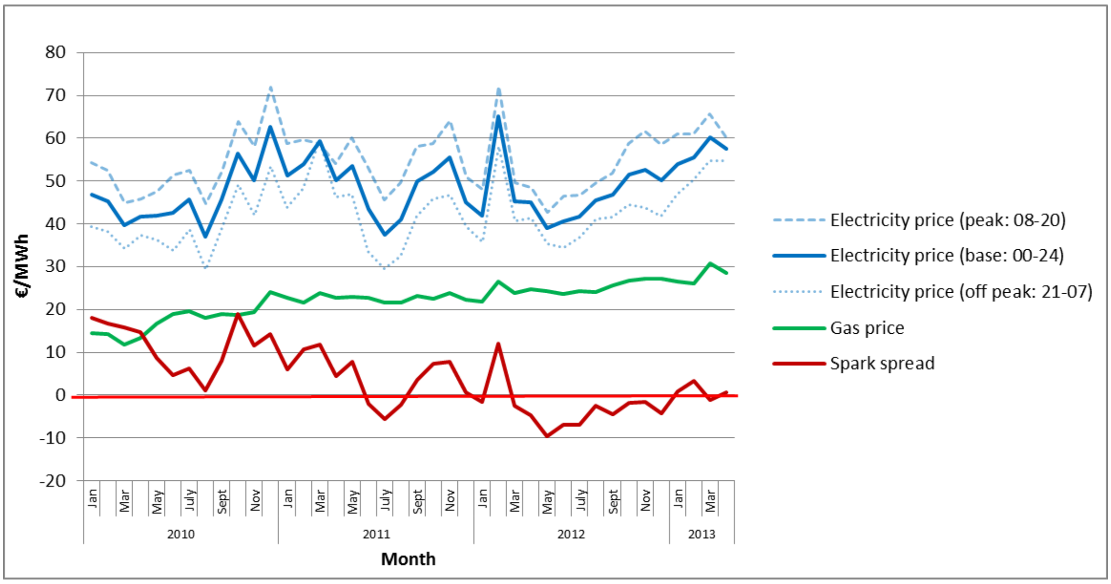


Figure 8: Electricity and gas price and spark spread in Belgium[2]

As can be seen in the figure, the average yearly spark spread (based on the base price for electricity) which was still around 11 € in 2010, became negative in 2012. Especially during the summer months the spark spread (monthly average) plunges to -5 or even -10 €.

However, these average monthly data represent only a part of the story. The actual spark spread for an individual case will depend on a number of other factors, which will be discussed below.

Peak and off peak prices

The above mentioned electricity prices are different between **day** (peak periods) and **night** (off peak). This results in different spark spreads.

Real efficiencies

The spark spread is by convention based on the efficiency of a CCGT (Combined Cycle Gas Turbine) and is calculated as follows:

Spark spread (€) = Price of electricity (€) – 2 x Price of Gas (€)

This calculation is based on an average efficiency of 50%. However the individual efficiency of an installation can be quite different and can have a different result.

Market price for gas and electricity

The spark spread can be considerably different due to different market prices for both electricity and fuel depending on the installed capacity and the amount of **taxes**.

Following figures are based on average electricity and gas prices for different sizes of businesses. Businesses can generally recover value-added-tax (VAT) but no other taxes including energy taxes,

[2] Gas price is based on Spot market price (TTF) and electricity price is based on Spot market (Belpex).

carbon taxes and climate-change levies, so the level of ex-VAT taxes is important. Figure 9 shows the prices of electricity and gas (without VAT-taxes) in Belgium.

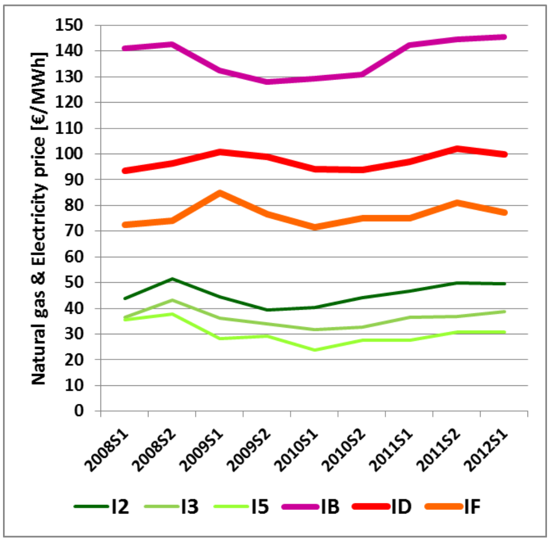


Figure 9: Electricity and gas prices for business in Belgium (source: Eurostat)[3]

As can be seen in Figure 9, for businesses the actual spark spread is relatively good, especially for the smaller ones. However, this figure also shows that for large companies, electricity prices are at the moment very low and current spark spread may be too low to invest in or maintain a CHP installation.

Individual opportunities

In reality the economic viability of a project will not only depend on these average prices and spark spreads. Businesses and even households can create specific opportunities which will enhance the return in many ways:

- Large businesses can **negotiate** fuel and electricity prices
- **Group** purchasing of fuel reduces costs (see different level of green lines in Figure 9) and makes the spark spread more positive
- Since the avoided cost of buying electricity when using it on site is much higher than the price for selling electricity to the grid, using as much electricity as possible makes the case more profitable. Correct sizing of the installation, buffering and providing **flexibility** in heat + electricity production, enhance this advantage even more.
- Selling electricity on the **imbalance, day ahead or intraday** market when prices are high can result in high benefits from the produced electricity.

The electricity and fuel prices that are used in the examples in Figure 11 are typical prices for 4 standard installations of a specific size, taking into account average opportunities for that category.

Type of fuel

Until now the spark spread for gas fired CHP has been used. However, other fuel sources will have a different spark spread. An additional opportunity for an individual installation can be to use local (waste) streams as energy sources.

[3] Gas prices (without VAT) for: 1.000 GJ < I2 < 10.000, 10.000 GJ < I3 < 100.000 GJ, 1.000.000 GJ < I5 < 4.000.000 GJ
Electricity prices (without VAT) for: 20 MWh < IB < 500 MWh, 2.000 MWh < ID < 20.000 MWh, 70.000 MWh < IF < 150.000 MWh

1.5.3. Investment and operational costs

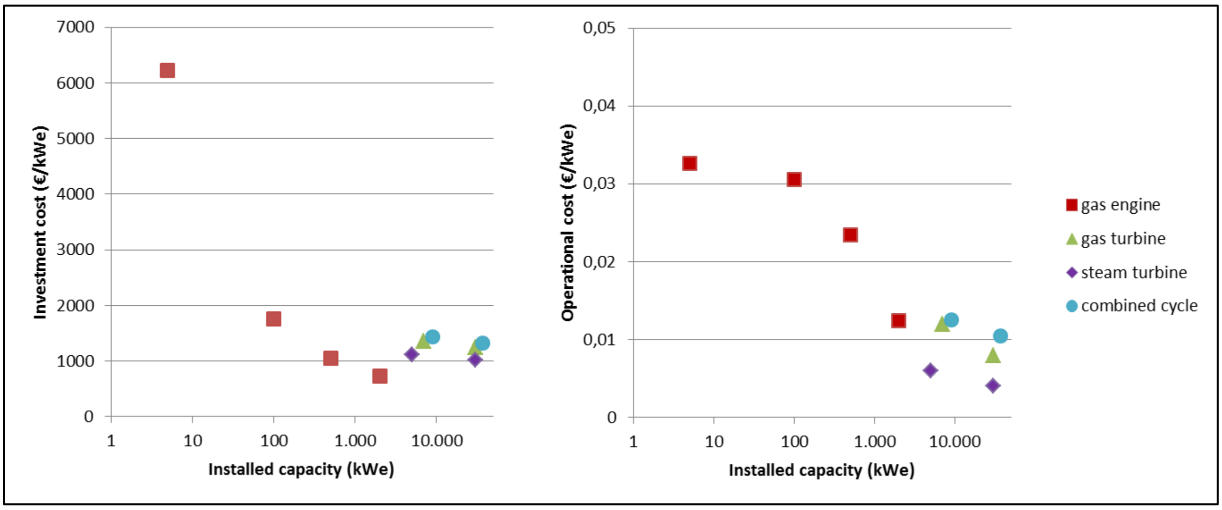


Figure 10: Average investment and operational costs per kWe for different technologies in Belgium.

Investment and operational costs for different CHP technologies tend to be lower per installed kWe for larger installations. An estimation of these costs for average installations of different size categories was made in to serve as a base of the Flemish support system (VEA, 2013). These prices (Figure 10) are the result of an operational and competitive market for CHP in industry and SMEs. They include all costs for a typical installation (all equipment and extra parts that were not needed with a conventional boiler, installation costs, …). Of course their real price will depend on different factors: different prices between producers and installers, different parts depending on the application and the sector,… E.g. in the case study (see Annex 5) of the Crowne Plaza Hotel in Brussels, the use of a special crane for moving the installation to the basement resulted in 5-10.000 € extra costs.

The costs in the economic assessment (below) are based on the average numbers.

It should be noted that the relative investment cost for smaller installations (e.g. in SMEs) is not only larger, but there is also a higher financial risk related to this cost. If something goes wrong, it can be a financial catastrophe for a small company, which is less the case in larger companies.

1.5.4. Support system

The support system in the three regions was discussed in paragraph 1.3 and Table 4. Following advantages were taken into account in the economic assessment (below):

- **Federal tax reduction**. This is only applicable for businesses that pay taxes; therefore the advantage for owners without tax obligation will have no benefit from this factor.
- **Certificates**. CHP and green electricity certificates in Flanders, green certificates in Brussels and Wallonia.
- **Investment support** in Brussels and Wallonia.

1.5.5. Examples economic assessment

The economic assessment is made for 4 reference installations. Operational hours, references and the other parameters discussed above are based on averages; **every individual project will be different!** For example, installation costs in a hotel will be much higher because the necessity of using cranes, tax reduction for companies is taken into account, although this is only valid for companies paying taxes, investment support in Wallonia depends upon the size of the company and the province, …

The input variables and assumptions are estimated for a number of reference installations in a simple calculation model. The resulting IRR and payback times are shown in Figure 11.

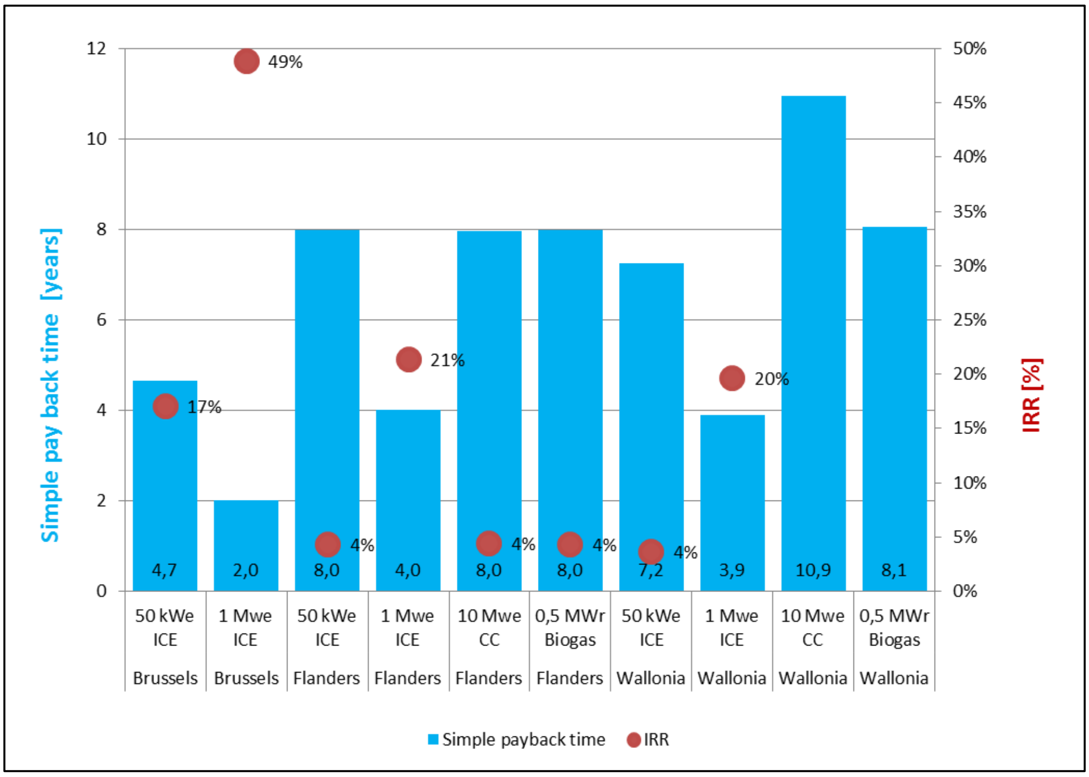


Figure 11: Pay back times and IRR for 4 reference installations[4]

The result shows that with the assumed variable and the current level of financial support, the IRR ranges between -2 and 49%, with payback times of 2 to 11 years for these average installations. In Brussels, both certificates as investment support are significantly higher than in Flanders, resulting in much lower simple payback times. The difference between the regions is in this model only the result of different support systems, which can clearly have a significant impact on the IRR and payback time.

Large industrial installations suffer from low or negative spark spreads and IRR's of even 4% are often not acceptable, especially in times of financial crisis.

1.5.6. Residential micro-CHP

The case for the residential micro-CHP is treated separately, since it is less dependent on the variables mentioned above, and since a simple payback time is generally not the determining factor for a household in its decision making process.

[4] ICE = Internal Combustion Engine, CC = Combined Cycle

It was already discussed that the relative **investment cost** (per kW installed capacity) is larger for smaller installations. In time, the price will decrease once the production increases. As a rule of thumb it can be assumed that the productions costs decrease with 20% when doubling the production (e.g. from 10.000 to 20.000 units). However at this moment the investment cost is still high (on average **15.000 €** for a 1 kW residential CHP with stirling engine and buffer tank; installed). Fuel cells are still more expensive and there is no competitive market yet.

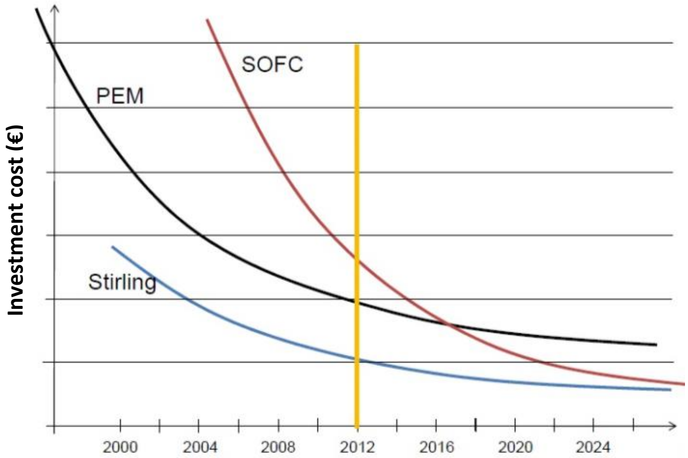


Figure 12: Estimation for decreasing investment cost

For **electricity and gas prices**, households cannot generally recover any taxes so the level of total tax levied is important. Electricity prices are above the European average resulting in a high price ratio. Of course the ratio is much higher during the daytime electricity tariff than in periods when the night rate electricity tariff applies.

