Low carbon business park manual:

a guide for developing and managing energy efficient and low carbon businesses and business parks

ACE

ANSWERS TO THE CARBON ECONOMY

Colophon

This publication is prepared by the partnership of the Interreg IVA 2 Seas project "Answers to the Carbon Economy" (ACE). The six project partners from three EU countries (UK: Hastings Borough Council (lead partner) and Sea Change Sussex; Belgium: wvi, City of Ghent and Ghent University; France: ECOPAL) actively cooperated and delivered input for this publication. The publication partly draws on case studies executed during the project in the 2 Seas region, partly on the doctoral research of two PhD students of Ghent University, carried out in the framework of the project.

The ACE project is part financed by the Interreg IVA 2 Seas Programme (European Regional Development Fund), which aims to promote cross-border cooperation between the coastal regions of four Member States: France (Nord-Pas de Calais), England (SW, SE, E), Belgium (Flanders) and The Netherlands (South coastal area). More information on the Interreg IVA 2 Seas Programme is available on **http://www.interreg4a-2mers.eu**.

The publication can be downloaded at: http://www.ace-low-carbon-economy.eu/en/results-tools/manual/

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Disclaimer

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Chapter 1

Project ACE

1 Project ACE

1.1 Background

Answers to the Carbon Economy (ACE) is a project in the INTERREG IVA 2 Seas programme, an initiative that promotes cross-border cooperation between the coastal regions of 4 EU member states: France (Nord-Pas de Calais), England (South West, South East, East of England), Belgium (Flanders) and the Netherlands (south coastal area). ACE addresses the 2nd priority of the 2 Seas programme: promoting and developing a safe and healthy environment. The project is financed by the European Regional Development Fund, Communauté Urbaine de Dunkirk and Enterprise Flanders, and has an overall budget of just over 4 million €.

1.2 Objectives

ACE responds to the European Union's climate and energy agenda and to its aim for sustainable economic growth. The project turns these targets into opportunities to increase the competitiveness of businesses and business parks in the project area. ACE supports its project partners in initiating and realising low carbon initiatives and projects and sharing knowledge and best practice. Legal, economic, social, technical and spatial measures to reduce carbon emissions related to energy consumption are promoted at 3 levels: from individual business level, over business cluster to business park level (and even on to the regional level).

1.3 Partners

Answers to the Carbon Economy cannot be found by working in isolation or behind international barriers. Successful ideas must be quickly shared if they are to have maximum impact. Therefore, a dedicated partnership of six partners has been established, under guidance of the lead beneficiary Hastings Borough Council (HBC). Two partners are located in South East England (HBC and Sea Change Sussex), one in Northern France (ECOPAL) and three in Flanders, Belgium (wvi: West Flanders Intermunicipal Association, City of Ghent and Ghent University).

1.4 Low carbon business park manual

The low carbon business park manual is an important deliverable of the ACE project. It combines the experience from the six project partners in three EU member states, and incorporates the lessons learnt during the 3 year project period. The manual serves as a guide in low carbon energy measures for companies and business park developers and also provides in-depth background information. Moreover, it describes the actual implementation of these measures in practical case studies realised by the partners. In conclusion, the manual aims to assist business park developers and managers, local authorities and businesses in their transition towards a low carbon economy.

Manual overview

- **Chapter 2** briefly describes climate change and indicates the share of the industry sector in European and national final energy consumption and related carbon emissions. It explores current European and national/regional climate and energy policies and lists policy measures that affect companies and business parks. A detailed comparison is made between energy policy measures in Belgium, France, the United Kingdom, the Netherlands and Germany.

- **Chapter 3** introduces sustainability concepts for business parks and provides worldwide examples. Next, the priority strategy for low carbon energy measures is described (Trias Energetica) and the different levels at which these measures can be applied are explained (business, business cluster, business park, and by extension regional level). The important concepts of carbon footprint and carbon neutrality are introduced and policy and regulations related to the development of low carbon business parks are analysed.

- In **chapter 4**, a generic layout of a business park energy system is presented and technological low carbon energy measures within this system are indicated. The importance of matching temperature levels of heat demand and supply is described in more detail. Therefore, some thermodynamic definitions are introduced. Also the use of techno-economic energy models is highlighted. These models allow us to calculate the configuration and operation of an energy system with the lowest costs and the lowest carbon emissions.

- In **chapter 5**, a company's energy consumption profile is broken down into energy services related to building use and to production processes. Methods for energy management at company level are presented (certification, energy audit, energy monitoring/management system). Energy efficiency measures related to building use and processes are listed and the relevant regulation is explored. More detail is given on Pinch and Total Site Analysis, which can be used to assess the potential of heat exchange between processes at company or even at business park level.

- **Chapter 6** focusses on renewable or efficient energy production technologies. Solar, wind, geothermal energy and biomass are discussed in terms of resource availability, technology types and performance. Next, the working and application of heat pumps is explained. The principle of cogeneration is introduced and the condensing boiler is described. Finally, the European system of guarantees of origin and certificate systems for green power production and cogeneration are discussed.

- **Chapter 7** explains the different possibilities and advantages of inter-firm cooperation in energy supply and energy-related services (energy clustering). It shows how energy synergies can be exploited between companies with complementary energy profiles. Possible business plans for collective energy production and the potential role of Energy Service Companies are described. The concepts of district heating networks and smart microgrids are introduced. Next, it is discussed how business park developers can promote energy clustering and which barriers must be overcome. Finally, energy clustering is illustrated with practical ACE case studies.

- **Chapter 8** focusses on micrograds and energy management. The structure and characteristics of microgrids are described and worldwide examples are provided. Energy management is also discussed in this chapter, at the level of individual energy production units, at the level of power exchange with the electricity grid, as well as at the level of energy demand (load shedding, peak shaving, active load control).

- **Chapter 9** sets out a stepwise approach for the low carbon retrofit of an existing business park or the development of a new low carbon business parks. The practical activity table presented in this chapter offers a guide for the implantation of low carbon energy measures throughout the different development phases of the project and indicates the involved stakeholders.

- In **Chapter 10**, detailed information is provided about 16 case studies that are realised under the ACE umbrella. The practical implementation of low carbon energy measures is discussed and barriers on technologic, economic, legal, social or spatial level are identified. Each case study is evaluated based on the experience of the partners involved.

LOW CARBON BUSINESS PARK MANUAL

Chapter 2

Climate and energy policy

2 Climate and energy policy

2.1 Introduction

To mitigate climate change, global greenhouse gas emissions have to be drastically reduced in the coming decades. Energy and climate policies are being developed at different administrative levels. This chapter focusses on policy measures taken in the industry and energy sectors, as those sectors are responsible for a large share of greenhouse gas emissions. First, the European climate and energy policy and its translation to national level are described. Subsequently, national policy measures applicable to the industry and energy sector are identified and categorised according to their approach. This analysis is carried out for Flanders, France and UK, but also for Brussels, Wallonia, the Netherlands and Germany.

2.2 Climate change

2.2.1 Greenhouse effect

About one third of the solar radiation that reaches the earth, is directly reflected back into space by the earth's surface and atmosphere. The other part is absorbed and converted into long-wave infra-red radiation, better known as heat. When heat is re-radiated from the surface, a certain share is absorbed by greenhouse gasses in the atmosphere, while the rest escapes to space. The greenhouse gas molecules re-emit the absorbed heat in all directions, heating up water, land and air. This natural greenhouse effect keeps earth's average surface temperature at a level suitable for life, around 15°C.

2.2.2 Global warming

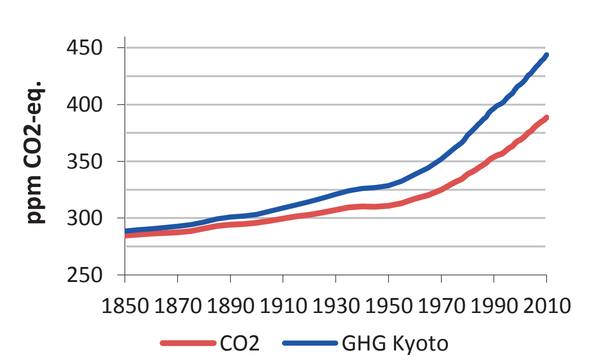


Fig. 1: Global atmospheric concentration of GHG (from www.eea.europa.eu/data-and-maps)

During the last decades, anthropogenic (man-made) greenhouse gas (GHG) emissions have drastically increased, in line with industrialisation and population growth. The natural balance between greenhouse gas sources and sinks is disturbed, which causes atmospheric greenhouse gas concentrations to rise (see Fig. 1). This leads to a gradually intensifying greenhouse effect, also referred to as global warming. Symptoms are global temperature rise, melting of polar ice and glaciers, sea level rise, extreme weather events, such as droughts, heat waves, flooding, acidification of the oceans, etc. This results in severe human, economic and environmental damage (IPCC, 2013). A global mean temperature rise of 2°C compared to pre-industrial times is seen as the point of no return, beyond which climate stability is no longer ensured. To stay below this temperature limit with a relatively high certainty, atmospheric greenhouse gas concentrations must be stabilised below 400 ppm CO_2-equivalents, whereas a limit of 450 ppm guarantees only a 50% certainty. However, at the moment the concentration has already reached 478 ppm and is increasing at a rate of about 2.1 ppm a year. To reverse this imminent evolution, worldwide GHG emissions should have peaked by 2020 and then be more than halved by 2050 relative to 1990. Global climate policy and action now and in the coming few decades will be decisive for the severity of climate change.

The main contributors to global warming are carbon dioxide (CO_2), methane (CH_4), nitrous oxide N_2O, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6), which originate from fuel combustion (including combustion in industry), chemical reactions in industrial processes, solvents, waste processing and agriculture (see Fig. 2). As the potential to absorb heat differs for each of those greenhouse gasses, their global warming potential (GWP) is expressed relative to that of carbon dioxide, over specified time spans of 20, 100 or 500 years. Over a 100 year timespan GWPs are: CO_2: 1, CH_4: 25, N_2O: 298, SF_6: 22800, etc. GWP values are published by the IPCC, but are reviewed in their 5th assessment report, in order to include climate-carbon feedbacks. A comprehensive interactive map developed by New Scientist shows the evolution of global warming from 1894 up to 2013.

Websites	
478 ppm:	globalchange.mit.edu/news-events/news/news_id/273
2°C limit:	www.greenpeace.org/international/en/publications/Campaign-reports/Climate-Reports/Point-of-No-Return/
CO_2 trends movie	www.esrl.noaa.gov/gmd/ccgg/trends/history.html
GWP	www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html
New Scientist map	warmingworld.newscientistapps.com
global warming time lapse	www.youtube.com/watch?feature=player_detailpage&v=gaJJtS_WDmI

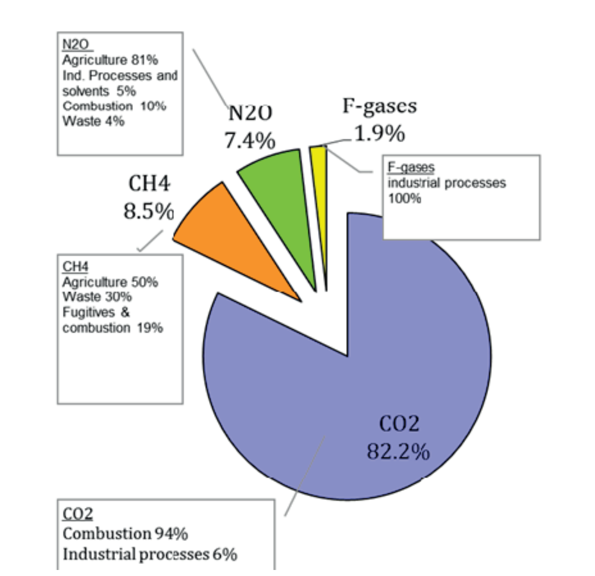


Fig. 2: Total GHG emissions by gas in EU-27, 2011 (www.eea.europa.eu/publications/european-union-greenhouse-gas-inventory-2013)

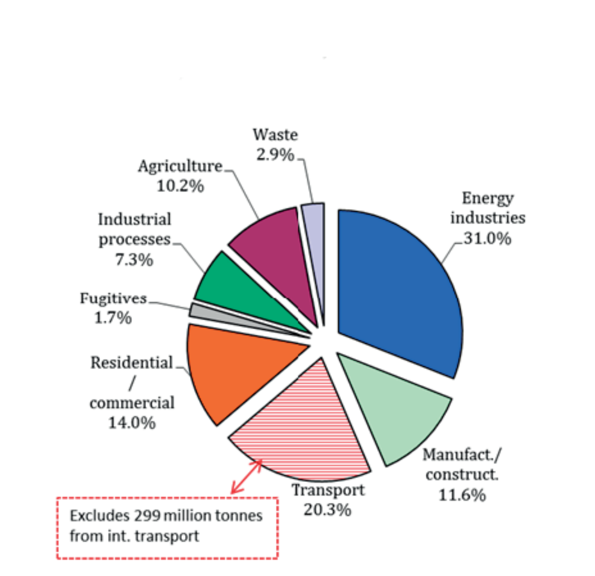


Fig. 3: Total GHG emissions by sector in EU-27, 2011 (www.eea.europa.eu/publications/european-union-greenhouse-gas-inventory-2013)

2.3 Role of industry

2.3.1 Greenhouse gas emissions

From global to regional level, the sectors energy and industry together are responsible for a large share of greenhouse gas (GHG) emissions (see Fig. 3). For policy purposes it is useful to allocate emissions to the end-use sectors, and in this case to the industry sector (see Table 1). The energy sector generates electricity and heat and provides the required amounts to industry. Accordingly, GHG emissions from the industry sector can be divided into **direct emissions**, related to fuel combustion within the sector itself, and **indirect emissions**, related to the heat and electricity received from the energy sector. Greenhouse gasses can also be emitted by industrial (chemical, biological) processes. These emissions are referred to as emissions related to **non-energy use**.

It is a complex task to calculate indirect emissions starting from the national energy balances. Therefore, sometimes **carbon intensities** are used, expressing average emissions related to electricity in gCO_2/kWh. Those factors depend on the type of fuels combusted and the efficiencies of technologies employed for electricity generation in the energy sector (see last column of Table 1). Renewable energy sources have zero carbon intensity.

Table 1: CO_2 emissions from fuel combustion and non-energy use in the industry sector (2010), carbon intensity of electricity generation (2010)

CO_2-emissions (million tonnes)	Total	Manufacturing industries and construction*				Carbon intensity
		excl. indirect emissions		incl. indirect emissions		g CO_2/kWh$_{electr.}$
Belgium	106,4	24,6	→23,1%	35,1	→33,0%	220
France	357,8	62,6	→17,5%	75,1	→21,0%	79
United Kingdom	483,5	51,1	→10,6%	109,0	→22,5%	461
Netherlands	187,0	42,3	→22,6%	63,9	→34,2%	415
Germany	761,6	116,0	→15,2%	244,5	→32,1%	457
EU27	3659,5	546,9	→14,9%	1005,9	→27,5%	347

*excluding unallocated autoproducers
source: www.iea.org/publications/freepublications/publication/name,32870,en.html

In Fig. 4, CO_2 emissions related to fuel combustion (direct emissions) within the EU's industry sector are allocated to the main sub-sectors. Emissions related to non-energy use or to imported electricity or heat (indirect emissions) are not included. The chart is derived from data provided by IEA (2012). The iron and steel, non-metallic minerals and chemical and petrochemical sectors are the largest CO_2-emitters, followed by the sector food and tobacco and the paper, pulp and printing sector.

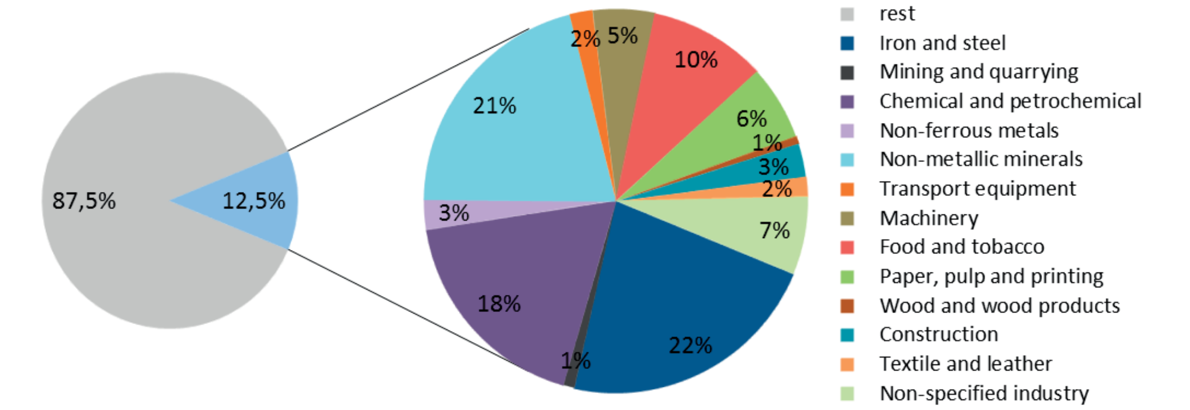


Fig. 4: CO_2 emissions from fuel combustion EU27 industry sector and sub-sectors, 2010 derived from IEA (2012)

2.3.2 Final energy consumption

For each country considered in Fig. 5, the industry sector's share in total final energy consumption is indicated. Consumption of energy carriers for non-energy purposes is excluded. Subsequently, final energy consumption within the industry sector is allocated to direct use of fossil or renewable energy sources, and to the import of heat and electricity coming from and generated in the energy sector. The share of renewables in heat and electricity varies between countries and depends on the mix of technologies in the energy sector that generate heat and electricity. The national mix is also important when calculating the amount of primary energy corresponding to a certain amount of imported heat or electricity. The charts in Fig. 5 are based on national energy balances for 2009, obtained from the International Energy Agency (www.iea.org/statistics).

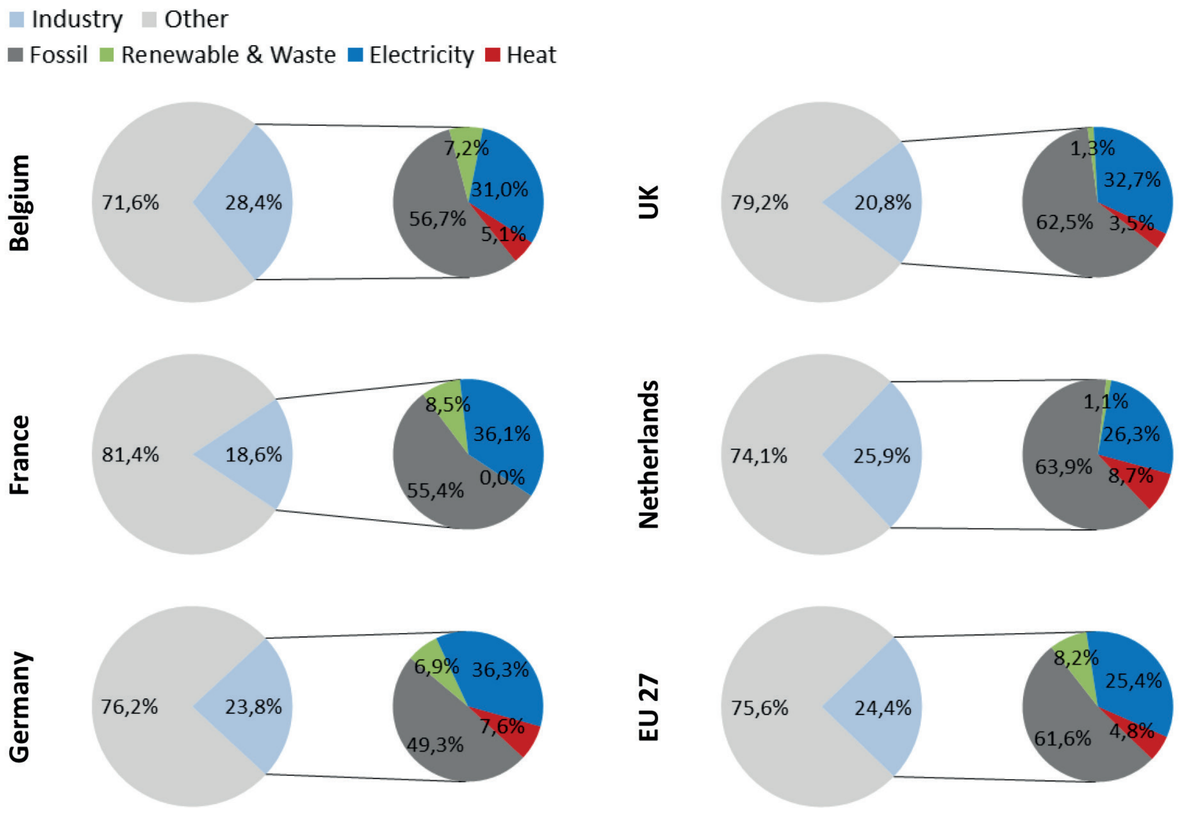
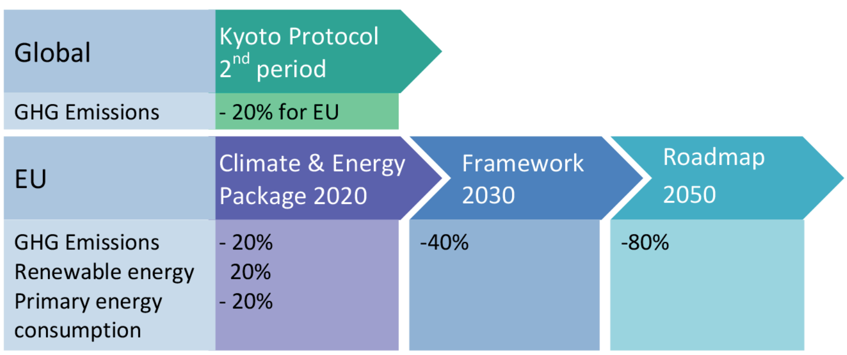


Fig. 5: Allocation of final energy consumption in the industry sector (excl. non-energy use) to fossil and renewable energy sources and to the import of electricity and heat (derived from energy balances 2009 available at www.iea.org/statistics)

2.4 European climate and energy policy

This paragraph provides an overview of the EU's climate policy. At a global level, the EU has committed to achieve the Kyoto Protocol targets. In addition, it has set out and initiated a transition pathway towards a low carbon economy, in which the key elements are: Climate and Energy Package (2020), Framework 2030 and Roadmap 2050 (Fig. 6). The Climate and Energy Package includes directives, which have to be transposed, together with other climate and energy related directives, into National Application Plans. These need to be put into practice by national authorities through concrete national policy measures (Fig. 7). Furthermore, the Climate & Energy package is part of the overarching Europe 2020 strategy.



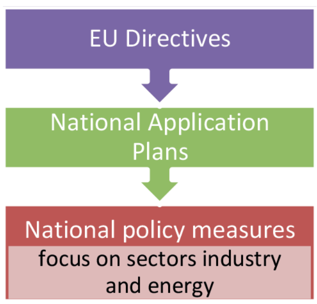


Fig. 6: Climate and energy policy

Fig. 7: Policy implementation

2.4.1 Kyoto Protocol

The Kyoto Protocol is the only legally binding treaty on global scale to reduce greenhouse gas emissions. It was adopted in 1997 and entered into force early 2005. The protocol's GHG basket includes carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and, from 2013 on, also nitrogen trifluoride (NF_3). Since CO_2 is the largest contributor to global warming in absolute terms, emissions of the other greenhouse gasses are converted into corresponding amounts of CO_2 that would have the same global warming potential over a specified timescale (CO_2-equivalents). Reduction targets are then set on total GHG emissions expressed in CO_2-equivalents.

In the **first commitment period** from 2008 to 2012, the participating developed countries needed to reduce annual GHG emissions over the entire period with an average of 5% below 1990 levels. However, in 2002, the 15 EU member states at that time raised their collective reduction target to 8% below 1990 levels. This has been translated under the **burden sharing agreement** (**BSA**) into national targets, ranging from -28 to +27%, depending on a nation's relative wealth (UK: -12.5%, France: 0%, Belgium: -7.5%, Netherlands: -6%, Germany: -21%). Countries that have entered the EU at a later time have set individual targets. The standard base year for emission reductions is 1990, but some countries in transition to a market economy use different base years. Additionally, for HFCs, PFCs and SF_6 some countries use 1995 as base year. By 2011, annual EU-15 emissions were already 14.9% and annual EU-27 emissions even 18.4 % below 1990 levels.

In the **second commitment period**, from 2013 to 2020, the 28 EU member states and Iceland commit to keep joint annual emissions at an average of 20% below 1990 levels over the whole period. On national level, the same base years as in the first commitment period apply.

To achieve Kyoto targets, countries are in the first place expected to take internal policy measures to lower emissions or to enhance carbon sinks. In addition, emission credits can be traded among developed countries or earned by financing emission reducing projects in either developed or developing countries. For EU countries this is regulated by the Emissions Trading System (see 2.4.3).

2.4.2 Europe 2020

In the overarching Europe 2020 strategy, the EU puts smart, sustainable and inclusive growth as its main priorities (see Fig. 8). These priorities are concretised into **five key targets**, covering employment, R&D, education, climate and energy, and social inclusion and poverty reduction. Subsequently, these overall objectives have been translated to the national level. **Seven flagship initiatives** provide a framework to achieve those goals. Climate and energy goals are bundled in the Climate and Energy Package and are referred to as the 20/20/20 targets. The implementation of the Europe 2020 strategy will improve security of energy supply and increase competitiveness of industry. Additionally, the European Commission aims at increasing industry's share of GDP to 20% by 2020, to establish a solid industrial base.

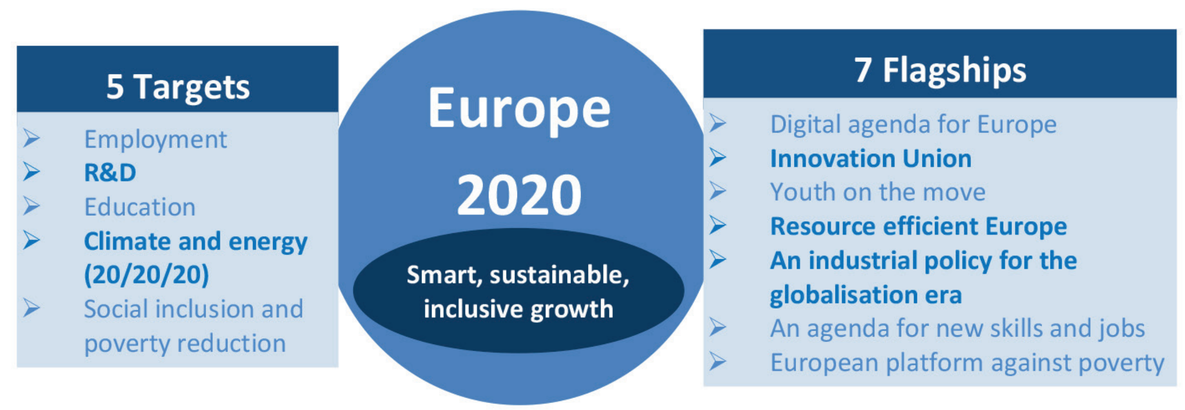


Fig. 8: Europe 2020 strategy

2.4.3 Climate and Energy Package

To curb greenhouse gas emissions, the European Union has set three major objectives towards 2020, also referred to as the **20/20/20 targets**: reduction of annual greenhouse gas **emissions** with **20%** beneath 1990 levels, increase of the share of **renewable energy** in final energy consumption to **20%**, and reduction of annual **primary energy consumption** with **20%** compared to Business As Usual (BAU) projections for 2020. Emission reduction may even be lifted to 30% if other major economies raise efforts. The first two targets are elaborated and disaggregated to the national level in the **Climate and Energy package**, launched in 2009. It establishes a legal framework through EU directives, imposing end results to member states that have to be included in national legislations and policies.

20% emission reduction

For practical reasons, the emission target has been reformulated as a 14% decrease of emissions in comparison to 2005. Efforts are divided among two complementary emission accounting schemes, being the **Emissions Trading System** (**ETS**) and the **Effort Sharing Decision** (**ESD**). Under the ETS, a collective emission reduction of 21% has to be achieved, while under the ESD, national targets are set, resulting in an overall emission reduction of 10% against 2005 levels.

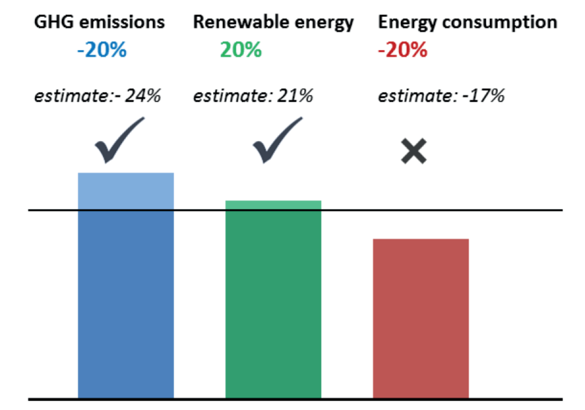


Fig. 9: EU 20/20/20 targets (European Commission)

Emissions Trading System (ETS):

The European Union's Emissions Trading System is a policy tool to gradually decrease overall European greenhouse gas emissions. It covers carbon dioxide (CO_2) emissions from power stations, energy-intensive industrial plants and commercial airlines, nitrous oxide (N_2O) emissions from the production of certain acids and emissions of perfluorocarbons (PFCs) from the aluminium industry. Each year, the companies included in the system are obliged to submit one emission allowance per ton of CO_2-equivalent emitted. For every missing credit a severe fine must be paid. Reduction of overall emissions is achieved by gradually decreasing the total amount of allowances available in the system. Depending on the sector, part of the available allowances are granted for free, according to harmonised EU-wide rules, that reward best practice in low-emission production.

Industries that face significant competition from regions outside the EU with less stringent climate legislation are granted a higher share of free credits. To fully cover their emissions, companies can buy additional credits at auction from other companies or from approved emission-saving projects around the world. Excess allowances, on the other hand, can be sold at auction or saved to be used at a later time. However, they can only be used once and are destroyed when submitted. At least half of the revenues made by auctioning have to be invested in low carbon technologies in European or other countries. In conclusion, the ETS was meant to put a price on emissions and to create an incentive for companies to invest in technologies that reduce emissions.

The ETS was established in 2003 under the **Emissions Trading Directive** (**ETD**), which has been revised in 2009. In its third trading period, 2013-2020, the ETS comprehends more than 11000 power stations and industrial plants in 31 countries (28 EU countries plus Iceland, Norway and Liechtenstein), and national and international flights. As a consequence, it covers about 45% of total 2013 emissions. For power stations and industrial plants, a declining emission cap is imposed, starting at 2.04 billion tonnes CO_2 in 2013, and subsequently decreasing each year with 1.74 % of the annual average of 2008-2012, reaching a reduction of 21% in 2020 against 2005 levels. Aviation, however, is subject to a separate cap and regulation. From 2013 on, free allocation of allowances is progressively phased out, making auction the main method. In the electricity sector, in most countries, all credits are now exclusively auctioned. In manufacturing industry, however, still 80% of the credits are granted for free in 2013, decreasing to 30% in 2020. The Union registry, an online database, ensures the accounting of all allowances issued in the ETS. Unfortunately, the ETS is currently facing a short-term problem, because the economic crisis created an excess of emission allowances, that has lowered the carbon price.

Effort sharing Decision (ESD):
The Effort sharing Decision establishes emission reduction goals for most of the sectors not included in the ETS, such as transport (except aviation), buildings, agriculture, waste and the non-ETS part of energy and industry. By 2020, total emissions under ESD have to decrease with 10% compared to 2005 levels. This has been translated into national reduction targets, ranging from -20% to +20%, according to the relative wealth of each country. The emission increases against 2005 levels for the least wealthy states nevertheless imply a reduction when compared with projected business as usual emissions. National emissions have to decrease linearly each year, starting in 2013, from average 2008-2010 levels down to the proposed 2020 target. To achieve those targets, countries or regions can employ flexibility mechanisms and acquire additional emission credits. Efforts sharing targets are depicted in Table 2 (Belgium: -15%, France: -14%, UK: -16%, Netherlands: -16%, Germany: -14%)

Additionally to reduction of carbon emissions, CO_2 from industrial sites and power plants can be captured and stored in underground geological formations where it does not contribute to global warming. The carbon capture and storage directive (CCSD) establishes a legal framework to ensure the environmentally safe implementation of CCS technologies.

20% renewable energy
The **Renewable Energy Directive** (**RED**) provides a legislative framework to promote the use of energy from renewable sources and the shift to cleaner forms of transportation. It translates the collective EU target of a 20% renewable energy share in final energy consumption into binding national targets, ranging from 10% to 49%, depending on the starting points and potentials of the different member states (Belgium: 13%, France: 23%, UK: 15%, Netherlands: 14%, Germany: 18%). Moreover, each member state has to achieve a 10% renewable energy share in final energy consumption of the transport sector by 2020. In this context, biofuels and bio liquids are only taken into account if they are qualified as "sustainable". To put this in practice, **national renewable energy action plans** (**NREAP**) for renewable energy and procedures for the use of biofuels are defined. Member states can exchange amounts of energy from renewable sources using a statistical transfer or cooperate in collective renewable energy projects within or outside the EU.

20% reduction primary energy consumption
By 2020, the EU aims to reduce its annual primary energy consumption with 20% compared to projections. However, the energy efficiency target is not directly addressed in the Climate and Energy package, but through the **Energy Efficiency Directive** (**EED**). The EED repeals and merges the previously issued Energy end-use Efficiency and Energy Services directive and the Cogeneration directive, and amends the **Ecodesign** and **Energy Labelling directives** (**EDD** and **ELD**).

In summary, the EED establishes a legal framework for the implementation of energy efficiency policies and measures proposed in the **Energy Efficiency Plan** (**EEP**). Those measures cover every stage of the energy chain from generation to final consumption. Especially the sectors energy, industry, buildings and transport hold great energy saving potentials. The public sector is expected to take the lead and is obliged to energetically renovate each year 3% of government building floor surface from 2014 on. Measures include promotion of combined heat and power generation in the energy and industry sector, district heating and cooling, smart grids, energy monitoring and audits for small and medium-sized enterprises, energy management systems, smart metering for buildings, labelling of energy performance of buildings and appliances, eco-design of products, etc.

EU member states are required to compose **national energy efficiency action plans** (**NEEAPs**), describing national strategies and measures to achieve individual indicative energy efficiency targets for 2020. Those national plans will have to be reviewed and improved every three year.

Summary national 2020 targets
In Table 2, the national targets towards 2020 under both the Climate and Energy package and the Kyoto Protocol are summarised for the countries analysed in this chapter.