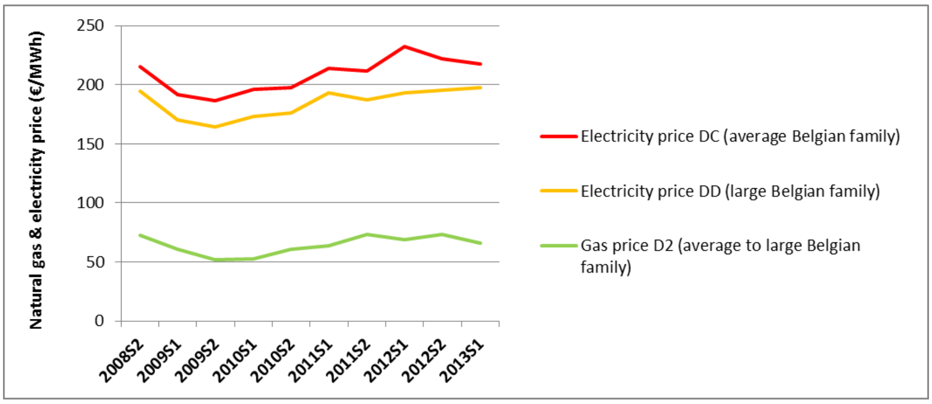


Figure 13: Electricity and gas prices for households in Belgium (source: Eurostat)[5]

For installations smaller than 10 kW (in Flanders and Wallonia) or 5 kW (in Brussels), the yearly amount of electricity produced is subtracted from the amount of electricity taken from the grid, therefore the **produced electricity is fully validated**. The amount of certificates is directly proportional to the installed capacity in Flanders, in Brussels and Wallonia it is directly proportional to the amount of avoided CO_2, while this is not the case for the investment cost. Therefore a small installation will receive a relatively **low amount of certificates** in Flanders (about 5 certificates per year at a value of 31 € yields for a 1 KW installation about 155 €/year in Flanders).

[5] Gas prices (all taxes included) for: 20 GJ < D2 < 200 GJ
Electricity prices (all taxes included) for: 2 500 kWh < DC < 5 000 kWh, 5 000 kWh < DD < 15 000 kWh
Average electricity and gas consumption for Belgium based on http://www.vreg.be/info-over-het-gemiddelde-elektriciteits-en-aardgasverbruik

In Brussels the total investment support for a 1 kW micro-CHP is 3.500 €, and the amount of certificates is about 2 per year at an average price of 82 € per certificate. In Wallonia 20 to 30% of the investment cost is refunded.

It is clear that despite the gains, the **payback time** compared to a condensing boiler will be **high**.

However households will not only base their decision only on the yearly profit, but also to their contribution to primary energy savings and CO_2 reduction and the autonomous electricity production (less dependency on electricity prices).

1.5.7. CHP economics matrix

The following matrix gives an overview on the economical situation of cogeneration in the main market segments for Belgium. For most types of installations, the investment climate is normal, with returns on investments which are acceptable for investors and no significant economic barriers for the implementation.

For residential micro-CHP the investment cost is still too high for many households. Large industrial installations with relatively low electricity prices suffer from low or negative spark spreads and IRRs which can be too low for investors.

Belgium	Micro *up to 50kWe*		Small & Medium *up to 10 MWe*		Large *more than 10 MWe*		
	NG	RES	NG	RES	NG	Coal	RES
Industry							
District heating							
Services							
Households							

Table 5: CHP economics matrix[6]

Legend:

- normal — Cogeneration Investment has good economic benefits, return on investment acceptable for the investors, interest for new investment exists; there are no significant economic barriers for the implementation.
- modest — Cogeneration Investment has modest/limited economic benefits and return on investment, limited interest for new investments.
- Poor — Cogeneration Investment has poor or negative return on investment or is not possible due to other limitations, no interest/possibilities for new investments.

[6] NG = natural gas or appropriate fossil fuel, RES = renewable energy source (wood biomass, biogas, …)

1.6 Barriers to CHP

In Belgium the most important barriers for reaching the CHP potential are: (1) the lack of (binding) targets for CHP, (2) the low spark spread, especially for large industrial installations, (3) complex and changing policies, (4) limited awareness among certain groups such as SMEs, and general misconceptions about CHP, (5) the slow start of residential micro CHP, (6) the lack of experience with district heating and (7) legal issues for the local use of electricity in common housing.

Different studies from the different regions have already identified a list of barriers. Although many of these barriers are still valid, this chapter tries to focus on the main barriers at this moment, which impede the growth of CHP in the sectors where there is still a potential for CHP for 2030, and which are important for the 3 regions. The aim of the roadmap for Belgium is to overcome these barriers and reach the potential.

1.6.1. No targets are set for CHP.

In the Belgian policy there are **no set targets for CHP**. The binding target for renewables in Belgium is set at 13% by 2020, and on top of that non-binding targets for renewables are being published and discussed, e.g. the study '*Towards 100% renewable energy in Belgium by 2050*' (FPB, ICEDD, VITO, 2013). No targets, binding or non-binding, are set for CHP. The only binding measures are the quota for CHP or green certificates that electricity suppliers have to acquire, but this is a tool for steering the certificate market and no long term target. The lack of targets for CHP increases the risk that **political choices** are rather made towards renewable solutions (covered by the targets for renewables) when they are in direct competition with CHP (e.g. solar water heaters).

1.6.2. Current spark spread is low.

Spark spreads have been declining and are historically low at this moment. This is especially true for **large industrial companies** who are facing low electricity prices, leading to low levels of investments, shutting down of gas fired CHP stations and high insecurities for the future. The result is that large scale projects, such as district heating projects, are sometimes designed without CHP, because the electricity injected to the grid has very little value. The Flemish CHP certificate system takes into account yearly changes in investment and operational costs, but does not follow changing power prices for existing installations, and it is limited to a maximum value, which is uninteresting with the current spark spread. Installations that use significant amounts of electricity on site have a more positive spark spread, but when the amount of electricity injected is uncertain, or large, this results in renouncing CHP as an option, even if there is a high and continuous heat demand.

At this moment grid operators and utilities are aware of the value of CHP for **grid stability and flexibility**, but this is not yet translated in (financial) benefits for CHP.

1.6.3. Policies and support are changing and complex, resulting in insecurity.

CHP policies and support systems are regulated on a **regional** level. This makes it very complex for investors, importers or producers who are willing to operate in the three regions, but who have to cope with 3 different legislations. Also CHP certificates are different and not exchangeable between all 3 regions (Walloon certificates can be imported in Brussels under certain conditions).

Within each region, policies and **support systems** have been changing regularly, creating more insecurity. Specific levels of support for new installations, for example for CHP certificates in Flanders, are subject to changes every year. In Wallonia it is expected that the support system will change in the future, but it is not known when or how.

This complexity and insecurity lead to a negative investment climate. In Brussels the policies are stable but the insecurity from the other regions has an certain negative influence on the investment climate.

1.6.4. Limited awareness among stakeholder groups and general misconceptions.

The awareness level among the different stakeholder groups was discussed in chapter 1.4. Compared to the European average, the level of awareness is very high in Belgium. The sectors where awareness is still lacking most are **households and SMEs.** These groups should be better informed because there is still a large potential for micro-CHP. Although many efforts have already been made (e.g. free online feasibility tools for SMEs[7], specific seminars for these stakeholder groups, … , information should be continuously disseminated.

Among other stakeholder groups awareness on the general principles of CHP technology is generally high. When awareness is still lacking, it is mostly on specific – and recent- subjects. It is important to inform all stakeholder groups on these new innovations and new roles of CHP.

What is, for example, still underrated among many stakeholders, is the **benefit of CHP for the grid** (as already partly discussed above). Many discussions are still focussing on the total amount of electricity produced from different sources. However with the changing market of decentralised production, the value of electricity will be highly dependent on the capacity of supporting the grid and offering flexibility. The role of CHP in this is not enough recognised.

This has also repercussions at policy level, for example, for 'nearly energy neutral buildings', the energy balance has to be made over the total period of one year. E.g. a house with PV and heat pump can be energy neutral in the total yearly energy balance, but can create high imbalances during the year (large electricity production in the summer, large electricity consumption in the winter).

A general misconception is the idea that fossil CHP directly competes with renewable technologies. However it should be made clear to all stakeholder groups that CHP is no energy source but a **conversion technology**, which efficiently converts valuable primary energy in heat and power. This primary energy source can be fossil or renewable.

Another important aspect, which is often overlooked, is the benefit of (fossil) CHP as a **transition technology**. Many stakeholders, for example research institutes exploring the transition towards 100% renewable energy (FPB, ICEDD, VITO, 2013), cities and communities wanting to become carbon neutral, developers planning district heating projects, NGOs and others, focus on a long term vision without fossil fuels. However, until the moment we reach this goal, efficient energy use should still be a priority. For example the most common type of residential micro-CHP (with stirling engine) has a high potential in the replacement market for renovated houses. Another sector were CHP can be an important transition technology is district heating. The potential for district heating in Belgium will have to be assessed in the framework of the EED (see further).

Finally, even though the awareness level is generally high, **new technologies and innovations** are emerging regularly, for example micro turbines, CHP combined with PCMs (phase change materials), fuel cells, fossil fired CHP coupled to CCS … Efforts should be continuously made to disseminate this information to all stakeholder groups.

1.6.5. Residential micro CHP market has known a slow start.

Different technologies for residential micro-CHP are available and despite the high potential, market entry has been slow because of different reasons:

- low **technical reliability** because of producers entering the market too early and bad adjustments of the installations (to the Belgian specifications of the electricity grid);
- incorrect implementation of CHP resulting to economic losses due to lack of experience;
- **bad adjustment** and regulation of installations as well as auxiliary burners, resulting in low electricity production or low efficiencies;

[7] http://www.energiesparen.be/node/3678

- limited experience of installers, resulting in for example heat losses from piping and buffer tanks;
- experienced technicians are required for this technology, but often micro CHP is not the core business of the people involved;
- a **limited amount of available models** on the Belgian market (at this moment only 1 or 2);
- some **negative connotation** of micro-CHP among potential users as well as some governmental institutions ;
- no investment support in Flanders and Wallonia;
- competition with other technologies;
- limited awareness;
- high investment **costs**;
- no micro-CHP has been withheld in Belgium in the conversion of the European directive 2009/28/EC for the 'minimum level of renewable energy' for new buildings, an option which has been implemented by e.g. France, Germany and Ireland; although the impact of CHP does have an effect on the energy level calculations of a building.

1.6.6. No experience with district heating.

In Belgium the interest in and awareness on district heating is increasing. Although Belgium has almost no history of district heating and there are only a few small district heating projects operational, more and more studies for potential future projects are being developed. However the process is very complex on different levels (technical, juridical, …) and the aggregated **knowledge** on this matter is **limited**.

The experience with including CHP in district heating projects is therefore also limited.

1.6.7. Legal issues for local use of electricity in common housing.

Although apartment blocks can have an interesting heat profile for CHP, it is not possible to distribute the locally produced electricity directly to the inhabitant, but only to the public spaces (e.g. elevators) of the building. The reason is that the European energy regulation on the liberalised energy market **impedes a direct dispatch of locally produced electricity** to home owners in apartment blocks. This is due to the requirement that each apartment unit has separate access to the electricity grid and that home owners can freely choose their energy supplier.

When a CHP installation produces electricity in an apartment block, most of the electricity will never see the grid, but will be used onsite, within the building. This local use means a lower amount of electricity being drawn from the grid, entailing lower transport and distribution losses and a general ease on the grid load. However, as the installation has to be connected to the grid via a separate electricity meter, it appears as if all electricity is injected into the grid. This means the CHP owner (collective of apartment home owners) doesn't receive a bonus for the locally used electricity, whereas he would if both CHP and electricity users were to be installed behind a single grid access point. Therefore most of the electricity will virtually pass through the grid, which induces extra costs (grid costs and taxes) and therefore provides very little financial benefit. Due this fact CHP is not financial feasible.

To compensate this lack of financial benefit, the Brussels Region has put in place an extra support by giving more certificates (2 times more for CHP <50 KW and 1,5 times more for CHP>50 KW). In Wallonia it is possible for a producer to sell the electricity to specific customers. However this system is rarely being used.

2 What is possible? Cogeneration potential and market opportunities

Although there are no recent potential studies for CHP in Belgium, existing studies estimate the total potential for Belgium for 2020 to be 3203 MWe. This is an increase of 25% compared to the installed capacity in 2012. The highest growth is expected in the market segment of micro CHP, both residential as larger (up to 50 kW). The conservation of the existing installed capacity and the expansion towards the potential are important for Belgium since they can realise a primary energy saving of between 18,7 and 22,9 TWh per year and a CO_2 saving of between 2,3 and 8,1 million tons per year in 2030.

2.1 Potentials and market opportunities

2.1.1. Potential studies for Belgium

Energetic potential study

An **energetic potential study** was made for Belgium in **1997** (VITO, 1997); all later studies were based on this energetic potential.