Table 2: National 2020 targets under Kyoto protocol and Climate & Energy Package

National 2020 targets		Belgium	France	UK	Netherlands	Germany
Kyoto 2nd period						
Emission reduction		-20%	-20%	-20%	-20%	-20%
base year CO_2/CH4/N2O		1990	1990	1990	1990	1990
base year F-gasses		1995	1990	1995	1995	1995
Climate & Energy Package						
Emission reduction	ESD	-15%	-14%	-16%	-16%	-14%
base year		2005	2005	2005	2005	2005
Renewable energy	RED	13%	23%	15%	14%	18%
Energy efficiency	EED	Indicative targets, different definitions see: ec.europa.eu/energy/efficiency/eed/reporting_en.htm				

2.4.4 Energy Performance of Buildings Directive
The **Energy Performance of Buildings Directive** (**EPBD**) creates a legal framework to promote reduction of energy consumption in the building sector, that currently accounts for 40 % of total EU energy consumption. Under this directive, EU states must establish minimum requirements for and certification of energy performance for existing and new buildings, next to a regular inspection of boilers and air-conditioning systems, introduce low carbon technologies for heating and cooling and electricity generation. By 2021 all new buildings should be **nearly zero energy buildings** (**NZEB**). Each member state has to develop an NZEB national plan.

2.4.5 Framework 2030
The EU is currently developing a green paper for a 2030 framework for EU climate change and energy policies, based on lessons learned from the 2020 framework and taking into account the pathways set out in the Roadmap 2050.

2.4.6 Roadmap 2050
The EU "roadmap towards a competitive low carbon economy" defines a cost-effective pathway to reduce greenhouse gas emissions by 80 to 95% in 2050 against 1990 levels, with intermediary steps of 40% in 2030 and 60% in 2040. Efforts are divided between different economic sectors, according to their technological and economic potential to reduce emissions.

The power sector has the highest potential and could almost totally eliminate greenhouse gas emissions by 2050 by fully employing renewable and low carbon technologies. This requires a strong decline of the ETS emission cap for the power sector and investment into smart grids. Part of transport and heating will shift from fossil fuel combustion to electricity, while heavy transport and aviation will be dependent on biofuels. In the transport sector, emission reductions of 60% could be achieved by improving efficiencies of traditional engines and fuels, followed by a shift towards hybrid and electric engines, and by better exploitation of transportation networks.

Emissions from the residential and tertiary sector can be cut by about 90%, by improving the energy performance of existing buildings, introducing low carbon technologies for individual electricity production and space heating, and promoting district heating. Moreover, nearly zero energy buildings will become the new build standard from 2021 on. Energy intensive industries could lower their emissions by about 80%, using cleaner and more efficient processes and carbon capture and storage technologies. Agricultural emissions need to be cut by more efficient farming practices and conversion of animal waste to biogas. Eventually, the low-carbon roadmap would lead to a 30% reduction of energy consumption versus 2005 levels by 2050. A desired pathway specifically for the energy sector is elaborated in the Energy Roadmap 2050 (see Fig. 10).

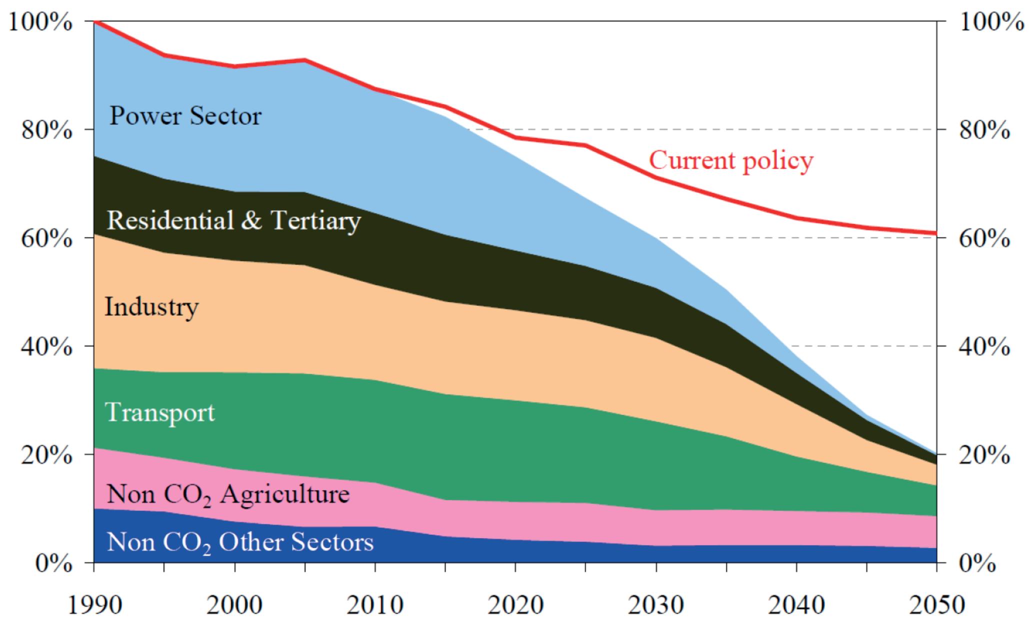


Fig. 10: Roadmap towards a competitive low carbon economy, sectoral perspectives (ec.europa.eu/clima/policies/roadmap)

2.4.7 Industrial Emissions Directive

The **Integrated Pollution Prevention and Control Directive** (**IPPCD**) together with six sectoral directives will be replaced in 2014 by the **Industrial Emissions Directive** (**IED**), which has a broader scope. The IED aims at reducing pollution of industrial sources across the EU, especially emissions of greenhouse gasses and acidifying substances, wastewater and waste. A higher material and energy efficiency is pursued. Therefore, environmental permits are linked to a positive evaluation of the complete environmental performance of a company and the application of Best Available Techniques (BAT), which are described in the BAT reference documents (BREFs).

2.4.8 Regulation F-gas emissions

The F-gas Regulation aims to curb fluorinated gas emissions on EU-level from industrial processes and from cooling installations and heat pumps. Measures include monitoring, labelling, restrictions to the use of certain products and containing F-gases, certification of staff, limit access to F-gas containing products, prescribe alternatives, etc. This regulation is incorporated in the national legislations.

2.4.9 Horizon 2020 instruments

The **flagship 'Innovation Union'** (2014-2020) under the Europe 2020 strategy aims at securing Europe's competiveness and is financially implemented through the **Horizon 2020 program**. Horizon 2020 basically needs to close the gap between research and the market. As a result, PPPs (Public Private Partnership), ETPs (European Technology Platforms) and Joint Technology Initiatives (JTIs) are established, that set out industrial research and innovation roadmaps and priorities.

SPIRE (Sustainable Process Industry through Resource and Energy Efficiency) is a public private partnership between the European Commission and the European process industry, including the sectors cement, ceramics, chemicals, engineering, minerals and ores, non-ferrous metals, steel and water. The partnership supports and enables the development of technologies and solutions needed to reach sustainability for European industry in terms of competitiveness, ecology and employment. SPIRE has set two targets for 2030, in line with the European climate and energy strategy. Firstly, a reduction in fossil energy intensity of 30% against current levels (2008-2011) is targeted. Secondly, a reduction of 20% in non-renewable, primary raw material intensity compared to current levels is aimed at. A roadmap towards these goals has been composed, identifying measures to be taken regarding energy and material resources. These measures include optimisation of energy systems, energy recovery, renewable energy and combined heat and power production, process optimisation, innovative energy-saving processes, recycling, renewable raw materials, process intensification, industrial symbiosis, enhanced sharing of knowledge and best practices, broadening of societal involvement, etc.

2.4.10 Summary

Year	Policy	EU targets	National targets	National Plans
2012	***Kyoto Protocol*** 2008-2012 ***BSA***	**average Em. -8%** EU-15	EU-15: average Em. -28% to +27%; rest EU: -5% to -8% vs. different base years	
2020	***Kyoto protocol***** 2013-2020	**average Em. -20%** EU, Croatia, Iceland	average Em. -20%	
	Climate & energy package			
		Em. -20% (-30%)		
	ETD rev. (ETS)	Em. -21% vs. 2005		
	ESD (non-ETS)	Em. -10% vs. 2005	Em. -20% to +20% vs. 2005	
	RED	**20% RE** (transport: 10%)	10% to 49% RE	***NREAP***
	EED*	**PEC -20%**	Indicative targets	***NEEAP***
	CCSD			
	EPBD		new-build: NZEB by 2021	***NZEB NP***
2030 ***2040*** } ***2050***	2030 Framework Roadmap 2050	Em. -40% Em. -60% Em. -80-95%		
IED, EDD, ELD, F-gas Regulation, PPPs, ETPs				

Em.	annual greenhouse gas emissions in CO2 equivalents, reduction compared to 1990 levels, unless other base year specified in table
PEC	annual primary energy consumption, reduction compared to projected levels for 2020
RE	renewable energy share in final energy consumption
rev.	revision
*	not directly part of Climate & Energy Package
**	The Kyoto Protocol and the EU Climate & Energy package do not cover the same economic sectors and the Kyoto Protocol uses different base years for some countries, instead of one collective base year.

2.4.11 Policy challenges

Kyoto

Despite all efforts, the Kyoto Protocol is not sufficient to cut global greenhouse gas emissions, as no binding targets are imposed to major emerging economies in the developing world (e.g. China, India, Brazil, Indonesia), the United States of America have never ratified it and Canada has withdrawn its support.

In the second Kyoto period, only the EU and a small number of other countries are participating, covering a minor share of global emissions (13,4% in 2010). In 2013, global carbon dioxide emissions stood at about 60%

above 1990 levels. Therefore, a new global legal framework with overall binding emission reduction targets needs to be established. This has been the subject of the subsequent international climate conferences, that are organised every year by the United Nations Framework Convention on Climate Change (UNFCCC). Eventually, the 2015 climate conference in Paris should result in a new global treaty, taking effect from 2020 on.

Despite the alarming conclusions of the IPCC (2013) on human-induced climate change, little progress was made in the Warsaw Climate Change Conference in November 2013, and major environmental and social organisations left the conference table. Keeping global temperature rise beneath the 2°C threshold seems to become virtually impossible.

EU-ETS

The EU-ETS faces several short-term problems. In 2013, the carbon price collapsed to about 5 €/ton CO_2-equivalents, due to an excess of emission allowances on the market (see Fig. 11). There are two reasons for this **surplus** of emission credits.

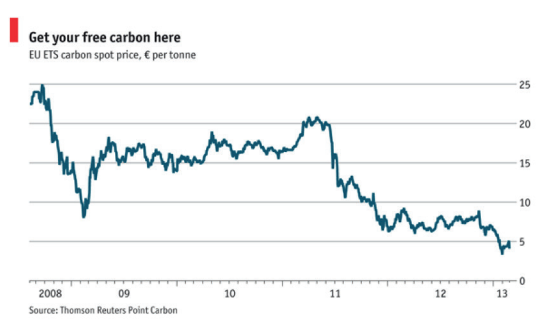


Fig. 11: Carbon price (www.pointcarbon.com)

Firstly, at the start of the second ETS trading period (2008-2012), the total volume of emission allowances was decreased by only 6.5% against 2005 levels. The major share of those allowances (90%) was allocated to companies for free, proportional to their emissions reported during the first period. When the **financial crisis** struck at the end of 2008, industrial production decreased, creating a growing surplus of unused allowances, which depressed the carbon price (see Fig. 11).

Secondly, a number of Chinese chemical companies flooded the carbon certificate market, increasing the surplus even more and flooring the carbon price. A large share of these certificates originated from a **refrigerant producer**, who reduced emissions of the by-product HFC-23, by capturing and incinerating it. This greenhouse gas is 11700 times more powerful than CO_2, and as a consequence, an enormous amount of certificates were created and sold on the market. The company even increased its production capacity with the sole purpose of earning more carbon credits. From May 2013 on, the ETS cancelled new certificates of this type. However, cheap carbon certificates had already been bought in massive amounts by large industrial polluters, in order to ensure enough emission space for the future. As a consequence, investments in new low carbon technologies are postponed (Valentino, 2013).

Energy intensive, fossil fuel based industries claim that European climate policy endangers their market position in comparison to regions outside Europe with less stringent climate legislation, forcing them to shut down their plants or to delocalize their production activity. This so-called **carbon leakage** would have negative effects on local economy. Emissions would decrease in Europe, but proportionally increase in the rest of the world. Therefore, a number of national governments have chosen to grant free emission allowances to ETS-companies and installations prone to carbon leakage, or to compensate the costs for emission credits charged through electricity prices. This approach clearly favours extending the operational lifetime of older less efficient technologies.

To achieve emission reduction targets, countries and companies can achieve extra emission credits by **carbon offset** projects. Due to weak regulations, some offset projects are questionable or even perverse (Mukerjee, 2009).

2.4.12 Sources

Websites	
Europe 2020	ec.europa.eu/europe2020/europe-2020-in-a-nutshell/index_en.htm
Kyoto	unfccc.int/kyoto_protocol/items/2830.php ec.europa.eu/clima/policies/g-gas
Kyoto:base years	unfccc.int/ghg_data/kp_data_unfccc/base_year_data/items/4354.php
Climate & Energy Package (ETD, ESD, RED, CCSD)	ec.europa.eu/clima/policies/package
Industry GDP target	ec.europa.eu/enterprise/initiatives/mission-growth
EED, EEP, EPBD, EDD, ELD	ec.europa.eu/energy/efficiency
Roadmap 2050	ec.europa.eu/clima/policies/roadmap
Energy Roadmap 2050	ec.europa.eu/energy/energy2020/roadmap
Green paper 2030	ec.europa.eu/energy/green_paper_2030_en.htm
IED	ec.europa.eu/environment/industry/stationary/index.htm
BREFs	eippcb.jrc.ec.europa.eu/reference
F-gas	ec.europa.eu/clima/policies/f-gas
Horizon 2020	ec.europa.eu/research/horizon2020/index_en.cfm
SPIRE	www.spire2030.eu
1990-2013: +60% CO_2	www.globalcarbonproject.org/carbonbudget
IPCC	www.ipcc.ch www.climatechange2013.org
HFC-23 Project	cdm.unfccc.int/Projects/DB/DNV-CUK1136817489.89/view
Fossil fuel subsidies	www.iisd.org/gsi/fossil-fuel-subsidies
Carbon market	www.pointcarbon.com

Legislative documents	
ETD	eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2003L0087:20090625:EN:PDF
ESD	eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0136:0148:EN:PDF
CCSD	eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0114:0135:EN:PDF
RED	eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF
EED	eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:EN:PDF
IED	eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010L0075&from=EN
EEP	eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0109:FIN:EN:PDF
EPBD	eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF
Roadmap 2050	eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0112:FIN:EN:PDF
Energy Roadmap 2050	eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0885:FIN:EN:PDF

References

IEA 2012. CO_2 Emissions from Fuel Combustion Highlights - 2012 Edition.

IPCC 2013. Summary for Policymakers. *In:* STOCKER, T. F., QIN, D., PLATTNER, G.-K., TIGNOR, M., ALLEN, S. K., BOSCHUNG, J., NAUELS, A., XIA, Y., BEX, V. & MIDGLEY, P. M. (eds.) *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, United Kingdom and New York, NY, USA.: Cambridge University Press

MUKERJEE, M. 2009. A Mechanism of Hot Air A popular carbon-off set scheme may do little to cut emissions. *Scientific American,* 300**,** 18-+.

VALENTINO, S. 2013. Europese klimaatfraude brengt gezondheid Gentse jongeren in gevaar. *MO*.* Brussels: Wereldmediahuis vzw.

2.5 National, regional and local climate and energy policy

National targets on GHG emissions, renewable energy and energy efficiency, imposed by the EU through the Climate and Energy Package, have to be implemented in national policies and legislations. Member states are obliged to submit national action plans to the European Commission, extensively describing the policy measures they will take, according to the Renewable Energy Directive (RED), the Energy Efficiency Directive (EED) and the Energy Performance of Buildings Directive (EPBD). At national level, these plans can be composed of regional plans or consist of various thematic plans.

In Belgium, for instance, the Action Plan Green Heat is part of the National Renewable Action Plan, which is composed of one federal and three regional plans. Also national or regional plans that address all 20/20/20 targets at the same time may be set up, such as the Flemish Mitigation Plan (FMP), that offers a framework to meet the non-ETS emission reduction target. The policy measures set out in different plans are translated into regulations, such as the Flemish Energy Decree and the Energy Decision, that regulate everything that concerns energy.

Some countries, such as Germany, already elaborated an intensive climate and energy policy long before the EU Climate and Energy Package. The Renewable Energy Act (REA) installed feed-in tariffs for renewable energy since 2000, which was complemented in 2009 by the Renewable Energy Heat Act (REHA), imposing a share of renewable heat for space heating. The Combined Heat and Power Act (CHPA) dates from 2002 and subsidises electricity production form qualitative CHP installations.

The Covenant of Mayors was launched by the EU to concretize the Climate and Energy Package at the level of cities and communities. The involved parties are obliged to make a greenhouse gas inventory and a renewable energy action plan (signatures: Belgium: 67, France: 112, UK: 33, Netherlands: 16, Germany: 53). A number of European cities have set even more ambitious goals and aim in the long term for climate neutrality (e.g. Gent, Leuven, Mechelen and Antwerpen in Belgium, Copenhagen in Denmark)

Websites	
NREAPs	ec.europa.eu/energy/renewables/action_plan_en.htm
FMP	www2.vlaanderen.be/economie/energiesparen/milieuvriendelijke/Nuttige_documenten/Nationaal_actieplan_HE.pdf
REA, REHA	www.erneuerbare-energien.de/die-themen/gesetze-verordnungen
CHPA	www.bafa.de/bafa/de/energie/kraft_waerme_kopplung/
CoM	www.covenantofmayors.eu/index_en.htm

2.6 National and regional energy policy measures for industry

The European climate and energy policy is incorporated in the national and regional policies, which in turn are put into practice through a series of policy measures. Measures in the industrial and energy sector can be subdivided according to their approach: regulation, financial support, funds and loans, voluntary agreements and information dissemination.

Building regulations follow the EPBD, and environmental permit regulations for industrial processes and energy production installations are based on the EID or the former IPPCD. Products and equipment are covered by the European directives about eco-design and energy labelling. F-gas emissions from industrial processes and equipment are controlled by an EU-wide regulation. Financial support mechanisms include income tax deduction, (proportional) investment support, (fixed) energy premiums, energy production or carbon saving certificates, subsidies for studies, audits and R&D, subsidies for energy monitoring systems, subsidies for business parks development. Information dissemination is done through consultancy, awareness raising campaigns, training programmes and informative websites.

Table 3: Types of policy measures	
Regulation	• Building • Process • Product
Financial support	• Tax deduction • Investment support • Energy premiums • Exploitation support • Certificates • Subsidies for audits, studies and R&d • Subsidies for energy monitoring • Subsidies for business park development
Funds and loans	
voluntary agreements	
Information dissemination	

Policy measures are first presented per country or region and subsequently an international overview is given in a comparative table. Measures that do not specifically target energy or eco- efficiency, renewable energy or greenhouse gas emissions are not included.

Sources for international overview policy measures	
Energy efficiency measures for SMEs	www.energiesparen.be/node/3687
Building Energy Efficiency Policies	www.sustainablebuildingscentre.org/pages/beep
Global buildings performance network	www.gbpn.org
Taxes and incentives for renewable energy	www.kpmg.com/Global/en/IssuesAndInsights/ArticlesPublications/Documents/taxes-incentives-renewable-energy-2012.pdf
Industrial Efficiency Policy Database	iepd.iipnetwork.org

2.6.1 Belgium

2.6.1.1 Regulation

Building

The regulation for energy performance and indoor climate (**EPB**) imposes targets for energy performance and insulation, puts limits on energy requirement for space heating, and requires a minimum share of renewable energy for new or substantially renovated buildings. In Flanders, Brussels and Wallonia, the energy performance of buildings is evaluated with the same mandatory EPB software tool. However, the targets to be achieved differ between the three regions (see 5.4.2). For new building projects in Flanders, it is compulsory to perform a feasibility study towards the implementation of renewable energy systems.

Process

In accordance with the IPPCD, the **Energy Planning Decree** of the Flemish government promotes the implementation of the most energy efficient technologies that are economically viable (Best Available Techniques Not Entailing Excessive Costs, BATNEEC), for energy-intensive processes. Companies have to identify and analyse such investments in an **energy study** or **energy plan**, which is linked to the environmental permit (see 5.4.5). Brussels has adopted an integrated regulation, named **COBRACE** (Code of Brussels for Air, the Climate and Energy Control). In Wallonia, the IPPCD principles are integrated in the **Decree Environmental Permits**.

2.6.1.2 Financial support

Tax deduction

The federal government pushes industrial investments in rational energy use, energy efficiency and waste heat recovery by reducing the taxable profit with a certain percentage. This so-called **enhanced investment deduction** amounts 14.5% for income year 2013. For new buildings in Flanders fulfilling or surpassing the energy performance level required by the EPB regulation, a **property tax rebate** is automatically granted. An energy level of E50 (E40 from 2014 on) or lower, corresponds to a tax reduction of 50%, while the property tax is completely remitted for E30 or lower, over a period of 5 years in both cases. **Energy scans** are also **tax deductible**. In Brussels and Wallonia, no additional regional tax incentives related to energy efficient investments exist.

Investment support

Flemish companies with a grid connection up to 70kW, can receive subsidies for energy saving investments from the Belgian electricity transmission network operator, **Elia**. The investments must be underpinned by an energy study and have a payback time between 2 and 5 years. Projects eligible for green power or CHP certificates are not taken into account. The subsidy amounts up to 40% of the investment costs, with a maximum of 200.000 €. The Flemish government incentivises investments in cutting edge green and clean process technologies by financing a certain share of the extra investment costs. The **Ecology Premium** is only valid for a limitative series of best available technologies and cannot be combined with green power or CHP certificates and the green warranty (see 2.6.1.3). The **Strategic Ecology Support** is intended for extraordinary technologies, that directly contribute to solutions for environmental or energy problems and that employ closed energy and material loops, such as geothermal systems, heat networks, the use of CO_2 as resource, etc. Both premiums cover up to 70% of the extra investment costs, with a maximum of 1 million € per 3 year. Green heat production (>1MW), heating networks, and waste heat recovery are eligible for financial support. Companies can apply for the support in a half-yearly call.

In Brussels, SME's can recover 30 to 40% of their investments in energy efficiency or renewable energy, due to the "**Investment support for a better environment**". This subsidy can be increased with 5% with the ISO 14000 certificate or the eco-dynamic enterprise label. In Wallonia a similar investment support mechanism exists for energy efficient or renewable energy technologies (excluding photovoltaic) and CHP (**Aide à l'investissement Environnement et Utilisation durable de l'énergie**). The subsidy amounts 30 to 40% (50% for CHP) of the additional costs compared to conventional technologies.

Energy Premiums

In Flanders, **grid operators** are obliged to promote rational energy use among their clients by awareness raising campaigns and financial incentives. Premiums are issued for the installation of heat pumps or solar boilers. Additionally, for existing buildings, financial support is given for the insulation of roofs, attics, floors and walls, the installation of high performance glass, optimisation of the heating system, energy saving relighting, and any energy saving measure underpinned by an energy audit.

Brussels issues energy **premiums** for insulation of the building envelope and the global thermal performance level achieved, for efficient ventilation and heating systems, including heat pumps, for renewable energy production and CHP, and for other energy efficient investments in new and existing tertiary and industrial buildings. Green roofs, sunshades and relighting are also eligible.

Wallonia grants **premiums** for the installation of condensing or radiant air heaters, condensing boilers, automatically fed biogas boilers, solar boilers, CHP, heat pumps for hot sanitary water, insulation, relighting, exhaust gas heat recovery systems, systems for energy management of electrical installations, optimisation of cooling cycles, natural gas burners for industrial processes, modulation systems for boilers and burners, variable frequency controlled pumps, ventilators and compressors and the connection of heat generators to a district heating network.

Exploitation support

Flanders, Brussels and Wallonia have no feed-in tariff schemes to support renewable electricity production.

Certificates

In Flanders, renewable electricity production and combined heat and power production (CHP) are financially rewarded through the **green power** and **CHP certificate** systems (**GPC and CHPC**). The amount of certificates received is proportional to the green electricity produced or to the primary energy saved by CHP. Brussels and Wallonia, however, do not have separate certificate schemes for green power and CHP. Instead, **green certificates** (**GCs**) are issued to qualitative CHP or renewable energy installations, proportionally to the CO_2 savings they achieve in comparison to reference installations. In Brussels, one certificate is issued per 217 kg of CO_2 saved, while in Wallonia, one certificate corresponds to a CO_2 reduction of 456 kg. Grid operators at federal and regional level, are obliged to buy these certificates at a guaranteed minimum prices, which in Flanders are technology dependent. For further details, see 6.9.

Subsidies for audits, studies and R&D

Flanders does not financially incentivise energy audits or studies. Brussels issues premiums for energy audits, **energy design studies** and **blower door tests**. Wallonia financially supports a number of **audits**, concerning overall energy consumption, electricity consumption, thermal losses through the building envelope (infrared thermography), next to **feasibility studies** for renewable energy production (wind and biogas), and audits supporting the development of a holistic energy efficiency plan. Also, Wallonia grants a premium for certification of products that contribute to energy management.

Subsidies for energy monitoring

Wallonia and Brussels grant subsidies for energy monitoring systems.

Subsidies for business park development

In Flanders only, **subsidies** for **business park development** are linked to carbon neutral electricity consumption (see 3.7). In 2013, the regulation was modified and now focusses on the redevelopment of brownfields and greenfields that cannot be developed without financial support. The province of East-Flanders grants an additional subsidy to sustainable business parks, up to 75% of eligible investments, with a maximum of 15.000 €.

2.6.1.3 Funds and loans

In Flanders, investments loans for energy saving technologies can benefit from a lower interest rate thanks to the **Green Warranty**. It is valid for technologies from a limitative technology list, with a maximum payback time of 10 year. The Green Warranty can be applied on maximum 75% of the total credit. In Brussels and Wallonia there are no funds specifically developed for green technology, although in Wallonia, **Novalia** provides subordinated loans for investments in innovative products or processes.

2.6.1.4 Voluntary agreement

In Flanders, The Audit and Benchmark Covenants (see 5.4.5) are succeeded by the **Energy Policy Agreement** (see 5.4.5). Under this agreement, industrial companies commit to implement profitable energy efficiency measures and to perform energy studies on a regular base. In return the Flemish government exempts them from additional policy measures concerning energy efficiency and emissions. Brussels has not organised such agreements. In Wallonia, the **Accords de Branche** are agreements between the industrial sectors and the Walloon government, analogous to the Audit and Benchmark Covenants in Flanders. Companies that sign the agreement are committed to increase the uptake of measures in energy efficiency and renewable energy and deliver a yearly progress report. In return they receive various administrative and financial benefits, such as reductions on taxes and levies, the exemption of the future carbon tax and a 75% subsidy for energy audits.

2.6.1.5 Information dissemination

The Flemish government provides **energy consultants** for sector federations and non-governmental organisations to advise SMEs, households and building professionals in energy efficiency and renewable energy production. Enterprise Flanders (Agentschap Ondernemen) offers a free **energy scan** (5.3.5) or eco-efficiency scan to interested SMEs. Companies that use the scan receive an extra bonus for the Ecology Premium. A self-scan tool has also been developed and is available on the website of Enterprise Flanders.

Through its website **energiesparen.be**, the Flemish Energy Agency (VEA) provides specific information for every stakeholder group about regulation and financial incentives for energy efficiency measures and renewable energy production. Enterprise Flanders provides information about energy-related regulation and financial support, specifically for SMEs via **agentschapondernemen.be.**

In Brussels, the **Facilitator Sustainable Buildings** is a public service offering support for new builds, refurbishments and management of buildings from the point of view of sustainability. The **Brussels** region issues the label **Eco-dynamic Enterprise** (Ecodynamische Onderneming) to companies that show good practice in environmental management, covering energy, waste, resource and mobility. Seminars and trainings about sustainable buildings are organised and information is disseminated via **www.leefmilieubrussel.be**

The Walloon government established a network of **Facilitators** that support companies with information and guidance about energy measures. It also organises the **training** of energy managers and energy auditors in companies, courses about energy performance of buildings, and publishes technical reports. A clear overview of energy policy measures can be found on **energie.wallonie.be.**

2.6.1.6 Sources

Flanders	
Regulation	
building	www.energiesparen.be/bouwenverbouwen www.energiesparen.be/milieuvriendelijke/wetgeving
Process	www.energiesparen.be/energieplanning
Financial support	
Tax deduction	www.energiesparen.be/verhoogdeinvesteringsaftrek www.onroerendevoorheffing.be/nlapps/docs/default.asp?id=170
Investment support	www.agentschapondernemen.be/themas/ecologiepremie www.elia.be/nl/producten-en-diensten/reg-actieplan www.energiesparen.be/node/3934
Energy premiums	www.eandis.be/eandis/klant/k_overzicht_premies_P.htm
Exploitation support	
Audits, studies, R&D	
Energy monitoring	
Certificates	www.vreg.be/systeem-groenestroomcertificaten-en-garanties-van-oorsprong www.vreg.be/systeem-warmte-krachtcertificaten
Business parks	www.agentschapondernemen.be/maatregel/ontwikkeling-en-herontwikkeling-van-bedrijventerreinen www.agentschapondernemen.be/maatregel/provinciale-subsidie-duurzame-bedrijventerreinen-oost-vlaanderen
Funds and loans	www.energiesparen.be/node/3301
Voluntary agreements	www.agentschapondernemen.be/artikel/moet-ik-een-energiebeleidsovereenkomst-afsluiten energiesparen.be/node/3341
Information	www.energiesparen.be/KMO agentschapondernemen.be

Brussels	
Regulation	
building	www.leefmilieubrussel.be/Templates/Professionnels/informer.aspx?id=32586
Process	www.leefmilieubrussel.be/Templates/news.aspx?id=37885
Financial support	
Tax deduction	www.energiesparen.be/verhoogdeinvesteringsaftrek
Investment support	www.werk-economie-emploi.irisnet.be/nl/pme-investir-pour-ameliorer-notre-environnement
Energy premiums	www.leefmilieubrussel.be/Templates/Professionnels/informer.aspx?id=36443
Exploitation support	
Audits, studies, R&D	www.leefmilieubrussel.be/Templates/Professionnels/informer.aspx?id=36443
Energy monitoring	www.leefmilieubrussel.be/Templates/Professionnels/informer.aspx?id=36443
Certificates	www.leefmilieubrussel.be/Templates/Professionnels/informer.aspx?id=32621 www.elia.be/nl/producten-en-diensten/groenestroomcertificaten/Minimumprice-legalframe documentatie.leefmilieubrussel.be/documents/IF_Energie_berekening_GSC_NL_juni2012.PDF?langtype=2067
Business parks	
Funds and loans	
Voluntary agreements	
Information	www.leefmilieubrussel.be/Templates/Professionnels/informer.aspx?id=32196 www.leefmilieubrussel.be/Templates/Professionnels/niveau2.aspx?maintaxid=11771&taxid=11789

Wallonia	
Regulation	
building	energie.wallonie.be/fr/la-reglementation-peb.html?IDC=6232
Process	environnement.wallonie.be/aerw/pe/
Financial support	
Tax deduction	www.energiesparen.be/verhoogdeinvesteringsaftrek
Investment support	forms6.wallonie.be/formulaires/BrochureENV-UDE.pdf
Energy premiums	energie.wallonie.be/nl/aides-et-primes.html?IDC=6358 energie.wallonie.be/fr/primes-energie.html?IDC=7029
Exploitation support	
Audits, studies, R&D	energie.wallonie.be/fr/etudes-audit-global-comptabilite-energetique-amure.html?IDC=6374
Energy monitoring	energie.wallonie.be/nl/mise-en-place-d-un-systeme-de-comptabilite-energetique-amure.html?IDC=6374&IDD=12271
Certificates	energie.wallonie.be/nl/systeme-d-octroi-de-certificats-verts.html?IDC=6384&IDD=12277 www.energik.be/belcogen
Business parks	
Funds and loans	energie.wallonie.be/nl/soutien-a-la-recherche-industrielle-de-base-au-sein-des-pme-et-des-grandes-entreprises.html?IDC=7625&IDD=63635
Voluntary agreements	energie.wallonie.be/nl/les-accords-de-branche.html?IDC=6244
Information	energie.wallonie.be/fr/demander-conseil.html?IDC=7886 energie.wallonie.be/fr/la-formation.html?IDC=6136

2.6.2 France

2.6.2.1 Regulation

Building
The '**Réglementation Thermique 2012**' sets energy performance targets for new buildings and building extensions. It focusses on an efficient bioclimatic building design and restricts the annual primary energy consumption related to building use. Overheating in summer must be avoided. For major non-residential retrofits, the energy consumption for building use needs to be lower than a reference value and must be reduced by at least 30% compared with the original situation. For smaller refurbishments, implementation of energy efficient building components is obligatory. More detail is given in 5.4.2.

Process
The legislative provisions of the IPPC Directive were incorporated into the national environmental **regulations for ICPE** installations (Installations Classified for the Protection of the Environment), which are included in the Environmental Code (**Code de l'environnement**).

2.6.2.2 Financial support

Investment support
Investments in renewable energy production and energy efficiency are promoted by means of **subsidies**, as a percentage of the investment costs, and energy **premiums**. They are granted by the Environment and Energy Management Agency (ADEME) and its regional departments.

Energy Premiums
See investment support

Exploitation support

The **Heat Fund** (Fond Chaleur), managed by ADEME, grants subsidies spread over 20 years for renewable heat production from installations, such as biomass heating systems, solar thermal collectors, ground source heat pumps, etc. These premiums cover 20 to 60% of the investment costs. Large biomass installations producing more than 11,6 GWh of heat per year can apply for the subsidy in a yearly national call scheme, named BCIAT (Biomasse Chaleur Industrie Agriculture Tertiaire). All smaller renewable heat projects are subsidised by the regional ADEME departments.

Grid operators are obliged to buy electricity from renewable energy producers and CHP at fixed, technology dependent feed-in tariffs, over a period of 15 to 20 years. Also for locally produced biogas a similar mandatory intake by the gas grid operator at a feed-in tariff is made legally possible, but has not been put into practice yet.

As of 2013, the French government has strengthened the financial support for photovoltaic solar energy. Rooftop or freestanding PV systems with a rated output larger than 100 kWp, can apply for subsidies via a yearly call scheme. Smaller roof PV systems are financially supported through a feed-in tariff that is adapted every trimester.

Certificates

Large energy suppliers are subject to triennial energy saving targets, proportionally to their sales volumes, and are committed to submit a corresponding amount of energy saving certificates (**ESCs**). They can acquire ECSs by realising eligible energy saving programmes at their costumers or they can buy them on the market from third parties (local authorities, housing agencies, landlords), that have implemented eligible energy saving measures themselves. Large companies cannot individually obtain certificates, but can do so through cooperation with the energy suppliers.

Subsidies for audits, studies and R&D

The Environment and Energy Management Agency (ADEME) subsidises audits and studies for companies, related to environmental emissions, energy efficiency and renewable energy, and innovative projects. ADEME also subsidises analyses and feasibility studies about the topics: air pollution, carbon footprint, waste recovery, energy efficiency, renewable energy and materials, environmental management and eco-friendly products, polluted sites and soils and transport.

2.6.2.3 Funds and loans

Investments in deep geothermal installations are subject to uncertainty about the characteristics of the underground resource. Therefore a special **fund** exists to limit the short term risks related to unsuccessful drills, and the long term risk, related to the sustainability of the resource and damage to facilities over a period of 20 years. A similar guarantee is provided for shallow hydrothermal installations using heat pumps above 30 kW, by the **AQUAPAC** fund. **OSEO**, renamed **Bpifrance** in 2013, also provides green loans to SMEs for investments in energy efficiency and renewable energy

2.6.2.4 Voluntary agreements

France: Various voluntary agreements exist between individual **firms** or industry **branches** and the government. These agreements aim at reducing emissions of CO_2 and pollutants, and increasing the share of biomass for combustion.

2.6.2.5 Information dissemination

France: ADEME organises courses and seminars, provides consultancy and promotes eco-entrepreneurship. Information is disseminated via www.developpement-durable.gouv.fr and www2.ademe.fr

2.6.2.6 Sources

France	
Regulation	
building	www.rt-batiment.fr
Process	www.legifrance.gouv.fr/affichCode.do?idSectionTA=LEGISCTA000006108640&cidTexte=LEGITEXT000006074220&dateTexte=20120601 www.techniques-ingenieur.fr/base-documentaire/environnement-securite-th5/reglementation-icpe-et-droit-environnemental-42439210/installations-classees-pour-la-protection-de-l-environnement-icpe-g4102/
Financial support	
Tax deduction	
Investment support	www2.ademe.fr/servlet/KBaseShow?nocache=yes&m=3&sort=-1&cid=96&catid=14984&p1=0 www2.ademe.fr/servlet/KBaseShow?sort=-1&cid=96&m=3&catid=25480
Energy premiums	idem investment support
Exploitation support	www2.ademe.fr/servlet/KBaseShow?sort=-1&cid=96&m=3&catid=25130 www.developpement-durable.gouv.fr/Les-tarifs-d-achat-de-l,12195.html www.developpement-durable.gouv.fr/IMG/pdf/0825_plan_d_action_national_ENRversion_finale.pdf www.developpement-durable.gouv.fr/IMG/pdf/DP_photovoltaique.pdf www.developpement-durable.gouv.fr/IMG/pdf/Dossier_de_presse_Methanisation.pdf
Audits, studies, R&D	www2.ademe.fr/servlet/KBaseShow?nocache=yes&m=3&sort=-1&cid=96&catid=14981&p1=0
Energy monitoring	
Certificates	www2.ademe.fr/servlet/KBaseShow?sort=-1&cid=96&m=3&catid=25007 www.developpement-durable.gouv.fr/-Certificats-d-economies-d-energie,188-.html www.eceee.org/events/eceee_events/energy-efficiency-obligations/2_ademe
Business parks	
Funds and loans	www2.ademe.fr/servlet/KBaseShow?sort=-1&cid=96&m=3&catid=25007 www2.ademe.fr/servlet/KBaseShow?sort=-1&cid=96&m=3&catid=25480
Voluntary agreements	www.developpement-durable.gouv.fr/spip.php?page=article&id_article=11827
Information	www.developpement-durable.gouv.fr www2.ademe.fr

2.6.3 United Kingdom

2.6.3.1 Regulation

Building

The **Building Regulations 2010** contain energy efficiency requirements applicable to new buildings and to the renovation or extension of existing buildings. Industrial sites, workshops and non-residential agricultural buildings are exempted from this regulation, provided that they have a low energy demand for space heating or cooling. For non-exempted buildings with a low energy demand, where only local heating is applied or where heating only serves as frost-protection free, milder requirements exist. For all building types covered by the building regulations, Energy Performance certificates (EPCs) are required for all new buildings and for existing buildings that are rented out or sold. Currently, regulations for setting a minimum EPC grade are still under development. Probably from 2018 on, a minimum EPC-rate of E will be imposed to all leases or just to leases that are renewed.

Process

Companies with an annual electricity consumption of more than 6000 MWh, that are not covered by the EU-ETS scheme or by Climate Change Agreements (CCAs) have to participate in the Carbon Reduction Commitment (**CRC**) Energy Efficiency Scheme. They must report their carbon emissions and buy and submit allowances for every tonne they emit. The CRC covers large, non energy-intensive organisations, such as supermarkets, water companies, banks, local authorities and government departments. Furthermore, the EID is implemented in the "**Environmental Permitting Regulations 2013**".

2.6.3.2 Financial support

Tax deduction
Under the **Enhanced Capital Allowances** energy scheme (**ECAs**) businesses can claim 100% first-year tax relief on their investments in energy-saving technologies and products included in the Energy Technology List (ETL).

Investment support
The **Electricity Demand Reduction** pilot project will encourage permanent reductions in electricity demand. Businesses that implement measures that deliver verifiable reductions in electricity demand, such as more efficient motors, air conditioning and lighting, will be able to bid for a financial incentive. The pilot will be backed with at least £20million of funding. It will be launched in spring 2014 and run for up to 24 months.

Exploitation support
The **feed-in tariff** scheme (**FITs**) supports **small-scale** low-carbon electricity generation lower than 5 MW (PV, wind, hydro, micro-CHP or anaerobic digestion), and consists of a generation tariff for the electricity generated and an export tariff for surplus electricity exported to the grid. Tariffs depend on the size and type of the installed technology and time of installation. These tariffs are paid by the electricity supplier to the generator, and will be recovered by the supplier through the electricity bills of its customers.

The non-domestic **Renewable Heat Incentive** (**RHI**) scheme subsidises the generation of renewable heat, the production of bio methane for injection, and heat networks in business, industry and public sectors. Eligible technologies are ground or water-source heat pumps, deep geothermal installations, solar thermal collectors, biogas or biomass-fired installations and bio methane injection. Three monthly payments, depending on technology type and size and corresponding to the amount of energy produced, are spread over 20 years.

The **Capacity Market** mechanism, which is part of the Electricity Market Reform, ensures that sufficient capacity will be available to secure electricity supply in the future. Through a competitive auction process, it offers financial incentives (**Capacity payments**) to capacity providers. In return, they commit to deliver energy when needed or they will face penalties. The first auction will be held in 2014, to deliver sufficient capacity in the winter of 2018-2019.

The Renewables Obligation scheme (RO), described in following paragraph, will be superseded by the Electricity Market Reforms scheme (EMR), following a transition period (2014-2017) during which both frameworks will coexist. The EMR scheme introduces **Contracts for Difference** (**CfD**), which are agreements between eligible low carbon electricity producers (renewables, nuclear and CCS technologies) and electricity suppliers or consumers, that guarantee pre-agreed "strike prices" for electricity. When the average market (reference) price for electricity is lower than the strike price, the difference will be compensated to the producer. However, when the market price exceeds the strike price, energy generators will have to pay back the difference to the electricity suppliers or consumers. This establishes a stable and predictable incentive for companies to invest in low-carbon generation.

Certificates
The **UK** certificate system is analogous to the Flemish system, but covers renewable energy production as well as CHP. Electricity suppliers are obliged by the Renewables Obligation scheme (RO) to annually submit a stepwise increasing amount of **Renewables Obligation Certificates** (**ROCs**), which they can acquire by self-production or by buying them from other large-scale electricity generators. Suppliers that do not comply are fined. As such, ROCs form a financial incentive for investments in renewable electricity and CHP installations. The number of ROCs issued to an installation is equal to the amount of MWh produced, multiplied with a technology-specific "banding" level (see also 6.9.6).

2.6.3.3 Funds and loans

The **Energy Efficiency Financing** (**EEF**) scheme provided by the Carbon Trust and Siemens Financial Services provides flexible and affordable financing in the forms of leases, loans at reduced credit and hire purchase of energy efficient technologies. Combined with the energy savings that are achieved, these forms of financing result in a positive cash flow from the start. The **Green Deal** framework promotes energy efficiency and renewable energy in businesses (and homes), by allowing energy measures to be implemented at little or no upfront costs. Measures are installed by an approved green deal provider, who recovers the investment costs from the company's electricity supplier. The latter is paid back in instalments added to the company's electricity bill, in such a way that the total bill remains lower than without measures.

2.6.3.4 Voluntary agreements

The voluntary **Climate Change Agreements** (**CCAs**) set energy efficiency and GHG emission reduction targets for energy-intensive businesses. In order to attain an aggregated improvement in energy efficiency of 11% by 2020 against 2008 levels, specific targets are imposed to 51 industrial sectors. Businesses participating in the CCAs receive a discount on the **Climate Change Levy** (**CCL**) of 90% for electricity and 65% for natural gas, liquefied petroleum gas and solid fuels.

This Levy is a tax on a company's energy bill, intended to encourage businesses to reduce energy consumption or use renewable energy. Fuels supplied to and electricity from qualitative CHP installations, electricity from renewable energy sources, and fuels supplied to auto-generators are exempted from the Climate Change Levy. From April 2013 on, fossil fuel supplies in the power sector are subject to special rates of the Climate Change Levy. These CPS (Carbon Price Support) rates are intended to maintain a clear price for carbon emissions and to encourage the electricity generation industry to invest in low carbon emission technology. For CHP installations, only the input of fossil fuels related to the electricity generation are taxed.

2.6.3.5 Information dissemination

The government provides a tool that helps businesses to measure and report environmental impacts, such as greenhouse gas emissions. The **Carbon Trust** helps companies to reduce their environmental footprint by offering custom tailored expertise and guidance on various topics: development of a sustainable business strategy, monitoring and evaluation of environmental impacts, identification, implementation and financing of cost-saving low carbon technologies and energy efficiency measures, and free software tools. Environmentally engaged companies can also join the **Carbon Trust Green Business Directory**. The website www.gov.uk gives an overview of all departments, including the Department of Energy & Climate Change, and of current policies, including all policies related to energy, climate and environment. Also www.carbontrust.com and www.environment-agency.gov.uk provides a great deal of information to companies about environmental and energy issues.

2.6.3.6 Sources

UK	
Regulation	
building	www.planningportal.gov.uk/buildingregulations/approveddocuments/partl/approved www.planningportal.gov.uk/buildingregulations/approveddocuments/partj/approved www.legislation.gov.uk/uksi/2010/2214/made
Process	www.gov.uk/government/policies/reducing-demand-for-energy-from-industry-businesses-and-the-public-sector--2/supporting-pages/crc-energy-efficiency-scheme www.environment-agency.gov.uk/business/145770.aspx
Financial support	
Tax deduction	www.gov.uk/government/policies/reducing-demand-for-energy-from-industry-businesses-and-the-public-sector--2/supporting-pages/enhanced-capital-allowances-ecas www.hmrc.gov.uk/capital-allowances/fya/energy.htm
Investment support	
Energy premiums	
Exploitation support	www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/feed-in-tariffs-scheme www.gov.uk/renewableheatincentive www.gov.uk/government/publications/electricity-market-reform-capacity-market-proposals www.gov.uk/government/publications/electricity-market-reform-contracts-for-difference www.gov.uk/government/policies/reducing-demand-for-energy-from-industry-businesses-and-the-public-sector--2/supporting-pages/electricity-demand-reduction-project
Audits, studies, R&D	
Energy monitoring	
Certificates	www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/the-renewables-obligation-ro
Business parks	
Funds and loans	www.carbontrust.com/client-services/technology/implementation www.gov.uk/green-deal-energy-saving-measures/how-the-green-deal-works
Voluntary agreements	www.environment-agency.gov.uk/business/topics/pollution/136236.aspx www.gov.uk/government/news/industry-agree-stretching-energy-efficiency-targets-with-government www.hmrc.gov.uk/climate-change-levy/index.htm
Information	www.gov.uk/measuring-and-reporting-environmental-impacts-guidance-for-businesses www.carbontrust.com www.environment-agency.gov.uk

2.6.4 Netherlands

2.6.4.1 Regulation

Building
The Energy Performance Regulation (**EPG**) sets energy performance coefficients (EPC) to be achieved for all new buildings, depending on the function of the building (offices: EPC=1.1). For buildings with an industrial function, however, no EPC target is imposed and no mandatory software tool is prescribed.

Process
The EID is put into force by modifying a series of existing national regulations (**Activities Decree and Law Environmental Management**).

2.6.4.2 Financial support

Tax deduction
The **Energy Investment Deduction** (**EIA**) grants a reduction of a company's taxable income with 41.5% of its investments made in renewable or energy efficient technologies. Eligible technologies are presented in the Energy List 2013 and include the categories building, process, transport and renewable energy. Investments in energy consultancy may also apply for the EIA. The **Environmental Investment Deduction** (**MIA**) reduces a company's taxable income with 13.5 to 36% of investments in environmentally friendly technologies from a limited list. The Arbitrary Environmental Investment Deduction (**Vamil** 2013) allows depreciation up to 75% of the investments in such technologies in a year of choice, which reduces income taxes for that year.

Exploitation support
The **SDE+** subsidy scheme compensates the extra costs of the production of renewable electricity, heat or gas compared to the production based on fossil fuels. This feed-in tariff per kWh increases over the year in 6 subsequent phases, so that the cheapest technologies are promoted first. It is granted for a period of 5, 12 or 15 years.

Subsidies for audits, studies and R&D
No financial incentives specifically intended for audits or studies related to energy efficiency or renewable energy exist. The program **Energy Research Subsidy** promotes R&D of new technologies that contribute to sustainable energy management.

2.6.4.3 Funds and loans

Environmentally friendly projects are supported by the **Regulation Green Projects** of the Dutch government so that a bank can offer a loan at a lower credit rate.

2.6.4.4 Voluntary agreements

The "**Multiyear Agreements Energy Efficiency**" aim to improve energy efficiency of companies (and municipalities) at an average annual rate of 2%, by promoting energy management, efficiency measures in processes and product chains and renewable energy. Companies that sign the agreement commit to achieve the proposed targets, and receive government support in exchange. Non-ETS companies and municipalities can subscribe to the **MJA3** agreement, while the **MEE** agreement is destined for ETS companies only. Under the MJA3 covenant, companies are obliged to put in place a system for systematic energy management within 3 years, based on ISO 14001 or ISO 50001. They also have to monitor their energy consumption and report it to Agency NL (Agentschap NL), to verify if energy targets are achieved. Companies have to submit an Energy Efficiency Plan (EEP) for the period 2013-2016 that identifies measures and plans their implementation. According to the Activities Decree and the Law Environmental Management, measures with a positive NPV at a discount ratio of 15% or, alternatively, a payback time of up to 5 years, have to be implemented. A concept version has to be available within the first 9 months. Finally the introduction of renewable energy production or purchase is mandatory.

The MEE agreement does not require companies to install an energy management scheme, nor does it set targets about renewable energy. It does demand energy monitoring and reporting and the submission of an energy efficiency plan. In return for these commitments, Agency NL helps companies to achieve them by providing useful information and by appointing competent consultancy companies. Furthermore, energy intensive companies with an electricity consumption exceeding 10 GWh (excl. chemical reduction, electrolysis and metallurgical processes), are eligible for the 'Energy Tax Refund Scheme' under the 'Law Environmental Taxes'.

2.6.4.5 Information dissemination

The government helps businesses to overcome regulatory, financial and organisational obstacles in sustainable projects by offering customised advice (**Green Deals**). The national informative website www.agentschapnl.nl assists companies in sustainable, innovative development.

2.6.4.6 Sources

Netherlands	
Regulation	
building	www.agentschapnl.nl/onderwerpen/duurzaam-ondernemen/gebouwen/energieprestatie-nieuwbouw-epn/regelgeving/bepalingsmethode
Process	www.infomil.nl/onderwerpen/duurzame/bbt-ippc-brefs/richtlijn/implementatie/wijzigingen
Financial support	
Tax deduction	www.agentschapnl.nl/subsidies-regelingen/energie-investeringsaftrek-eia www.agentschapnl.nl/subsidies-regelingen/miavamil www.antwoordvoorbedrijven.nl/subsidies/zoek
Investment support	
Energy premiums	
Exploitation support	
Audits, studies, R&D	www.agentschapnl.nl/subsidies-regelingen/energieonderzoek-subsidie-eos/formulieren-eos
Energy monitoring	
Certificates	
Business parks	
Funds and loans	www.agentschapnl.nl/subsidies-regelingen/groen-beleggen
Voluntary agreements	www.agentschapnl.nl/subsidies-regelingen/meerjarenafspraken-energie-efficiency
Information	www.agentschapnl.nl www.agentschapnl.nl/subsidies-regelingen/miavamil/onderwerpen-toegelicht/green-deals

2.6.5 Germany

2.6.5.1 Regulation

Building

Energy performance of residential and non-residential buildings is controlled by the **Energy Conservation Regulation** (**EnEV**). Annual primary energy consumption related to building use, calculated with a mandatory software tool, should not exceed the reference value corresponding to that building. The calculation includes HVAC (heating, ventilation and air conditioning), hot water, lighting (non-residential only), bio-climatic design and individual renewable energy production. The **Renewable Energy Heat Act** (**EEWG**) demands that for space heating and cooling in new buildings, a minimum share of renewable heat is used. Minimum renewable heat shares are technology dependent: 15% for thermal solar energy collectors, 50% for installations that extract geothermal heat or heat from the environment, 50% for installations on solid or liquid biomass, 30% for biogas. Eligible alternatives are waste heat recovery, heat from efficient CHP, insulation of the building envelope 15% better than governing regulations, or connection to a district heating network.

Process

The EID is implemented in German law by modifying a set of existing laws (Federal Pollution Control Act, Law on Life-Cycle Management, Water Resources Act, Law on Environmental Impact Assessments).

2.6.5.2 Financial support

Investment support

Energy efficient investments in new or existing air-conditioning or refrigeration systems are subsidised by the Federal Office of Economics and Export Control (**BAFA**) for 15 to 25% of the investment costs. An additional bonus of 25 to 35% can be granted for innovative systems. The **National Climate Initiative** also subsidises innovative cooling system projects and audits for companies and is funded from the auction of emission allowances.

Energy Premiums

BAFA grants subsidies for heating with **renewable energy**. The subsidy is available for thermal solar collectors, heat pumps, and biomass-fired boilers destined for process heating, hot water, district heating, and space heating/cooling in existing buildings. Bonuses can be added when investing in multiple technologies at the same time, when a technology is applied to a highly energy efficient building, when installing a condensing boiler, when the solar thermal system is connected to the heat network, or when using a very efficient pump.

Innovative technologies are subsidised for existing and new multi-family houses and non-residential buildings. These technologies include large thermal solar power plants for process or space heating and automatically fed biomass boilers. **CHP** plants up to 20 kW are subsidised with a one-off premium. Heating and cooling networks receive 100 €/m new laid supply line, up to 30 to 40% of investment cost with a maximum of 10 million €. The BAFA promotes the implementation of highly efficient **cross-cutting technologies** in SMEs in two ways. Firstly, highly energy efficient types of electric motors, pumps, air-conditioning systems, compressed air systems, and systems that recover heat from the latter two, are individually subsidised. Investments between 5000 and 3000 € are eligible and can be subsidised up to 30% for SMEs and up to 20% for large companies. Secondly, a holistic optimisation approach of the entire energy system is promoted. A premium of maximum 100.000 € can be granted, provided that an energy study is performed and at least two cross-cutting technologies are implemented with a minimum investment of 30.000 €. A reduction in final energy consumption of at least 25% also needs to be attained.

Exploitation support

According to the **CHP Act**, for all sizes of CHP plants the generated power is subsidised by the electricity supplier over a certain period of time, though micro-CHP plants are subsidised with one-off premiums. The **Renewable Energy Act** established feed-in tariffs and priority on the grid for electricity from renewable sources. Grid operators are obliged to buy green electricity from plant operators at fixed rates over 20 years, dependent on technology type and size, in order to provide a return on investment irrespective of electricity prices on the power exchange. Furthermore, biofuels are supported through fiscal regulation.

Subsidies studies and R&D

In its program "**SME Energy Efficiency Advice**", the government-owned development bank KfW subsidises energy audits for SMEs.

Subsidies for energy monitoring

80% of the acquisition costs and 20% of the costs of certification of energy monitoring systems for companies are subsidised by **BAFA**, with a maximum of 8.000 €.

2.6.5.3 Funds and loans

KfW provides affordable **green loans**, with up to 3 repayment-free start-up years for investments in environmentally friendly, energy efficient, innovative and renewable technologies. It also covers the risk connected to geothermal installations.

2.6.5.4 Voluntary agreements

In the **Climate Change Agreement**, dating from 2000, the German government has set out energy efficiency and greenhouse gas emission reduction targets for 19 industry associations. They have to be fulfilled by 2012, in exchange for exemption of additional European environmental regulations and of mandatory energy audits. Targets are sector specific, as the scopes, the greenhouse gasses included in the inventory and the definition of the target (specific or absolute emissions) differ. However, the overall objective of 35% of emissions compared to 1990 emissions was achieved in 2010, while set for 2012.

2.6.5.5 Information dissemination

The **Partnership for Climate Protection and Energy** is based on two pillars. Firstly, the **Companies for Climate Protection** initiative (**klimaschutz-unternehmen**) reunites businesses that commit to implement energy efficiency and climate protection in their strategy, monitor their results and regularly perform energy and emission audits. Best practices are highlighted. Secondly, the Deutsche Industrie- und Handelskammertag (DIHK) and the German chambers of industry and commerce organise information sessions and provide free energy consultants, as well as grants to train company staff members as energy managers. The websites www.bafa.de and www.kfw.de disseminate information related to climate and energy issues for businesses.

2.6.5.6 Sources

Germany	
Regulation	
building	www.buildup.eu/publications/30238 www.erneuerbare-energien.de/die-themen/gesetze-verordnungen/waermegesetz-eewaermeg
Process	www.bfu-ag.de/index.php/en/industrieemissionen-ied
Financial support	
Tax deduction	
Investment support	www.bafa.de/bafa/de/energie/kaelteanlagen/index.html www.bmu.de/en/topics/climate-energy/climate-initiative/general-information www.klimaschutz.de/en/taxonomy/term/31
Energy premiums	www.bafa.de/bafa/de/energie/erneuerbare_energien/index.html www.bafa.de/bafa/de/energie/kraft_waerme_kopplung/index.html www.bafa.de/bafa/de/energie/querschnittstechnologien/index.html
Exploitation support	www.bafa.de/bafa/de/energie/kraft_waerme_kopplung/index.html energytransition.de/2012/10/renewable-energy-act-with-feed-in-tariffs/ www.res-legal.eu/search-by-country/germany/single/s/res-e/t/promotion/aid/feed-in-tariff-eeg-feed-in-tariff/lastp/135
Audits, studies, R&D	www.kfw.de/inlandsfoerderung/Unternehmen/Energie-Umwelt/index-2.html
Energy monitoring	www.bafa.de/bafa/de/energie/energiemanagementsysteme/index.html
Certificates	
Business parks	
Funds and loans	www.kfw.de/kfw.de-2.html
Voluntary agreements	iepd.iipnetwork.org/node/249 www.bdi.eu/Klimaschutzvereinbarung.htm
Information	www.klimaschutz-unternehmen.de energie-und-rohstoffe.ihk.de iepd.iipnetwork.org/node/255 www.bafa.de www.kfw.de

2.6.6 Comparative table national energy policy measures

International overview policy measures industry

	Flanders	Brussels	Wallonia	France	United Kingdom	Netherlands	Germany
Regulation							
Building	EPB regulation	EPB regulation	EPB regulation	Réglementation Thermique 2012	The Building Regulations 2010	Energy Performance Regulation (EPG)	Energy Conservation Regulation (EnEV), Renewable Energy Heat Act (EEWG)
Process	Energy Planning Decree	COBRACE	Decree Environmental Permits	regulations for ICPE installations	Environmental Permitting Regulations 2013, Ccarbon Reduction Comittment (CRC)	Activities Decree and Law Environmental Management	IED in diferent national environmental laws
Financial support							
Tax deduction	federal enhanced investment deduction, property tax rebate, energy scans tax deductible	federal enhanced investment deduction	federal enhanced investment deduction	-	Enhanced Capital Allowances (ECAs)	investment Deductions EIA and MIA/Vamil 2013	-
Investment support	investment support Elia, Ecology Premium and Strategic Ecology Support, Green heat call	investment support for a better environment	Aide à l'investissement Environnement et Utilisation durable de l'énergie	regional subsidies ADEME	Electricity Demand Reduction pilot	-	BAFA airco and refrigeration, National Climate Initiative
Energy premiums	premiums grid operator	energy premiums regional government	energy premiums Regional government	regional premiums ADEME	-	-	BAFA renewable heat, CHP, cross cutting technologies
Exploitation support	-	-	-	Heat Fund, feed-in tarrifs For renewable and CHP electricity	feed-in tariffs renewable electricity, Renewable Heat Incentive (RHI), Capacity Payments	SDE+	electricity feed-in tariffs (Renewable Energy Act, CHP Act)
Certificates	Green power and CHP certificates (GPCs and CHPCs)	Green certificates for CO2 savings (GCs)	Green certificates for CO2 savings (GCs)	Energy Savng Certificates (ESCs)	Renewables Obligation Certificates (ROCs), Contracts for Difference (CfDs)	-	-
Subsidies audits, studies and R&D	-	energy audit, design study, blowerdoor test	energy audits, Feasibility studies	subsidies audits and Studies ADEME	-	Energy Research Subsidy	SME Energy Efficiency Advice KfW
Subsidies energy monitoring	-	subsidies regional government	subsidies regional Government	-	-	-	BAFA
Subsidies business park development	coupled to carbon neutral Electricity consumption	-	-	-	-	-	-
Funds and loans	Green Warranty	-	subordinated loan Novalia For innovative projects	Geothermy fund, AQUAPAC, OSEO	Energy Efficiency Financing (EEF) Carbon Trust, Green Deal	Regulation Green Projects	green loans KfW
Voluntary agreements	Energy Policy Agreements	-	Accord de Branche	with industry branches Or individual firms	Climate Change Agreements (CCAs)	Multiyear Agreements Energy Efficiency MJA3, MEE	Climate Change Agreement
Information dissemination							
Consultancy	Energy consultants, Free energyscan AO	Facilitator Sustainable Buildings	Network Energy Facilitators	ADEME	Environmental impact tool, Carbon trust	Green Deals	DIHK
Sensitivising		Label Eco-Dynamic Enterprise		ADEME eco-enterprise	Carbon Trust Green Business Directory		Companies for Climate Protection
Informative websites, sensitivising, education,Training	www.energiesparen.be, www.agentschapondernemen.be	www.leefmilieubrussel.be	energie.wallonie.be	www.developpement-durable.gouv.fr, www2.ademe.fr	www.gov.uk, www.carbontrust.com www.environment-agency.gov.uk	www.agentschapnl.nl	www.bafa.de, www.kfw.de

LOW CARBON BUSINESS PARK MANUAL

Chapter 3

Low carbon business parks

3 Low carbon business parks

3.1 Introduction

This chapter defines the concept of low carbon business parks and identifies four activity levels on which low carbon measures can be taken, in line with the Trias Energetica strategy. Carbon footprint as a measuring tool for greenhouse gas emissions is explained and the conditions for carbon neutrality and carbon neutral electricity consumption are elaborated. Possible incentivising and awareness raising actions are suggested. Finally, some worldwide examples of low carbon business parks are described.

3.2 Sustainability concepts for business parks

A number of different approaches towards sustainability on business parks can be distinguished. Sustainable industrial parks focus on inter-firm cooperation in all aspects, while eco-industrial parks specifically aim to exploit synergies in the supply chains of energy, materials and water (industrial symbiosis). Green industry parks, on the other hand, are a collection of individually sustainable companies. Low carbon business parks combine elements of both eco-industrial and green industrial parks (see Fig. 12).

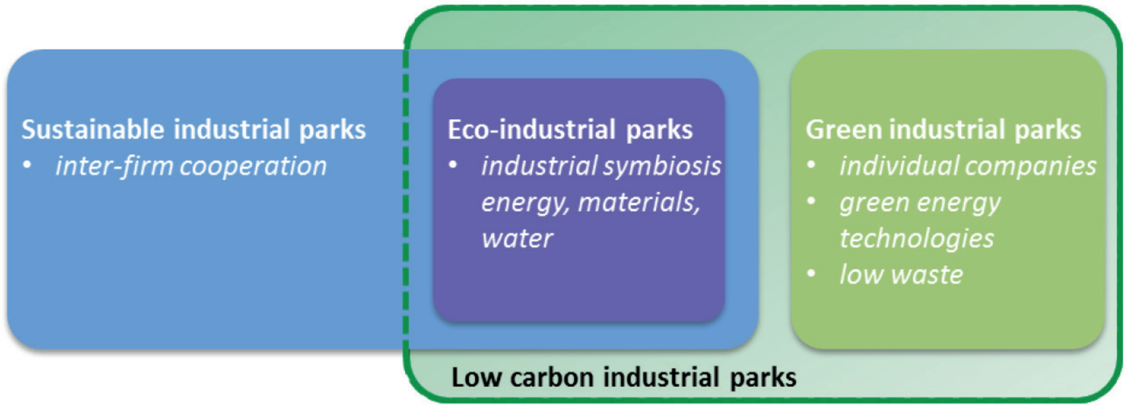


Fig. 12: business park sustainability approaches

3.2.1 Sustainable industrial parks

Sustainable industrial parks aim at exploiting the technologic, economic, ecologic, social and spatial advantages that originate from local inter-firm cooperation in the field of facility and utility management, infrastructure and industrial processes (Van Eetvelde et al., 2007). More specifically, inter-firm cooperation may include collective organisation of energy and resource supply, waste water treatment, transport and green space maintenance, the collective use of equipment and facilities (fitness centre or daycare), the exchange of material or energy streams between companies or with the surrounding region, etc. A complete integration of this concept requires measures and actions in every phase of the park development and can be facilitated by installing a multidisciplinary business park management. Voluntary inter-firm cooperation requires immediate benefits on short term, a better competitiveness on medium term and a sustainable relation with all stakeholders on the long term.

3.2.2 Eco-industrial parks

On eco-industrial parks, the individual companies specifically exploit synergies in supply chains of energy, material, water and services in order to enhance economic performance, while reducing environmental impact (Roberts, 2004). In this concept, also referred to as industrial symbiosis, waste products of one company serve as resource for another, and heat is cascaded and exchanged between companies. To enhance the potential of synergies, companies with complementary water, material or energy profiles must be clustered. Furthermore, eco-industrial parks must be integrated into the industrial metabolism of the region. A well-known example of industrial symbiosis is the eco-industrial park of Kalundborg in Denmark. At the moment, 27 symbiotic relations in terms of energy, water and materials are created and exploited between nine public and private enterprises, and the system is still expanding (see Fig. 13).

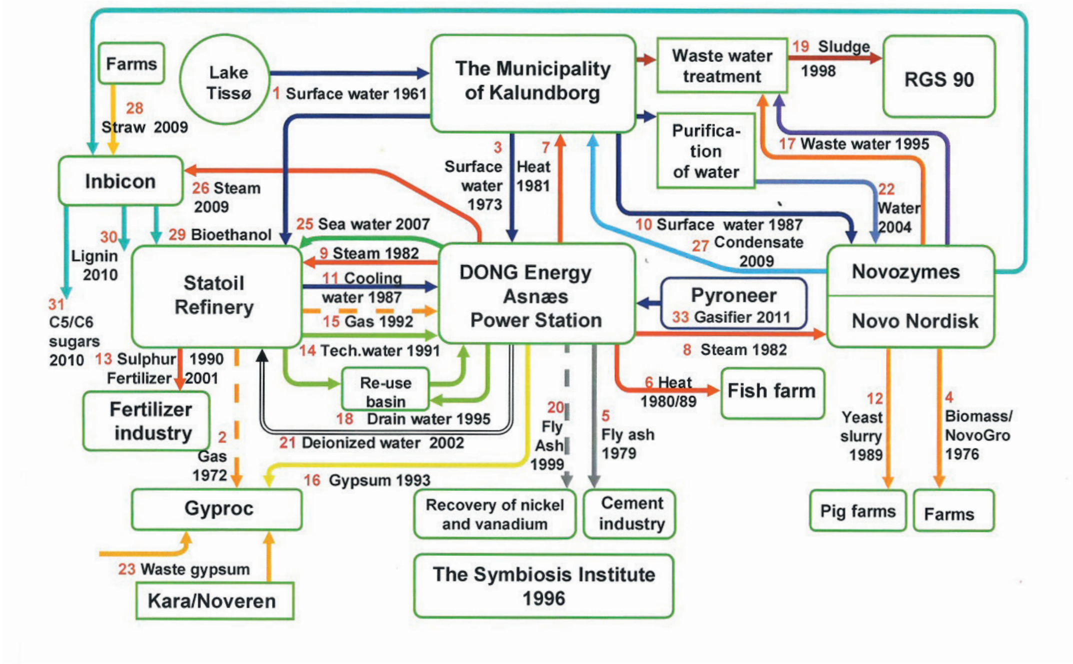


Fig. 13: Kalundborg eco-industrial park (www.symbiosis.dk)

The eco-industrial park in Kymenlaakso, Finland, exploits various symbiotic relations between the Kymi pulp and paper plant, a power plant, three chemical plants, a regional energy supplier and a municipal waste water treatment plant. The pulp and paper plant partly generates its own energy by combusting the waste product (black liquor) from pulp production. Remaining steam, electricity and heat demands are purchased from the power plant, while excess heat and electricity production is sold to the chemical factories. The power plant receives bark, wood chips, fibre suspension and milled peat from the pulp and paper plant to be used as fuel and sells electricity and heat to the regional energy supplier, which, in turn, sells electricity to the municipal waste water treatment plant (Sokka et al., 2011).

When also considering the regional scale, the potential of industrial symbiosis increases, as more synergetic relations and possible partners appear. In the UK, regional industrial symbiosis is stimulated and facilitated by the National Industrial Symbiosis Programme (NISP), a nationwide demand and supply database of energy, water, material, logistics, capital and knowledge of about 12500 companies. The extension of the programme to other countries is in preparation.

3.2.3 Green industry parks

Green industry parks consist of a collection of companies that employ clean and renewable energy technologies and processes in order to reduce emissions and minimise waste, without specifically searching for and exploiting synergies (Roberts, 2004). Until now, most of the business parks that qualify for the Flemish financial support under the condition of carbon neutral electricity consumption are green industry parks.

3.2.4 Low carbon business parks

Low carbon business parks cover green industry parks as well as eco-industrial parks. The application of renewable energy and clean processes and products is combined with the exploration and exploitation of synergies in energy, material and water supply chains, in order to drastically lower greenhouse gas emissions, while creating economic benefits.