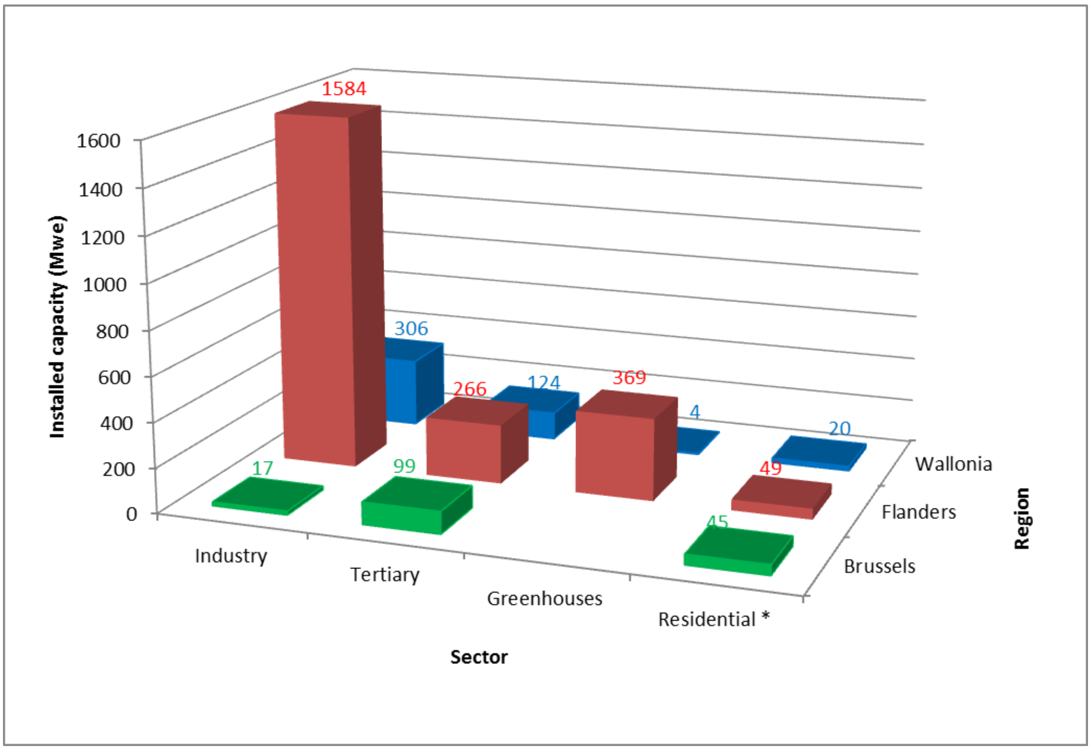


Figure 14: Total energetic potential for the three regions and four sectors in Belgium (VITO, 1997).

*** residential: only apartments are considered**

The potential that was calculated is the 'energetic potential' for CHP, and these figures show the basic potential for Belgium based on the maximum heat production by CHP. Remark that only installations > 85 kW are considered in this study! The total energetic potential for Belgium was estimated at **2883 MWe**, of which 66% in industry, 17% in the tertiary sector, 13% in the agricultural sector (greenhouses) and 4% in the residential sector (only apartments). 6% of the potential was situated within Brussels, 79% within Flanders and 16% within Wallonia (Figure 14).

In total 60% of the potential could be realized with gas turbines and 40% with engines.

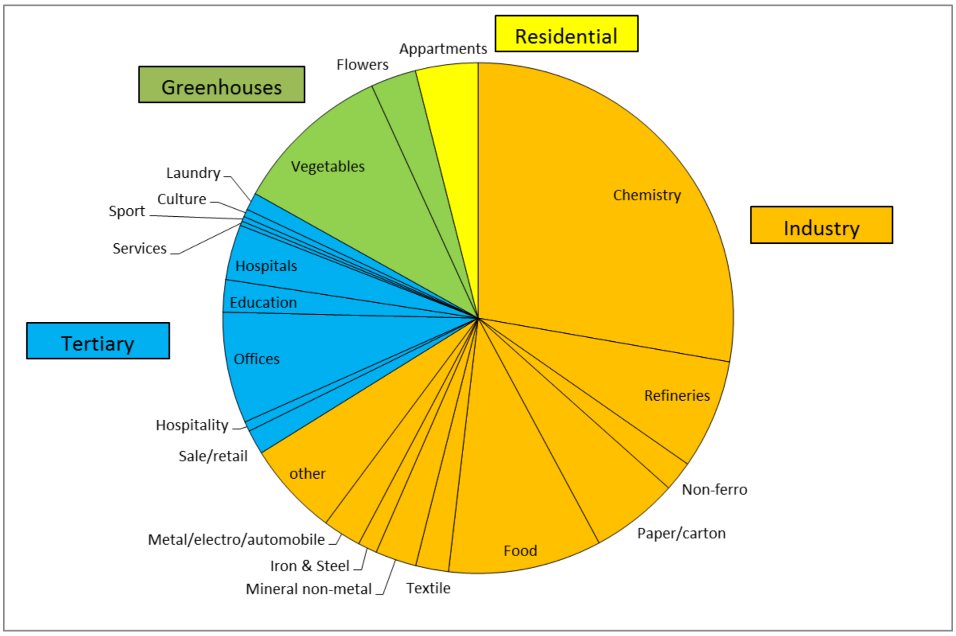


Figure 15: Division of the energetic potential for Belgium among (sub)sectors (VITO, 1997).

Micro CHP potential study

In the CODE2 micro-CHP potential study, the total potential for micro CHP in Belgium is estimated. The goal of this study is to evaluate reasonable uptake scenarios and thus the implementation potential, not the theoretical maximum potential.

The study takes into account two types of micro-CHP:

- Household/residential micro-CHP (0,1-5 kWe)
- SME & collective micro-CHP (> 5-50 kWe)

Micro-CHP is primarily seen as a replacement product in the domestic heating market, whereas for the SME & collective sector micro-CHP is seen as an add-on on the existing heating system. The uptake scenarios and specific penetration rate are based on the 2013 boiler market and its projections and an evaluation and weighing of market alternatives, economic analysis, legislative environment, awareness among stakeholders and purchasing power (only for the household sector). Three scenarios are calculated: maximum potential, expected potential and low expectations. More information can be found in 'Annex 2: Micro CHP potential assessment' and on the CODE2 website.

Following table gives the expected potential for micro-CHP in Belgium. Since the capacity is 1,2 kWe for a household CHP, and 12 kWe for a SME/collective CHP[8], the expected total installed capacity for 2020 and 2030 can be calculated (Table 6).

		2020	2030
Number of installations	Residential micro CHP	8100	376000
	SME & collective micro-CHP	15700	71300
Installed capacity (MWe)	Residential micro CHP	10	451
	SME & collective micro-CHP	188	856

[8] Based on certified installations in Flanders in 2012 (www.VREG.be).

Table 6: Potential for micro CHP in Belgium

2.1.2. Potential for Brussels-Capital Region

The Belgian potential study (VITO, 1997) estimated the energetic potential for Brussels at 161 MWe. A revision of this study (ICEDD, 2006) estimated the additional economic potential at 123 MWe; added to the existing capacity this gives a total energetic potential of 138,5 MWe (without micro CHP) (see division among sectors in Figure 16). A new study (Brugel, 2011) estimated the energetic potential for 1 kW micro CHP of 12.276 in 2020; representing 12 MW. This takes into account that the technology, price, know-how and market information will be well developed, like the boiler market today. The total economic potential for bio-CHP (based on rapeseed oil) was estimated at 43 MW. However, because of the actual cost of rapeseed oil, this scenario is not considered any more.

The same study estimated the total economic potential in three scenarios: BAU, intermediate scenario (with an extensive awareness campaign) and ambitious scenario (with the scope of reaching the 13% renewable energy production by 2020). It was estimated that the intermediate scenario could be reached by 2020 while the ambitious scenario is taken as the target for 2025 for Brussels. As shown in Table 7, the total economic potential is 118 MWe including residential micro-CHP **(111 MWe** without residential micro-CHP) and including existing capacity.

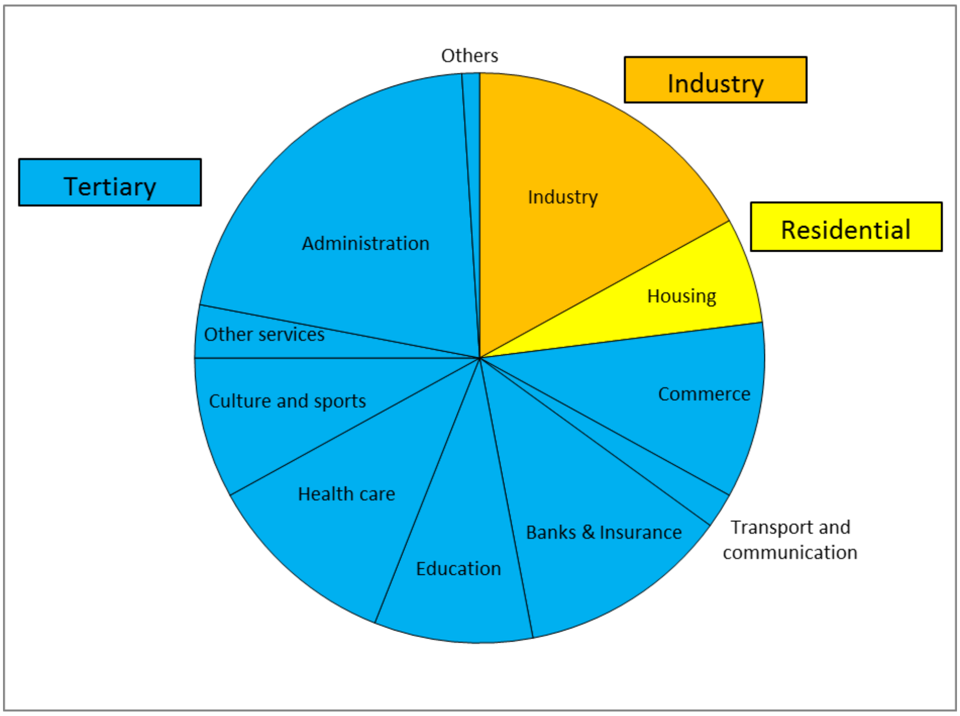


Figure 16: Division of the potential for electricity production for Brussels among (sub)sectors (ICEDD, 2006).

	Intermediate scenario (2020)		Ambitious scenario (2025)	
	number of installations	installed capacity (MWe)	number of installations	installed capacity (MWe)
Fossil CHP	9785	117 (of which 7 micro)	12737	172 (of which 9 micro)
Bio CHP (biogas)	1	1	1	1
Total	9786	118	12738	173

Table 7: Economic potential study for Brussels (Brugel, 2011).

2.1.3. Potential for Flemish Region

In 2009 a study was made by VITO (Flemish Institute of Technological Development) on the potential for renewable energy and CHP towards 2020 (VITO, 2009). The study is based on two scenarios: the 'Business as usual' (BAU) and the PRO, based on a pro-active policy. This study was made within the context of the European directive 2009/28 which obligates Belgium to reach a target of 13% renewables in 2020 (see chapter 1.2).

The prognoses are a series of economic potentials which are valid for a certain year between 2010 and 2020. They are based on production data of green electricity or heat/cold and a consumption rate of biofuels.

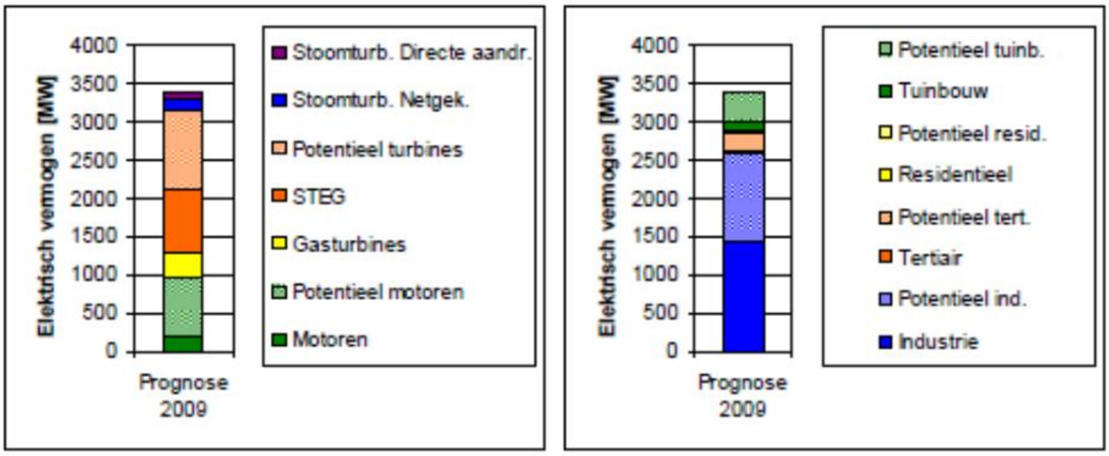


Figure 17: Technical potential for CHP in Flanders per technology and per sector (VITO, 2009). [9]

The total energetic potential, which was estimated for Flanders in the previous study (VITO, 1997) at 2268 MWe, was recalculated and estimated at 3400 MWe (Figure 17). Remark: micro-CHP is still not taken into account (only installations > 85 kW are considered). In the BAU scenario, 2000 MWe is assumed to be realised by 2020; in the PRO scenario this is 3000 MWe.

The study recognises that a growth in this sector is only possible with adequate financial support.

These numbers have been revised in 2011 (VITO, 2011) and in the revised PRO scenario the potential for 2020 is estimated at **2414 MWe**. Within this potential, the highest installed capacity (1485 MWe) can be obtained with turbines (Figure 18). It can be noted that the potential for green ORC is at this moment estimated lower. Within the different sectors the highest growth between 2010 and 2020 is expected in the industry and agricultural sector (about 150 MWe each), but the highest relative growth is expected in the tertiary sector. The potential in the residential sector (non-micro) in this study is much lower than in the original study from 1997 (Figure 14), which was mainly based on the technical potential but too optimistic if we take the current economic potential into account.

A potential study for residential CHP estimated that about 300.000 to 600.000 houses in Flanders have the potential for installing a residential micro-CHP (VITO, 2009), resulting in 300 to 600 MW.

[9] Electrical capacity per technology (steam turbines with direct drive; steam turbines with grid coupling, potential for turbines, CCGT, gas turbines, potential for engines, engines) and per sector (potential for horticulture, horticulture, potential residential, residential, potential tertiary, tertiary, potential industry, industry). ,

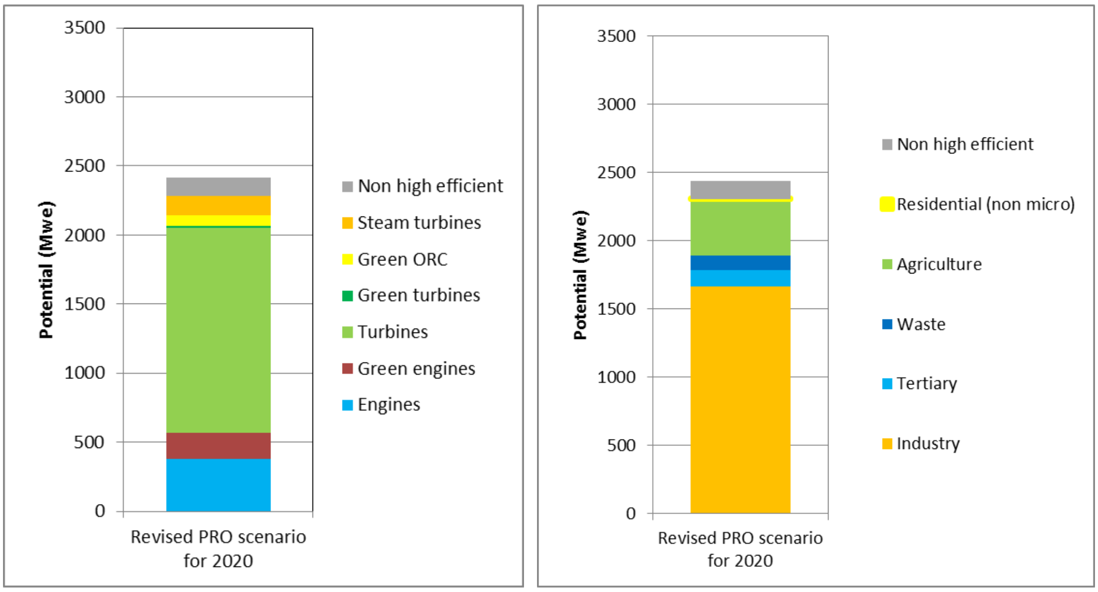


Figure 18: Flemish CHP potential in the revised PRO scenario for 2020 (VITO, 2011).

2.1.4. Potential for Walloon Region

The Belgian potential study (VITO, 1997) estimated the energetic potential for Wallonia at 454 MWe.

The economic potential for fossil CHP in 2020 was calculated (ICEDD, 2007), taking into account the increase in the price of equipment and energy prices. Another important factor to determine the economic potential is the support through green certificates. Based on the minimum price guaranteed by the Walloon Region on one hand, and the maximum price corresponding to the amount of penalty for the suppliers on the other hand, two economic potentials were calculated: respectively the pragmatic potential for 2020 (253 MWe) and the proactive potential (291 MWe) (ICEDD, 2009).

Additionally, the potential in the residential sector is estimated at 200,000 units of 1 kWe, thus an additional capacity of 200 MWe (ICEDD, 2009).

In the same study (ICEDD, 2009) the potential for bio-CHP for 2020 is estimated at about 200 MWe. In this study the potential for wood fired CHP is based on the total availability of local resources of wood.

The results of these studies are summarised in Table 8.

	Electricity	Heat	Total	Installed capacity
	GWh	GWh	GWh	MWel
Fossil CHP (non micro)	1626	1928	3554	253
Micro (1 kW)	600	1272	1872	200
Biomass	800	1350	2150	100
Biogas	375	500	875	94
Waste incineration	90			11
Total	3491	5050	8451	**658**

Table 8: Economic potential studies for 2020 in Wallonia.

The total economic potential for Wallonia in these studies is in total estimated at **658 MWe**.

It can be seen that these studies are **not very ambitious** for the larger fossil CHP. At this moment the total installed capacity in Wallonia is already 503 MWe.

2.1.5. Market opportunities

Between now and 2030 the CHP sector should pay special attention to following market segments.

Residential micro CHP

The residential micro-CHP has slowly entered the Belgian market. Although different **technologies** are being developed (internal combusition engine, stirling engine, micro-ORC, micro-turbine, micro steam machine and fuel cell), the stirling engine is probably the technology which is the most mature in the market.

Because this technology has a relatively low electricity production and high heat production, it is ideally suitable for the replacement market. For example in 2012 about 50.000 new houses were built in Belgium (Statistics Belgium, 2013). Because this is about 1,2% of the housing stock, it would take 85 years to completely replace all houses. Therefore the potential for residential micro-CHP in less isolated older houses is high.

Although the potential market is large, it was not yet exploited, due to a difficult market entry of malfunctioning technologies, a limited amount of available models, the removal of investment support in Flanders and the competition with other technologies. Even with the investment support in Brussels and Wallonia it was not a success. The limited market entry and the negative connotation have resulted in the withdrawal of a possible investment support from the private sector.

Recently fuel cells have entered the Belgian market. Because of their high electric efficiencies and limited heat production, they are an interesting solution for low energy buildings. However the high investment cost is currently the limiting factor.
Still, the total potential for residential micro-CHP in Belgium is large.

Micro CHP for SMEs

In Belgium a large potential still exists in CHP for SME's. These companies are becoming more and more interested in investing in energy efficiency, in reducing CO_2 emissions and in lowering the electricity bill. Many specific sectors have an interesting heat profile for CHP, e.g. car washes, nurseries, hotels, … However, although a high potential exists in these sectors, this is until now hardly filled in. Therefore there are still many market opportunities in this sector.

Bio CHP

There are two reasons why there is a guaranteed future for bio-CHP in Belgium:

1. Policy visions as well as public opinion are highly focussing on renewables.
2. Current potential studies mainly focussed on locally produced renewables for CHP. However with important international ports such as Antwerp, there is also a high potential for sustainable produced imported biomass.

In Flanders, Bio CHP is taking up a relatively small fraction of the total installed CHP power, whereas in Wallonia, the opposite is true.

An important fraction of bio CHP in Flanders is connected to **anaerobic digestion** of manure and organic waste. The CHP heat is mainly being used in drying processes, drying the digestate for easy transport and export. Reason for this is a strict legislation on what can be spread over farming land. The additional potential of anaerobic co-digestion (manure in combination with food or feed waste streams), however, is relatively limited, due to the low availability of input co-waste streams. A certain potential can still be found in **small scale** digestion, where locally produced manure is digested on a farm scale level. Other potential for (dry) digestion can be found in the organic waste streams from households (garden waste, vegetable and green waste) currently being composted but in near future predigested producing biogas and afterwards composted.

Apart from digestion, an important potential for bio CHP can be found in **green electricity production from biomass**. Right now, this kind of installations are purely oriented towards electricity production, because of different reasons: (1) the high support level for green electricity production, (2) no support for a limited heat recovery or lower financial support for installations working in CHP modus, due to the high quality restriction for the CHP-certificates which can't be met by a bio-CHP and (3) the lack of continuous users of large amounts of low quality heat, e.g. district heating projects. However, it bears a potential for large primary energy savings through CHP.

Finally, some new evolutions seem to indicate (the possibility of) a **greener gas grid** as well. Biogas, resulting from the abovementioned anaerobic digestion, can be purified into methane and injected into an existing natural gas grid. In a future scenario with high penetration of renewables, surplus electricity (e.g. high wind and solar availability) can be converted into H_2 and/or CH_4, and injected into the gas grid as well. When the natural gas grid becomes more 'green', classic CHP units connected to the grid can evolve to bio-CHP as well.

CHP in district heating

The utilization of waste heat is energetically the most interesting option for district heating. Where waste heat is absent or insufficient, or when it is expected to be available only in the long term, high-efficiency CHP could be an interesting addition.

Especially when green heat is considered in these district heating projects, CHP is the most interesting option. Indeed, the **direct application of valuable biomass** for the single production of **low temperature heat** (and therefore per definition low-grade heat) directly opposes the principles of a sustainable energy policy.

Although there is little experience with district heating in Belgium, many incentives are made and initiatives are taken at this moment. In Flanders a resolution for the development of district heating has recently been adopted. Many cities and provinces are also exploring the possibilities for district heating.

In the Brussels Capital Region, earlier studies have raised questions around the financial feasibility of such bio-CHP feed district heating networks. Further researches will be carried out with the work relating to the preparation of the comprehensive assessment expected by the European Commission no later than 31/12/2015 (implementation of the EED).

Industry and tertiary sectors

According to the energetic potential study for Belgium (2.1.1), the main potential for CHP within the industrial sector is expected in following areas: 50% within **chemistry and refineries**, 15% in the food sector, 8% in the paper/cardboard sector and the remaining within other subsectors.

Within the tertiary sector, 40% of the potential is expected from **office buildings**, 20% from hospitals, 12% from education and the remaining within other subsectors.

Within the sale/retail sector, it is expected that large warehouses or shopping malls have a high potential for CHP.

2.2 Total CHP potential for Belgium

Based on following assumptions the total potential for CHP in Belgium for 2020 and 2030 is summarized in following graph.

- The potential for micro CHP in Belgium, that has been estimated within the CODE2 project (see Table 6), is used for the residential and SME/collective potential estimation. The data are in the same order of magnitude as the residential micro-CHP studies made in the three regions.
- For Brussels the intermediate scenario is used to estimate the total potential for 2020, and the ambitious scenario is, as an estimation, taken for 2030 (see Table 7). The division among sectors is taken from Figure 16.
- For Flanders the revised PRO scenario for 2020 is used (Figure 18), without taking into account non-high efficient CHP.
- For Flanders, there is no estimate for the potential for 2030. As a rough estimate, the total energetic potential of Figure 14 is used, with the same division among the sectors as the PRO scenario of 2020.
- According to the existing potential studies for Wallonia, no growth is expected in the industrial and agricultural sector. It is assumed that for the other market segments, the estimated energetic potential of Figure 14 can be reached in 2030, with half of the growth in 2020.
- No potential for CHP based district heating is yet taken into account. This will be evaluated with the implementation of the EED.

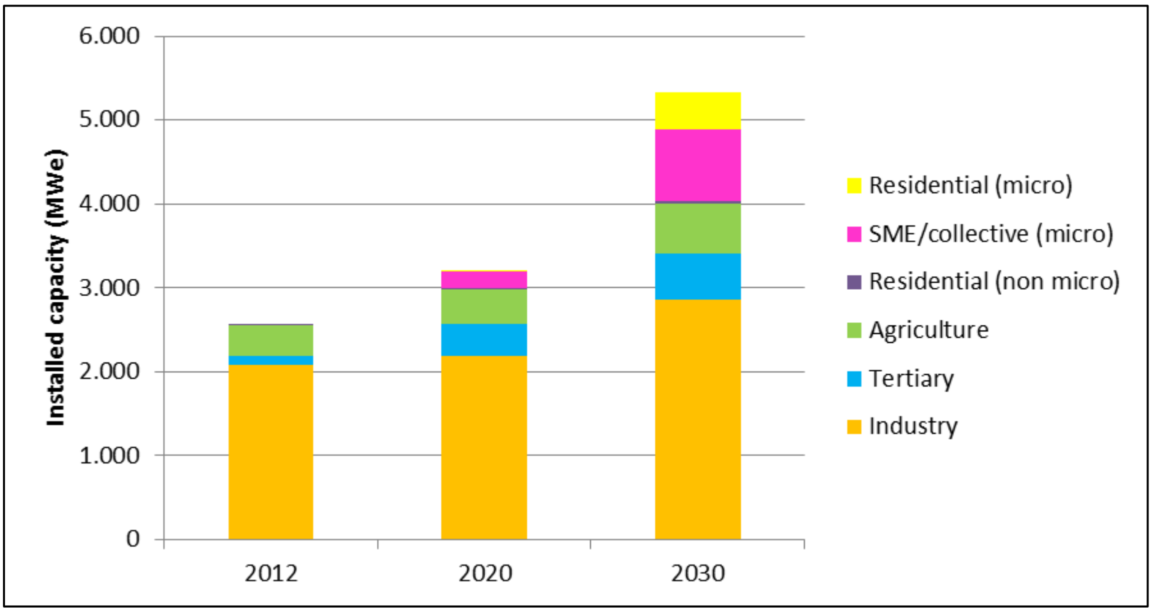


Figure 19: Total CHP potential for 2020 and 2030.

The total potential for Belgium for 2020, based on different existing studies, is estimated **at 3203 MWe**. The total potential for Belgium for 2030, based on a few studies and the estimated energetic potential, is optimistically estimated at 5336 MWe.

However these potentials can only be reached if the several actions in favour of CHP are being taken. These actions are discussed in the next chapter: the **roadmap** for Belgium.

2.3 Saving of primary energy and CO_2 emissions by the CHP roadmap

Primary energy saving (PES) and CO_2 emissions saving projections resulting from increased use of CHP require assumptions about not just what types of fuel and technology are displaced, but also their operation on the market. Within CODE2 two approaches are developed. These represent two different analytic considerations which are summarised here and more fully explored in Annexe 4.

2.3.1. Methodology according to Annexes I and II of the EED.

This method is used at a member state level today for national reporting to the European Commission and at project level for determining if a specific CHP plant is highly efficient. In the methodology, the efficiency of each cogeneration unit is derived by comparing its actual operating performance data with the best available technology for separate production of heat and electricity on the same fuel in the market in the year of construction of the cogeneration unit using harmonized reference values which are determined by fuel type and year of construction.

2.3.2. Substitution method.

This method has been developed within the project and estimates the amounts of electricity, heat and fuel which are actually replaced by additional new CHP based on a projection of the supply base changes in the member state supply over the period are calculated. The situation in 2030 is compared to the current status. Two scenarios were calculated based on the fuel input for new CHP: a low case scenario, where the share of renewable CHP in 2030 remains constant compared to 2010, and a high case scenario where the fuel share of renewable CHP increases from 14% in 2010 to 25% in 2030. This higher renewable fuel share was calculated in the bio CHP potential study (see annex 3).

The actual saving is particularly dependent on the efficiency increase through upgrading both current power plant and CHP technology efficiencies. The CO_2 reduction achieved is due to both higher energy efficiency and fuel switching towards low carbon (natural gas) or non-carbon (bio energy) fuel, but CHP development and fuel switching are anticipated to be an integrated process driven by policy objectives.

2.3.3. Results

Primary energy savings for Belgium through implementing the roadmap for CHP is estimated to be between 18,7 and 22,9 TWh per year and CO_2 savings are estimated to be between 2,3 and 8,1 million tons per year in 2030.

	Substitution method				EED method			
	low case		high case		low case		high case	
PE saving	22,7	TWh/a	22,9	TWh/a	18,7	TWh/a	21,1	TWh/a
CO_2 saving	6,7	Mio t/a	8,1	Mio t/a	2,7	Mio t/a	2,3	Mio t/a
- per kWh el[10]	0,61	kg/kWh el	0,73	kg/kWh el	0,24	kg/kWh el	0,21	kg/kWh el

Table 9: Saving of primary energy and CO_2 by the Belgian CHP roadmap

[10] This value represents the CO_2 reduction of the power generation. It includes the avoided CO_2 emissions from fuel savings for separate heat generation in boilers; it must not be confused with the considerably lower CO_2 emissions of the substituted condensation electricity or with even lower emissions of compared power production according to the BAT approach in accordance with the EU CHP directive reference values.

3 How do we arrive there? The Roadmap

3.1 Preliminary remarks

This chapter is based on the facts and figures presented in the previous chapters, particularly on the most important barriers for CHP (see chapter 1.6). The proposals have been, and are still being, developed in discussion with different stakeholders and experts.

It aims at realising the potential for CHP (see 2.2 Total CHP potential for Belgium), under the wider framework of the following common goals and actions:

- maximizing overall fuel efficiency, measured as primary energy saving compared to BAT;
- energy supply safety, complementarity to fluctuating RES (wind & solar);
- economics and political feasibility.

A combination of the main actions, summarised on the next page, is considered necessary to overcome the existing barriers, and to create a framework for action in order to achieve the Belgian CHP potential. The concrete roadmap steps will be described at the end of this chapter.