Advantages of low carbon business parks are manifold. Synergies between company supply chains reduce the need for energy resources, raw materials and fresh water, while waste can be recycled, energetically valorised or even totally eliminated when resource loops are closed. This results in a significant reduction of operational and production costs. Clean and efficient processes and equipment, and renewable energy production or purchase decrease emissions of greenhouse gasses and other polluting substances. Consequently, present or future environmental penalties and taxes can be avoided. In addition, local renewable production lowers dependence on fluctuating fossil energy prices and is beneficial for local employment and enhances local anchorage. It also puts the control of energy supply in the hands of companies, business park managers or local energy service companies. Excess in local renewable energy can be sold, thus creating an extra export product. Next, companies located on low carbon business parks show social and environmental commitment and can use this to attract more customers. Finally, success stories such as Kalundborg prove that innovation between and in companies is triggered and companies are positively challenged.

Table 4: Advantages low carbon business parks

Ecologic	***Economic***	***Strategic and social***
• reduced consumption of energy resource, raw materials, water • recycling, revalorisation, elimination of waste products • reduction of emissions of greenhouse gasses and other polluting gasses and substances • healthier working environment	• reduced operational and production costs • avoided environmental taxes and penalties • innovative and sustainable investments can be financially supported • for a large number of sustainable technologies, investments are paid back even in the short term • excess energy as export product	• increase energy independency • promote local employment • local anchorage • show social and environmental commitment • image of responsible and sustainable company • trigger innovation, challenge, attract talent

3.3 Trias Energetica

The Trias Energetica strategy, proposed by Lysen (1996) provides a general three step approach to reduce carbon emissions related to energy consumption:

1. Reduce energy demand
2. Maximise renewable energy production
3. Fulfil remaining energy demand by efficient use of fossil fuels.

To customise this priority sequence of energy measures to low carbon energy management on business parks, sub-steps have been described by Maes et al. (2011). In step 1, first the demands for energy services (see 5.2.1) need to be reduced. In a following sub-step, the efficiencies of the equipment supplying these energy services need to be upgraded. A third sub-step comprises recovery of residual heat by heat exchange and the energy valorisation of waste. Step 3 can be extended with carbon capture and storage. Nonetheless fossil-based energy must be avoided as much as possible.

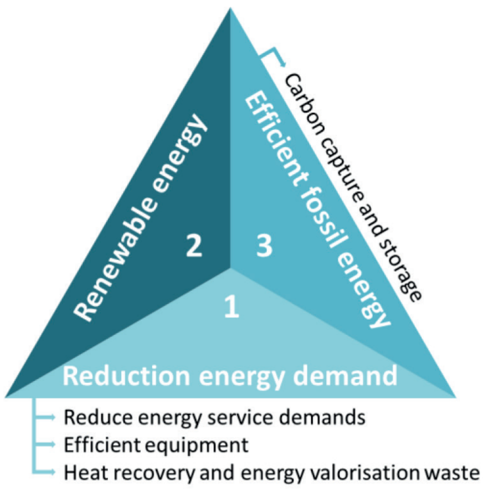


Fig. 14: stepwise approach towards low carbon energy supply

3.4 Application levels of energy measures

Low carbon energy measures, corresponding to the Trias Energetica strategy, can be taken on 4 different levels: business, business cluster, business park and region (see Fig. 15).

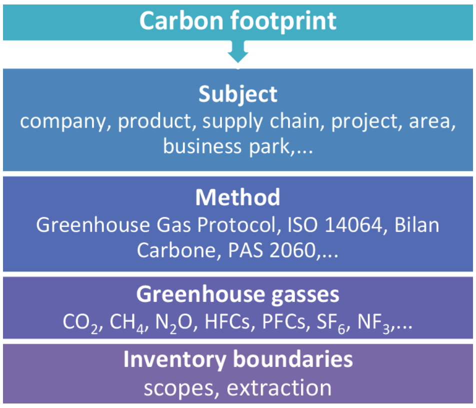
Fig. 15: Activity levels low carbon business park: business, cluster, business park, region
(image: business park Sappenleen in Poperinge, Belgium)

Energy measures on individual **business level** comprise: improvement of energy performance of buildings and processes, recovery and exchange of heat and waste between processes or energy services, and individual production or purchase of energy based on cogeneration or renewable resources, etc. On **business cluster** level, certain facilities (e.g. catering, waste water treatment) or logistics of different companies, or activities requiring the same energy services may be joined in collective buildings, waste heat can be exchanged between two companies through direct heat links or waste of one company can be energetically valorised in another one. Production or purchase of energy based on cogeneration or renewable sources can also be jointly organised.

At **business park level**, the park layout can be conceived in such a way that companies with complementary energy profiles are clustered and certain company tasks can be bundled in collective buildings. Furthermore, a park-wide collective energy production system, energy network and energy management system can be implemented, or energy services can be provided collectively. When extending the scope to the surrounding **region**, business parks can be connected to the local district heating network or use energy sources or waste from the surrounding area.

Table 5: Activity levels low carbon business parks			
Level	***Energy demand reduction and energy efficiency***	***Heat recovery and exchange, waste to energy***	***Renewable energy and cogeneration***
Business	improved building and process performance	direct exchange between processes/energy services	individual production or purchase
Cluster	shared company buildings, bundling company functions and (energy) services	exchange between different companies via direct links	joint production or purchase
Business park	shared company buildings, collective supply of (energy) services, collective energy management system	exchange between all companies via networks	collective energy production system, smart grid, clustering complementary energy profiles
Region		connection to regional network	renewable resources or waste from region

3.5 Carbon footprint



The carbon footprint of a company is the yearly inventory of greenhouse gas emissions that can be associated with it, according to a chosen methodology and within a selected scope. This concept is not restricted to companies only, but can also easily be applied to products, supply chains, projects, areas or business parks. A number of methodologies to determine the carbon footprint have been developed, such as the Greenhouse Gas Protocol, ISO 14064 and the Bilan Carbone, and are being used as GHG emission reporting standards.

The **Greenhouse Gas Protocol** and the **ISO 14064** list emissions of the 6 Kyoto gasses (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6), expressed in CO_2 equivalents, within three complementary scopes (see Fig. 16). **Scope 1** contains all emissions from sources that are directly owned or controlled by the company under study. These include emissions from fuel combustion in stationary installations for electricity, heat or steam generation (e.g. boilers, furnaces, turbines) and in company owned vehicles, emissions from physical and chemical processes, and unintended gas leakages. **Scope 2** comprises the indirect emissions related to the imported electricity, steam, heating media and cooling water, for own use. **Scope 3** bundles the indirect emissions embodied in the life cycle of products and corporate supply chains. These include emissions related to extraction and processing of purchased raw materials, production of purchased goods and services, transport, distribution, use and end-of life treatment of products, disposal of waste, outsourced activities, employee commutes, business travel, etc. The emissions related to fuel combustion in scope 1 can be derived from the company's yearly energy consumption profile, by multiplying fuel consumptions with corresponding carbon emission factors. To calculate the emissions in scope 2 linked to purchased electricity, either a grid average or a contractual emission factor can be applied.

The Greenhouse Gas Protocol website provides guidance documents and calculation tools, custom tailored for the energy intensive industrial sub-sectors, but also for small office-based companies. Moreover, the standard is used in the Carbon Disclosure Project (CDP), that monitors the carbon footprint of the 500 largest companies in the world. Since 2013, the Greenhouse Gas Protocol requires to also include nitrogen trifluoride (NF_3) in greenhouse gas inventories. This greenhouse gas is mainly produced in the manufacture of semiconductors and LCD panels, and certain types of solar panels and chemical lasers. Over a 100-year time span it is 17200 times more powerful than carbon dioxide in trapping atmospheric heat.

The **Bilan Carbone**, developed by the French Environment and Energy Management Agency (ADEME), does not focus on accuracy, but on completeness in order to identify the principal emission sources and to define effective actions to reduce the carbon footprint. Next to the 6 Kyoto gasses, it includes CFCs and water vapour, and average emission factors are applied. By default, the Bilan Carbone lists all direct and indirect emissions, but also three standard extractions can be used. The internal (in-company) extraction comprises emissions from fuel combustion in stationary installations for electricity, heat or steam generation, process emissions, and fugitive emissions (leakages). The intermediate extraction extends the internal extraction with indirect emissions related to purchased electricity and steam, in-house transport, transport of products, employee commuting and business travel. Finally, the global extraction comprises all direct and indirect emissions related to the company's operation (see Fig. 17). The scope of the EU-ETS (Directive) is, for each company or installation included in the system, similar to the internal extraction of the Bilan Carbon, but only comprises emissions of CO_2, N_2O and PFCs.

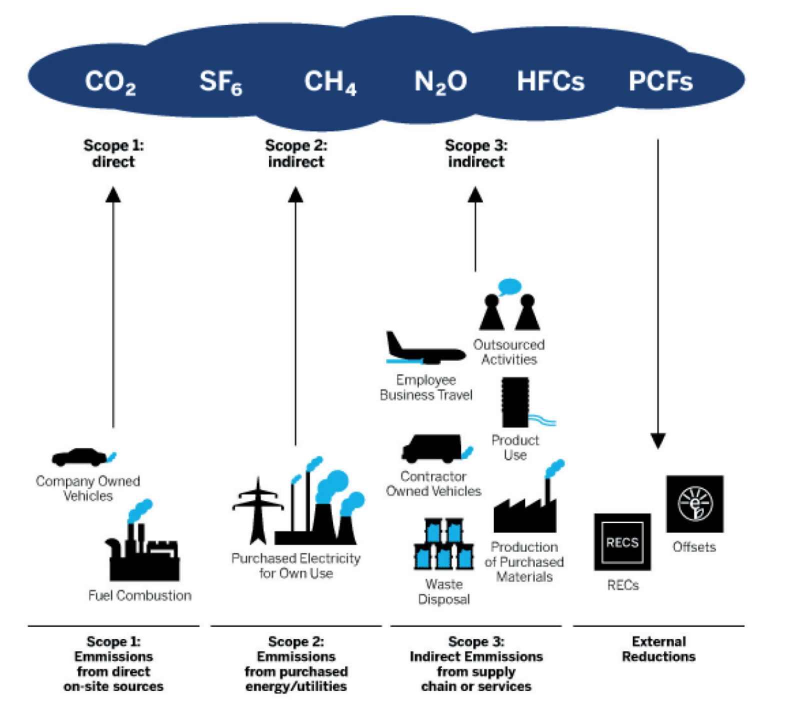
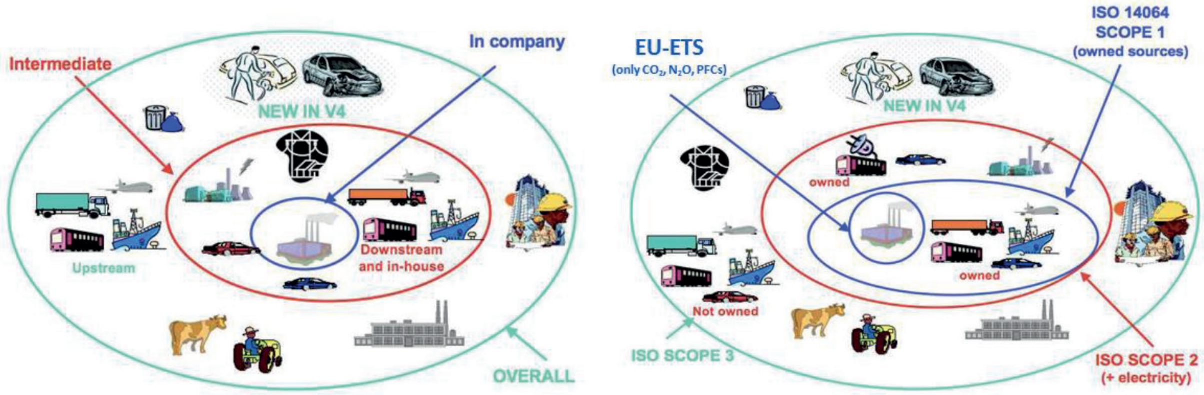


Fig. 16: Scope definition in Greenhouse Gas Protocol

Bilan Carbone *ISO 14064 and EU-ETS*



3.6 Carbon neutrality

Carbon neutrality is attained when greenhouse gas emissions within the selected scopes of the chosen method are completely avoided or when they are fully compensated by external emission reductions (carbon offsets). As a consequence, carbon neutrality can be defined in many different ways. The international standard **PAS 2060** (Publically Available Specification), developed in 2010 by the British Standards Institution, standardises the definition of carbon neutrality for companies. It specifies the inventory boundaries (scope 1, 2 and part of scope 3 of ISO 14064) and the greenhouse gasses to be included, and sets out energy measures to be taken.

Carbon neutrality on the level of a company's energy supply chain is referred to as **carbon neutral energy consumption**. The footprint includes direct and indirect greenhouse gas emissions from extraction, processing and transport of energy carriers, from their use or conversion and from the manufacture of energy conversion installations.

A business park could be labelled carbon neutral if carbon neutral energy consumption is achieved, but so far the definition of this concept is not yet standardised. In the context of business park development subsidies in Flanders, carbon neutrality refers to **carbon neutral electricity consumption** (see 3.7). In that case, the carbon footprint is limited to carbon dioxide (CO_2) emissions, totalled over the business park, from onsite fuel combustion for electricity generation, or linked to purchased electricity. This corresponds to the scope 1 and scope 2 carbon dioxide emissions of the business park's electricity supply chain. The most straightforward way of accomplishing carbon neutral electricity consumption is to locally generate or to purchase renewable electricity, as it is considered to be CO_2 neutral. However, it must be noted that in this way, emissions resulting from the harvest, processing and transport of renewable fuels and the manufacture of energy conversion installations are ignored. Also, non-renewable power can be labelled as green, when a corresponding amount of guarantees of origin is purchased (see 6.9.1). Companies or business parks may purchase carbon emission credits to achieve carbon neutrality, and so their actual emission reductions are prone to the reliability of the emission trading system. Consequently, it may be more effective to lower the carbon footprint onsite, without compensations, then to aim for carbon neutrality while exploiting compensation mechanisms. Onsite efforts should be favoured.

3.7 Policy and regulations

On European or national level, no specific policy towards the establishment of low carbon business parks has been encountered, except in the Flemish region. In Flanders, the development of business parks is regulated by the **Spatial Structure Plan for Flanders** issued by the Flemish government. This plan sets out guidelines for localisation of business parks and businesses, and for spatial planning and infrastructure layout on business parks.

To compensate the lack of focus on energy measures, from 2007 up to 2012, **subsidies** for expansion, development or redevelopment of **business parks** in Flanders were bound to the condition of carbon neutrality related to electricity consumption (Vlaamse Regering, 2007). This condition can be fulfilled by purchasing or producing green electricity or by compensating carbon emissions originating from the use of non-renewable electricity. Non-renewable electricity can be labelled green by purchasing a corresponding amount of guarantees of origin (see 6.9.1). Since the beginning of 2012 the situation changed, and the subsidy is now only available for the reconversion of brownfields or for greenfields that cannot be profitably developed. However, the condition of **carbon neutral electricity consumption** is maintained (Vlaamse Regering, 2013).

As described in the "Decree subsidies business parks" (Vlaamse Regering, 2013) subsidies are granted to the business park developer in the preliminary, the (re)development or the management stage (see Table 6). To qualify for funding, the developer is obliged to submit a (re)development plan, an issuance plan, a management plan and a carbon neutrality plan. The **(re)development plan** is a general plan of action for efficient and sustainable use of space. In the **issuance plan**, the issuance conditions towards candidate companies are elaborated, and in the **management plan** the sustainable exploitation of the business park is described. The **carbon neutrality plan** sets out measures to guarantee carbon neutral electricity consumption on the business park. In order to achieve the demanded quality and carbon neutrality targets, a number of obligations and rules are composed to which candidate businesses have to comply. Only companies on new lots have to fulfil the carbon neutrality condition in order to acquire the subsidies. If the requirements are not met, subsidies can be reclaimed from the business park developer.

Table 6: Subsidies for business park development according to Decree subsidies business parks (Vlaamse Regering, 2013)

Stage	Subsidy	Maximum	Eligible costs
Preliminary stage	50%	€ 200.000	research, feasibility studies, process management
(Re)development stage unprofitable projects strategic projects obsolete business parks	 50% 60% 85%		collective and public infrastructure for mobility, energy supply and waste treatment, collective facilities, green spaces
Management stage	50%	€ 200.000	staff and overhead park management

3.8 Incentivising and awareness raising

Complementary to the advantages given in 3.2.4, different methods can be used to persuade companies to contribute to the low carbon transition. The **stick approach** obliges companies to attain certain targets in renewable energy, energy efficiency and greenhouse gas emissions. These targets can be imposed e.g. by the authority that grants environmental permits, or by business park developers, included in the selling or issuance conditions (see 9.1.3). The **carrot approach** rewards companies if they accomplish certain goals or make certain investments in terms of clean or renewable energy technologies or processes. Rewards include financial investment or operation support, by the authority (see chapter 2) or by the umbrella park management. Strategic, non-financial rewards are, for example, labels that prove social and environmental commitment, quality and innovative spirit. Besides, also sustainable products or services can be labelled. The **carrot and stick approach** combines obligations, subject to sanction, with rewards.

Selling conditions on business parks could include concrete low carbon commitment by implementation of specific measures in return for discounts on utilities and facilities provided by the park management. Nonetheless, companies can also voluntary perform low carbon action. Therefore, information about low carbon practice needs to be disseminated through energy audits, magazines, websites, trainings, conferences, etc.

3.9 Worldwide examples

Worldwide a number of newly developed business parks are integrating sustainability and low carbon concepts, such as Ecofactorij and Hessenpoort in the Netherlands, Evolis in Belgium and TaigaNova and Innovista in Canada.

Ecofactorij is a recently developed business park destined for large scale production and distribution companies in Apeldoorn, that promotes sustainability and carbon neutrality as the primary objective. A park management organisation has been established and is located in a low energy building, equipped with a wood pellet stove, thermal salt panels for internal climate regulation and solar cells. The park also has its own private electricity grid to which five wind mills will be connected, and a number of companies are equipped with individual cold heat storage systems.

On business park **Hessenpoort** in Zwolle a number of companies have installed individual cold heat storage systems and solar cells, and the possibilities for adapting an existing biomass fermentation plant for collective energy production have been investigated. In Kortrijk, Belgium, the intermunicipal organisation Leiedal is developing a new business park, **Evolis**, which has its own park management. Four wind turbines have been installed and space is reserved for a future biomass CHP.

Taiga Nova, in Fort McMurray, and **Innovista**, in Hinton, are conceived as eco-industrial parks for light to medium industry. Sustainability principles are incorporated into the park's spatial design and into a set of mandatory and optional development guidelines for companies. These guidelines relate to energy consumption, production and efficiency, exchange of waste and residual heat, infrastructure, mobility and green spaces. Candidate businesses are evaluated by the number of sustainability measures they are willing to implement. However, the integration of sustainability principles is not confined to business park scale and also larger scale initiatives arise.

The **Climate Initiative Rotterdam** aims at a reducing carbon emissions within its territory with 50% by 2025, compared to 1990. Meanwhile, the petrochemical industry cluster needs to shift to alternative raw materials and fuels. In London, the entire **Green Enterprise District** is dedicated to the creation of jobs in the low carbon economy, by attracting businesses in low carbon products, services and technologies, waste valorisation and renewable energy.

3.10 Sources

Websites	
GHGProtocol	www.ghgprotocol.org
GHGP tools	www.ghgprotocol.org/calculation-tools
GHGP movie	www.youtube.com/watch?v=_urMCfkPdus
GHGP offices	www.ghgprotocol.org/files/ghgp/tools/working9-5.pdf
Fig. 16	www.sapintegratedreport.com/2012/en/performance/non-financial-notes/2.html
Bilan Carbone	www.associationbilancarbone.fr/
PAS 2060	www.bsigroup.com/en-GB/PAS-2060-Carbon-Neutrality www.carbon-clear.com/resource/white-papers/P10
CDP	www.cdproject.net

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SOKKA, L., PAKARINEN, S. & MELANEN, M. 2011. Industrial symbiosis contributing to more sustainable energy use – an example from the forest industry in Kymenlaakso, Finland. *Journal of Cleaner Production*, 19, 285-293.

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VLAAMSE REGERING 2007. Besluit van de Vlaamse Regering houdende subsidiëring van bedrijventerreinen.

VLAAMSE REGERING 2013. Besluit van de Vlaamse Regering houdende subsidiëring van bedrijventerreinen

LOW CARBON BUSINESS PARK MANUAL

Chapter 4

Business park energy system

4 Business park energy system

4.1 Introduction

In this chapter, insight is gained into the configuration of an energy system on business park scale. Technological measures to improve the system's overall energy efficiency and lower its carbon emissions are identified and situated within the system. Special attention is paid to the appropriate matching between energy production technologies and energy services in terms of temperature profile. Therefore, the important concept of exergy is introduced and briefly explained. To analyse past or future system operation or to determine which technologies should be invested in to cost-effectively reduce greenhouse gas emissions, the energy system needs to be technically and economically modelled. The different types of techno-economic models and their applications are described. Energy flows through the energy system can be inventoried on a yearly or monthly basis by means of an energy balance table.

The **holistic** or systems approach described in this chapter assists in good decision making concerning an energy system's components and configuration. It is intended for people involved in energy system planning or design (technical manager of a company, business park developer, engineering company, energy service company,...). Although this chapter targets a broad audience, paragraph 4.4 maybe somewhat more challenging for non-technical people.

4.2 Energy system superstructure

An intuitive general superstructure of a business park energy system is presented in Fig. 18: **Energy sources** are transformed by **energy conversion technologies** (see 5.6) into forms (heat and electricity) suitable for **energy services** (see 5.2.1). These conversion technologies can be directly linked to individual companies or first be connected to a **local energy network** with **storage** facilities, supplying a number of companies (see 7.5 and 7.8). The local network, as well as individual companies, can exchange energy with the regional electric **grid** or **district heating network**.

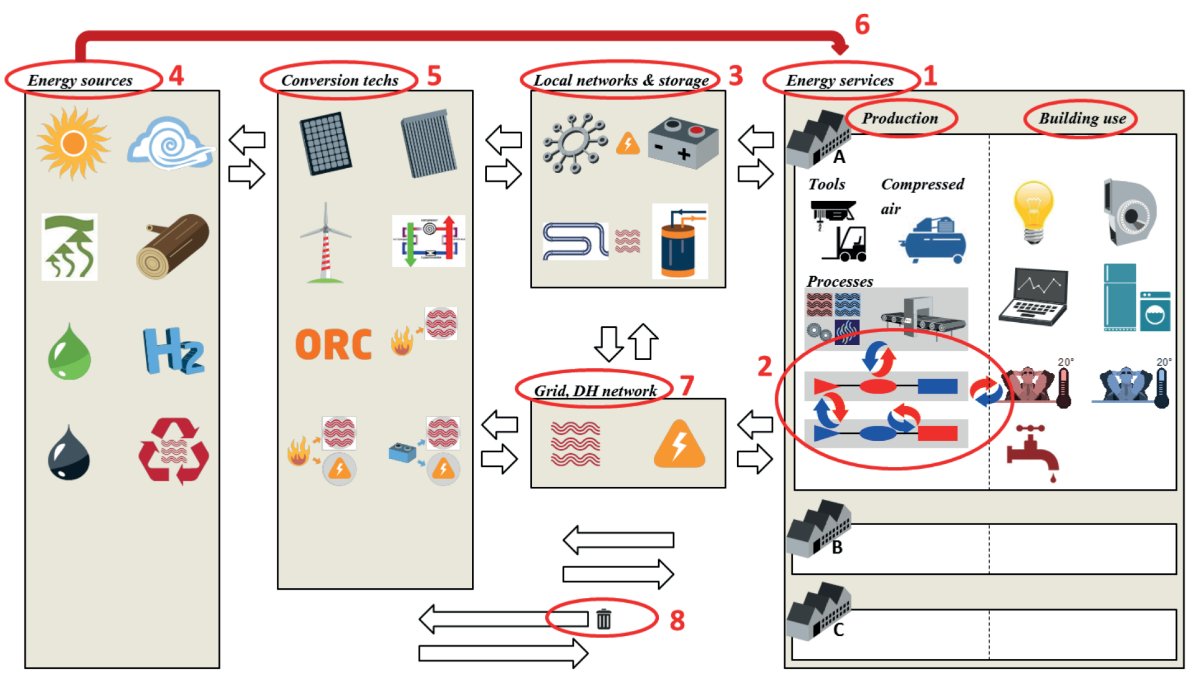

Fig. 18: Indicative energy system superstructure and indication of technological energy measures

4.3 Overview technological energy measures

The energy system's overall efficiency can be improved and its carbon emissions reduced by implementing a series of **technological measures**, indicated on Fig. 18. (**1**) Following the Trias Energetica strategy (see 3.3) energy measures must focus in the first place on **reducing** the **demand** for energy services related to building use and production processes at business level. These measures include installing efficient devices, optimising equipment operation, applying sufficient insulation, choosing efficient processes and low carbon product design (see.5.4). (**2**) Secondly, **heat recovery** at business level, by exchanging heat between process units, processes and energy services for building use, shows great opportunities (see 5.5). (**3**) Next, **local networks and storage** enable exchange of residual heat and excess electricity between companies and allow to set up a **collective** energy production system for a collective energy demand profile (see chapter 7). (**4**) Furthermore, zero-carbon energy can by generated from **renewable energy** sources and corresponding conversion technologies (see chapter 6). (**5**) Moreover, by employing the most **efficient technologies**, energy losses during conversion are minimised. (**6**) By **matching** energy services and energy production in terms of energy **quality** (temperature profile), the destruction of energy quality is minimised (see 4.4). (**7**) Any difference between local energy production and consumption, that cannot be compensated by charging or discharging of storage facilities, is levelled out by **exporting** excess energy to or **importing** low carbon energy from the public electrical distribution network and the district heating network. (**8**) Finally, **waste** produced in industrial processes can be recycled in the system as 'renewable' energy source. These technological measures clearly involve all application levels presented in paragraph 3.4: business, cluster, business park and region.

4.4 Matching thermodynamic quality of energy production and demand

To understand the importance of finding a good match between energy demand and supply, a basic understanding of exergy analysis is required. Below, some key concepts are briefly introduced. The main references for paragraph 4.4 are Torio and Schmidt (2011) and Moran et al. (2011).

4.4.1 Definitions

Thermal energy is contained by matter (e.g. the air in a room) and is related to its temperature. It includes both sensible heat and latent heat, which is related to phase changes (condensation, evaporation,...). **Hot thermal energy** is a surplus of thermal energy relative to (is hotter than) the environment, whereas **cold thermal energy** is used to indicate a lack of thermal energy relative to (is colder than) the environment. A **heating demand** and a **cooling demand** correspond to the need to increase or decrease the thermal energy of matter (e.g. the air in a room).

Heat (transfer) is not related to matter and refers to the transfer of energy between two systems as a result of a difference in temperature. **Cold** refers to heat transfer at temperatures below environmental temperature T_0

4.4.2 Exergy theory in a nutshell

***Exergy** expresses the **quality** of energy, being the ability to produce mechanical or electrical **work**.*

By definition the exergy corresponding to a quantity of energy is the **maximum theoretical work** (mechanical or electrical) that can be obtained from it (Fig. 19), when it is brought into **equilibrium** with a reference **environment** using a reversible process.

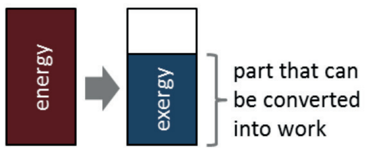

Fig. 19: Exergy

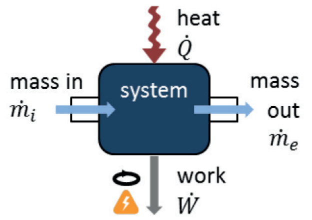

Fig. 20: Thermodynamic system

A thermodynamic system can receive **heat**, deliver mechanical or electrical **work** and be subject to **mass** in- and outflows (see Fig. 20). All these transfers of energy and matter are accompanied by transfers of exergy:

Heat transfer: Exergy related to heat transfer (by conduction and convection) can be interpreted as the work that could be generated from it by a theoretical device, called a Carnot cycle, operating between the heat source itself and the reference environment. As heat can never fully be converted into work (2nd law of thermo-dynamics), its exergy content is always smaller than its energy content. This definition is valid for heat transfer above as well as below the temperature T_0 of the environment. (see Fig. 21).

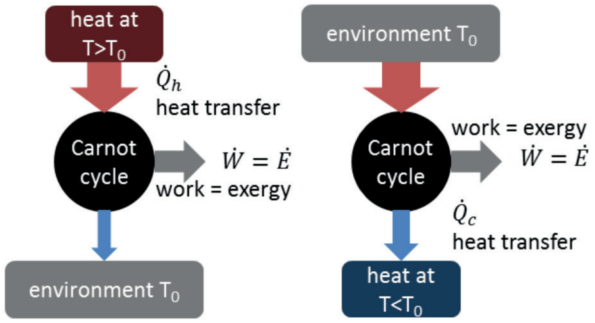

Fig. 21: Exergy of heat transfer = work produced by Carnot cycle between heat source and environment

Thermal energy: Exergy related to the thermal energy contained in a quantity of matter is equal to exergy of the heat transfer that can be obtained when bringing the matter into equilibrium with its environment. This heat may partly consist of latent heat transfer, which takes place at constant temperature, and partly of sensible heat transfer, occurring at changing temperatures as the system comes closer to equilibrium.

Work: The exergy content of energy transfer by work is equal to its energy content, because it can be fully converted into any other form of energy

In exergy analysis of buildings, exergy demand represents the minimum amount of work needed to keep temperatures within the required range, by providing energy (heating) or removing energy (cooling). As reference environment the surrounding outdoor air can be chosen. Consequently, the reference temperature T_0 varies over time.

4.4.3 Quality factor

The quality factor q of energy is the ratio of exergy content over energy content. For heat transfer, q is calculated with equation (1), which is also valid for latent heat of matter. For sensible heat of matter, however, expression (2) must be used. In contrast, energy transfer by work has a quality factor of 1, see expression (3). These formulas are graphically represented in Fig. 22. At temperatures above the temperature T_0 of the reference environment, the quality factors given by equations (1) and (2) increase with the heat source temperature T. Below T_0, they increase with decreasing temperatures. In order to simplify comparison of energy below and above environmental temperature T_0, the quality factor is put between absolute brackets. Of course, if the reference temperature T_0 varies throughout the year, this is also the case for the value of the quality factor. When a quantity of matter is heated up or cooled down from temperature T_1 to T_2, the quality factor can be calculated with formula (4), which is derived from (2). This expression can be applied to assess the quality of district heating or solar thermal heating as a function of inlet and return temperatures, while (1) is used for infinite heat sources, such as ground heat, or for heating demands, such as space heating.

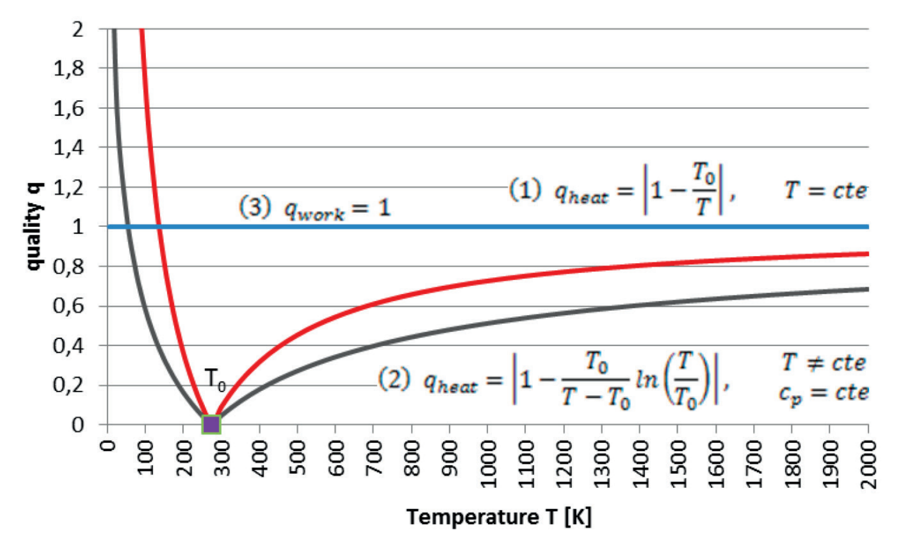

Fig. 22: Formulas energy quality factors, for T_0= 0°C = 273.15 K

As an example, some quality factors are calculated in Table 7. Fuels have combustion factors of about 0.9, due to the very high combustion temperatures (about 2000 °C). In contrast, energy demands for space heating and sanitary hot water have low qualities of about 7% and 13% respectively, because demand temperatures are relatively close to the temperature of the reference environment. Low quality heat sources are district heating, solar thermal and ground heat. However, since the temperature of the heat output from a solar thermal system or a shallow ground source heat pump vary significantly with changing outdoor reference temperature, quality factors may show strong variations throughout the year.

Table 7: Calculation of quality factors

equations		quality factors	T_0	T_1	T_2	q	eq.
$(1)\ q_{heat} = \left|1 - \frac{T_0}{T}\right|$	$T = cte$	***energy supply***	[°C]	[°C]	[°C]		
		electricity				**1**	(3)
$(2)\ q_{heat} = \left|1 - \frac{T_0}{T - T_0} ln\left(\frac{T}{T_0}\right)\right|$	$T \neq cte$, $c_p = cte$	fuel combustion	0	2000		**0,88**	(1)
		district heating	0	90	70	**0,23**	(4)
		solar thermal heat	0	70	50	**0,18**	(4)
		low T district heating	0	50	30	**0,13**	(4)
$(3)\ q_{work} = 1$		ground heat	0	10		**0,04**	(1)
$(4)\ q_{heat} = \left|1 - \frac{T_0}{T_2 - T_1} ln\left(\frac{T_2}{T_1}\right)\right|$	$T \neq cte$, $c_p = cte$	***energy demand***					
		space heating	0	20		**0,07**	(1)

4.4.4 Exergy efficiency heating and cooling systems

Exergy efficiencies are useful to compare the performances of different heating and cooling systems. For a combustion based heating system, the exergetic efficiency ε is expressed as the ratio of the exergy transfer $\dot{E}_u$, accompanying useful heat output at temperature T_u, to the exergy transfer $\dot{E}_s$, accompanying heat input at temperature T_s (see equation 5). For heat pumps, the exergy efficiency could be calculated in a similar way, as the ratio of the exergy related to the heat output to the required electrical work (equation 6).

Consider a closed heating system with combustion temperature T_s = 2000 °C and energetic efficiency η = 100%. For this system, Fig. 23 shows the exergetic efficiency in function of the heat demand temperature (T_0 = 0°C). The graph shows that for a demand temperature of 50 °C (inlet temperature of a low temperature radiator), the exergetic efficiency achieves only 18%, although the energetic efficiency is 100%. However, when the same system is used to provide heat at 450°C, e.g. for an industrial furnace, the exergetic efficiency achieves 68%. Obviously, the exergetic efficiency of a combustion based heating system is much higher when used for industrial furnaces than for space heating. When the qualities, and thus the temperatures, of energy source and energy demand are matched, the exergetic efficiency approaches the energetic efficiency.