Main actions to reach the Belgian CHP potential for 2030:

1 **Take continuous as well as specific actions at policy level.**

- *There should be a continuous dialogue between the policy level and the CHP sector to keep the role of CHP in a continuously evolving energy scene up to date.*
- *(Binding) CHP targets should be set at national and regional level, in order to have stronger foundations for the implementation of the EED, and to stimulate incentives towards CHP.*
- *Elaborating further on the positive initiatives adopted in the Brussels Capital Region, a correct remuneration should be introduced for the advantages of decentralized production and to solve the legal problems of local consumption of electricity in common housing projects.*

2 **Expand the operational field of the CHP associations.**

- *Three regional CHP associations should be formed with the support of the CHP sector and the regional government in order to actively create opportunities for CHP and ensure the best implementation of high efficiency CHP in Brussels, Flanders and Wallonia.*
- *Cross-regional cooperation and exchange of CHP associations would be beneficial for all CHP stakeholders operational at regional and national level.*

3 **Provide an efficient, effective and stable financial support system.**

- *Existing support systems should be stable and earlier investment decisions should be respected, thus maintaining a stable investment climate.*
- *An investment support can be necessary to support the start-up of emerging technologies.*

4 **Improve research and dissemination activities**

- *Strong coalitions should be formed between stakeholder organizations to combine knowledge and expertise and conduct research on the existing knowledge gaps of CHP.*
- *Propagation of expert knowledge matching the actual needs and dissemination of research results are crucial in keeping the CHP sector and stakeholders up to date and informed.*

5 **Develop CHP based district heating**

- *When planning district heating plans, legislation, support or projects, the temporary or long term role of CHP should be taken into account.*

6 **Involve CHP in smart grids, demand response and virtual power plants**

- *All stakeholders such as producers, grid operators, smart grid networks, owners of CHP installations, … should be prepared and ready to operate in a smart way in order to take full advantage of the benefits of CHP for direct use of the produced electricity or flexible production.*
- *The role of CHP in maximizing grid efficiency and balancing should be validated with incentives, as imposed by the European EED.*

7 **Strengthen the position of bio-CHP.**

- *Research institutes should be stimulated to continue the exploration of new possibilities for bio CHP such as small scale anaerobic digestion and injection of bio-methane in the gas grid.*
- *Legislation in the three regions should promote the production of green electricity from biomass and the injection of green gas into the grid.*

8 **Launch residential micro-CHP**

- *The whole production and market chain should make an effort to kick-start the implementation of residential micro CHP in Belgium.*
- *A better position of CHP in building regulations would support the implementation of residential micro-CHP.*

9 **Increase the general and specific level of awareness.**

- *The general level of awareness on CHP will be further enhanced by disseminating information and knowledge, promotion campaigns and providing education and training, as required by the EED.*
- *Specific groups such as SMEs and households which have a high potential for CHP but a low level of awareness should be specifically addressed.*
- *Uncertainties and insecurities for possible interested stakeholders should be cleared by continuous up-to-date awareness actions.*

3.2 Overcoming existing barriers and creating a framework for action

3.2.1. Take continuous as well as specific actions at policy level.

Several of the barriers can be overcome by political decisions. In Belgium there is a relatively good understanding between the CHP associations, the CHP stakeholders and the political institutions. By maintaining this good relationship and through good communication and consultation we can overcome these barriers.

There should be a continuous dialogue between the policy level and the CHP sector to keep the role of CHP in a continuously evolving energy scene up to date.

The government should keep realising that CHP has an important role to play in the energy policy, in the framework of increasing energy-independency, decreasing emissions through efficient implementation of our scarce energy resources and through its contribution to a healthy economic climate with lower energy costs and therefore lower production costs.

With the recent evolving energy landscape, the role and the advantage of cogeneration is continuously changing. Technologies and possibilities of CHP are also evolving rapidly. Therefore the dialogue between stakeholders and policy makers should be maintained continuously to keep the message of CHP up to date.

For example when elections are being held, political parties are deciding about the focus points in their election programmes (e.g. the regional, federal and European elections in 2014). It is therefore important that the concerns from the CHP sector are sent to the different political parties at this moment, and that once the new government has been elected, a memorandum will be handed over.

Although most policy actions will have to be taken at regional level, CHP stakeholders from the three regions have many concerns in common. By exchanging points of view and lining up on certain matters the message will be stronger.

It is important that all stakeholders from the CHP sector keep this message alive. More specifically, CHP associations can facilitate the discussion and the propagation of information between policy and stakeholders in the two directions, either continuously (regular platform meetings) or in case of specific events (e.g. changing legacy). In Flanders this might be easier since a CHP association is operational which actively carries out this role, while in Brussels and Wallonia there is still room for a better dialogue between the sector and the policy makers.

(Binding) CHP targets should be set at national and regional level, in order to have stronger foundations for the implementation of the EED, and to stimulate incentives towards CHP.

There are no binding targets, and even no non-binding scopes for CHP. However, Article 3 of the European Energy Efficiency Directive (EED) states that each member state has to set indicative energy efficiency targets. As cogeneration will be an important part of the EED, a vision should be developed on how cogeneration will contribute to Belgian energy efficiency targets. If the Commission decides to make this a binding target, Belgium will be obliged to meet these requirements.

Therefore, it is time for CHP targets being set in Belgium, both on national and regional level, and for the development of a consistent framework to achieve these objectives.

Elaborating further on the positive initiatives adopted in the Brussels Capital Region, a correct remuneration should be introduced for the advantages of decentralized production and to solve the legal problems of local consumption of electricity in common housing projects.

At this moment, injection of electricity in the grid can only result in injection *fees* (costs*)*. Local production of electricity, however, can result in lower operation costs for the grid as well. These grid advantages should give rise to an injection remuneration.

Especially in common housing (apartment blocks) projects, where most of the produced electricity from CHP will be used locally, a lower amount of electricity is drawn from the grid, entailing lower transport and distribution losses and a general ease on the grid load. However, as the installation has to be connected to the grid via a separate electricity meter, it appears as if all electricity is injected into the grid. This means the CHP owner (collective of apartment home owners) doesn't receive a bonus for the locally used electricity, whereas he would if both CHP and electricity users were to be installed behind a single grid access point. This can be solved (partly) by a correct recompense for the benefits local production brings about on the grid level in these situations.

To compensate this lack of financial benefit in common housing projects, the Brussels Region has put in place an extra support by giving more certificates (twice more for CHP <50 KW and 1,5 times more for CHP>50 KW).

3.2.2. Expand the operational field of the CHP associations.

CHP associations play an important communication and consultation role for both the CHP stakeholders and the government. They also unite the stakeholders to have a stronger voice in the energy debate. In Belgium this is extra challenging because energy regulations are made on a regional level, therefore a CHP association for each region is desirable.

Three regional CHP associations should be formed with the support of the CHP sector and the regional government in order to actively create opportunities for CHP and ensure the best implementation of high efficiency CHP in Brussels, Flanders and Wallonia.

At this moment there is one COGEN association in Flanders representing the specific requirements of the CHP sector in that region, while the association in Wallonia (COGEN Sud) is currently not active.

In Brussels and Wallonia, instead of an association, support is given through a 'CHP facilitator'. These are 'private or associated experts in specific fields of competence, who have the task to advise any institution, company, investor… wanting to improve the energy performance of their facilities'.

Although these experts respond to all the questions from the stakeholders, they undertake no lobby actions.. For example there is no regular platform involving CHP stakeholders and policy makers.

If the CHP sector in the Brussels and Walloon region wants to join and combine forces and knowledge, to actively create more opportunities for CHP, it should plea for a more active role of a CHP association with the necessary resources. However if there is no demand from the sector, chance are small that any action from the policy level or the existing institutions will be undertaken.

Once a CHP association has been established, as is already the case in Flanders, CHP stakeholders should continue to combine their strength and knowledge in this association and thus create a platform for discussion, a centre for expertise in existing and new CHP tasks and technologies, a networking organ and a project partner in promotion, awareness building and information gathering and dissemination. The association should also facilitate the tasks of the (regional) governments by collecting and summarising stakeholder concerns, disseminating policy messages, objectively collecting technical and market information and research results and organising consultations. In order to take up these tasks and in order to promote the best and most optimal implementation of high efficiency CHP, the associations could be financially supported by the regional government.

Cross-regional cooperation and exchange of CHP associations would be beneficial for all CHP stakeholders operational at regional and national level.

Although CHP policy is regulated mainly at the regional level, markets are operational across the regions. All regions would benefit from a closer cooperation and exchange between stakeholders and policy makers. This can be facilitated by a closer cooperation between the future CHP associations, or at this moment, the Flemish CHP association and the Brussels and Walloon facilitator.

Benefits include among others:

- to provide clarity towards CHP stakeholders on national level, e.g. clarity on the different regional support systems or environmental standards for investors;
- to reduce costs and efforts, e.g. membership fees of other sector organisations or representations of the sector on seminars;
- to improve communication at European level, e.g. reporting of statistics of Member States;
- to improve the implementation of the CHP related aspects of the EED.

3.2.3. Provide an efficient, effective and stable financial support system.

European Member States are required to adopt policies which encourage reaching the cogeneration potential, as defined by article 14 of the EED. Belgium will have to carry out a comprehensive assessment of the potential for high-efficiency cogeneration based on a cost-benefit analysis which identifies the most resource- and cost-efficient solutions for heating and cooling needs. When the cost-benefit analysis is positive, Belgium will have to take adequate measures to accommodate the development of high-efficiency cogeneration or any other relevant heating and cooling solution.

Financial support for a technology that realises external benefits can be given for different reasons:

1 to become market competitive (e.g. through benefits of scale). This type of support should eventually be phased out;

2 to create a level playing field. This type of support should globally be lower than the external benefits that are realised. It can also have a cyclic character and be higher in those periods where it is necessary (e.g. low spark spread), in order to avoid bad long term choices such as choosing for conventional instead of sustainable energy production.

It is important, however, that support mechanisms have the smallest possible effect on the normal operation of energy markets. A lot of support mechanisms in European member states reduce the marginal costs for renewable energy production, leading to a decrease of electricity prices. This in turn increases the support required for a profitable operation of these technologies.

Finally, with respect to support mechanisms, it is important that government decisions are well advised and calculated, and that the effect on other technologies is taken into account. A technology receiving support can push another technology without support out of the market. These effects have to be evaluated.

Existing support systems should be stable and earlier investment decisions should be respected, thus maintaining a stable investment climate.

An example of the second type of support is the certificate based system. This system has been developed and adapted, keeping in mind the concerns of the stakeholders. Although there are still some specific points that have to be addressed in the different regional certificate systems, it is important at this moment to create a stable investment climate. Earlier investment decisions are to be respected, and the policy is not to be adjusted retroactively to the detriment of the investor. Secondly, it is necessary to keep an eye on existing systems. Upon reaching the end of the initial support period, these installation might be confronted with an operational loss and be shut down. An adapted support level can ensure these systems remain operational.

Policy makers should keep close track of the evolutions and problems related to the support system.

It should be ensured that support mechanisms have no disruptive effect on the electricity market . If support mechanisms cause electricity prices to fall, this could cause a higher need for support in new projects. The overall aim should be a well-functioning market with stable and proper electricity prices. This can be achieved for example through a more flexible allocation of support. Also, an effective emissions trading system would benefit CHP, with minimum prices for CO_2. Higher CO_2 prices are favourable for CHP, since they stimulate higher efficiencies. It could therefore be an option to increase CO_2 taxes at a federal or regional level, and to grant exceptions for CHP.

A stable framework should therefore also be pursued at European level. For example, the price of electricity is no longer a national issue, but is an international parameter due to the linked markets. Policy actions in neighboring countries also affect the market in Belgium, implying that here is a need for mutual alignment.

At this moment it is important that the support system takes into account investment decisions which are made in the long term and are highly dependent on fluctuating electricity prices, as is the case in large industrial CHP installations. It is important to keep these projects viable.

An investment support is necessary to support the start-up of emerging technologies.

The first type of support is necessary when new technologies emerge which are still expensive, such as residential micro-CHP or fuel cells. The capacity of an individual installation is so low that financial benefits from certificates are negligible. Investment support for this type of technology, like for example in the Brussels region, is more beneficial.

Specific for micro-CHP, several articles in the EED support the growth in this sector. The EED recommends financing for research, demonstration and accelerated introduction of the technology and optimization of the grid connection.

The financial support can be given by the regional governments if they want to validate the external benefits of residential micro-CHP or by the energy sector if they wants to support the start-up of new technologies. This investment support can eventually be phased out once the technology has become market competitive.

In order to overcome the reluctance of the government or the energy sector to support these systems, they should be well informed of the benefits and advantages of these installations, and of the actual performances, efficiencies and energy saving potential. If necessary more research or objective field trials should be conducted (see further).

3.2.4. Improve research and dissemination activities.

CHP is subject to many innovations, not only in new technologies but also in the role it is playing in energy storage, grid balancing, demand response, district heating …

Enough resources are therefore needed to facilitate these developments and conduct the necessary research. These resources can come from within industry, certainly for technological innovations, or from general funding for more basic research. These funds exist already, but are not being exploited for CHP-related research.

Strong coalitions should be formed between stakeholder organizations to combine knowledge and expertise and conduct research on the existing knowledge gaps of CHP.

Once the precise scope of the research has been defined, coalitions can be formed between the CHP associations mutually and between the CHP associations and other organisations or persons. These associations have the advantage of combining different fields of expertise necessary for the research: different topics as well as different abilities (technical fieldwork, calculations, innovative research, supervising bachelor's or master's theses, …).

The organisations can be other umbrella organisations (SME, smart grid, district heating …), universities or colleges, research institutes or engineering or consulting agencies. CHP associations can play a leading role in this, or they can establish a good working relationship with these other organisations, and clarify that CHP should be taken into account when launching project proposals.

These coalitions can apply for existing grants, or present their research goals to the authorities or industry and request specific research funds.

Propagation of expert knowledge matching the actual needs and dissemination of research results are crucial in keeping the CHP sector and stakeholders up to date and informed.

When CHP stakeholders are involved in research projects, the results should be disseminated among interested parties. CHP associations can play the role of knowledge centre, collecting and disseminating the relevant information.

Workshops can be organised, aimed at specific target groups, and successful projects can be highlighted in informative case studies.

Moreover, continuous dissemination of existing expertise and new knowledge through basic courses, lessons in universities and colleges, specific training classes and seminars should be stimulated in the three regions.

3.2.5. Develop CHP based district heating.

Under the EED, Belgium has an opportunity to develop and test concepts of district heating under the heating and cooling plan of Article 14. The obligation for identifying the potential for efficient district heating should be a driver to overcome the barrier of the lack of experience in district heating. Belgium also has the obligation to analyse the costs versus the benefits of the opportunities and to make adequate provisions to ensure the cost effective potential is developed.

In Flanders, a relatively recent resolution on green heat and waste heat, seeks to actively promote the implementation of district heating. Support will be given through investment grants.

In the three regions, different district heating projects are starting up.

When planning district heating plans, legislation, support or projects, the temporary or long term role of CHP should be taken into account.

When policy is developed or when district heating plans are being made, CHP should always be considered as an option, either temporary or permanently, and the advantages should be considered and compared to other solutions.

In this case, CHP associations should emphasize the benefits of CHP within district heating. They can actively get in touch with district heating projects and open the discussion on the advantages of CHP.

Resources should be made available to conduct research on the role of CHP in district heating (see previous action point). With existing data from planned projects, the impact CHP can have on primary energy savings, costs and environmental impacts can be calculated.

Awareness should be increased in this sector of the advantages of CHP compared to central boiler rooms, especially when considering the use of biomass.

3.2.6. Involve CHP in smart grids, demand response and virtual power plants.

CHP can have several advantages for the electricity grid (synchrony between operating hours of (micro) CHP and electricity demand, flexible use of CHP within the heat demand of the company and especially if a buffer tank is installed, electricity production which is complementary with PV or wind, … These advantages should be further validated.

All stakeholders such as producers, grid operators, smart grid networks, owners of CHP installations, … should be prepared and ready to operate in a smart way in order to take full advantage of the benefits of CHP for direct use of the produced electricity or flexible production.

Already, CHP is actively being used for flexible production. Installations with a buffering capacity (e.g. greenhouse installations, but building heating as well) can easily decouple electricity production from the instantaneous heat demand. As such, the CHP installation can follow the electricity market signals, and produce at times of high electricity prices (or, accordingly, high electricity demand or low electricity availability). This happens already with CHP installations in the greenhouse sector, be it not in a fully automatic way. It is clear, however, that as such, CHP can play an important role in VPP's (virtual power plants).

Grid operators should be ready for this and should develop the necessary market models. For example the demand for flexibility of increased/decreased capacity is often relatively well known for a medium term time span (about 2 weeks), because of weather predictions and prognoses from Elia. Therefore additional flexibility mechanisms could be offered in this medium term, between the short term regulation (day ahead and intraday) and the long term plans (e.g. capacity compensation).

Large industrial installations, which are now facing low spark spreads and low IRRs, will probably need to be equipped to offer this flexibility in order to maintain viable projects.

On a smaller (residential) scale, similar solutions can appear for residential micro-CHP with the introduction of smart metering. At this moment, smart metering and smart grids are still at an embryonic stage, and it is not yet fully clear what the final possibilities will be, but one can easily imagine a residential micro-CHP producing heat when demand (local or on the grid) is the highest. Small scale producers/CHP owners could also organise themselves in an association and offer their production/flexibility to an aggregator as a group, thus increasing the advantages.

CHP will also be an important partner for other intermittent sources in a virtual power plant.

Flexibility in electricity supply and demand will also depend on flexibility in heat storage, a key part of the installation which should be well designed and dimensioned.

Flexible electricity production of CHP in smaller installations can be offered through the use of buffer tanks. However, this will result in additional heat losses of the buffer tank. Especially in small (residential) installations these losses are already relatively large.

It might be interesting to start a study to compare the advantages and reduced costs for the grid and the smaller need of large scale energy storage, with the losses of heat, primary energy and costs when the use of buffer tanks is increased for flexible production (see: research).

Also in individual projects, gains and losses in energy efficiency, CO_2 emissions and costs should be considered when designing buffer tanks with additional capacity for offering flexibility.

The role of CHP in maximizing grid efficiency and balancing should be validated with incentives, as imposed by the European EED.

The Belgian authorities have to reinforce and reward the advantages of CHP for the grid. This is also supported by the European EED. The aim of Article 15 of the EED is to maximize grid and infrastructure energy efficiency and to promote demand response. Tariff regulations which are detrimental to overall energy efficiency and participation in demand response and balancing are removed in Article 15. Also, the Belgian authorities have, according to Article 15, to provide incentives for grid operators to improve efficiency: the regulator should strongly recommend energy management services, innovative pricing formulas, intelligent metering or smart grids. An assessment of the improvement in energy efficiency in the design and operation of the gas and electricity infrastructure has to be undertaken.

It is important that the role of CHP within the electricity grid is considered when implementing this regulation.

For example, exceptions on taxes or grid costs can stimulate CHP.

3.2.7. Strengthen the position of bio-CHP.

Bio-CHP installations in agriculture are currently feeling the impact of relatively high input prices and relatively low electricity prices. In order to maintain the current level of agricultural CHP, previous roadmap steps should be followed: maintaining a stable investment climate and support policy, ensuring that installations can be used flexibly, …

Specifically for bio CHP some additional steps should be taken into account.

Research institutes should be stimulated to continue the exploration of new possibilities for bio CHP such as small scale anaerobic digestion and injection of bio-methane in the gas grid.

As already discussed in paragraph 2.1.5, some new technologies or implementations of bio-CHP still offer high possibilities and room for expansion, such as small scale anaerobic digestion, green electricity production from biomass and injection of bio-methane in the gas grid. Research needs to be conducted to further explore the possibilities, develop the technologies and realize the potential.

Legislation in the three regions should promote the production of green electricity from biomass and the injection of green gas into the grid.

It has been mentioned that currently, many biomass installations are mainly oriented towards electricity production because of a strict interpretation of high quality CHP restrictions for certificates which cannot be met by most bio-CHP installations. The regional governments should take these considerations into account and give enough incentives for the use of CHP in the production of green electricity from biomass.

The injection of green gas into the grid is currently not completely implemented in Belgium. There is need for a clear and stable legislative framework for injecting green gas (biomethane, …) into the grid.

3.2.8. Launch residential micro-CHP.

Several steps should be taken to overcome the barriers for micro-CHP. Several actions have been discussed in previous roadmap steps, e.g. investment support for micro CHP, or will be discussed later, e.g. awareness building among residential users. Some other specific steps are the following.

The whole production and market chain should make an effort to kick-start the implementation of residential micro CHP in Belgium.

First, the market should further develop in Belgium, with currently only one or two systems being available.

Because it is crucial that these systems are of high quality, reliable and efficient, it is useful to perform independent field tests. Field tests can be used on the one hand for improving local implementation of the technology (e.g. adapting installation control mechanisms or peripherals). On the other hand, assuming that the installations are market ready and perform well, the results can be used to convince both consumers to acquire micro-CHP installations, as well as governments to support these when necessary.

Investment support for residential micro-CHP has already been discussed above. Right now, with the current product and energy prices, a purely economic reasoning will not result in the purchase of a residential micro-CHP unit. Prices can be expected to decrease with increasing production numbers, but the first consumers have to be convinced on the basis of different reasons: primary energy savings, sustainability, technology,…

Therefore information and research results should be disseminated.

A better position of CHP in building regulations would support the implementation of residential micro-CHP.

In EPB regulation in Flanders, electricity from CHP is disadvantaged in comparison to other production installations. Secondly, a stimulant for residential micro-CHP could be the acceptance of micro-CHP in the 'minimum level of renewable energy' for new buildings, turning it into a 'minimum level of sustainable energy'. This legally enforced minimal level is a transposition of the European directive 2009/28/EC. It only applies for new buildings so the potential impact will be limited with the existing technologies.

3.2.9. Increase the general and specific level of awareness.

The general level of awareness on CHP will be further enhanced by disseminating information and knowledge, promotion campaigns and providing education and training, as required by the EED.

Article 8 of the EED requires auditing and empowerment of customers. Raising technical knowledge of CHP among stakeholders will be part of Article 16 of the EED, in which Belgium can ensure that, by 31 December 2014, certification or accreditation schemes, or equivalent qualification schemes, including suitable training programs, become available for providers of energy services, energy audits, energy managers and installers of energy-related building elements. Article 17 also states that information on available energy efficiency mechanisms and financial and legal frameworks should be transparent and widely disseminated to all relevant market actors, such as consumers, builders, architects, engineers, environmental and energy auditors, and installers of building elements. Member States shall, with the participation of stakeholders, including local and regional authorities, promote suitable information, awareness-raising and training initiatives to inform citizens of the benefits and practicalities of taking energy efficiency improvement measures. Article 19 of the EED mentions that Member States shall evaluate and if necessary take appropriate measures to remove barriers to energy efficiency. The measures may be combined with the provision of education, training and specific information and technical assistance on energy efficiency. Article 19 of the EED mentions that Member States shall remove barriers with provision of education, training and specific information and technical assistance on energy efficiency.

Give CHP a place in the energy landscape with a 'blue label'.

A 'blue label' for high efficiency CHP could be used for awareness, communication and promotion purposes. A first step should be an official acknowledgement of this label.

Specific groups such as SMEs and households which have a high potential for CHP but a low level of awareness should be specifically addressed.

It is the task of both the CHP sector organisations and the energy agencies to clearly disseminate information to all stakeholder groups.

Certain groups of stakeholders are still lacking awareness. Dissemination activities should be focussing on these group, e.g. SME's where there is still a large potential for CHP but very little knowledge. It has been shown in the past that this groups is difficult to address so the actions should be well aimed. In article 8 of the EED there is a special reference in SME's that should be encouraged to undergo energy audits. It is also important to help commercial premises realise that pay back times are not the only or most important sales argument. Work on publicity and marketing campaigns and emphasise corporate responsibility, social and environmental benefits and energy independence ('Make conservation conspicuous'). Finally, not only initial awareness is important for SMEs, but they should also be guided during the implementation and operation of the CHP.

Other specific subsectors where CHP still has a high potential can be addressed as well. For example it is expected that in large warehouses or shopping malls there is still a large potential for CHP.

Uncertainties and insecurities for possible interested stakeholders should be cleared by continuous up- to-date awareness actions.

Changing legislations on the level of energy, emissions, certificates and support for green heat in the three regions have resulted in much insecurity among stakeholders. They should be well informed on the legal aspects in the three regions. More importantly, insecurity on the level of energy prices and the spark spread is inhibiting investments. Although the spark spread is indeed a factor which cannot be estimated for the future, it is important to inform stakeholders about elements which can and will improve the viability of CHP projects, as discussed in chapter 1.5. Uncertainties on the technical performance of installations, especially for household micro-CHP, have raised questions in this sector and have resulted in a negative image. This should be reversed by clear information on the available technologies as well as on the new innovations. Attention should also be paid to the benefits of CHP as a transition technology.

3.2.10. Overview of the roadmap steps

Action	Steps	Main actors	Time planning (1 = urgent; 4 = long term)
Take continuous as well as specific actions at policy level.	Have a continuous dialogue with policy level about the role of CHP.	CHP sector, CHP associations	1
	Increase active response and consultation activities .	CHP sector and facilitators in Brussels and Wallonia	2
	Define energy efficiency targets (EED) and national and regional CHP targets.	Policy level	2
	Introduce correct remuneration for decentralized production.	Grid operators, policy level	3
	Provide a specific solution for local use in common housing projects.	Flemish and Walloon policy makers	3
Expand the operational field of the CHP associations	Form and support CHP associations in Brussels and Wallonia.	CHP sector in Brussels and Wallonia	2
	Support CHP association in Brussels and Wallonia.	Brussels and Walloon policy makers	3
	Continue the operation of the Flemish CHP association.	Flemish CHP sector, government and CHP association	2
	Organize regular meetings to improve general cooperation between CHP associations.	CHP associations/facilitators	4
	Organize combined activities/events across regional boundaries .	CHP sectors or sector organizations	4
	Exchange and disseminate expert technical, legal, financial, environmental information between regions.	CHP sectors or sector organizations	1
Provide an efficient, effective and stable financial support system	Maintain a stable support system and stay in touch with the sector to evaluate the impact of the system.	Policy level	1
	Lobby at European level for a stable framework and minimum prices for CO_2.	Policy level	3
	Provide investment support for residential micro-CHP.	Flemish and Walloon policy makers or industry/utilities.	3
Improve research and dissemination activities	Set up long term as well as temporary research coalitions.	All CHP stakeholders, CHP associations and partners with common research goals	2
	Apply for grants, request funds and conduct research.	Coalitions of CHP stakeholders and other partners	3
	Disseminate research result through newsletters and websites.	CHP and other umbrella organizations.	4
	Disseminate existing basic and expert CHP knowledge through basic courses, lessons, trainings and seminars	CHP associations, universities, colleges and research institutes	1
Develop CHP based district heating	Develop DH legislation and support.	Policy	3
	Always consider CHP when making DH plans or when preparing specifications for	City/regional planners.	1

	contractors.		
	Conduct research on the impact (financial, economic, environmental) of CHP on existing district heating plans.	Research institutes, CHP associations, DH planners	2
	Disseminate information and research results on CHP based DH.	CHP associations	3
Involve CHP in smart grids, demand response.	Involve CHP in smart grid and VPP research and dissemination projects.	CHP and smart grid umbrella organizations, research institutes	1
	Prepare CHP installations with the necessary control and support systems for the (future) implementation in smart grids or VPPs.	Producers, installers, consultants	2
	Carefully design and dimension buffer tanks.	Producers, installers, consultants	2
	Develop market models and structures for the implementation of VPPs including CHP.	Grid operators, aggregators	3
	Prepare installations in order to offer flexibility and improve financial viability of projects.	Large industrial projects or installations	2
	Develop tariff structures which stimulate the most efficient energy mix.	Grid operators	2
	Assess and validate the role of CHP when implementing article 15 of the EED.	Policy makers	2
Strengthen the position of bio-CHP	Support and conduct research on new technologies and implementations.	Research institutes	1
	Provide incentives for the use of CHP in the production of green electricity from biomass.	Policy makers	1
	Provide adequate legislation for the injection of green gas into the grid.	Policy makers, grid operators	2
Launch residential micro-CHP	Increase the number of available and mature systems on the Belgian market.	Producers and importers	1
	Provide objective information on the performance of residential micro-CHP and the ecologic and economic benefits.	Producers, CHP and energy institutes	1
	Disseminate results and information.	CHP associations, producers and importers	2
	Adapt buildings regulations.	Policy makers	4
Increase the general and specific level of awareness	Implement articles 16, 17, 19 for CHP awareness.	Policy makers	2
	Develop a blue label	CHP sector	3
	Provide awareness building for specific groups (e.g. campaigns in general media, publications…).	CHP associations, producers, policy makers	3
	Provide up-to-date information on websites, newsletters, seminaries….	CHP associations, energy institutions	1

Sources

Brugel Proposition relative aux quotas de certificats verts à exiger des fournisseurs d'électricité à Bruxelles pour les années 2013 à 2020 [Report]. - 2011.
Cornelis Cogeneration's 20-year history in Flanders [Article] // COSPP. - 2013.
CWaPE L'évolution du marché des certificates verts [Report]. - 2012.
Enerpedia Innovatie in energie - Praktijkcases 2012 [Journal]. - 2012.
FPB, ICEDD, VITO Towards 100% renewable energy in Belgium by 2050 [Report]. - 2013.
IBGE - BIM Plan voor structurele verbetering van de luchtkwaliteit en de strijd tegen de opwarming van het klimaat 2002 – 2010 [Report]. - 2002.
ICEDD Etude du potentiel technico-economique de la cogénération en Région de Bruxelles-Capitale. [Report]. - 2006.
ICEDD Projet d'actualisation du Plan pour la Maîtrise Durable de l'Energie (PMDE) en Wallonie à l'horizon 2020. [Report]. - [s.l.] : ICEDD, Econotec, IBAM, 2009.
ICEDD Scénarios de développement de la cogénération en Région walonne, Namur, étude réalisée pour le compte de la CWaPe. [Report]. - 2007.
LNE Vlaams Mitigatieplan 2013-2020 [Online]. - 2013. - http://www.lne.be/themas/klimaatverandering/klimaattips/klimaattips/wat-doet-de-vlaamse-overheid/vlaams-klimaatbeleidsplan.
Région Wallonne Plan air climat [Report]. - 2007.
Sandton http://www.sandton.eu/en/gent/Duurzaam [Online]. - Sandton Grand Hotel Reylof, 2013.
Statistics Belgium [Online]. - 2013. - http://statbel.fgov.be/nl/statistieken/cijfers/economie/bouw_industrie/.
VEA Rapport 2013/2 Deel 1: definitief rapport OT/Bf voor projecten met een startdatum vanaf 1 januari 2014 [Report]. - 2013.
VITO Doorrekening ter ondersteuning van evaluatie GSC en WKC-systeem [Report]. - 2011.
VITO Energetisch potentieel warmtekrachtkoppeling in België [Report]. - 1997.
VITO Oriënterende studie micro warmtekrachtkoppeling in Vlaanderen [Report]. - 2009.
VITO Prognoses voor hernieuwbare energie en warmtekrachtkoppeling tot 2020. [Report]. - 2009.
Vlaanderen [Online]. - 2009. - http://codex.vandenbroele.be/Zoeken/Document.aspx?DID=1018092&param=inhoud.
Vlaanderen [Online]. - 2010. - http://codex.vandenbroele.be/Zoeken/Document.aspx?DID=1019755&param=inhoud.