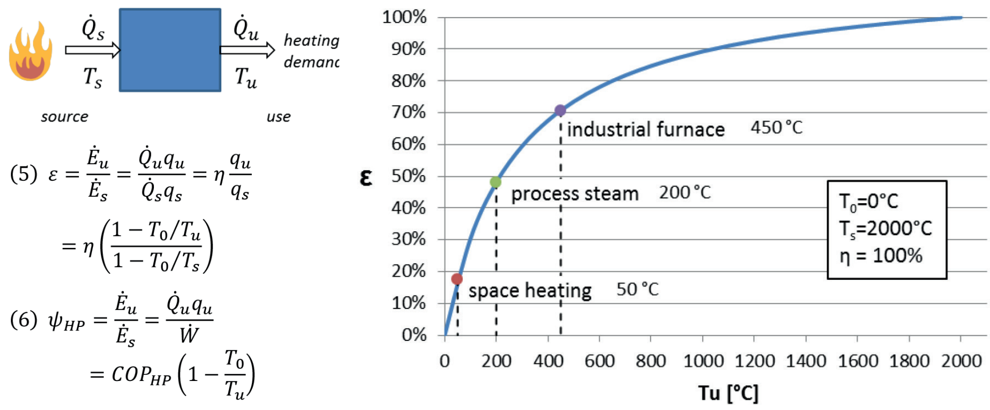

Fig. 23: Exergetic efficiency for the supply of different energy functions by combustion (Moran et al., 2011)

4.4.5 Matching energy supply and demand

When the energy required for a low quality heating (or cooling) demand is produced by a high quality energy source, a large portion of this exergy is destroyed without practical use. As shown in paragraph 4.4.4, this results in a low exergetic efficiency. Therefore, energy demands and energy sources of comparable quality should be matched. The arrow diagram in Fig. 24 graphically represents the matching of supply and demand qualities. Of course these quality factors depend on the chosen reference environment temperature T_0.

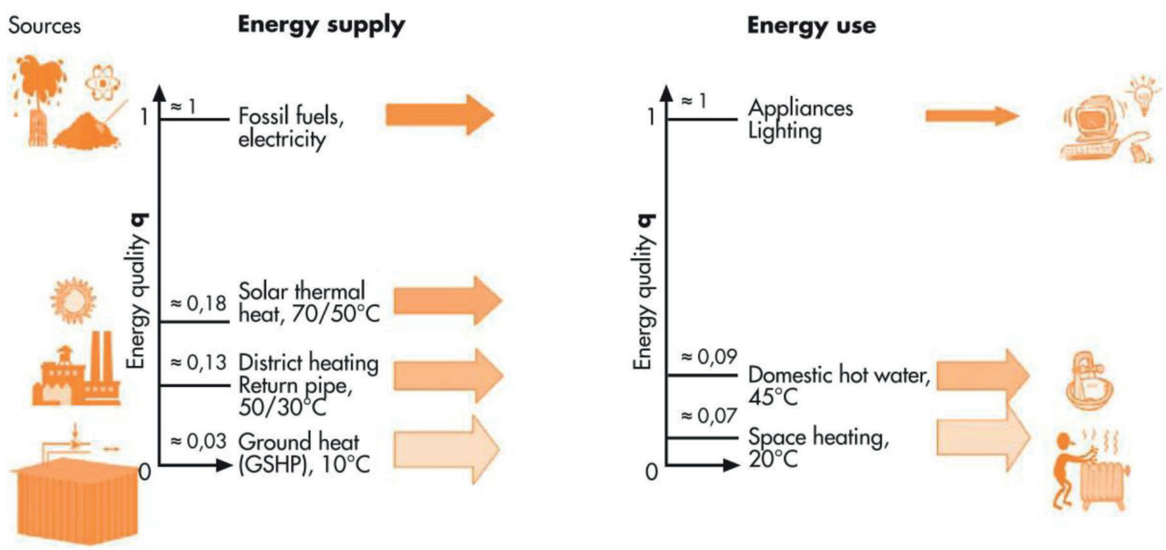

Fig. 24: Matching quality of energy generation and energy demand – arrow diagram (Torio and Schmidt, 2011)

In an exergy efficient energy system, low temperature heat for space heating and hot water should be produced by low exergy sources (solar thermal heat, geothermal heat, ground heat, recovered waste heat,...) instead of by fuel combustion or electricity. To allow the introduction of those low temperature sources, conventional high temperature emission systems, such as radiators operating in a 90/70°C regime, should be replaced by low temperature emission systems, such as floor heating or thermally activated building components. It is clear that a floor heating system connected to a gas boiler does not perform better than a conventional radiator with the same boiler. Also high temperature cooling systems, such as chilled ceilings, that provide cooling at temperatures close to indoor temperature, facilitate the introduction of low exergy sources. Furthermore, electricity use by pumps, fans and heat pumps should be minimised.

Combined heat and power production is used to maximally exploit the high exergy content of fuels. In a cogeneration plant, the high quality combustion heat drives a steam turbine coupled to an electricity generator, while the residual heat of lower temperature can be used for industrial processes. Moreover, when heat is cascaded down through a series of heating demands of decreasing temperature, the exergy destruction can be drastically reduced.

Renewable energy sources, such as solar thermal and ground heat, as well as waste heat, come at low temperatures, and thus low qualities. By consequently matching them to low quality demands, these renewable technologies can be more widely applied. Moreover, renewable resources yielding high quality energy such as biofuels, wind power, concentrated solar power, photovoltaic power and deep geothermal power, should be matched with high quality demands for an efficient use of energy.

The **primary energy ratio** is defined as the ratio between useful energy output and fossil energy input. Contrary to the quality factor (see 4.4.3), it takes into account whether an energy source is fossil or renewable. Since exergy analysis does not distinguish renewable from fossil energy sources, it has to be considered as complementary to low carbon design principles. In sustainable energy system design, energy demands are reduced, then the use of renewable energy sources is maximised and subsequently all energy sources are matched to energy demands of comparable quality.

4.5 Energy modelling

4.5.1 Time profiles energy production and demand

The actual operation of an energy system in every time step depends on the behaviour of its components in time (see Fig. 25), determined by:

- time profiles of uncontrollable energy sources (solar, wind,...)
- time profiles of energy service demands (lighting, space heating/cooling, process heating,...)
- dispatch strategies of controllable (fuel-driven) energy generators

For an energy system to be in balance, energy supply must equal energy demand at every time step. Therefore, the difference between uncontrollable energy production (solar, wind,..) and energy demand is compensated by dispatching controllable (fuel-driven) energy generators, activating energy storage, or trading energy with external networks. Consequently, the operation of an energy system is a complex time-varying interaction between its components.

Photovoltaic and solar thermal energy technologies are subject to the inter-annual variations of solar irradiance. Solar energy is only available during the day, and longer and more intense in summer than in winter. Wind turbines follow inter-annual variations in wind speed. In some regions, average onshore wind speeds during the day tend to be higher than at night and more wind energy is available in winter then in summer. On the demand side of the energy system, for certain energy services, typical time profiles can be identified. The time profile for automated outdoor lighting for example can be derived from the yearly time profile of daylight. For space heating, the profile depends on outside temperatures and solar irradiance. Moreover, for many energy services their time profile depends on the operation schedule of the individual companies.

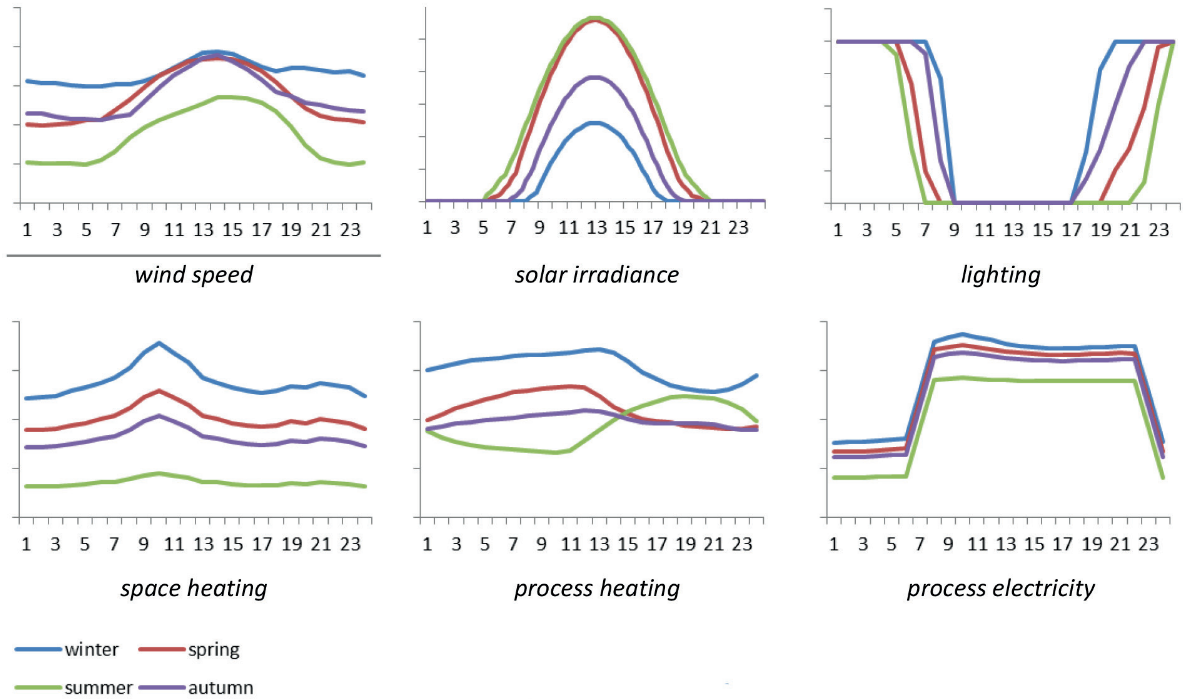

Fig. 25:Indicative time profiles of energy sources and energy services

4.5.2 Techno-economic energy model

When optimising single components of an energy system, without considering the complete system architecture, opportunities for more efficient system operation and configuration can be overlooked. This may even have a negative influence on the overall system efficiency. Therefore, energy system analysis and (grass-root or retrofit) design require a **holistic approach**, which is provided by techno-economic energy models.

A **techno-economic energy model** is a mathematical representation of an energy system. It describes the techno-economic and environmental characteristics of the individual system components and the interconnections between them. As an example, the superstructure of the energy modelling framework EnergyPLAN, representing all possible system components and interactions is shown in Fig. 26. Moreover, the model description includes the time profiles of uncontrollable energy technologies and energy service demands, the dispatch strategies of controllable energy generators, as well as the temperature levels of heat producing technologies and thermal demands.

Techno-economic energy models either **evaluate** the (energetic, economic, environmental) performance of a proposed energy system or **optimise** the configuration and operation of a system to obtain an optimal trade-off between (energetic, economic, environmental) performance indicators. These models are used to find the best design or to analyse past or to predict future behaviour of energy systems.

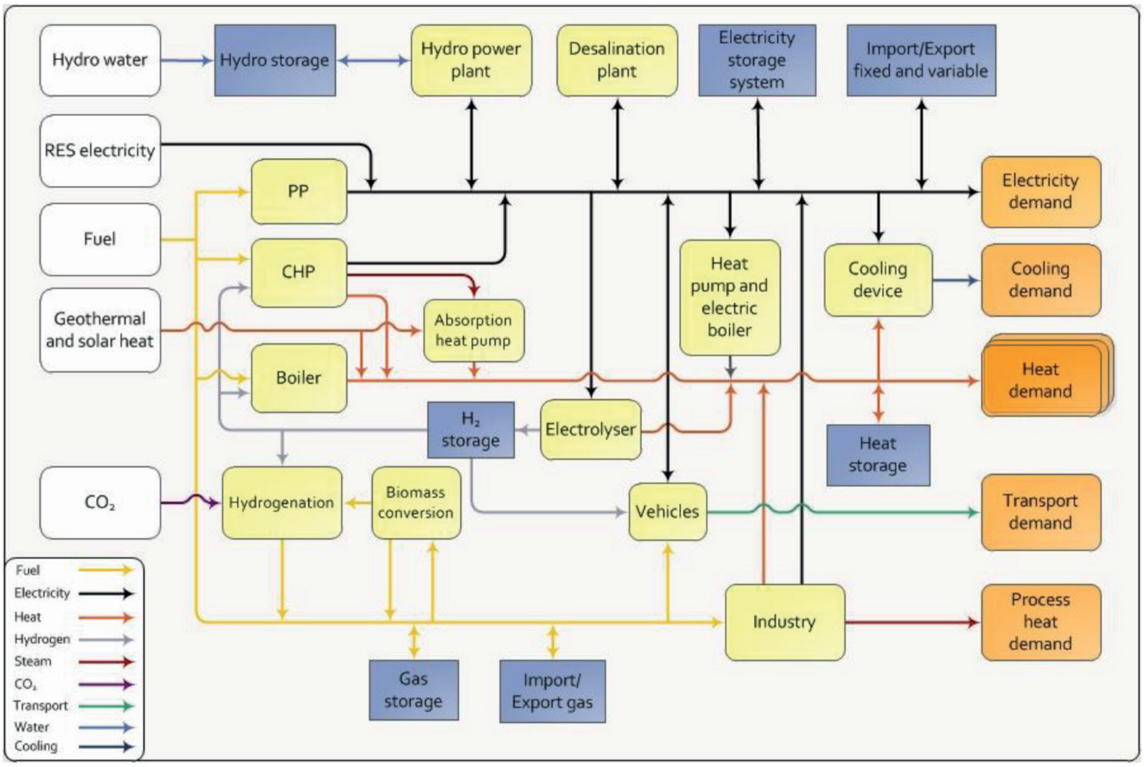

Fig. 26: Example of model superstructure (www.energyplan.eu)

4.5.3 Model categorisation

A categorisation of modelling tools and a comprehensive description of their key features is given by Timmerman et al (2013) and elaborations thereof: (**a**) **Energy system evolution models** identify the least cost pathway of an energy system towards a desired long term future. (**b**) **Energy system optimisation models** calculate the least cost system configuration and operation in a single representative year. (**c**) **Energy system simulation models** are used to compare different configurations or to analyse different operation strategies in a representative year. (**d**) **Energy system accounting models** are used to quickly assess the energetic, economic and environmental performance of a proposed energy system in comparison to a reference case. (**e**) **Energy system integration models** focus on optimal integration of energy conversion technologies, starting from thermal energy demands that have been minimised by heat exchange between process streams, using Pinch analysis (see 5.5). These model types have been applied for energy system analysis on international to local project scale. Energy system integration models are primarily developed for the optimal design of complex thermal energy systems, such as industrial processes, industrial plants and heat networks, but have recently also been employed for energy analysis on municipal or regional scale. An important difference is that type a, b and some type e models employ an optimisation algorithm to automatically **calculate** the **optimal** system **configuration** (or a set of near-optimal configurations), whereas type c and d models **evaluate** the performance of **user-defined configurations**.

4.5.4 Application to business park energy systems

So far, no techno-economic energy models custom tailored for business parks are available. Consequently the development of such a model by combining features of the model types described above, is of high priority. An appropriate energy model for business parks includes following properties: Next to **electrical** also **thermal** energy flows are covered, and they are defined by means of **temperature-heat curves** to correctly take into account temperature levels. Thermal energy demands are reduced a priori by modelling **heat exchange** between companies via heat links or networks, using Total Site Analysis methods (see 5.6). Key trends in annual time profiles of uncontrollable energy production technologies and energy service demands are captured with sufficiently high and customised **temporal detail**. For controllable energy technologies, typical **operation strategies** are incorporated. **Part-load efficiency** between operation limits, and **size-dependent** investment **costs** are modelled in order to accurately replicate the techno-economic characteristics of individual technology units. The different **energy services** that compose the aggregated electricity or thermal energy demand are distinguished. An **optimisation** algorithm automatically searches for optimal configurations and avoids the need for configurations proposed by the analyst. Moreover, to facilitate the trade-off between multiple conflicting objectives, such as minimisation of both costs and carbon emissions, **multi-objective optimisation** methods are employed.

The optimal configuration and operation calculated by the model depends on the chosen performance targets. A variety of targets can be envisioned, such as minimisation or limitation of total discounted system costs (or investment costs, operational costs, import costs,…), total carbon emissions, fossil fuel consumption, the total energy volume exchanged with external networks, thermodynamic quality loss, etc. Maximisation or minimum thresholds could be targeted for overall energy efficiency, profits on individual generator or system level, the share of renewable energy production or consumption, etc. Typically, total discounted costs are minimised, while limiting carbon emissions and energy trade, while attaining a minimum share for renewable energy production.

Techno-economic energy model for low carbon business park energy systems.	
Requirements	
• Represent:	✓ Electrical and thermal energy flows ✓ Heat-temperature curves for thermal energy flows ✓ Heat exchange between companies via heat links or networks ✓ Key trends in annual time profiles uncontrollable energy production and energy service demands ✓ Operation strategies of controllable energy technologies ✓ Part-load efficiency and size-dependent technology costs ✓ Distinction of energy services
Objectives	
• Minimise or limit:	✓ Total discounted system costs ✓ CO_2-emissions ✓ Fossil fuel consumption ✓ Energy exchange with external networks
• Maximise or minimum threshold:	✓ Overall energy efficiency ✓ Profits on individual generator or system level ✓ Introduction of renewables
Results	
• Configuration:	✓ Technologies, capacities, (if applicable: investment plan over time)
• Operation:	✓ Dispatch of technologies

4.6 Sources

References

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TIMMERMAN, J., DECKMYN, C., VANDEVELDE, L. & VAN EETVELDE, G. Techno-economic energy models for low carbon business parks. 16th Conference on process integration, modelling and optimisation for energy saving and pollution reduction, 29 September- 2 October 2013 2013 Rhodes, Greece. Chemical Engineering Transactions, 571-576.

TORIO, H. & SCHMIDT, D. 2011. Detailed Exergy Assessment Guidebook for the Built Environment In: PROGRAMME, I. E. R. (ed.) Annex 49: Low Exergy Systems for High-Performance Buildings and Communities, Final Report. Germany: Fraunhofer IBP.

LOW CARBON BUSINESS PARK MANUAL

Chapter 5

Energy consumption in companies

5 Energy consumption in companies

5.1 Introduction

In this chapter a company's energy consumption profile is broken down into energy services related to building use, and energy services related to production processes. The temporal variation of energy services is explained and the different temperature ranges of thermal energy demands are discussed. In order to identify effective energy measures, a good understanding of a company's energy consumption profile is essential. Therefore, a step by step approach to efficient energy management is outlined: energy audit, energy monitoring system, energy management system. Energy efficiency measures related to building use and production processes are listed with some examples. Finally, Pinch Analysis and Total Site Analysis are explained. The Pinch method assesses the reduction in thermal energy requirement that can be achieved by direct heat exchange between a company's processes. Total Site Analysis extends the Pinch method to business park scale, but only allows heat exchange between companies via heat links or heat networks. The last two paragraphs are more theoretical, but offer technical insight in heat exchange at company as well as business park level.

5.2 Energy consumption profile of a company

Fully determining a company's energy profile comprises different steps (see Fig. 27). Firstly, the annual consumptions of all energy carriers (electricity and fuels) are inventoried. Subsequently, these consumptions are allocated to the different energy services within the company. Next, time profiles are assigned to each energy service, or on a more aggregate level, to the consumption of an energy carrier (e.g. as a yearly distribution of hourly values). Next, the temperature levels of all thermal demands for energy services are defined. Once all these data are gathered, the energy profile is completely known. Energy data can be acquired by performing an energy audit, a onetime energy monitoring campaign, or they may be available from a permanent energy monitoring or energy management system (see 5.3).

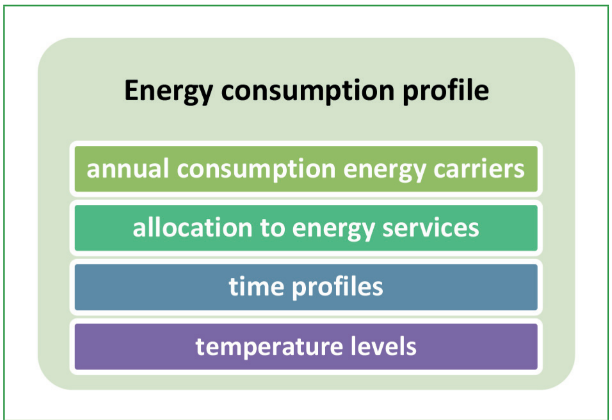

Fig. 27: Energy consumption profile

5.2.1 Energy services or energy functions

The yearly consumption of different energy carriers (electricity and fuels) within a company can be allocated to various energy services (or energy functions), which are related either to the usage and occupancy of the buildings or to the industrial production itself. To graphically represent this yearly energy profile, a pie chart can be used for each energy carrier (see Fig. 28). Such charts can be obtained from an energy audit (see 5.3.2). It is impossible to compile representative yearly energy profiles per company type. Indeed, even within the same industrial sub-sector, large variations in yearly energy consumption profile occur due to differences in type and performance of processes, occupancy rate, performance of buildings, etc. However, an idea of the relative distribution of energy consumption (electricity and fuels) over the different energy services can be obtained from a global analysis of the regional or national industry sector and its sub-sectors. This type of analysis has been performed for the German industry and its sub-sectors (see Fig. 29) by the Fraunhofer Institute (Schlomann et al., 2010), and could also be used as an approximation for the energy profile of industry sectors in other countries.

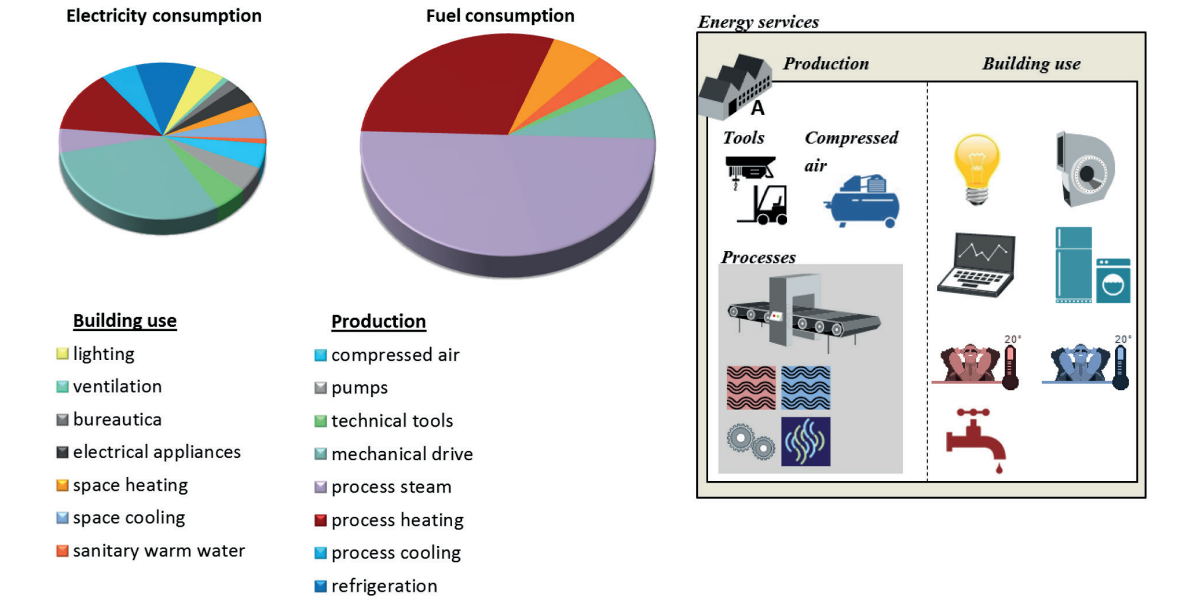

Fig. 28: Energy services and allocation of annual consumption of energy carriers (fictive example)

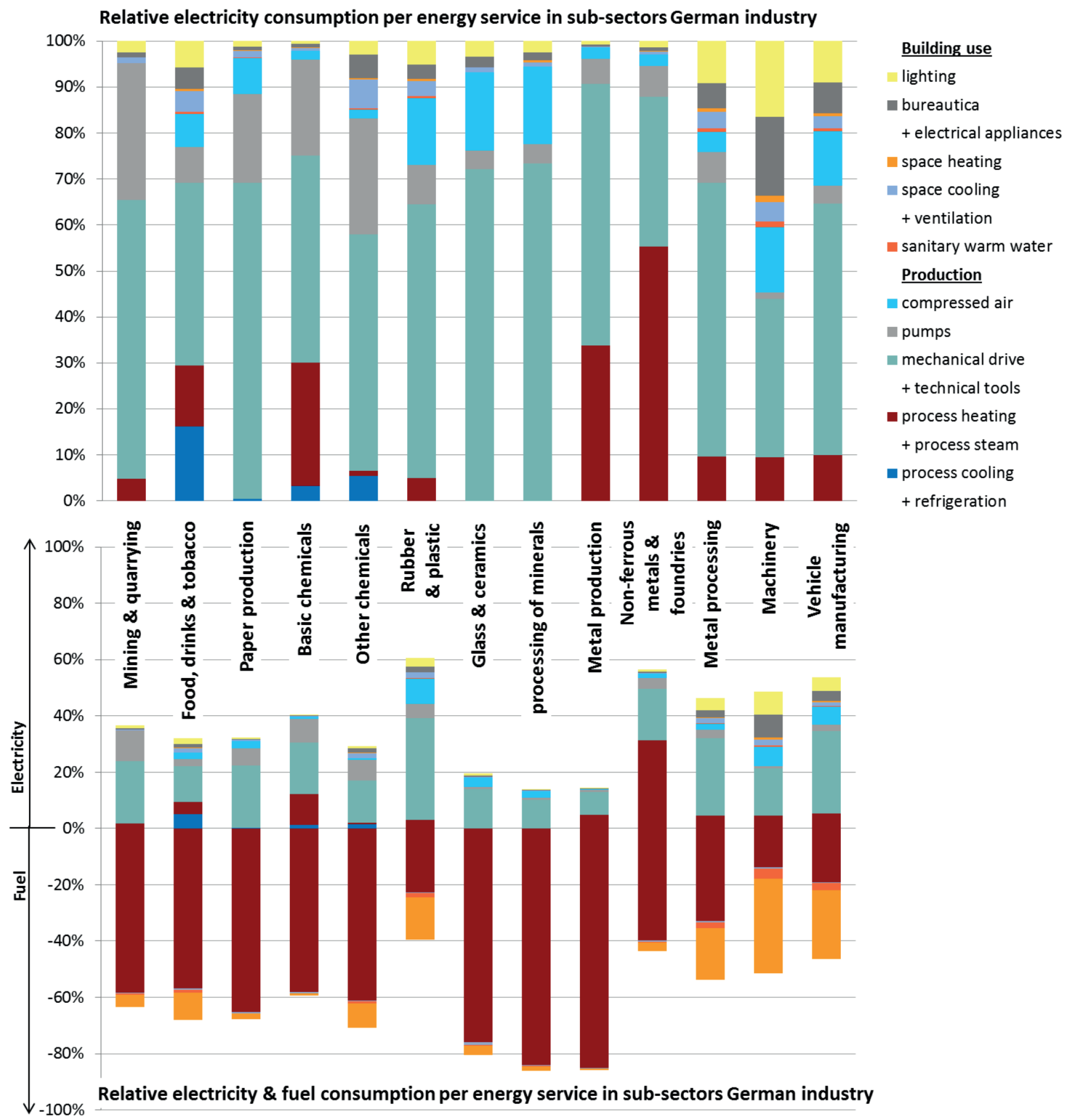

Fig. 29: Allocation to energy functions of electricity and fuel consumption in German industry (Schlomann et al., 2010)

5.2.2 Time profiles

Time profiles of energy services correspond to variations in natural conditions, to the company's working schedules or to both. Lighting, space heating, space cooling and sanitary hot water are subject to day/night rhythm, seasonal variations in daylight and outside temperature, but also to weekly and daily working schedules. Automated outdoor lighting does not depend on working schedules. The other energy functions mainly depend on daily and weekly working schedules.

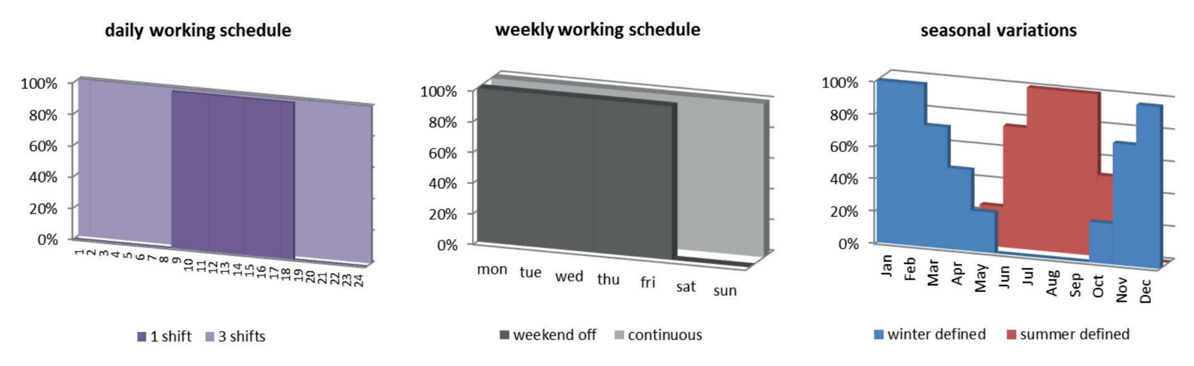

Fig. 30: Time profiles

The Flemish energy regulator (VREG) provides synthetic load profiles for non-residential electricity and gas consumers (see Fig. 31). These artificial time profiles, with a time step of 15 minutes take into account holiday periods, weekly and daily working schedules, and also diurnal and seasonal influences. Since not all companies have meters installed to register their gas and electricity consumption on a 15 minute level, energy suppliers use these profiles to assess the consumption of their customers. When time profiles at the level of individual energy services are not available, these synthetic profiles could be used to get a rough idea of the energy profile of a company. The VREG provides also synthetic load profiles for electricity and gas consumption of residential consumers and an electricity time profile for public lighting.

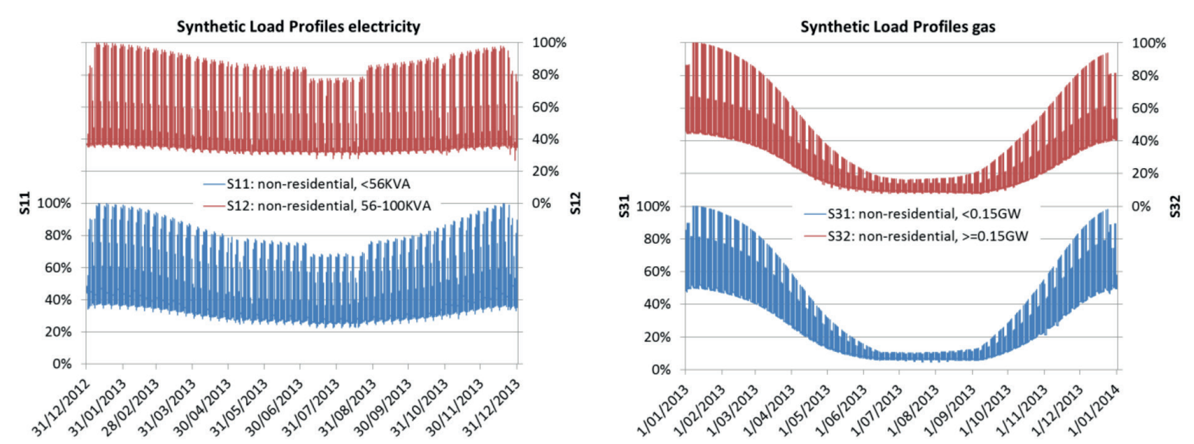

Fig. 31: Synthetic Load Profiles electricity and gas

5.2.3 Temperature levels of thermal demands

Many **building use** related energy services require thermal energy. **Space heating** serves to ensure a comfortable indoor temperature of about 20°C during the day and about 16°C at night. The minimum temperature of the heat that needs to be generated depends on the heat emission system. High temperature emission systems, such as conventional radiators and convectors, require a feed-in temperature of more than 55°C, while low temperature emission systems, such as floor, wall heating, heated ceilings, and concrete core activation, work on regimes lower than 55°C (WTCB, 2010). To produce **sanitary warm water**, at least 60°C has to be attained to prevent incubating bacteria colonies. **Space cooling** is achieved by extracting heat from the indoor air and exchanging it with the outside air. Conventional space cooling systems, such as compression based air-conditioning systems extract heat at temperatures of about 0°C. High temperature cooling systems, however, extract heat at temperatures just below indoor air temperature. Space heating and cooling can also be partly done by preheating or precooling fresh outside air, before injecting it in the building. For all heating and cooling systems applies that the smaller the temperature difference between the emission system and the indoor air, the larger the heat exchanger surface needs to be.

In industrial processes, washing, rinsing, cleaning, drying, pasteurising, blanching, cooking and melting, require heat at temperatures below or just above 100°C, while higher temperatures are needed for distillation, sterilisation, vaporisation, drying in/out, etc. Very high process temperatures are required in mineral (cement), metal, non-ferro, glass & ceramics, and chemical industry. As for annual energy profiles, it is not possible to accurately allocate temperature levels to company types, as many differences occur in process composition. However, at the national level, the division of low (>100°C), medium (100°C – 400°C) and high (>400°C) temperature heat between industrial sub-sectors can be obtained (Difs et al., 2009). Fig. 32 represents the distribution of industrial heat demands for German industrial sub-sectors in 2001. These figures can be used to give an approximation of the temperature distribution in subsectors in other countries.