Annex 1: Stakeholder group awareness assessment

1	Poor	(red)
2	Low	(orange)
3	Early awareness	(yellow)
4	Interest	(light green)
5	Active market	(green)

Customers	
Industry	CHP is becoming more and more common in the a range of industrial sectors. The Industry, especially process-industry, was already using CHP to increase energy-efficiency, but since the implementation of the certificate-based CHP support system in 2005 in Flanders there has been an rise in the use of CHP in a variety of sectors, particularly greenhouses between 2005 and 2011. Interesting new applications have emerged where CHP is used in combination with other technologies, such as buffering of heat in PCM (Sandton, 2013) and using CO_2 from the CHP in greenhouses as fertilizer (Enerpedia, 2012). High penetration of CHP in agriculture (greenhouses).
Utilities	CHP is commonly known in the utilities sector.
Commercial	Larger installations in hotels, office buildings, hospitals, nursing homes, swimming pools and wellness centres have become more and more common; and people are generally aware of the technology. Although the potential for (micro-)CHP for SMEs is very high, these companies are not always aware of opportunities and the support mechanisms for CHP. It is also very difficult to reach this group of people, whose core business is often very distinct from energy, and who due to the nature of their business have little possibilities to attend seminars.
Households	Residential micro-CHP is becoming slightly more known. However due to the slow start of the introduction of the technology in Belgium and some negative experiences with manufacturers have resulted in a negative connotation of the household micro-CHP, not only among potential customers but also among potential investors and government. Although the general public is slowly becoming aware of micro CHP, through building fairs and publications in general and specialised press, they are often not aware of the true benefits and the optimum siting and sizing.
Market and supply chain	
Manufacturers	Suppliers of all types of technology are active on the market. Many major manufacturers of cogeneration equipment have an office in Belgium and are providing information and advertising to customers. However the market of domestic micro CHP and innovative techniques such as fuel cells is still limited (only one producer of a 1kW micro CHP is currently supplying). Unsuccessful introductions of residential micro CHP in the past have led to a negative awareness for the technology.
Installers	Several installers are offering the appropriate technology. There is no lack of technical knowledge and awareness. Suppliers and installers provide their own training for personnel to insure they are technically qualified both on electrical aspects as on plumbing skills. On micro CHP level installers are not always aware and competent to combine both the electrical and the heat aspect of the installation.
Grid operators	Grid operators are well aware of the impact of decentralized production such as CHP on safety parameters and balancing requirements of the grid. They are also becoming aware of the advantages of CHP for steering and balancing requirements. They are willing to discuss grid tariffs and flexible prices with CHP stakeholders in the future.
Consultants	Consultants are aware of CHP. They do however struggle with the necessary permits and paperwork. This can lead to unexpected extra costs (e.g. for metering), time delay, uncertainties and therefore extra risks. This could be a barrier for other interested parties.
Architects	Architects are not always aware of the potential of (micro) CHP.

Engineering companies	Well aware but not always technically updated.
Banks	Many of the Belgian financial institutions have experience with CHP and are therefore favourable towards giving loans. Some banks have even developed 3rd party financing schemes for CHP projects.
ESCOs	ESCOs are becoming more common in the CHP sector; and the sector is aware of the possibilities offered by the ESCO. However the implementation has until now been limited.
Policy	
National	There has been an effective implementation of the EU legislation and there exists a good awareness and understanding among policy makers at all levels. On the federal level, financial support for investments in CHP is given through a reduction of the taxable profits.
Regional	CHP is covered within the regional legislation, keeping in mind the specific geographical and industrial characteristics of each region.
Local	Some cities or communities have signed the Covenant of Mayors or are adopting Sustainable Energy Action Plans. However the role CHP could play within these plans is generally not so well understood.
Urban & Regional planners	City and community planners have sometimes obtained awareness towards CHP from study days, trainings or information brochures. However this knowledge is not always put into practice.
Energy agencies	Energy agencies such as VEA (Flemish Energy Agency) implement the legislation and inform the stakeholders and the general public on these topics These agencies are very well aware of the situation of CHP.
Influencers	
Sector organisations	There is no national sector organization for CHP, since energy is a regional regulated matter. In Flanders the sector organization active and helps closing the gap between the CHP sector and the regional government. Wallonia and Brussels each have their own CHP facilitator who is responsible for the development of CHP in the region, by sharing expertise and by guiding the government towards a CHP oriented support system. The sector organisations also provide CHP guidelines with technical and practical support for companies, calculation tools for (pre)feasibility studies and they organise courses and study days. Other sector organisations also exist, e.g. for the agricultural sector (greenhouses). By grouped gas purchasing and supporting the members in selling electricity at the best prices the members are gaining more profit from their CHP.
General public	People are becoming aware of CHP and are interested in the technology. Individual people who are interesting in the implementation of (micro)CHP can find information from different sources, such as websites, events and publications. Low entry level excel – tools are available on relevant websites and enable interested parties to make a quick pre-feasibility study for their potential project. However the image of CHP is less favourable than that of renewables due to complexity of the technology, the greener image of renewables and a number of negative experiences in the past.
Media	Some articles are being published in specialised scientific literature as well as in more accessible (electronic) newsletters of sector organisations. More attention is being paid to the role of CHP in the future of energy generation.
Academia	CHP technology is a part of the educational program of several master programs in energy and engineering in universities and colleges. When master students choose a thesis subject related to CHP technology they are often supported by the industry or sector organisations. Other regional research institutions are working on CHP, for example the Flemish Institute for Technical Research. Regional CHP organisations are sometimes involved.
Research	Both fundamental as well as applied research (conceptual design, feasibility studies, …) is elaborated at universities and colleges. While research topics are launched by these institutions, funding often is based on scholarships with governmental support. In this case the research topics have to be justified and preferably has to fit within the topics of policy notes. This creates a link between governmental policy and research. More applied research is necessary in the changing energy landscape.
NGOs	Some NGO's are active on the energy and building market, e.g. the Flemish Network Sustainable Building. In their advice towards builders they mention CHP, but it is certainly not a widely covered topic.

Annex 2: Micro CHP potential assessment

micro-CHP potential summary Belgium

Country statistics

Population: 11 000 000 (2010)
Number of households: 4 790 000 (2010)
GDP per capita: € 29 900 (2010)
Primary energy use: 36 400 ktoe/year (2010)
GHG-emissions: 132 Mton $CO_{2,eq}$/year (2010)

Household systems (±1 kWe)

Boiler replacement technology

Present market (2013)
Boiler stock: 2 200 000 units
Boiler sales: 174 000 units/year

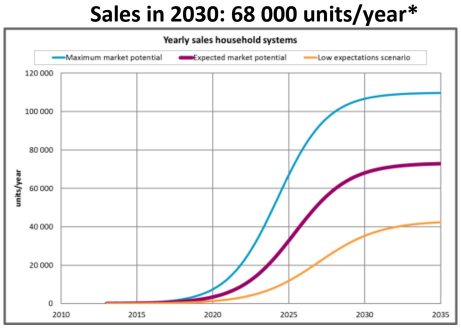
Potential estimation

Indicator	*Score*
Market alternatives	1
Global CBA	4
Legislation/support	2
Awareness	0
Purchasing power	2
Total	**8 out of 12**

Expected final market share: 42% of boiler sales in Household sector

Yearly sales

Sales in 2020: 3 500 units/year*
Sales in 2030: 68 000 units/year*



Stock

Stock in 2020: 8 100 units*
Stock in 2030: 376 000 units*
Stock in 2040: 726 000 units*

Potential savings in 2030

Primary energy savings:
6 PJ/year*
154 ktoe/year*
GHG-emissions reduction:
0 Mton $CO_{2,eq}$/year*

SME & Collective systems (±40 kWe)

Boiler add-on technology

Present market (2013)
Boiler stock: 450 000 units
Boiler sales: 35 000 units/year

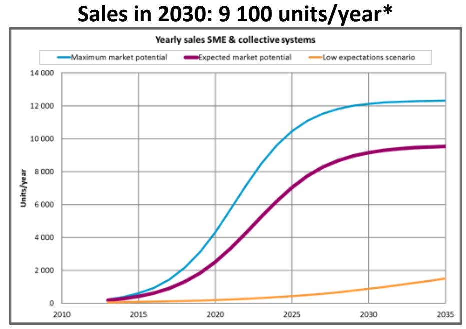
Potential estimation

Indicator	*Score*
Market alternatives	1
Global CBA	4
Legislation/support	2
Awareness	1
Total	**7 out of 9**

Expected final market share: 27% of boiler sales in SME & Coll. sector

Yearly sales

Sales in 2020: 2 500 units/year*
Sales in 2030: 9 100 units/year*



Stock

Stock in 2020: 15 700 units*
Stock in 2030: 71 300 units*
Stock in 2040: 97 500 units*

Potential savings in 2030

Primary energy savings:
54 PJ/year*
1 280 ktoe/year*
GHG-emissions reduction:
0 Mton $CO_{2,eq}$/year*

*Corresponding to the expected potential scenario.

micro-CHP Score card Argumentation

The score card is used to assess the relative position of an EU country based on current regulations, markets and economics. The score itself functions as input to the implementation model to 2030.

±1 kWe systems (Households)

Boiler replacement technology

Scorecard

Indicator	Score
Market alternatives	1
Global CBA	4
Legislation/support	2
Awareness	0
Purchasing power	2
Total	**8 out of 12**

Market alternatives

Estimates for other 'boiler replacement technologies in current national roadmaps on other technologies, ie DH, Heat pumps: **Flanders: potential for DH small, potential for other green heat about 50% of CHP potential in 2020 (for all technologies, not only micro).**

Global CBA

SPOT: ***4 years***

Legislation/support

Current incentives on microchip: **Federal: tax reduction; all regions: certificates (small for 1 KW); Brussels: support for feasibility study + investment support + additional certificates for collective housing; Wallonia: support for feasibility study + investment support**

Current incentives on other technologies: **Federal: tax reduction, Flanders: certificates for renewables, investment support solar heater**

Awareness

Are stakeholders aware of the microCHP technologies

Homeowners? ***medium***

Consultants? ***high***

Installers? ***high***

Purchasing power

GDP: ***€ 29 900 per year***

±40 kWe systems (SME & Collective systems)

Boiler add-on technology

Scorecard

Indicator	Score
Market alternatives	1
Global CBA	4
Legislation/support	2
Awareness	1
Total	**7 out of 9**

Market alternatives

Global CBA

SPOT: ***4 years***

Legislation/support

Current incentives on microchip: **the same, but amount of certificates will be more substantial**

Current incentives on other technologies: **Federal: tax reduction, Flanders: certificates for renewables, support for SME's such as ecology investment support for bioenergy and heat pumps, investment support from grid operator for SME's for heat pump and solar heater**

Awareness

Are stakeholders aware of the technology

Homeowners? ***medium***

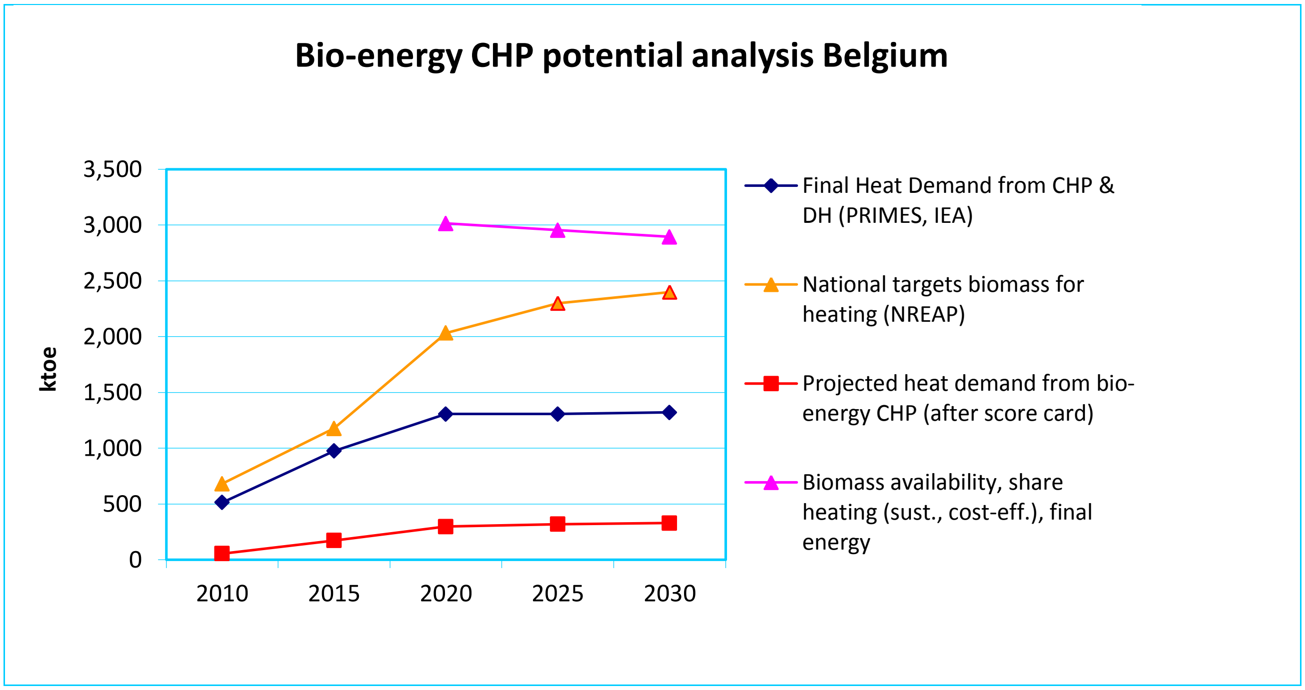
Consultants? ***high***

Installers? ***high***

Annex 3: Bio-CHP potential assessment

Bio-energy CHP potential analysis
Belgium

Figures (projections)	2010	2020	2030
Final heat demand from CHP and DH (PRIMES, IEA), ktoe	515	1.308	1.321
(Projected) heat demand from bio-energy CHP and DH, ktoe[11]	57	299	330
Bio-energy penetration rate in CHP markets (2009: EEA, Eurostat)	11,0% (2009)	22,9%	25,0%
Biomass availability, share heating (sust., cost-eff.), final energy (Biom. Futures), ktoe		3.015	2.895



[11] Based on assessment of the following sources:
- *Prognoses voor hernieuwbare energie en warmtekrachtkoppeling tot 2020, VITO, 2009 (Flanders)*
- *Doorrekening ter ondersteuning van evaluatie GSC en WKC- systeem', VITO, 2011 (Flanders)*
- Cogeneration region Wallonne (directive 2004/8/EC), Direction générale Energie, 2011 (Wallonia)
- CHP Supplementary Reporting for European Union Countries Under the EU DIRECTIVE 2004/8/EC, 2011 (Brussels).

Framework Assessment	Score	Short analysis
Legislative environment	+ 2 (of 3)	Wallonia: support through certificates with extra support for bio-CHP; Flanders: both CHP and green certificates for bio-CHP Many bio-CHP installations are not qualified as 'qualitative' and therefore receive no certificates.
Suitability of heat market for switch to bio-energy CHP	+ 2 (of 3)	Large heat demand in the industry, however not always suitable for biomass CHP.
Share of Citizens served by DH	- 0 (of 3)	Almost no district heating
National supply chain for biomass for energy	o 1 (of 3)	Flanders: large competition for use of biomass, according to the waste chain materials should first be reused, recycled, composted and only the remains can be used for burning. Also large competition with paper industry.
Awareness for DH and CHP	++ 3 (of 3)	Bio-CHP fits well within the general idea of changing towards an energy policy with 100% renewables, therefore there is a more positive awareness for bio-CHP than for fossil fired CHP.

Annex 4: Methodologies used to calculate the saving of primary energy and CO_2 emissions under the roadmap.

Substitution method

This method has been developed in the CODE2 project. In doing this, two other approaches have been considered: 1) the "replacement mix method[12]" from the Munich FfE institute, which however cannot be used directly for a long term comparison as needed in CODE2; 2) a method used to calculate the CO_2 saving resulting from a voluntary commitment of the German industry for CO_2 reduction[13], however this method has been considered as too simple. Therefor the following more differentiated approach has been developed:

Based on an estimate of the increase in cogeneration electricity the thereby caused decrease of CO_2 emissions and primary energy consumption is estimated. In this approach, an attempt is made to determine the actual quantities saved compared to the base year (e.g. 2010). Hence it refers to the actual saving of fuels for the production of the amounts substituted by modern CHP plants

a. of electricity and heat in the replaced or retrofitted old CHP plants

b. of electricity in power plants

c. of heat in boilers.

The savings result from a combination of three effects:

- CHP effect
- Technology effect (improved CHP technologies)
- Fuel switching (e.g. lower carbon content of natural gas compared to coal, CO_2 neutrality of bioenergy)

The results show the savings actually induced by the expansion of CHP compared to the situation in the base year.

This approach differs fundamentally from the methods for checking the high-efficiency according to the CHP Directive or in accordance with ANNEX II of the EED (Directive 2012/27/EU on energy efficiency), in which a comparison between CHP and the best available Technology (BAT) of separate production of electricity and heat produced is carried out strictly on a same-fuel basis.

This procedure is considered to be inappropriate to deliver an estimate of the actual fuel saving quantities by CHP over a longer period, which is considered relevant value, representing meaningful the contribution of CHP to the long-term objectives of the EU to reduce CO_2 emissions and primary energy consumption. The BAT approach of the CHP Directive has been developed to verify the high efficiency of individual plants, but not to determine actual saved CO_2 emissions and primary energy quantities by CHP expansion.

[12] 10. FfE Forschungsstelle für Energiewirtschaft e.V., Energiezukunft 2050; http://www.ffe.de/die-themen/erzeugung-und-markt/257

[13] The calculation has been made by the VIK Verband der Industriellen Energie- und Kraftwirtschaft e.V., 2010, Unpublished.

In fact, the CHP expansion is closely associated with a replacement of old by new cogeneration technologies and a change in the structure of fuel away from coal to natural gas and bio-energy. These three developments,

- replacement of separate generation by cogeneration
- replacement of old by new cogeneration technologies
- replacement of carbon-rich by low-carbon fuels,

can be usefully seen only as an integrated process.

To account for the uncertainties in particular with regard to fuel shares and technology development, a window of possible developments with an upper value and a lower value of emission reduction and savings has been determined. The different levels of results are due to assumptions about key parameters such as current share of electricity from cogeneration, which is replaced by electricity from new or retrofitted units, fuel shares in the replaced CHP plants, power plants and boilers as well as in the new CHP plants.

The results have been calculated based on the following input values: growth of CHP power production, share of current old CHP to be replaced by new installations and retrofitting, fuel efficiency and electric efficiency of new CHP and replaced CHP for different fuels, electric efficiency of replaced power from conventional power plants for different fuels, heat efficiency of replaced heat from boilers, corresponding fuel shares.

EED method

The Primary Energy Savings methodology of the EED is used at a country level for national reporting to the Commission, and at project level for determining if CHP is highly efficient. In the methodology, each cogeneration unit is compared with the best technology for separate production of heat and electricity on the same fuel on the market in the year of construction of the cogeneration unit and the harmonized reference values are determined by fuel type and year of construction.

The underlying principle is that, knowing that regularly new investments have to be made in new energy production units, it is necessary to compare CHP with the centralized production installation which could be built using the same fuel rather than assuming a displacement of a different fuel or introduction of a new fuel. It is a logical approach when looking at the decision making process of investors or a member state government. By investing in or supporting CHP, a certain electricity generating capacity will be produced by CHP and NOT by centralized production based on the same fuel (= principle of 'avoided production').

For the timeframe of the roadmap (between 2010 and 2030), and especially in countries where there is no overcapacity, it is relevant to compare installing a certain capacity (at national level) of CHP compared to installing new capacity with another technology (power plant + gas boiler). Older installations being replaced with state-of-the-art technology.is a typical reinvestment decision. New CHP-plant (or combination of smaller installations) would not necessarily lead to less production in older production installations, but would rather preempt investments in e.g. new CCGT investments.

Annex 5: Case studies

Anheuser-Busch InBev
Leuven, BELGIUM

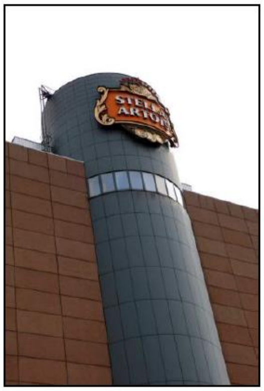
AB Inbev

Brewery

Main CHP project indicators

Heat capacity (total)	kW	75 t/h steam 3,5 bar(g)
Electrical capacity (total)	kW	4200
Technology	Gas turbine	
No. of units	3	
Manufacturer	Callens Vyncke	
Type of Fuel	Natural gas	
Heat: yearly generation	MWh	550000 GJ
Electricity: yearly generation	MWh	25000
Year of construction	2011	
Total investment costs	EUR	approx. 12 M€
Financing	Own founds	
State support	Certificates	
Location	Leuven	

Picture



General description of the case

Steam generation for the ABI brewery in Leuven; electricity generation with Gas turbine (CHP). Boiler water treatment. New building compliant with the actual targets of noise reduction. Relocation of the boiler house.

Success factors

The steam and electricity capacity are well adapted to the steam supply to the energy needs of the brewery.

Greenhouse gas emissions are reduced with a factor 3, energy consumption is reduced with 5-10% and water consumption with 15%. A financial analysis proved that the ROI (return on investment) would be less than 4.5 years. The financial support (certificates) was crucial in the decision process, without these the investment would probably not have been made. However, one of the decision criteria is the requirement that the installation should still be profitable in global market conditions, i.e. without any incentives.

The installed CHP has an overall efficiency of 92%.

Main barriers

As a company whose core business is not electricity generation, obtaining certificates took a lot of time. Furthermore, some technical details had to be modified during the project to comply to regulatory changes. This can lead to unexpected extra costs (e.g. for metering), time delay, uncertainties and therefore extra risks.

More difficult than the installation itself, was the city planning and the alignment of industrial development with development of city of Leuven, e.g. a relocation of the installation was necessary in order to free the old industrial area for residential development (Master plan '2-Waters' Leuven). Due to the proximity of this residency, the new building had to be compliant with the actual targets of noise reduction. The noise emission outside the boiler house is less than 35 dBa.

Conclusions

Even when steam and electricity production are well adapted to the energy needs, and payback times are interesting, other barriers may hamper the decision making process.

Crowne Plaza hotel
Brussels, BELGIUM

Pandox group

Hotels

Main CHP project indicators

Heat capacity (total)	kW	207
Electrical capacity (total)	kW	140
Technology	Motor engine	
No. of units	1	
Manufacturer	ESS-VIESSMANN	
Type of Fuel	Natural gas	
Heat: yearly generation	MWh	1400
Electricy: yearly generation	MWh	850
Year of construction	2010	
Total investment costs	EUR	230000
Financing	Own founds; estimated pay-back time of 2,3 year.	
State support	Investment subsidy Certificates Tax reduction	
Location	Brussels, Belgium	

Picture

General description of the case

Crowne Plaza "Le Palace Hotel" in Brussels is part of the PANDOX group and has 350 rooms and an area of 28,000 m². Compared to 2008, the hotel has reduced its 2010 energy consumption by 60% in natural gas and 20% in electricity through the implementation of energy savings actions. A VIESSMANN - ESS cogeneration unit with an electric power of 140 kW and a heat power of 207 kW was then installed in October 2010. This unit operates 24h/24h from mid-summer season and 16h/24h in summer.

Success factors

A preliminary energy audit leading to a heat demand reduction together with a detailed study including energy online monitoring are the key factors for effective sizing. After commissioning, the key factor is online monitoring creating the opportunity to optimize the unit. After several years the financial gains from this optimisation were used for the complete financing of a new CHP. No other internal or external financing was required.

Because of the success of this project, Pandox is currently installing CHP other hotels.

Main barriers

- Technical aspects of the installation
- Complex administration of the certificates
- Boiler room control in order to optimize the operating hours.

Conclusions

Good controlling strategy for boilers and preliminary heat demand reduction together with a sound detailed study.

Case study factsheet
Brussels Region, Belgium

KBC Brussels HQ CHP facility: "KBC BRUhav2 CHP"

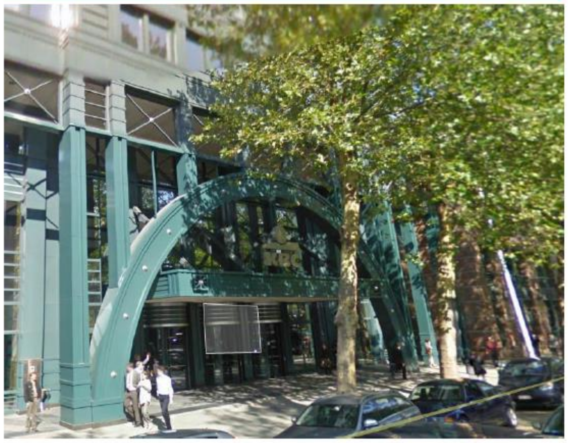
KBC Bank & Insurance Belgium

Main CHP project indicators

Heat capacity (total)	kW	203
Electrical capacity (total)	kW	140
Technology	gas fired piston engine	
No. of units	1	
Manufacturer	Bobinindus	
Type of Fuel	Natural gas	
Heat: yearly generation	MWh	848 av.
Electricity: yearly generation	MWh	530 av.
Year of construction	2011	
Total investment costs	kEUR	550
Financing	Own founds	
State support	Certificates Tax reduction	
Return of investment (payback period)	Years	6 yr (°)
Location	KBC Brussels HQ Havenlaan 2 1080 Brussels	

(°) including maintenance costs, without subsidies

Picture



General description of the case

CHP covering at least the energy needs of the in-house catering

Success factors

- correct dimensioning (no overdimensioning)
- support by knowledge partners (engineering office, governmental support)
- high end machinery installed by experienced installation partner
- decent maintenance and follow-up

Main barriers

- investment
- technical complexity

Comparison: before and after

- buildings total electricity and on-site fossil energy consumption lowered
- no changes in used fuel type
- more complex and somewhat elevated maintenance expenses

Conclusions

- due to positive experience, the application of an CHP in other KBC HQ's with in house catering facilities is now examined
- critical success factors are: correct dimensioning, decent installation, maintenance and follow-up by experienced partners

Contacts

Project partners

The project consortium exists of the following partners that have a solid expertise on cogeneration:

- COGEN Europe, the European Association for the promotion of cogeneration, is the project coordinator (Belgium) – contact: fiona.riddoch@cogeneurope.eu
- Hellenic Association for the Cogeneration of Heat and Power (HACHP) (Greece) – contact: hfa@heatflux.eu
- Jožef Stefan Institute (Slovenia) – contact: stane.merse@ijs.si
- Federazione d' associazioni scientifiche e tecniche (FAST) (Italy) – contact: giorgio.tagliabue@gmail.com
- COGEN Vlaanderen (Belgium) – joni.rossi@cogenvlaanderen.be
- Energy Matters (Netherlands) – contact: Arjen.deJong@energymatters.nl
- Berlin Energy Agency (Germany) – contact: hermann@berliner-e-agentur.de
- KWK kommt (Germany) – contact: adi.golbach@kwkkommt.de