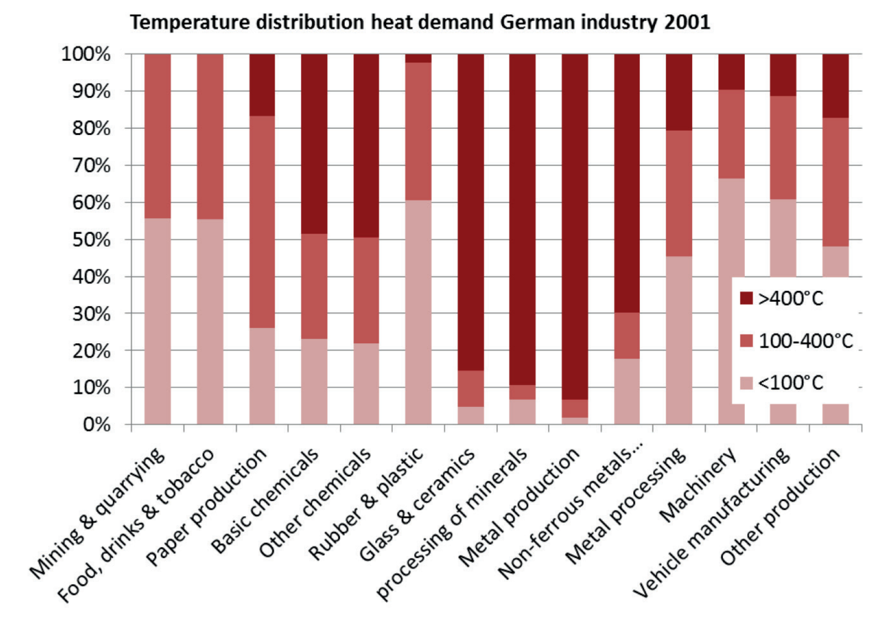

Fig. 32: Relative distribution of heat demand according to temperature for industrial sub-sectors in Germany (Difs et al., 2009)

5.3 Energy Management

Energy management aims at **mapping**, **adjusting** and **controlling** a company's energy profile in order to reduce energy consumption, and the costs and carbon emissions related to it. Efficient energy management comprises three key elements: **energy audit**, **energy monitoring system** and **energy management system** (see Fig. 33 and paragraphs 5.3.2, 5.3.3 and 5.3.4). Firstly, during an energy audit, the company's energy consumption profile is analysed and potential energy saving measures are identified. Secondly, a monitoring system is installed to record the energy consumption of specific energy services into more detail and to detect deviations from expected energy consumption patterns. Thirdly, an energy management system is implemented in order to simultaneously monitor and control appliances and processes. The Energy Efficiency Planning and Management Guide, composed by the Office of Energy Efficiency of Natural Resources Canada (2002) provides a comprehensive guidebook towards efficient energy management. A comprehensive manual and spreadsheets for energy audit and monitoring, that can readily be used, have also been developed by the Canadian Industry

Program for Energy Conservation (CIPEC, 2011). The energy agency of the Netherlands (Agency NL) explains the advantages of energy management for companies in an instructive online movie clip (see 5.7).

Fig. 33: 3 elements in energy management

5.3.1 ISO 50001

ISO 50001 is an international standard for energy management and companies can attain ISO 50001 certification if their energy management system complies with the standard guidelines and rules. In the context of ISO 50001, 'energy management system' (EnMS) refers to the process of establishing and implementing an energy policy to attain energy performance targets, rather than to the electronic system that monitors and controls appliances and processes. The standard is based on a continuous Plan-Do-Check-Act (PDCA) approach and incorporates energy management into everyday practices. In the Plan phase, the company's energy policy is established and concrete action plans are developed. After analysis of the company's energy consumption profile, key energy performance indicators are identified and targets are set. The Do phase comprises the implementation of the organisational and technical energy measures, stated in the action plans. Next, in the Check phase, energy monitoring results are analysed and energy performance indicators are evaluated and corrective measures are identified. These measures are then implemented in the Act phase to improve energy performance and the procedures of the EnMS.

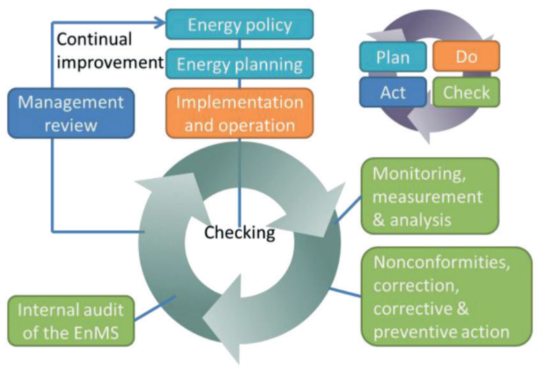

Fig. 34: Plan-Do-Check-Act approach in ISO 50001

5.3.2 Energy audit

The first step in an energy audit is the assessment of the company's annual energy consumption profile, starting from the (monthly) energy data available from **energy bills** (electricity, gas, fuels). Next, an **inventory** is made of all appliances and process units, listing nominal capacities, temperature levels, yearly operating hours and load factors (see Table 8). Based thereon, the yearly consumption of energy carriers is allocated to energy services. The audit makes it possible to identify large energy consumers, and to detect deviations from expected monthly energy consumption patterns. From this preliminary analysis, the most cost-effective energy saving measures can be identified. Quick wins are for example the detection and repairing of air leaks, changing the set points of space heating and cooling, heat recovery between processes, installing efficient light bulbs, etc. (see also 5.4 and 5.5). The energy audit is a necessary preparatory step before organising an energy monitoring campaign, as it provides a base for the design of the monitoring system. A more detailed stepwise description of the audit process can be found in the annex.

Table 8: Energy consumption inventory template with indicative example of a steel processing company

Company department / Energy service / Process unit/device	Example	# units	Rated power consumption kW	Rated fuel consumption kW	Temperature levels °C	Operating hours/year h	load factor %
A	**production hall**						
A.1	***steel pre-treatment***						
A.1.1	cutting machines						
A.1.2	rolling machines						
A.1.3	bending machine						
A.1.4	punch press						
A.2	***steel hardening***						
A.2.1	hardening furnace						
A.2.2	tempering furnace						
A.3	***end treatment***						
A.3.1	welding station						
A.3.2	milling machine						
A.3.3	printing press						
A.4	***compressed air***						
A.4.1	compressor						
B	**office**						
B.1	***lighting***						
B.2	***...electrical appliances***						
B.2.1	computers						
B.3	***space heating***						
B.4	***ventilation***						
... ...							

5.3.3 Energy monitoring

An energy audit provides only a one-time rough and quick scan of a company's energy profile from the past year(s). More insight can be gained with an energy monitoring system that monitors specific energy services within the company, continuously and in real-time. More specifically, an energy monitoring system measures and records energetic and physical characteristics (electrical current, voltage, active and reactive power, mass flow rate, temperature, etc.) of appliances and processes with high accuracy and temporal detail. Measured data series can be represented in numeric or graph form, with indication of min/max values, trends, warnings and alarms (see Fig. 35). In this way key characteristics and events in the energy profile (base load, peak demand, operation schedules, start-up, shut-down) can easily be identified. Deviations from expected energy consumption patterns can quickly be detected so that adjustments can be made on time. Practical guidelines for interpreting measured time series of energy data are given in chapter 6.5 of the Energy Savings Toolbox (CIPEC, 2011). The energy consumption inventory from the audit phase (see Table 8) can be compared with the monitoring results and adjusted if necessary.

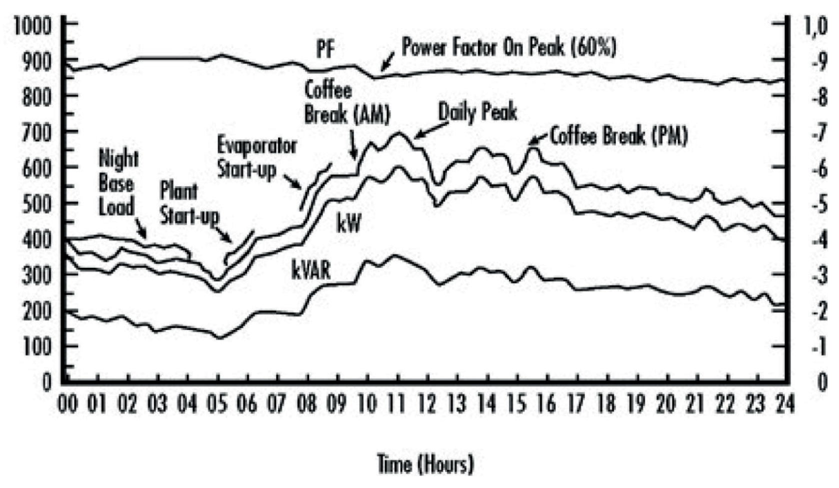

Fig. 35: Energy demand profile with identification of key characteristics

Periodic manual readout of main utility meters

The most basic form of energy monitoring is to manually read out the company's main utility meters (electricity and gas) at periodic intervals. In practice, only a limited time resolution can be obtained in this way, but no costs are involved besides staff costs for the readings. Some energy suppliers offer an online tool, that displays the total energy consumption of the facility at monthly to quarterly level.

Automated energy meter recording

A more detailed picture of a company's energy profile is obtained by equipping appliances and process installations with meters that automatically record energy consumption data.

- Ampere meters (ammeters) measure only electric current. Power meters measure both electric current and voltage and automatically compute active power, reactive power and power factor. Clamp-on versions of these meters can be temporarily clipped over an electric wire.
- Flow meters measure the flow rate of fluids (gas or liquid) through pipes. A variety of flow meter types is available, each based on different physical working principles. Gas consumption can be measured with a gas meter, which is a customised flow meter. Industrial installations using gas often have a build-in gas meter with a magnetic pulse output that can be read by a pulse meter.

Measured data can be managed in different ways. One option is to equip each energy meter with a memory card, so that data is stored locally. Another option is to physically connect the energy meters with a data logger by means of a data cable network or via the company's data network itself. Wireless connection between meters and data loggers is also possible. The data can be stored in a data logger or be sent to a webserver, using TCP/IP protocol. **Smart energy meters** combine meter data logger and two-way communication technology in one device. A practical implementation of smart meters is given in 5.3.5.3.

A fully elaborated energy monitoring system visualises the real-time energy parameters of all key energy services. Energy monitoring systems can also be employed to monitor local energy production, by means of sensors that collect meteorological data and meters that register the performance of the energy production system.

5.3.4 Energy management system

An energy management system is an electronic system that enables both monitoring and control of processes and appliances in an industrial environment. It interprets and visualises the measured energy parameters in real-time, calculates optimal control set-points and sends these parameters to devices and process units. Such a system is able to detect irregularities and trigger an alarm or take measures to solve the problem. It inventories all energy flows and related costs. Furthermore, demand-response strategies can be implemented, which adapt the activity level of processes to spot market energy prices or to climatic conditions. The system configuration, presented in Fig. 36, includes a software platform, data acquisition hardware and a cabled or wireless communication network. Communication between the different system components could also be organised over the company's own intranet.

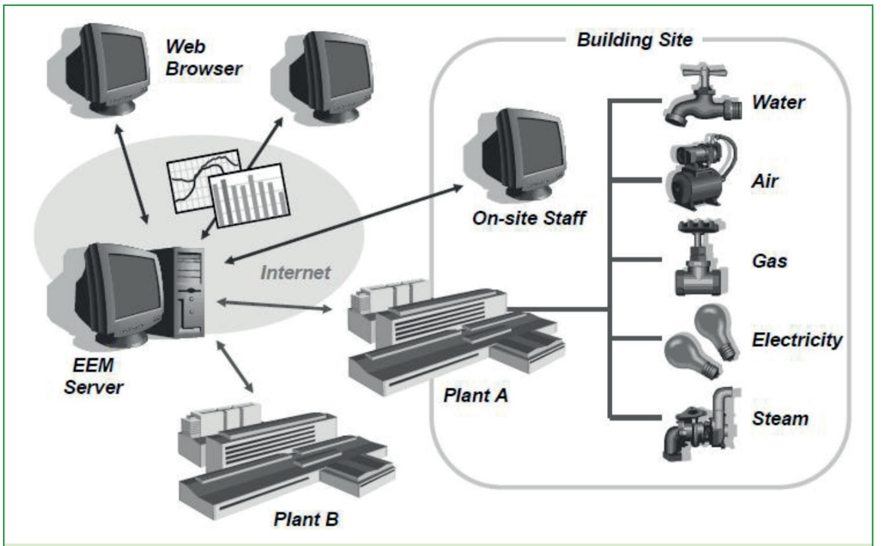

Fig. 36: Enterprise energy management system architecture[[http://www.powerlogic.com]:

5.3.5 Case studies

5.3.5.1 Energy scan and energy monitoring business park Sappenleen

ACE reserved a budget for gathering company energy data. Within this budget, companies on business park Sappenleen in Poperinge, Flanders, were offered a free energy scan and monitoring campaign, provided that the results could be used for research. After an information session, organised at Sappenleen, three companies responded to the offer: Weweler-Colaert, Connect Group and a printing company (Fig. 37). In each company, an energy scan was performed and reported by Enterprise Flanders, assisted by Ghent University. Based on the energy scan report, Ghent University composed an energy monitoring plan, and for each company to be monitored, a separate tender for executing the energy measurements was sent out. Subsequently, competitors were evaluated according to quality and price.

Fig. 37: Location energy scans and energy monitoring

Energy scan

The energy scan resulted in the allocation of energy consumption to energy services, the identification of quick wins and the breakdown of gas and electricity costs. The charts in Fig. 38 provide a quick insight into a company's annual energy profile, the relative share of each energy service in the consumption of electricity and fuels, identification of the major energy consumers, and the ratio between total electricity and total annual fuel consumption. In the monitoring plan, energy flows were mapped more accurately. Technical tools are lose of processes, not used continuously or used for several processes.

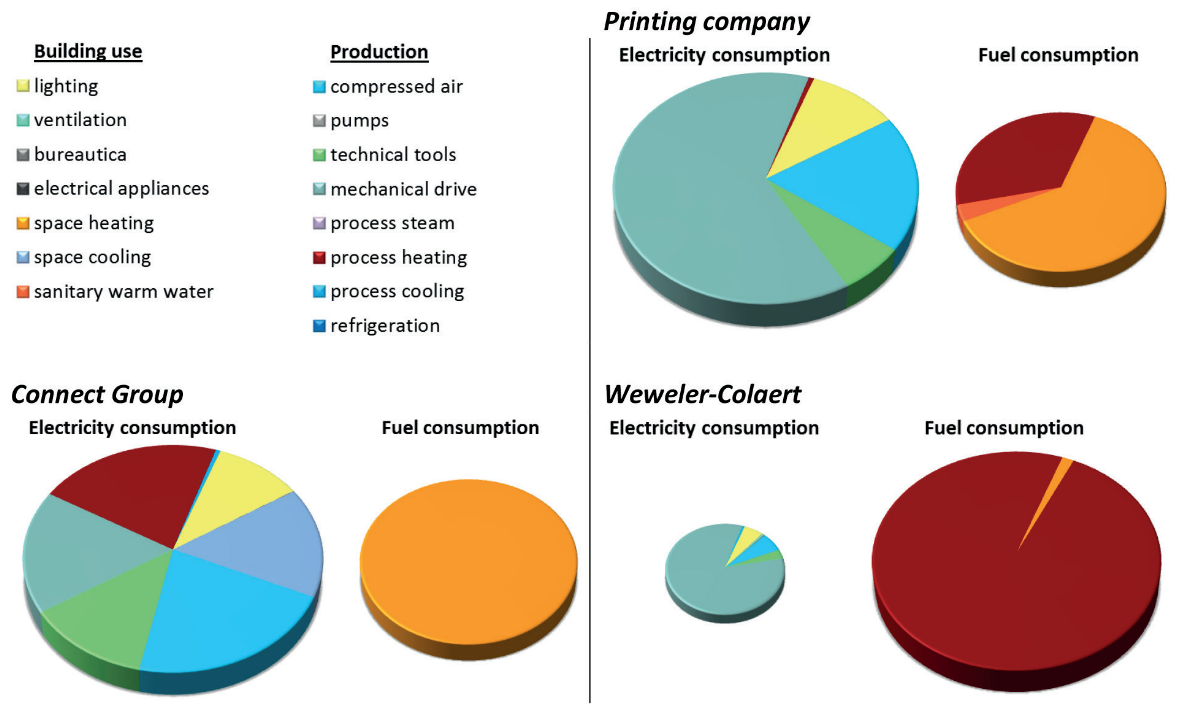

Fig. 38: Allocation energy consumption to energy services

Energy saving measures identified during the energy scan include adjusting the operation of centralised space heating for offices and air heaters in industrial halls, eliminating standby energy consumption, installing more efficient lighting and presence detectors, insulation of installations and pipes, recovering and reusing waste heat from process heating, repairing compressed air leaks, replacing motors by efficient frequency controlled electro-motors, optimising vacuum production installation, improving insulation and airtightness of heated or cooled spaces, etc.

Energy monitoring

The preparation of the energy monitoring tenders and the subsequent company visits, offered the opportunity to verify and refine the rough results of the energy scans. Companies also gained deeper insight into the layout of their internal electricity distribution circuit and identified possible improvements and simplifications. During the energy monitoring campaign, the main energy consumers detected by the energy scan were monitored during a time span of ca. 4 weeks. Energy data are processed and made available to the companies and will be used under confidentiality for energy research at Ghent University.

Preliminary screening based on energy scan

Weweler Colaert NV manufactures suspension systems and springs for heavy duty automotive markets. In an interview with Ghent University opportunities for improvements in the company's energy system were discussed. The main electricity meter profile shows a low load factor due to high peaks in electricity consumption. As electricity costs are largely determined by peaks in demand, they should be flattened or avoided. This can be realised by a wider spread in time of installation start-ups. For example, part of the installations that operate in the morning shift can already be started during the last quarter of the night shift.

The manufacturing process consists of hot forming (punching, rolling and bending) and hardening. In the overall process, the largest gas consumption is related to the hardening installation, where steel springs are first heated to about 940°C in a gas furnace and then quickly cooled to about 80°C in an oil bath. The oil bath is kept at constant temperature by a cooling water circuit that releases its heat to the outside air via a ventilation unit. By this way of cooling a large amount of water vapour is annually emitted. The cooling circuit is replenished partly by rainwater and partly by drinking water, which induces a high yearly cost. At the moment, offices are heated by a natural gas boiler, while distribution halls are not heated. The cooling circuit of the hardening installation could be connected to the central space heating installation of the offices and additionally the circuit could provide space heating for the distribution halls. In this way, waste heat from the cooling circuit is usefully applied for space heating purposes. As a result, gas consumption for space heating is reduced to zero and the need for cooling water is reduced.

Furnaces for hot forming are open at one side to allow manipulation of the springs. Therefore, they cannot easily be insulated and it is difficult to recover waste heat for reuse elsewhere. In the past, significant energy savings have been achieved by combining multiple automated manipulations in one heating session. The fact that the company produces a large number of different products in small to medium size batches limits the options for combining installations into a single production line.

In 2013, VDL Weweler BV opened a new company building on business park Ecofactorij (see 3.9). Here production comprises fewer, but larger production batches then in Poperinge. Instead of gas furnaces, induction is used to heat up the steel. The springs are first hot-formed and then hardened in a continuous process while the residual heat from the first step is reused in the second one. This cuts energy requirements by 35% and reduces production time. Steel hardening is done in a salt bath and the residual heat thereof is used for floor heating in the industrial halls. Offices are heated and cooled by a ground source heat pump.

5.3.5.2 Guidance programme as stepping stone towards ISO 50001

The city of Ghent launched a guidance program on energy management in which businesses are offered a free energy audit followed by assistance and advice during one year (for more information see 10.1). For many companies, the programme is a stepping stone to an ISO 50001 certified energy management system. Such system allows companies to keep track of and to analyse their own energy consumption.

5.3.5.3 Energy monitoring Theaklen Drive

Smart Meters take automatic, accurate readings of electricity and gas consumption on an hourly basis. The measured data series can be read remotely and presented in numeric or graph form. Energy monitoring allows companies to analyse energy consumption related to their business activities, and to identify unusual or unexpected peaks in energy consumption. Hastings Borough Council installed smart meters on the Theaklen Drive business units at Ponswood Industrial Estate in order to monitor electricity consumption. The readings in Fig. 39 show a higher average electricity consumption from 28th October 2013 onwards, which reflects the activation of the space heating system as the outside temperature declines.

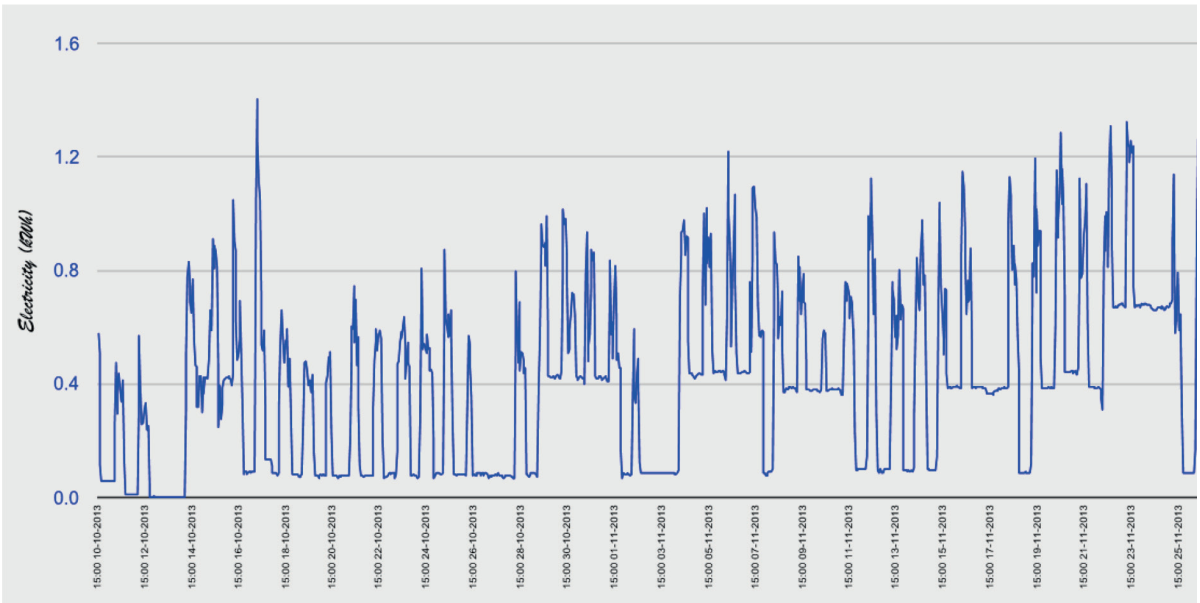

Fig. 39: Smart meter readings Ponswood Industrial Estate, Theaklen Drive 34

5.4 Energy efficiency

Measures to improve a company's energy consumption profile can be associated with energy services that are either related to the energetic performance of the building or to the production activities and processes of the company. This paragraph describes the different types of measures and prevailing regulations for an improved energy performance of buildings and processes. These energy measures should be carefully considered in the design phase of new company buildings or at the start of the retrofit of existing company buildings.

5.4.1 Energy efficiency measures - Building

A building's **energy performance** can be significantly improved by making appropriate design choices in terms of **building layout**, **building envelope** and **technical installations** (see overview in Table 9).

First of all, a well-considered **building layout** reduces energy demands for space heating, space cooling, and lighting. More specifically, **compact** building design and **attaching or stacking** multiple building volumes, minimise the heat loss surface and consequently the heat exchange with the outside. To optimally use solar radiation for space heating and lighting, **large window surfaces** should be integrated in the east, south and west façades, while limiting the window area on the north side. **Skylights** can be provided in the roof structure. However, overheating due to high midday summer sun has to be prevented by shielding south faced windows with **sun shades** or deciduous trees. Frequently used rooms that require space heating, such as offices and living areas, are optimally located on the **south and west façades**, while rooms with opposite characteristics, such as storage, technical, sanitary and conference rooms, and also industrial halls, should face **north or east**. To prevent overheating in the summer, rooms with high internal heat production, such as densely occupied offices, showrooms and industrial halls with thermal processes, have to be located on the cooler north and east façades. Heated rooms should be **grouped** and **thermally separated** from rooms that do not require heating or that have to be cooled, to limit heat losses. The Greenbridge incubator at Oostende, Belgium is an example of energy efficient building practice (see Fig. 40)

Fig. 40: Energy efficient industry building: Greenbridge incubator

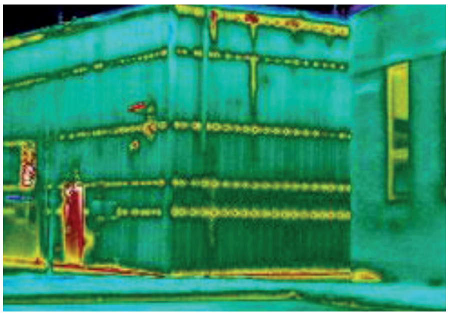

Fig. 41: Thermographic survey showing thermal losses through the building envelope

Secondly, a properly **insulated** and **airtight building envelope** prevents unwanted heat exchange with the outside, being heat loss in winter and heat gain in summer (see Fig. 41). The quality of the building envelope can be tested with a thermography scan and a blower-door-test. In **passive** buildings, the need for space heating and cooling may even be eliminated. In case of industrial halls with gates to the outside, airtightness cannot be achieved. However, excessive air displacement and corresponding heat loss can be limited by applying **automatically closing** or high speed industrial roll-up doors. Besides, outside **colours** of the building envelop play an important role, as light coloured façades and roofs reflect most off the solar radiation, preventing overheating. The latter effect can also be attributed to **green roofs and green walls**. Surplus heat in summer is absorbed in during the day by the **thermal mass** of massive walls and slabs and can be evacuated through ventilation at night.

Thirdly, efficient **technical installations** enhance the energetic building performance. An airtight building envelope requires a controlled **ventilation system** to ensure the indoor air quality. Four **types of ventilation** systems can be distinguished, according to whether pulsion, extraction or both are naturally or mechanically driven. In case of full natural ventilation, air can be **preheated** by **hot air collectors or greenhouses**. When applying mechanical ventilation, during wintertime, a **heat exchanger** could preheat ingoing air with heat recuperated from outgoing air, while in summer, ingoing air could be precooled through **ground tubes**. Hybrid systems combine mechanical and natural cooling, getting the best of both.

Space heating for homes, offices and small industrial halls can be adequately provided by **central heating systems**, that distribute heat from a central location to multiple rooms in the building. Various technology options arise at the **heat generation side**. The most energy efficient combustion-based heat generation technology is the **condensing boiler**, for which natural gas is the least carbon emitting fossil fuel, whereas biofuel is the renewable alternative. In a much more exergy efficient way (see 4.4), heat can also be produced as a side product of electricity generation in a combustion or fuel cell-based **micro-CHP** installation (see 6.7). Alternatively, heat can be extracted from the ground, ground water, surface water or outside air by heat exchangers and lifted to a higher temperature level by means of a **heat pump** (see 6.5.3.2 and 6.6). This system is most suitable at lower temperature regimes. Furthermore, solar heat can be harvested directly by **solar thermal collectors** at sufficiently high temperatures (see 6.5.1.5). In Flanders, reference values for space heating are 100 kWh/m² for offices down to 50 kWh/m² for industrial halls.

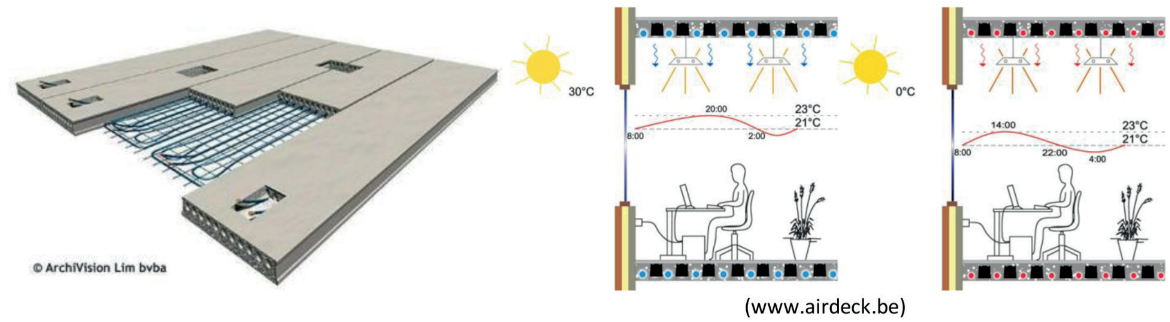

Fig. 42: Concrete core activation

Besides, different technologies for **heat emission** can be distinguished. At a higher temperature regime, radiators are standard practice, but at lower temperatures, **floor, wall or ceiling heating** systems and **oversized radiators** can be employed. **Concrete core activation**, on the other hand, can be used for both space heating and cooling. Cool (16°C) or warm (25-30°C) water runs through tubes integrated into the concrete floor slabs, cooling down or heating up the thermal mass of the concrete. The concrete regulates the indoor air temperature, while its large termal inertia ensures gradual heat transfer, while flattening and shifting temperature peaks. This system can be coupled to a ground source heat pump system. Floor and ceiling heating systems as well as concrete floor activation are based on heat radiation, whereas radiators also use convection and may cause unwanted air flows. Note that a low temperature emission system must be supplied by a low temperature heat source in order to match energy quality levels. Otherwise the exergy efficiency is not improved in comparison to conventional space heating systems on natural gas combustion (see 4.4). A newly developed climatisation system involves phase change materials (PCMs) embedded in walls and floors, that release or absorb heat when passing a certain temperature level. This system has been implemented in the information centre of business park Ecofactorij (see 3.9).

For large industrial halls, the energy loss over the distribution pipes of a central heating system may become too high. In that case it is more appropriate to generate heat at the spot by means of **decentralised** electric or gas-fired air **heaters** in combination with **destratificators**. If the indoor air volume is too large, and in case of dispersed work stations, intermittent occupancy or poor airtightness and insulation, **radiant ceiling panels** and **radiant point or tube heaters** are more appropriate. These systems increase sensible temperature without heating up the entire indoor air volume. In every case, a well tuned control system for heating, cooling and ventilation is essential. For production of hot sanitary water, heat pumps, thermal solar panels, modulating geysers or a combination can be used.

High windows and light coloured ceilings and walls carry daylight deep into the building, reducing the need for artificial indoor **lighting** during daytime. Daylight penetration can be even further improved by installing **lightcatchers** in the roof (see Fig. 43). These are mirrors that follow the sun and direct the captured daylight inside the building. Furthermore, **presence detectors** or **time switches** avoid the lighting to be switched on where and when not necessary, while **daylight sensors** and **dimmers** adjust the intensity of lighting to the level of incident daylight. The efficiency of artificial lighting can be enhanced by using efficient lamps and armatures, electronic balasts, etc. A lighting system is called efficent if its electricty consumption is limited to 1.5 à 2 W/m² per 100 lux of light intensity. For offices, a minimum light intensity of 500 lux is needed, for work places 200-300 lux, and for storage halls 100-200 lux. As a consequence, office lighting correponds to to an electricty use of about 7.5 W/m² to 10 W/m². LEDs and fluorescent bulbs (e.g. TL5) are the most efficient indoor lighting

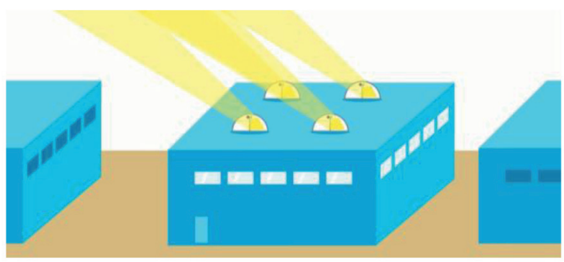

Fig. 43: Lightcatcher (www.econation.be)

systems, reaching system efficencies of repectively 110 lumen/W and 90 lumen/W. Like indoor lighting, also outdoor lighting can be controlled by daylight sensors, presence detectors or time switches. **Metal hydride** and **natrium lamps** are among the most efficient outdoor lighting on the market.

Table 9: Energy measures - building

building layout	technical installations	
✓ compact ✓ attached or stacked buildings ✓ optimal window orientation ✓ skylights ✓ sun shades or deciduous trees ✓ optimal room orientation ✓ grouping heated spaces	***ventilation*** ✓ preheating ventilation air (hot air collectors, greenhouses) ✓ precooling ventilation air (ground tubes) ✓ heat recovery ventilation exhaust ***lighting*** ✓ light inside colours ✓ light catcher ✓ light sensors, presence detectors ✓ LED or fluorescent ✓ metal hydride & sodium lamps	***space heating & cooling*** ✓ condensing boiler ✓ micro-CHP ✓ (ground source) heat pumps ✓ solar thermal collectors ✓ floor, wall or ceiling heating ✓ oversized radiators ✓ concrete core activation ✓ phase change materials ✓ decentralised heaters ✓ radiant heaters
building envelope		
✓ insulation ✓ airtightness ✓ passive building standard ✓ fast closing gates ✓ light outside colours ✓ green roofs and walls ✓ use of thermal mass		

5.4.2 Regulation energy performance buildings

Belgium

In Belgium, new or substantially renovated buildings destined for person occupancy and requiring energy for indoor acclimatisation, have to comply with the **EPB regulation**. This regulation imposes targets to thermal insulation, energy performance and indoor climate, according to a building's function (home, school, office, industrial hall, etc.). Energy performance is indicated by the energy level (**E-level**), which expresses the ratio of a building's net primary energy consumption, calculated for the actual situation, compared to that in a reference situation. For offices and industrial buildings, the E-level takes into account energy consumption for building use (lighting, space heating & cooling, ventilation, humidification, auxiliary energy), internal thermal loads, and individual renewable energy production (PV, CHP). The **K-level** indicates the building's global insulation level. Flanders, Brussels and Wallonia use the same calculation tool, but with different set-points.

Table 10: EPB Targets Belgian regions 2014

Targets		Flanders	Wallonia	Brussels
Offices	K-level	K40	K45	K45
	U-values	U_{max}	U_{max}	U_{max}
	E-level	E60	E80	E75
	RE	min.share		
Industrial	K-level	K40	K55	–
	U-values	U_{max}	U_{max}	–
	E-level	–	–	–

Flemish EPB regulation prescribes a maximum E-level of E70 for new office buildings and housing units with building permit applications dating from 2012 and 2013. From 2014 on, an E-level of E60 has to be achieved. All types of new builds are bound to a maximal K-level of K40 and have to comply with maximal heat transfer coefficients (**U-values**) or minimal thermal resistances (**R-values**) for all building envelope components. Furthermore, also ventilation is subject to minimum requirements. For new housing units, net annual energy requirement for space heating needs to stay below 70kWh/m². Moreover, as an implementation of the EU's Renewable Energy Directive, a minimum share of renewable energy is imposed for offices, schools and homes. For individual homes this can be fulfilled by installing solar thermal collectors, PV panels, a biomass boiler or CHP or a heat pump, or by connecting to a district heating or cooling system. Another option is to participate in a renewable energy project within the province. For collective housing units, offices and schools, minimum 10 kWh/year per m² floor surface has to originate from previously mentioned systems, on penalty of a 10% decrease of the maximum E-level to be attained. The EPB regulation will gradually be strengthened to finally achieve the nearly zero energy building standard in 2021. When selling or leasing residential buildings, an energy performance certificate (**EPC**) has to be provided, although this is still not required for industrial buildings. A comparison of present performance targets for offices and industrial buildings in Flanders, Brussels and Wallonia is given in Table 10.

France

In **France**, the '**Réglementation Thermique 2012**' (RT 2012) sets three types of performance targets for **new buildings or building extensions**, including offices and most industrial buildings. Firstly, an efficient bioclimatic design of the building through well orientated windows and sufficient insulation is imposed in order to reduce energy requirements for heating, cooling and lighting. The bioclimatic design is evaluated by a score that needs to be lower than a certain reference value (Bbiomax), which varies according to geographic location and altitude. Secondly, the annual primary energy consumption related to building use (lighting, HVAC, hot water, heat recovery and auxiliary systems) has to stay below a reference value. This value (Cpemax) varies from 40 to 65 kWh/m²/y for residential buildings and from 48 to 72 kWh/m²/y for offices, according to climatic zone, altitude, building type and size, and fuels used. Thirdly, overheating in summer during 5 subsequent days has to be avoided.

For major non-residential **retrofits**, according to the 'Réglementation Thermique Existant Globale' the energy consumption related to building use must be lower than a corresponding reference value and must be reduced with at least 30% compared with the original situation. Furthermore, during summer, indoor temperature must stay below a certain limit. Smaller refurbishments need to comply with the 'Réglementation Thermique Existant par élément', to guarantee the implementation of energy efficient building components.

United Kingdom

In the **UK**, the **Building Regulations 2010** exempt industrial sites, workshops and non-residential agricultural buildings from energy performance targets, provided that they have a low energy demand for space heating or cooling. However, when dwellings and non-dwellings, such as factories, offices, retail premises and public sector buildings are built, sold or let, an energy performance certificate is required. From 2018 onwards the UK government plans to introduce an EPC minimum requirement of grade D or above.

Fig. 44: EPC levels

5.4.3 BREEAM

The Building Research Establishment Environmental Assessment Method (**BREEAM**) is a voluntary **international** standard for sustainable design and operation of buildings. BREEAM evaluates environmental performance of buildings according to a checklist of benchmarked measures, resulting in a weighted final score and rating level (see Fig. 45). A number of countries have customised the BREAM scheme to their specific national situation.

Fig. 45: BREEAM rating levels

5.4.4 Energy efficiency measures - Process

To reduce the **energy consumption** of industrial processes, different measures can be taken in terms of product design, process design, equipment, control, operation, monitoring and maintenance (see Table 11).

The energy and material footprint of a product can be drastically reduced over the entire life cycle by conceiving it in a sustainable way. Sustainable **product design** may implicate that the product can be completely recycled (cradle to cradle) or easily repaired, or that it has a long lifetime.

Prior to optimising the process layout, **alternative options** for the fabrication of a desired product, have to be analysed and compared. As an example, the current very carbon intensive method for steel production could in the future be replaced by electrolysis, driven by renewable electricity (Allanore et al., 2013). Another example is given by a steel spring producing company that has substituted the gas furnace for steel heating by the induction furnace (see 5.3.5.1).

For complex thermal processes, an **intelligent thermodynamic process design** (process integration or Pinch analysis) may lead to significant energy savings (see 5.5). Residual heat can be recycled within the process itself by **heat exchange** between different process flows, reducing external thermal energy requirements. In this way, heat is cascaded through the process from high to low temperatures. The exchange can be direct, from flow to flow or indirect, via an intermediate heat transfer system, such as a steam or hot water network. Such networks also enable heat exchange between different process installations within a company or even between different companies. The potential of internal heat exchange can be increased by raising the temperature level of low temperature residual heat by means of **heat pumps**.

Steam turbines and ORCs allow to convert residual heat into electricity. Like heat pumps, these electricity generators can be integrated either between two process streams or between the process and the environment. A slight **modification** of **process conditions**, such as pressure and temperature, may result in significant reductions of external energy requirements. Finally, in order to avoid unnecessary exergy loss, external heating and cooling requirements must be supplied at **temperatures** as close as possible to the temperatures demanded by the process. Therefore, appropriate types of heating, cooling and refrigeration technologies must be selected (see 4.4). Also, lowering the temperature levels of processes facilitates the introduction of low-grade renewable heat sources, such as solar thermal or geothermal energy.

Considerable energy savings can be achieved by increasing the energy **efficiency** of the **equipment** composing a process. For example, modern electric motors, that can operate at different speeds, are more efficient than older ones, condensing boilers also use the latent heat contained in the exhaust gasses, and alternative refrigeration technologies consume less energy than conventional ones. In order to limit thermal losses from heat and cold generation, storage and distribution, these systems must be sufficiently insulated. Compressed air systems must be avoided if possible, as they are prone to leakage and have an inherently low efficiency.

Another way to enhance energy performance is by equipping the process with an adequate **process control system**, which controls the dispatch of different process units. When processes are operated near their maximum capacity, so at a high load factor, energy efficiency is maximised. Process **intensification** is a way to maximise the effectiveness of process reactions, minimising the materials and energy required and reducing waste.

Another important energy measure is to continuously **monitor** the performance and the operating condition of the process, so that leakage, deterioration of equipment and incorrect process regulation can be detected in an early stage, avoiding unnecessary costs (see 5.3.3). Alternatively, occasional energy audits can provide a snapshot of a company's energy management. A frequent **maintenance** of the installation prolongs the life duration of equipment. (Maes, 2011).

Table 11: Energy measures - process

- **sustainable product design**
- **alternative process design**
- **intelligent thermodynamic process design**
  - ✓ *heat exchange between process flows*
  - ✓ *heat pumps steam turbines and ORCs*
- **process monitoring**
- **frequent maintenance**
- **efficient equipment**
  - ✓ *frequency controlled engines*
  - ✓ *condensing boilers*
  - ✓ *insulation of thermal processes*
  - ✓ *avoid compressed air*
- **process control and operation**
  - ✓ *maximum load factors*
  - ✓ *process intensification*

5.4.5 Regulation energy performance processes

Belgium

In accordance with the **Energy Planning Decree** of the Flemish government, companies or installations that are labelled as **energy intensive,** are obliged to employ the most energy efficient technologies that are economically viable (**Best Available Techniques**), and to implement economically feasible **energy measures** that decrease specific energy consumption. Therefore, when applying for an environmental permit or renewal thereof, an energy plan and an energy study must be submitted,. The **energy plan** is prepared by an accredited expert and contains a list of energy efficiency measures. All measures in this list with an internal rate of return (IRR) > 15% must be implemented within 3 years. In an **energy study**, a company proves that it uses the best available techniques and that all energy efficiency measures with an IRR > 15% have been implemented. The **energy plan** applies to **existing** companies or installations with a primary energy consumption >0,5 PJ per year. Also companies with a consumption between 0,1 and 0,5 PJ per year need to prepare an energy plan for their first upcoming environmental permit renewal. The **energy study** applies to **new** companies or installations with a primary energy consumption >0,1 PJ per year or to **modifications** of an existing one that entail an increase in consumption of more than 10 TJ per year.

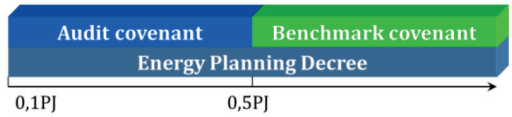

Fig. 46: Limits primary energy consumption Energy Planning Decree and covenants

Instead of these minimum requirements, Flemish companies could until 2013 voluntarily join the Benchmarking or Audit Covenants. The **Benchmarking Covenant** is intended for companies with a primary energy consumption of more than 0,5 PJ per year. Member companies have to **benchmark** the **specific energy consumptions** of their process installations against the world's most energy efficient installations, and gradually implement optimisation measures above a certain IRR. In exchange, the Flemish government releases those companies from additional Flemish, federal, European or global obligations related to energy consumption and carbon emissions.

The **Audit Covenant** is an analogue, but less stringent agreement, open to companies with a primary energy consumption between 0,1 and 0,5 PJ. In the Audit Covenant, specific energy consumption does not have to be benchmarked as in the Benchmark Covenant and a standard energy audit is sufficient. However, Audit-companies are not released from European policy measures concerning the trade of carbon emission permits. Additionally, covenant members can obtain reductions on taxes and levies. **Brussels** has not organised voluntary agreements and in **Wallonia**, the Accords de Branche are agreements between the industrial sectors and the Walloon government, analogue to Flemish ones.

In Flanders, the Benchmark and Audit Covenants will be succeeded by the **Energy Policy Agreement** (2014-2020). Companies that sign this agreement are obliged to perform an energy audit every 4 years in order to identify profitable energy measures. For non-ETS companies, measures with an IRR greater than 12.5% are regarded as profitable, whereas for ETS companies a lower limit of 14% is taken. Audit results are summarised in the energy plan, which contains a list of profitable energy measures and a chronological roadmap of their implementation, together with an analysis of the evolution of specific energy consumption. Companies are also committed to perform studies about the potential of CHP, heating and cooling networks and energy management. The agreement aims at a 1% energy efficiency improvement per year. Companies that comply with the conditions of the agreement are exempted from additional Flemish policy measures on energy efficiency and emissions.

France, United Kingdom

See Chapter 2

5.4.6 Evaluating investments

To evaluate the performance of an investment, different indicators can be used, such as payback period, net present value and internal rate of return. The simple **payback period** (PP) in years is equal to the amount of money to be invested I, divided by the expected annual net cash flow C. Here, the net cash flow is equal to annual revenue minus annual cost, or equal to annual savings compared to a base case. However, the payback period does not take into account the time value of money and also provides no information about the period after the payback period.

Table 12: Investment performance indicators

$$PP = I/C$$

$$NPV = \sum_{n=0}^{N} \frac{C_n}{(1+r)^n}$$

$$0 = \sum_{n=0}^{N} \frac{C_n}{(1+IRR)^n}$$

A better indicator is the **net present value** (NPV), which is the sum of the discounted values of the annual net cash flows C_n over a predefined number of years N. The annual net cash flow includes revenues, investment costs, operation and maintenance costs (or savings compared to a base case), subsidies and taxes.The discounted value of an annual net cash flow C_n in year n is found by dividing it by $(1+r)^n$. In this expression, the discount rate r expresses that an amount of money in the future is worth less than the same amount of money today, given that money today has the capacity to earn interest. The **discounted payback period** expresses after how many years breakeven is achieved (NPV = 0).

Another indicator is the **internal rate of return** (IRR), which is the value of the interest rate r, that would result in a net present value of zero, over a total period of N years. In other words, the IRR indicates the maximum rate at which the value of money may diminish in the future so that the NPV still stays positive at the end of the period of N years. The distance between the actual discount rate r and the IRR indicates the efficiency of the investment. It is a measure of how much better the investment performs than the breakeven point. Projects with IRRs that exceed a minimum acceptable value or cost of capital should be implemented, as it is economically profitable. The cost of capital is the rate at which money could be earned in an alternative investment of equivalent risk. However, the IRR should not be used to compare projects of different duration. NPV is the most accurate indicator for comparing different projects.

5.4.7 Barriers

Various barriers slow down the implementation of energy efficiency measures. Often, energy efficiency measures are given low priority because they are in competition with investments in the company's core activity. Investments are only considered as economically viable at very short payback periods (< 2 year) or high internal rates of return (>30%). In this way, investment opportunities that are profitable on slightly longer time scales are missed. The simple payback period is not an accurate measure, as it disregards the time value of money. Better, the net present value (NPV), the discounted payback period or the internal rate of return (IRR) should be used.

Other obstacles are lack of holistic view and technical knowledge, poor involvement in environmental issues, and a false feeling of security of energy supply. Another barrier is given by the difference in financial benefit for landlord and tenant (=split incentive). This problem can be countered by a third party, such as an Energy Service Company (ESCO) (see 7.6). In case a company rents its buildings for only a short to medium period, it cannot benefit from the residual value of investments in energy efficiency of the building, while the owner has no direct benefit from the reduced daily operation costs.

5.4.8 Case studies

The Theaklen Drive units at Ponswood Industrial Estate have been refurbished by Hastings Borough Council (HBC) (see 10.16). Based on the results of a thermographic scan they decided to apply new insulation on walls, roof and perimeter plinths. Light tubes or sun pipes have been installed on the roof to enhance daylight penetration.

Fig. 47: light catchers or sun tubes – Theaklen Drive

5.5 Pinch analysis

A company with significant process heating or cooling demands can save energy by exchanging heat between its process streams (parts of processes). Pinch analysis is a practical tool to assess the energy saving potential thereof. More specifically, energy integration or pinch analysis is a methodology for minimizing the thermal energy requirements of industrial processes, by means of **heat exchange** between process streams, rationalised **modifications** of process operating conditions, and **optimal integration** of energy conversion technologies and resources. The methodology comprises different steps: (1) calculation of heating and cooling loads, (2) calculation of maximum heat recovery and minimum hot and cold utilities, (3) integration of energy conversion technologies, and (4) heat exchanger network design. In this context, an industrial process consists of streams of matter that either need to be heated up (cold streams) or cooled down (hot streams). With a well-designed heat exchanger network, companies with significant external process heating and/or cooling requirements, can achieve reductions in energy consumption of 30% or more.

5.5.1 Calculation of heating and cooling loads

For each process stream, the required **heating or cooling load** in function of temperature is determined. This can be done with a thermodynamic model that mathematically simulates the process, or starting from actual measurements. Next to the streams from industrial process also those from energy services, such as space heating and cooling, can be included. The heat-temperature profiles of all hot and all cold process streams are combined to form respectively the Hot and the Cold Composite Curves. (see Fig. 48)

Stream	Stream type	Supply Temperature (°C)	Target Temperature (°C)	Duty (kW)	CP (kW/°C)
1	Hot	200	100	2000	20
2	Hot	150	60	3600	40
3	Cold	80	120	3200	80
4	Cold	50	220	2550	15

Necessary data:

- mass flow rate (kg/s)
- specific heat capacity (kJ/kg°C)
- supply and targets temperatures (°C)
- latent heat for streams with phase change (kJ/kg)
- available utitlities
- existing heat exchangers

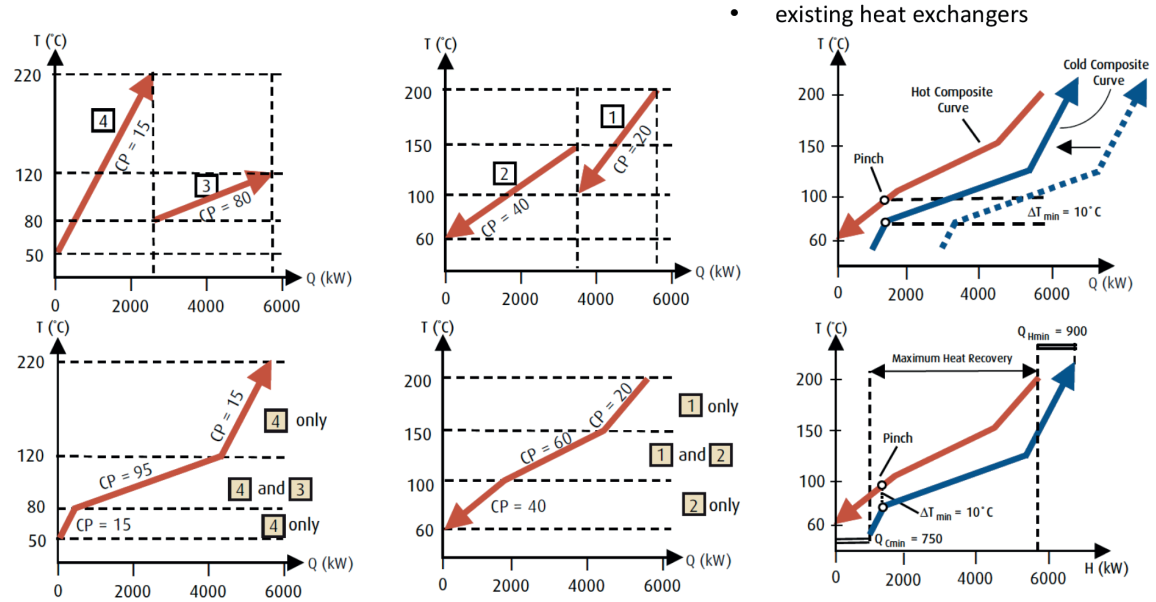

Fig. 48: Construction of hot and cold composite curves and calculation of maximum heat recovery (CANMET, 2003)

5.5.2 Calculation of maximum heat recovery and minimum hot and cold utilities

The closest approach between the Hot and Cold Composite Curves, attained by shifting along the enthalpy axis, while ensuring a minimum positive temperature difference ΔT_{min}, yields the maximal theoretical heat recovery by counter-current heat exchange from hot to cold streams. The minimum approach temperature originates from the trade-off between energy (utility) costs and heat exchanger investment costs. The remaining external heating and cooling requirements are referred to as the minimum hot and cold utilities, while the point of closest approach is called the Pinch point (see Fig. 48). Above the Pinch point, the process requires external heat (heat sink), while beneath the pinch point, excess heat needs to be released (heat source). The Grand Composite Curve is constructed by shifting the Cold and Hot Composite Curves towards each other along the temperature axis over a distance $\Delta T_{min}/2$ and plotting the heat load difference between those curves. This curve graphically represents how heat is cascaded from the hot utility through the process to the cold utility (see Fig. 49).

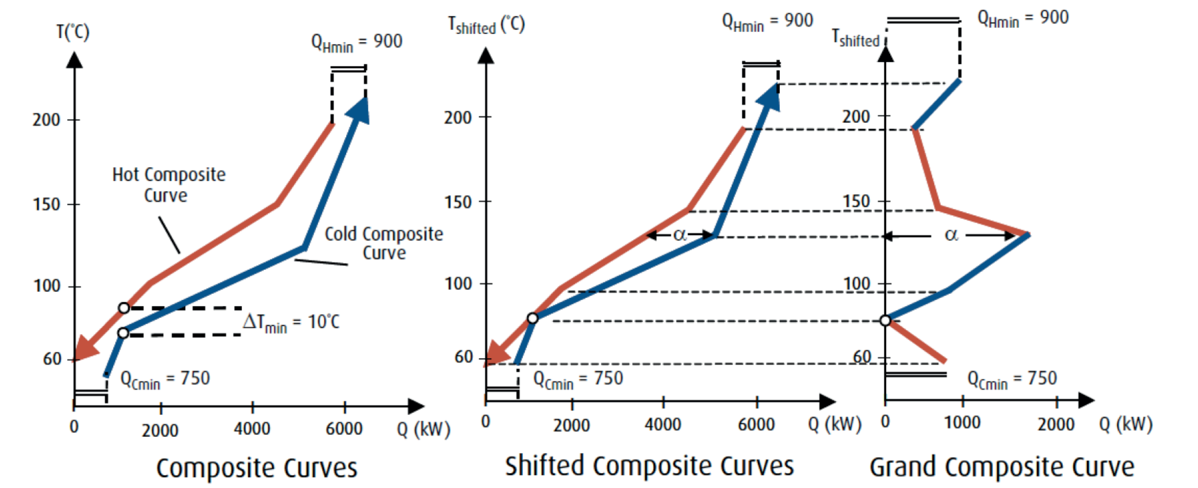

Fig. 49: Calculation maximum heat recovery and minimum hot and cold utility (CANMET, 2003)

5.5.3 Integration of energy conversion technologies

Starting from the Grand Composite Curve, hot and cold utilities can be significantly decreased by modifying process operating conditions or by correcting existing penalising cross-pinch heat exchangers. The correspondence between Hot and Cold Composite Curves can be improved by shifting hot streams from below to above the pinch and cold streams from above to below the pinch (the plus-minus principle)

Next, heat and cold supply technologies can be optimally selected and integrated in a way that their temperature-heat profiles approach those of the process streams as close as possible, resulting in a minimal loss of thermodynamic quality (exergy). This can be achieved by consecutively maximising the heat provided at the lowest temperatures and the heat extracted at the highest temperatures, until utility pinch points are activated, while minimising the mass flow rates of the fuels being used. Eventually, the hot and cold utility streams must envelop the process grand composite curve. In most cases the optimisation of an energy system exists in minimising both total costs and emissions, which are conflicting objectives. This problem can be tackled by using multi-objective optimisation, and optimal solutions can be presented in a Pareto curve, that depicts the trade-off between multiple objectives. In temperature intervals where heat is not being used, it can be converted by for example a heat recovery steam generator (HRSG) into (free) power. Heat pumps are used to lift low temperature of residual heat to a higher temperature level, where it can be recovered by cold streams.

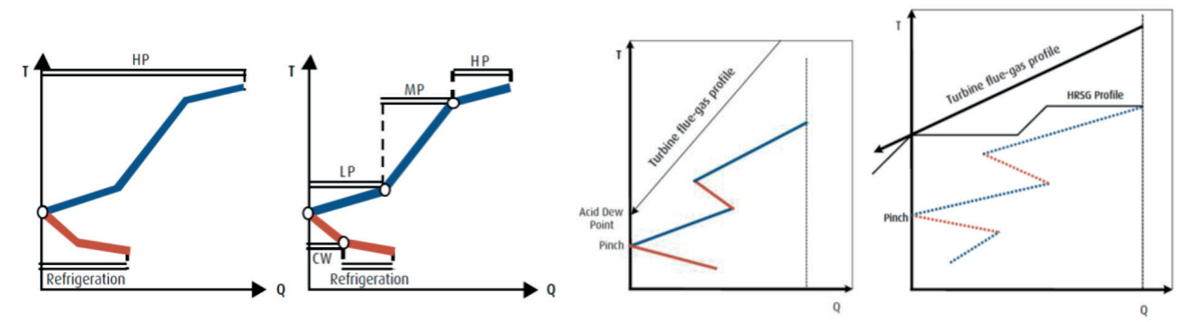

Fig. 50: Integration of cold and hot utilities (high, intermediate and low pressure steam, cooling water refrigeration and flue gas), and integration heat recovery steam generator (CANMET, 2003)

5.5.4 Heat exchanger network design

In a final step, the heat exchanger network, that physically enables the exchange of heat between hot and cold streams, but also between utility streams and process streams, is designed and optimised.

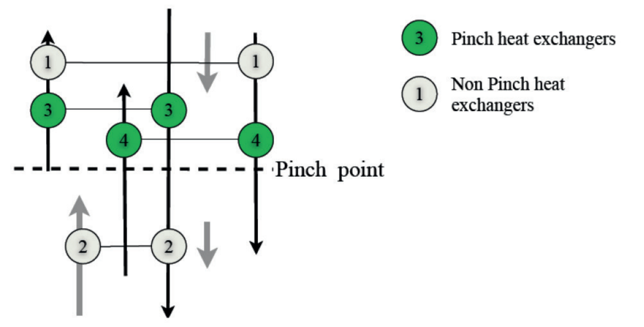

Fig. 51: Schematic Representation of heat exchanger network (HEN)

5.5.5 Rules

There are a number of basic rules for achieving minimum energy requirements:

- Do not transfer heat across the Pinch, except with a heat pump
- Do not use a cold utility above the Pinch, or a hot utility below the Pinch
- Do not mix streams at different temperatures
- Do not include utility streams in process data, unless they cannot be replaced.

5.6 Total Site Analysis

Pinch analysis concentrates on maximal heat recovery by direct heat exchange between hot and cold process streams, at the level of one single company (see 5.5). Total Site Analysis, on the other hand, focusses on heat exchange between hot and cold process streams at different companies via one or more heat transfer networks, also referred to as utility networks. The heat transfer media used in these networks are (very) high, medium or low pressure steam (VHP, HP, MP, LP), hot water (HW), or cooling water (CW).

In Total Site Analysis, a process can be represented either as a black, grey or white box, corresponding to increasing level of detail. In the black box approach, process streams are represented simply by their existing hot or cold utility consumption profiles (i.e. the demand for steam, hot water, cooling water). In the grey box approach, the actual cold and hot streams of the process are represented (as in 5.5.1). In the white box (or full detail) approach, a process is represented by the Grand Composite Curve that results from maximal heat recovery by heat exchange between the process's hot and cold streams (Pinch analysis as in 5.5.2). All black and grey box profiles, that need to be cooled down and the heat sources of the white box profiles are combined to form the total site source profile (see Fig. 52). Analogously, all black and grey box profiles that need to be heated up and the heat sinks of the white box profiles are combined to form the total site sink profile.

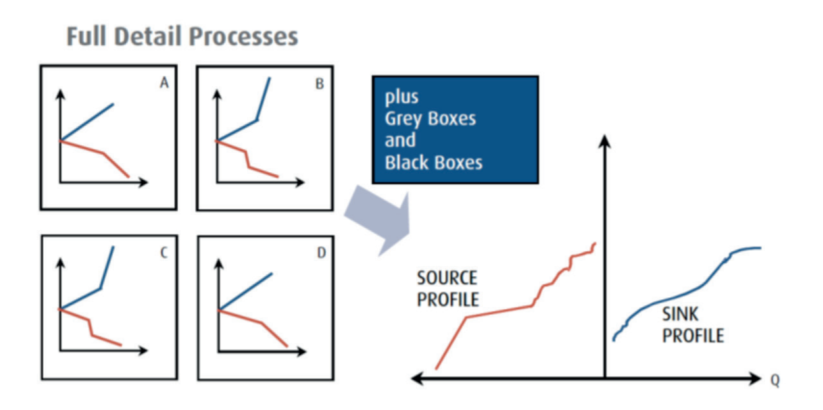

Fig. 52: Composition Site Source and Sink Profiles (CANMET, 2003)

Now the potential of transferring heat from the total site heat source to the total site heat sink profile via the heat transfer (utility) networks is can be calculated (see Fig. 53). In summary, Total Site Analysis calculates the theoretical potential of heat exchange between companies using various heat transfer networks. A comprehensivenumerical method and example have been developed by Liew et al. (2012).

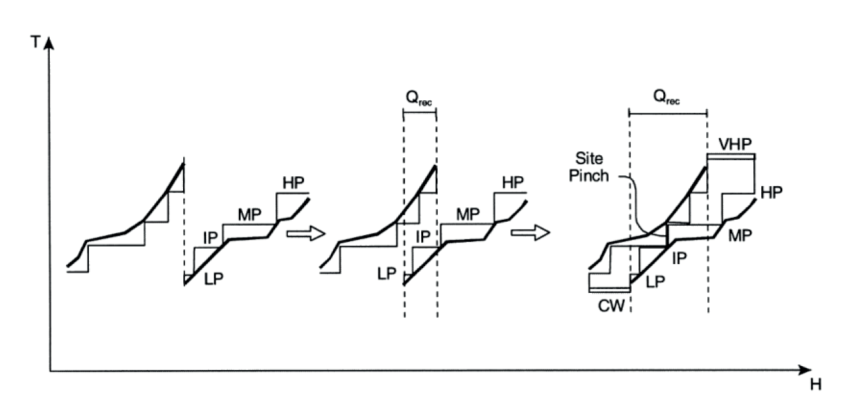

Fig. 53: maximal potential heat recovery via utility networks (Zhu and Vaideeswaran, 2000)

5.7 Sources

Websites	
Synthetic Load Profiles	www.vreg.be/verbruiksprofielen-0
Energy Efficiency Planning and Management Guide	oee.nrcan.gc.ca/sites/oee.nrcan.gc.ca/files/pdf/publications/infosource/pub/cipec/Managementguide_E.pdf
Movie clip energy management Agency NL	www.youtube.com/watch?v=ol7DeW93dEA&feature=youtu.be
Energy Savings Toolbox – An Energy Audit Manual and Tool	oee.nrcan.gc.ca/industrial/technical-info/9156
ISO 50001	www.iso.org/iso/home/standards/management-standards/iso50001.htm
EPB	www.energiesparen.be/epb/welkeeisen www.energiesparen.be/bouwenverbouwen www.meeroverepb.be
RT 2012	www.rt-batiment.fr
Building	www.planningportal.gov.uk/buildingregulations/approveddocuments/partl/approved
Regulations 2010	www.planningportal.gov.uk/buildingregulations/approveddocuments/partj/approved
EPC UK	www.gov.uk/government/collections/energy-performance-certificates
BREEAM	www.breeam.org
Energy plan, energy study	www.energiesparen.be/energieplanning
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LOW CARBON BUSINESS PARK MANUAL

Chapter 6

Low carbon energy production

6 Low carbon energy production

6.1 Introduction

Energy conversion technologies need to transform imported or locally extracted energy sources into electricity, heat or mechanical work in order to fulfil the energy service demands of the energy system (see 4.2) This chapter gives an overview of the different renewable and non-renewable sources and technologies that can be applied on business park scale. Solar, wind and geothermal energy and biomass are described in terms of resource potential, available technologies and performance. Next, the working, performance and application of heat pumps is explained. Furthermore, the principle of cogeneration is introduced and the condensing boiler is described. Finally, the European system of guarantees of origin and the certificate systems that promote green power production and cogeneration in Belgium, France and the UK are explained.

6.2 Energy sources

Energy sources can be labelled renewable or non-renewable (see Table 13). Non-renewable energy sources are exhaustible and have a damaging effect on the environment, whereas renewable energy sources are inexhaustible and their exploitation does not generate hazardous waste or net greenhouse gas emissions. At the level of a business park's energy system, fossil fuels, such as coal, natural gas, oil, and oil derivatives are non-renewable energy sources. Wind, solar radiation, geothermal or environmental heat, biomass and derived biofuels (solid, liquid or gaseous), and hydrogen are renewable. The characteristics of renewable energy sources differ greatly. Wind and solar energy show intermittent behaviour, while geothermal and environmental heat can be tapped when needed. Biomass, biofuels and hydrogen however, can be stored and converted at any moment and therefore offer controllability. Hydrogen cannot be found in nature but is derived from fossil fuels or generated by hydrolysis. Only when green electricity is used for the hydrolysis process, hydrogen can be labelled as a renewable energy source. For a process or company, externally supplied waste heat can also be considered as an energy source.

Table 13: Types of energy sources

Non-renewable	***Renewable***
• Coal	• Wind
• Natural gas	• Solar radiation
• Oil & derivatives	• Geothermal heat
	• Environmental heat
	• Biomass & biofuel
	• Hydrogen
	• (Waste heat)

6.3 Energy conversion technologies

Energy conversion technologies (see Table 14) transform energy sources into heat, electricity or mechanical work. Renewable technologies include photovoltaic solar panels, thermal solar collectors, concentrated solar power (CSP) systems, wind turbines and geothermal installations. Combustion-based boiler stations and thermal power plants can be fired with both fossil and renewable fuels.

Different types of thermal power installations can be distinguished. In a steam power plant, fuel is combusted in a boiler to generate steam, which expands through a steam turbine, driving an electricity generator. In a gas power plant, a mixture of compressed air and fuel is ignited and the combustion gasses are expanded through a gas turbine, which drives the electricity generator. A combined cycle power plant merges both systems, by using the heat of the exhaust gasses from the gas turbine to generate steam for the steam turbine. Other types of thermal power installations are based on reciprocating engines or on the Stirling engine.

Some thermal power installations can also be driven by solar, geothermal or waste heat instead of by combustion heat, such as a steam power installation or a Stirling engine. Fuel cells directly generate electricity by an electro-chemical reaction that requires hydrogen and oxygen, while water is generated as a by-product. Depending on the fuel cell type, hydrogen is added in pure form or in the form of natural gas, coal gas or biogas. Combined heat and power generation does not refer to a specific technology, but to the recovery and useful application of residual heat from electricity generation, for industrial processes or space heating.

Table 14: Types of energy conversion technologies

Non-renewable & renewable	*Renewable*
• thermal power plants (steam or gas turbine, combined, engine)	• PV solar panels
• boilers	• thermal solar collectors
• fuel cells	• CSP
	• wind turbines
	• geothermal installations
	• hydrogen
	• (Waste heat)

6.4 Energy storage technologies

Heat can be stored in the form of sensible heat in a water, graphite or oil reservoir, in the ground, by phase change of some materials or by thermochemical processes. Possibilities for electricity storage on business park scale are: lead-acid batteries, lithium ion batteries, electric capacitors and flywheels, and conversion to and storage of compressed air. For installations connected to the grid, the grid serves as electricity storage (IEA-ETSAP and IRENA, 2013).

6.5 Renewable energy production

6.5.1 Solar

6.5.1.1 Solar irradiation

The average annual solar irradiation at a specific location depends on its latitude and the local climate conditions. In Europe, irradiation on a horizontal surface varies from 1900 kWh/m²/y in southern Spain to less than 800 kWh/m²/y in northern UK. More specifically for the ACE project area, Flanders receives about 1000 kWh/m²/y, while the Dunkirk region and the South coast of the UK can count on 1150 kWh/m²/y (see Table 15). Solar irradiation has a periodic variation on daily (day/night) and yearly (seasons) level. However, atmospheric conditions disturb this predictable variation and part of the incident sunlight is diffused by clouds.

Table 15: Solar irradiation ACE project area

Irradiation [kWh/m²/y]	*Flanders*	*Dunkirk Hastings*
horizontal	1000	1150
Inclination opt. direction south	1100	1340
tracking	1390	1770

Fig. 54: Solar tracking system at Greenbridge (argus powermonitor.be)

Solar modules can be mounted on inclined and flat roofs or attached to walls or integrated into windows and sun shades. In the ACE project area, the optimal inclination is about 35° to the horizontal, directed south (Huld et al., 2008a), allowing to capture 1100 – 1340 kWh/m²/y of solar radiation. For inclinations between 20 to 60 degrees and directions between southeast and southwest, losses are limited to 5-10% compared to the optimal position. Solar tracking systems always position the panel surface perpendicular to the beams of the sun by rotating about two axes, achieving 1390 - 1770 kWh/m²/y (see Table 15 and Fig. 54). Shadow must be avoided and panels must be placed so that they can be sufficiently ventilated by outside air streams. Solar potential maps are available on: re.jrc.ec.europa.eu/pvgis

6.5.1.2 Solar photovoltaic technologies

Photovoltaic solar panels convert solar radiation into direct electric current by using the photovoltaic effect of semiconductors. To feed into the grid, this direct current first needs to be converted to alternating current by an invertor. PV modules of various designs and materials are available on the market, but two major technology groups are crystalline silicon and thin film (see Table 16). Crystalline silicon is the dominating technology and comprises three varieties according to the cell manufacturing process: mono crystalline, poly crystalline or ribbon-sheet grown silicon. The individual silicon cells are electrically connected in series, encapsulated and framed to form practically manageable modules. Thin film technology, however, uses a micrometre thin layer of photovoltaic material, deposited on a low-cost substrate, such as steel, glass or plastic. Four thin film technology variants can be distinguished, according to the nature of the active layer: amorphous silicon, amorphous and micromorph silicon multi-junction, cadmium telluride (CdTe) and copper-indium- gallium-selenide (CIGS). New PV technologies are emerging, with a potential for higher efficiency and lower cost than c-Si and thin films. They include concentrating photovoltaic installations, which is a combination of mirrors or lenses that concentrate a larger area of direct sunlight onto a high performing multi-junction solar cell, organic solar cells and dye-sensitized solar cells.

Table 16: Types of solar photovoltaic technologies and nominal efficiencies

Crystalline silicon	η	Thin film	η	Emerging
mono	13-19	amorphous	4-8	concentrating
poly	11-15	multi-junction	7-9	organic
ribbon-sheet grown	-	CdTe	10-11	dye-sensitized
		CIGS	7-12	

On average, nominal conversion efficiencies (η) now attain 15% for crystalline silicon modules and 7% for amorphous silicon and multi-junction modules, while those based on alternative materials attain around 10% (see Table 16). Losses in inverters are negligible, as efficiencies reach 98%. Panel lifetimes extend to 25 years or more, while in the ACE region it only takes less than 3 years to balance the embedded energy of the complete PV system. Producers even guarantee 80% of peak power after 25 years. Prices for PV installations have been decreasing continuously over the last decades and achieved around 1800 €/kWp mid-2013 (Fraunhofer Institute For Solar Energy Systems ISE, 2012, IEA-ETSAP and IRENA, 2013).

6.5.1.3 Installation issues

For company buildings, it is often difficult to fix the solar PV panels directly to the roof, due to complications with the weathering membrane. A ballasted PV system offers a solution, provided that the load carrying capacity of the roof structure is sufficient. Thin film technology may offer an alternative to panel type arrays in the medium to long term. The film will possibly also be integrated into the weathering membrane, thus obviating any loading issues.

6.5.1.4 Calculation actual electricity output PV system

The nominal electric power of a solar panel (P_{STC}) is expressed in Watt-peak (Wp). It is measured under standard test conditions (STC), being incident radiation (I_{STC}) of 1000 W/m² with a specified spectrum and a module surface temperature of 25°C. The nominal efficiency of the panel expresses the ratio of the nominal power to the total incident radiation on its surface (A): $\eta = P_{STC}/(A \times I_{STC})$. As an example, a module of 1 m² with an efficiency of 15% has a nominal power of 150 Wp, or for 1 kWp an area of 6.67 m² would be required.
Because local environmental conditions diverge from STC, and energy losses occur throughout the PV system, theoretical yields have to be decreased by a performance ratio (PR) or quality factor. This depends on the geographic location and the on PV system (e.g. PR = 0.75 for a crystalline silicium PV system in the ACE project area). The actual energy yield of PV modules () can be expressed in terms of annual electricity output per kilowatt peak (1) or per m² module (2).

$$E = PR \times \eta \times I_{solar} \times A \qquad \eta_{nom} = \frac{P_{STC}}{I_{STC} \times A} \quad \Rightarrow \quad \begin{cases} \frac{E}{P_{STC}} = PR \times \frac{I_{solar}}{I_{STC}} & (1) \\ \frac{E}{A} = PR \times \eta \times I_{solar} & (2) \end{cases}$$

For fixed crystalline silicon panels directed south, with an optimal inclination, the actual annual electricity yield in the ACE project area is about 850 kWh/kWp/y (Huld et al., 2008b). Alternatively, considering a module efficiency of 0.15, the annual yield can be expressed as 127,5 kWh/m²/y. The calculation method for both expressions is illustrated in Table 17. For vertical panels in the optimal direction, the energy yield is 500 – 600 kWh/kWp.

Table 17: Calculation example actual yield PV system

location:	Flanders	$I_{solar} = 1100 \frac{kWh}{m^2.y}$
inclination:	optimal	
direction:	south	(see Table 15)
technology:	crystalline silicon	$PR = 0.75$

$$\frac{E}{P_{STC}} = 0{,}75 \times 1100 \frac{kWh}{m^2.y} \times \frac{m^2}{kW} = 825 \frac{kWh}{kW.y} \rightarrow 825 \frac{kWh_e}{kWp.y}$$

$$\frac{E}{A} = 0{,}75 \times 1100 \frac{kWh}{m^2.y} \times 0{,}15 = 124 \frac{kWh}{m^2.y} \rightarrow 124 \frac{kWh_e}{m^2.y}$$

6.5.1.5 Solar thermal systems

Solar thermal collectors convert solar radiation into heat and deliver it to a fluid circulating in a closed circuit through a water storage tank. From there, the water can be tapped to provide sanitary hot water or space heating via radiators or floor heating. Temperatures of 100°C can be achieved. Also applications in industrial process are possible, to assist preheating or washing. Various designs exist, such as plate and vacuum tube collectors. The optimal positioning is analogous to PV panels. Hybrid systems combine solar collectors with a condensing gas boiler to limit collector area and to provide backup. Concentrated solar thermal power systems consist of mirrors or lenses that concentrate sunlight captured over a large area onto a very small area, reaching temperatures up to 250 °C. The generated heat is used to drive a thermal power plant or a thermochemical reaction.

6.5.2 Wind

Wind has an intermittent character, but wind speeds tend to be higher at night and increase significantly with the height above the surface. For Flanders, at 75 m annual averages of 5 m/s inland to about 9 m/s at the coast are attained and large wind turbines achieve 2000 full load hours. A wind turbine converts wind energy into direct electric current. The airflow across the wing-shaped blades causes the rotor to turn around its axis, driving an electric generator. To reduce losses in transportation the voltage is subsequently stepped up by a transformer integrated into or outside of the turbine. The nominal power output of a wind turbine is determined by its rotor area and its conversion efficiency. Annual yields depend on nominal power, rotor height, and yearly availability of the turbine and on the annual wind speed profile. Different technical varieties are available on the market: two, three or multiple bladed horizontal axis wind turbines and vertical axis turbines with various blade designs. Three bladed horizontal axis turbines are the most common and can reach tip heights of 150 m and a nominal capacity of 2 to 5 MW. To avoid mutual influence, the spacing between wind turbines perpendicular to the main wind direction must be at least 4 to 5 times the rotor diameter, whereas in the parallel direction, spacing has to exceed 7 to 8 times the rotor diameter.

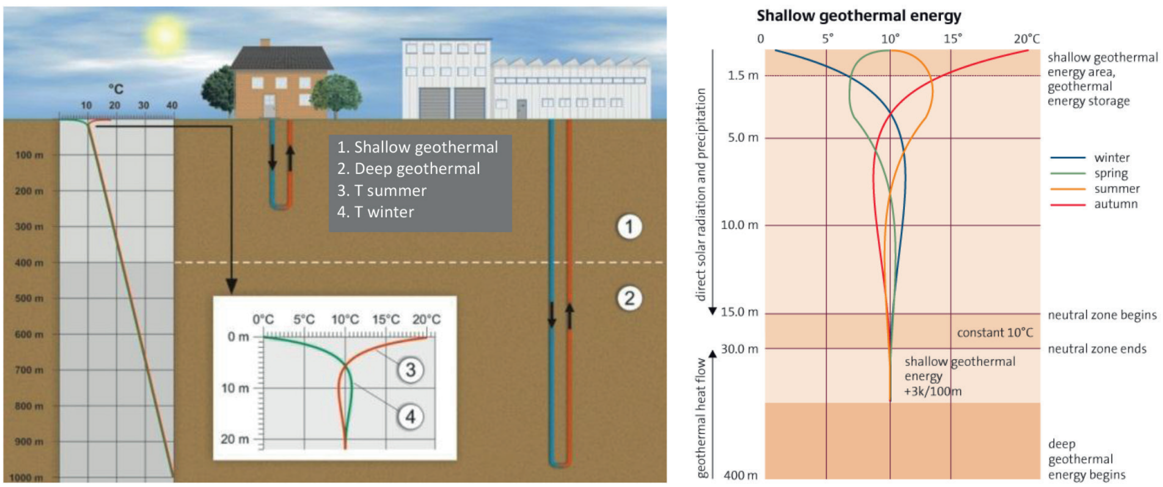
In Flemish regulation, three classes of wind turbines are distinguished: small or urban (<15m), medium (>15m, <300kW) and large wind turbines (>15m, >300kW). The province of East-Flanders has identified and reserved suitable areas for large wind turbine developments, enough to increase the total number of wind turbines on its territory to 300 by 2020 (www.energielandschap.be). Categorisation of wind turbine sizes differs between countries. In the UK for example, wind turbines are categorised according to their rated power: micro (<1,5 kW), small (1,5-50 kW), medium (50-500 kW) and large (>500 kW).

When searching suitable locations for wind turbines, the impact on the surroundings has to be analysed, such as visual intrusion, cast shadow on buildings, noise pollution, interference with aircraft radar and security area in case of technical failure. When the local community participates and benefits in the wind project, social acceptance can be enhanced. The applicability of urban wind turbines is very dependent on the specific local wind conditions. Standards for small wind turbines do not yet exist and technical and economic performances vary greatly. More information on small wind turbines can be obtained from www.windkracht13.be and www.swtfieldlab.ugent.be.

6.5.3 Geothermal energy

6.5.3.1 Geothermal heat

Geothermal heat originates from heat retained in the earth's core since its formation, from friction between tectonic plates and with the underlying mantle, and from radioactive decay of minerals within the earth's crust. This heat is slowly transferred to the surface by conduction and convection mechanisms at an average rate of 0,063 W/m². The upper surface layer is heated up in summer by absorbing solar radiation and cooled down in winter by emitting heat radiation. Also infiltrating precipitation transfers heat to the upper layer. At 5 m below the surface, temperatures fluctuate between 8 and 12°C. At 20 m below the surface, however, seasonal variations are completely damped out because of the low thermal conductivity of the soil, resulting in a constant temperature of about 10 °C. At higher depths, the temperature increases with 3°C per 100 m (see Fig. 55). This implicates that heat of 40°C, the minimum temperature for direct heating purposes, can only be found at 1000 m depth. However, in areas with volcanic activity, much higher temperatures can be found near the surface. **Shallow geothermal energy** refers to the heat retained in the ground at depths up to 400 a 500 m below the surface, at relatively low temperatures, whereas **deep geothermal energy** refers to heat below 500 m and at higher temperatures. Geothermal energy can only be called renewable if heat extraction and replenishment are in balance (De Boever et al., 2012).



www.gunt2e.de/s4963_1.php

www.smartgeotherm.be/ondiepe-geothermie

Fig. 55: Profile of ground temperature

6.5.3.2 Shallow geothermal technologies

Shallow geothermal energy systems can be used to **extract heat** from the ground, lift it to a suitable temperature and supply it to a space heating system. A first way of ground heat extraction is by means of a closed circuit in which glycolic water is circulated. This circuit may be conceived as a series of vertical geothermal probes, inserted into 25 to 300 m deep boreholes, or as a horizontal loop, buried beneath frost depth. Alternatively, the circuit can be integrated into a building's concrete foundation (piles, diaphragm walls). The geothermal doublet is an open system variety in which groundwater from an aquifer is pumped up through a vertical borehole. After heat extraction, the cooled water is injected into the same aquifer through a second borehole at a distance of the first one. In shallow geothermal systems the temperature of the heat transport fluid (glycolic or ground water) is not high enough for direct space heating, and therefore it is first led through a heat pump. The heat pump extracts the heat from the water, elevates the temperature, and delivers the heat to the building's space heating system. To limit the electricity consumption of the heat pump, low temperature space heating systems are required, such as floor heating or concrete core activation. Another open system variant includes ground tubes to heat up or to cool down ventilation air. A technology overview is given in Table 18.

Depending on the soil type, vertical geothermal probes deliver 20 to 70 W of heat per m probe (from dry sand to wet loamy soil and bedrock). Horizontal loop systems can produce 10-35 W of heat per m^2 (from dry sandy to wet loamy soil). The yield of a geothermal doublet depends on the extraction flow rate and the temperature drop over the heating installation and is only applicable in sandy soils with sufficient ground water flow (Van de Meulebroecke et al., 2007).

6.5.3.3 Use of shallow geothermal technologies for seasonal thermal energy storage (STES)

Due to the high insulating capability of the ground, vertical shallow geothermal energy systems (probes, energy piles, hydrothermal) are perfectly fit for **seasonal thermal energy storage (STES)**. Excess heat from CHP plants, waste heat from industrial processes, heat from air conditioning equipment, or heat harvested by solar asphalt collectors in summer can be stored in the ground in order to use it for space heating in the following winter. Due to the increased ground temperature the performance of the heat pumps also increases. When high temperature heat is stored, heat pumps can be avoided. Similarly, the ground can be cooled down during winter by means of heat exchangers in contact with the outside air, such as asphalt solar collectors. When the flow of the heat transport fluid is reversed in the following summer, the "stored cold" is available for cooling.

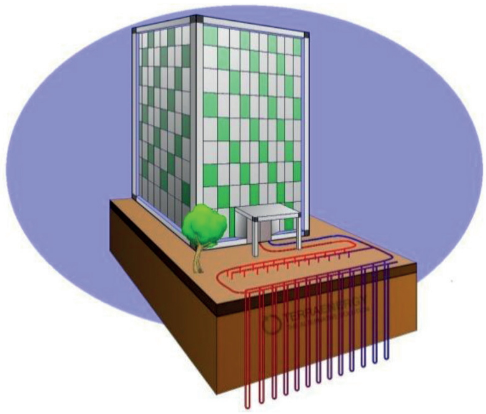


Fig. 56: BTES
(www.terra-energy.be)

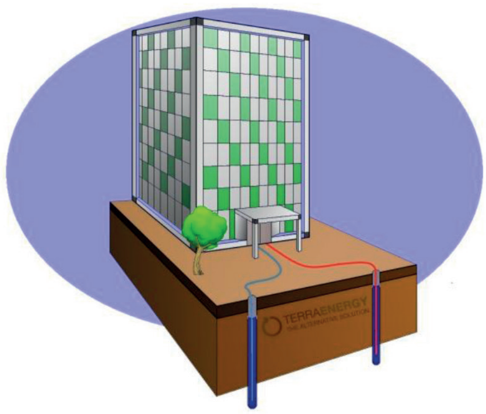


Fig. 57: ATES
(www.terra-energy.be)

More specifically, vertical shallow geothermal energy systems can be employed for **combined space heating & cooling with seasonal thermal energy storage.** In this context, these systems are referred to as Borehole Thermal Energy Storage (**BTES**) and Aquifer Thermal Energy Storage (**ATES**) (see Fig. 56 and Fig. 57). During summer, the ground temperature is beneath inside air temperature and therefore the system can be directly used for space cooling. The heat extracted from the building is then transferred to the ground, restoring the temperature of the geothermal source for space heating in winter time. Additionally, the source can be regenerated in summer by means of thermal solar collectors.

A **heat and cold storage system** is an ATES system (see Fig. 58). It is an open system connected to an aquifer in which the flow of the ground water can be reversed. When the building is cooled in summer, the water is pumped up from the cold reservoir, passes through the heat exchanger with the building circuit and is injected in the hot reservoir. In winter, the water flow reverses. Also systems with an unidirectional flow exist. Furthermore, also flooded mines and tunnels offer possibilities for extraction of geothermal heat and thermal storage (De Boever et al., 2012, Dreesen and Laenen, 2010).

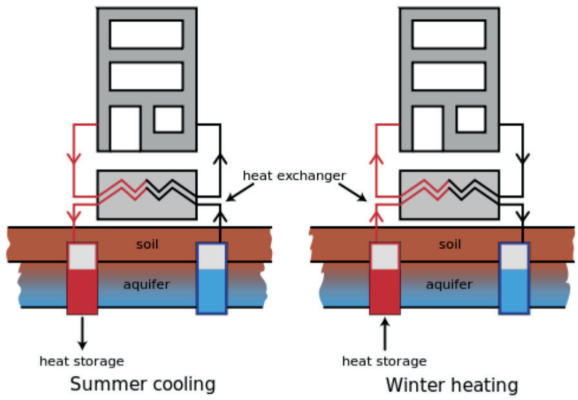


Fig. 58: Heat and cold storage system

6.5.3.4 Deep geothermal systems

Deep geothermal energy systems extract heat at depths of 500 m to several kilometres. Depending on the temperature level, they can directly supply heat to thermal energy networks for industrial processes or space heating or drive a thermal power plant, such as a steam power plant, an Organic Rankine Cycle (ORC) plant or a Stirling engine. Hydrothermal systems, similar to the shallow version, draw hot water from an aquifer through a borehole and feed it back via a second borehole after heat extraction. Enhanced geothermal systems, however, artificially fissure dry rock layers at great depths of 3 to 6 km and temperatures over 150°C. Water or another heat transfer medium is pumped under high pressure into the injection well, where it is heated by the rock. The hot water returns to the surface via an extraction borehole. Deep geothermal probes similar to the shallow version, are closed systems in which a heat transfer medium is circulated to extract the geothermal heat. Hydrothermal systems can only be applied in regions with sufficiently permeable aquifers, while deep geothermal probes can be deployed anywhere (Dreesen and Laenen, 2010). A technology overview is given in Table 18.

Table 18: Types of geothermal technologies

Geothermal systems	Circuit	Techniques	Applications
Shallow geothermal			
• vertical probes	closed: glycol water	heat extraction, STES	space heating/cooling
• horizontal loop	closed: glycol water	heat extraction	space heating/cooling
• energy piles	closed: glycol water	heat extraction, STES	space heating/cooling
• geothermal doublet	open: ground water	heat extraction, STES	space heating/cooling
• ground tubes	open: air	heat exchange	preheating/-cooling ventilation air
Shallow geothermal			
• vertical probes	closed: water	heat extraction	space/process heating
• hydrothermal	open: ground water	heat extraction	{ space/process heating
• enhanced geothermal	open: water/other fluid	heat extraction	electricity generation

6.5.4 Biomass

By definition, **biomass** is material from recent biological (vegetal or animal) origin. In the context of energy sources, biomass refers to the biodegradable fraction of industrial and residential waste, and to the biodegradable fraction of products, waste and residues from agriculture and forestry. This includes dedicated energy crops, wood and wood residues, food and green residues, paper waste, sludge, manure, etc. Some forms of **raw biomass**, such as wood, can be combusted directly, but in most cases biomass first has to be manipulated and converted into solid, liquid or gaseous biofuels, depending on the application.

Solid biofuels are fabricated by compressing biomass into pellets, cubes or pucks, whereas **liquid or gaseous biofuels** are generated by various biological and chemical processes. Biogas is formed from anaerobic digestion of wet organic residues or directly extracted from landfills, whereas producer gas is generated by gasification of dry biomass. Fermentation and transesterification processes allow to convert energy crops into liquid biofuels.

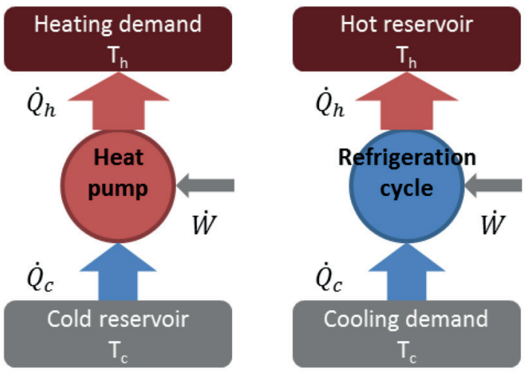
Biofuels can be transformed into heat, electricity or mechanical work by combustion based **thermal power installations and boilers**. When exploited in a sustainable way, biomass is a carbon neutral energy source, because when burned it emits exactly as much carbon as it has extracted from the environment during its lifecycle. However, the carbon emissions related to harvest, treatment and transportation also have to be taken into account.

6.6 Heat pumps and refrigeration cycles

Heat pumps are applied for heating of sanitary water, buildings and processes. A **heat pump** extracts heat from a cold reservoir at temperature T_c by evaporation of its working fluid (refrigerant), subsequently compresses the vapour until it reaches sufficiently high temperatures, and then delivers the heat to a hot reservoir at temperature T_h (> T_c) by condensation of the vapour. Finally, the condensed liquid is passed through an expansion valve, to reduce its temperature and pressure, and returned to the evaporator. Heat exchangers in the evaporator and the condenser enable the heat exchange between the working fluid and the cold and hot reservoirs. Possible reservoirs from which the required heat can be extracted are the ground, sewage, surface or ground water, and outside air. Heat pumps can also be used to increase the temperature level of waste heat, solar heat or to lift the temperature in a heat network. Different techniques are available, such as compression heat pumps, that are electricity-driven, and ab- or adsorption heat pumps that are driven by heat.

The coefficient of performance (**COP**) expresses the ratio of the heat delivered by the heat pump over its electricity consumption and depends on the temperature lift ($T_h - T_c$) to be realised (see Fig. 59). Qualitative heat pumps attain a COP of 3 to 7. A heat pump with a COP of 4 uses 1 kWh of electricity to extract 3 kWh of heat from the cold source, and the resulting 4 kWh is available to fulfil the heat demand. The seasonal performance factor (**SPF**) takes into account the variation of the temperature of the heat source throughout the year and is lower than the COP.

Refrigeration cycles are identical to heat pumps, but instead of supplying heat to a hot reservoir, their purpose is to evacuate heat from a cold reservoir (see Fig. 59). Reversible heat pumps are able to switch the functions of evaporator and condenser, and can thus also operate as refrigeration cycle.



$$COP_{heat\ pump} = \frac{\dot{Q}_h}{\dot{W}} = \frac{T_h}{T_h - T_c}$$

$$COP_{refrigeration\ cycle} = \frac{\dot{Q}_c}{\dot{W}} = \frac{T_c}{T_h - T_c}$$

Fig. 59: Thermodynamic principle heat pump and refrigeration cycle

Ground source heat pumps are employed to extract heat from the subsurface for space heating or hot water production (see 6.5.3.2). The heat is extracted from the ground by a glycol water circuit that flows through vertical or horizontal ground heat exchangers or by pumping up ground water. This heat is delivered to a heat pump, that elevates the temperature and transfers it to the circuit of the heating system. A reversible ground source heat pump can also be used to provide active space cooling in summer. As the inside air to be cooled is hotter than the ground, vapour compression and related electricity consumption can be avoided, resulting in COPs of 15 to 20. This is referred to as passive or free space cooling.

6.7 Combined heat and power generation

A thermal power installation can only convert part of the heat it receives into mechanical and eventually electrical power. This is a result of the second law of thermodynamics which demands that part of the heat must be transferred to a cold reservoir. When the installation is modified or conceived in such a way that this residual heat can be recovered and used for thermal processes, hot water production or space heating, the installation is referred to as a **cogeneration or combined heat and power installation**.

CHP installations can be fired by either fossil fuels, biofuels or hydrogen. Suitable technologies for cogeneration are steam turbine, gas turbine, combined cycle, reciprocating internal combustion engine, fuel cell, Organic Rankine Cycle and Stirling engine (see 6.3). Cogeneration starting from the **steam turbine** is achieved by draining steam after being partially or fully expanded, and supplying it to the thermal load. In case of a backpressure steam turbine, the steam flow is entirely fed to the thermal load, whereas in case of a condensing steam turbine part of it is directly sent to the condenser after expansion. Consequently, for the former, electricity production follows the heat load, while for the latter, electricity and heat generation are to a certain extent independent from each other. The heat from the condenser can also be usefully applied.

Cogeneration with a **gas turbine** or micro turbine installation implicates that the heat contained in the exhaust gasses is recovered by means of a steam boiler or by a heat exchanger for drying or high temperature heating purposes. In case of cogeneration with a reciprocating internal combustion **engine** (gas or diesel), heat is not only recovered from the exhaust gasses**,** similarly to the gas turbine, but also from the engine's cooling circuits by mean of a heat exchanger. In **fuel cells**, the electrochemical reactions are exothermic, which makes them suitable for cogeneration. An **ORC** installation is similar to a steam turbine and thus also suitable for combined heat and power generation by recovering residual heat. Moreover, the working fluid evaporates at much lower temperatures than water and therefore it is fit for electricity generation from low temperature geothermal or residual heat. In the **Stirling cycle**, heat from an external heat source is transferred to an external cold reservoir, while generating power. Cogeneration is achieved when using the heat of the cold reservoir for a thermal load. (Cogen, 2006, Daoud and Lebbe, 2009).

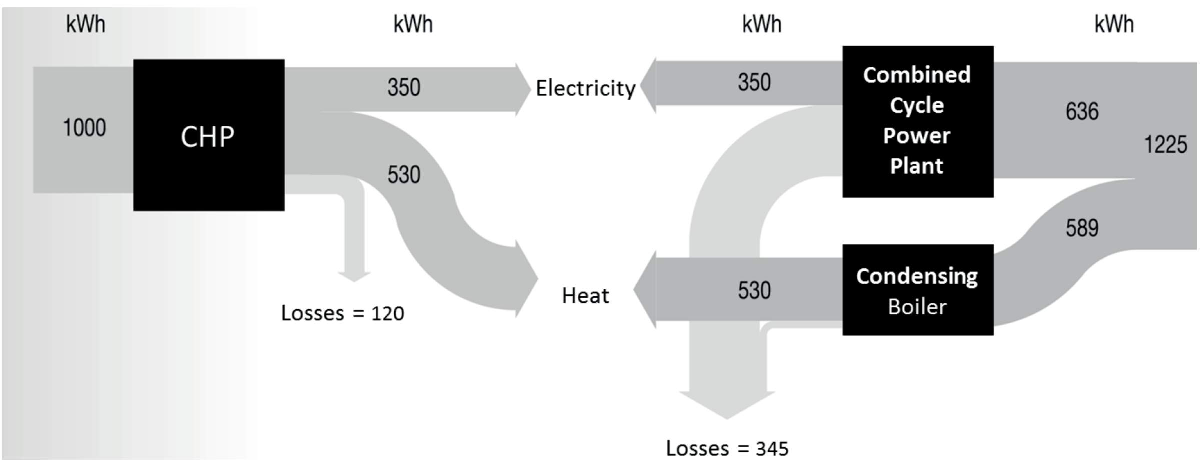


Fig. 60: Comparison cogeneration and separate heat and power generation (Daoud and Lebbe, 2009)

In comparison to separate generation of electricity and heat, cogeneration reduces primary energy consumption with 15% to 30%. For separate heat and power generation, standard efficiencies are defined, depending on the energy source (fuel) and the generated voltage. Conventionally, electricity is imported from the grid, corresponding to a primary energy efficiency of 55% and heat is generated with a condensing boiler, with an efficiency of 90% (see Fig. 60). To account for the lower energy content of biofuels compared to fossil fuels, reduced reference efficiencies for separate generation can be applied for bio-based CHP. When excess heat from a CHP in summer is used to drive an absorption chiller, simultaneously electricity, heat and cold are produced, called trigeneration.

6.8 Condensing boilers

Combustion boilers are used to generate steam for industrial processes and power production. The steam is created by evaporating water with heat from the flue gasses. In case of water-tube boilers, the flue gasses are led over water filled tubes, while in case of fire-tube boilers, combustion gasses flow inside tubes immersed in a pressure vessel containing water. The steam can be saturated, superheated or supercritical. Water tube boilers are more suited for high pressure steam generation because smaller tubes can withstand pressure better. Efficiency can be improved by recovering the heat contained in the exhaust gasses to preheat the feed water or to preheat the combustion air, Also, higher efficiencies may be achieved by improving the heat exchange by introducing turbulence in the pipes of a fire-tube boiler, and by insulation of pipes and valves. In a condensing boiler, the water vapour contained in the flue gasses is condensed, while the resulting latent heat is used to preheat the cold water entering the boiler. This increases the energy efficiency by about 10% compared to conventional boilers (ETSAP, 2010).

6.9 Guarantees of origin and certificates

6.9.1 EU

Guarantees of origin are electronic documents that indicate the origin of electricity provided to the grid. **Green** guarantees of origin prove that somewhere in the EU 1 MWh of electricity has been produced from **renewable energy** sources and injected into the electricity grid. Similarly, **blue** ones apply to electricity from **combined heat and power generation**. It is not possible to combine both types of guarantees. Within the EU, these guarantees are issued to the electricity producers by members of the Association of Issuing bodies. In Flanders this is the responsibility of the VREG. If electricity suppliers want to sell electricity with the label green or blue, they have to acquire a corresponding number of green or blue guarantees of origin. These can be obtained by producing green or blue electricity and providing it to the grid, or by buying them from producers. When selling electricity to a costumer, a guarantee can only be used once, to prove the origin, and afterwards it is destroyed. Guarantees of origin can be traded separately from electricity. Greenpeace Belgium provides an overview of the real green character of Belgian electricity suppliers on their website.

6.9.2 Flanders

Furthermore, the Flemish government has also implemented a system of certificates to enhance green electricity production and combined heat and power generation within its territory. **Green power certificates** prove that 1 MWh of electricity has been generated from renewable energy sources, whereas **CHP certificates** prove that 1 MWh of primary energy has been saved by applying combined instead of separate heat and power generation. CHP certificates require that a minimum primary energy saving is achieved and that the applied technology is recognised as 'qualitative cogeneration'. To qualify for green power and CHP certificates the energy must be generated within the Flemish territory. The electricity produced may as well be used locally as be injected into the grid. Both types of certificates are **issued to the energy producers** by the VREG, that also manages the certificate database.

Every year, Flemish **electricity suppliers are obliged to submit** a gradually increasing number of green power and CHP certificates to the VREG. If they do not comply, they are penalized per missing certificate. To acquire the necessary certificates, electricity suppliers can organise own production or they can buy them from electricity producers. Consequently, this certificate system functions as a subsidy scheme for green electricity production installations. Producers can sell certificates on the bilateral certificate market at a negotiated price, on the Green Certificate Exchange of BelPEx at a market price, or to the transmission or distribution grid operators at a minimum price, provided that installations are connected to the grid. The minimum price, paid out by the grid operator over a certain period, depends on the technology and the date of commissioning. Green power certificates are valid for five years and CHP certificates for six years. Both can only be submitted to the VREG once and can be traded separate from electricity. Moreover, they can be combined.

However, for installations commissioned after January 2013, the certificate system has been modified. The number of certificates received is now calculated by multiplying the MWh of green electricity produced or primary energy saved by CHP, with a technology and project specific banding factor. In other words, the amount of green electricity to be produced or primary energy to be saved for one certificate is equal to the quotient of 1MWh and a **banding factor**. In addition, the minimum certificate prices for grid connected installations have been fixed at 93 € per green power certificate and 31 € per CHP certificate (VREG, 2013). For photovoltaic installations, a more specific regulation has been worked out. So far, no regulation concerning green heat certificates has been implemented.

6.9.2.1 Photovoltaic Installations

Until 2013, grid operators in Flanders were **obliged** to buy **green power certificates** from PV installations at a **minimum price** and over a certain timespan, fixed on (and decreasing with) the date of commissioning. In 2013 the PV subsidy scheme for new installations was modified in order to fix the rate of return at 5%. Each certificate is worth 93 € and will be paid out over a period of 15 years. For one certificate, the amount of green electricity to be produced is equal to the quotient of 1MWh and a banding factor depending on the size of the installation. Banding factors are reviewed every six months by the Flemish Energy Agency.

For example, for systems installed in 2013, banding factors for the period 1 Jan–31 July 2013 were:

$P_{STC} \leq 10$ kW:	0,23	resulting in a subsidy of	21 €/MWh
10 kW $< P_{STC} \leq 250$ kW:	0,63		59 €/MWh
250 kW $< P_{STC} \leq 750$ kW:	0,49		46 €/MWh

For PV systems installed in the second half of 2014, banding factors are:

$P_{STC} \leq 10$ kW	0,00	resulting in a subsidy of	0 €/MWh
10 kW $< P_{STC} \leq 250$ kW:	0,687		64 €/MWh
250 kW $< P_{STC} \leq 750$ kW:	0,593		55 €/MWh

This implicates that installations < 10 kW will no longer receive green power certificates.

PV installations smaller than 10 kW are connected to the grid by means of a back counting electricity meter and only the positive yearly net electricity consumption is charged on the electricity invoice. Larger installations require a separate electricity consumption and injection meter. The electricity produced is injected into the grid at a price negotiated with an electricity supplier, and producers are in turn subject to injection taxes.

6.9.3 Brussels

In **Brussels**, electricity suppliers are obliged to annually submit a gradually increasing amount of green power certificates (**GPC**s), relative to their sales volumes, on a penalty of 100 € per missing certificate. They can acquire certificates by self-production or by buying them on the certificate market. Green power certificates are issued by the Brussels Regulator for Energy (**BRUGEL**) to qualitative CHP or renewable energy installations, proportionally to the CO_2 savings they achieve in comparison to reference installations and provided that a minimum emission reduction of 5% is achieved. As a base rule, one certificate is issued per 217 kg of CO_2 saved, considering a natural gas power plant as a reference, with an efficiency of 55% and a CO_2-emission of 217 kg per MWh of gas burned. This implicates that a carbon free renewable electricity generator receives 1/0.55= 1.82 certificates per MWh of produced electricity. However, for PV, natural gas driven CHP in collective housing and bio-methanation installations, a technology-specific coefficient is applied. For capacities above 1 MW, maximum 1 certificate per MWh is issued. Grid operators are obliged to buy certificates at a minimum price of 65 € per certificate over a certain period.

6.9.4 Wallonia

The **Walloon** green certificate system is analogous to that used in Brussels. **Green certificates** are issued by the Walloon Commission for Energy (**CWAPE**) to qualitative CHP or renewable energy installations, proportionally to the CO_2 savings they achieve compared to reference installations and provided that a minimum CO_2 reduction of 10% is achieved. As a base rule, one certificate is issued per 456 kg of CO_2 saved, considering a natural gas power plant as a reference, with a CO_2-emission of 456 kg CO_2 per MWH of electricity produced. As such, a carbon-free renewable electricity generator will receive one certificate per MWh of electricity produced. For cogeneration plants, also the heat production has to be taken into account. Furthermore, in the

Walloon and Brussels certificate system, guarantees of origin are a necessary precondition. Grid operators are obliged to buy certificates at a minimum price of 65 € per certificate over a certain period.

6.9.5 France

Large energy suppliers are subject to energy saving targets, proportionally to their sales volumes. These triennial targets amount in total 345 TWh of final energy savings for the period 2011-2013 and will be further increased for the period 2014-2016. At the end of each period, energy suppliers have to submit a number of energy saving certificates (**ESC**s) proportionally to the amount energy savings to be made, on penalty of 0.02€ per missing kWh. Energy suppliers can acquire certificates by realising energy saving programmes at their costumers or they can buy them on the market from third parties that implement eligible energy saving projects. Third parties include local authorities, the National Agency for Housing, social housing agencies or social landlords, but individual actions from large companies are not eligible. A list of eligible energy saving measures has been elaborated for the sectors residential and tertiary buildings, industry, energy networks, transport and agriculture. Currently, the majority (80%) of certificates concern energy saving measures (insulation, efficient heating, ventilation, lighting) in residential buildings. In industry, certificates mostly relate to electronic speed control of asynchronous motors.

6.9.6 UK

The **UK** certificate system is analogous to the Flemish system, but covers simultaneously renewable energy production and CHP. Electricity suppliers are obliged to annually submit a stepwise increasing amount of Renewables Obligation Certificates (ROCs), which they can acquire by self-production or by buying them from other electricity generators. Suppliers that do not comply are fined. The number of ROCs issued to an installation, is equal to the amount of MWh produced, multiplied with a technology-specific banding level.

6.10 Case studies

6.10.4 Business Park The Loop

Different energy technologies were considered in the feasibility study concerning collective energy production on business park The Loop in Ghent (Belgium): condensing boilers, CHP installations, and a water loop connected to the nearby channel. The water loop would provide free chilling in intermediate seasons, space cooling in summer, in combination with a compression chiller, and space heating in winter, in combination with a central or individual heat pumps and a backup gas boiler. For further details see 10.4.

6.10.8 Site Sugar Factory Veurne

At the Sugar Factory site in Veurne (Belgium), the feasibility of a heat network supplied either by the available waste heat form a nearby business park in combination with a gas boiler or by a CHP on natural gas and an additional condensing gas boiler was investigated. For further details see 10.8.

6.10.11 Business park De Spie

For future low carbon energy production on the new business park De Spie in Ghent (Belgium), the potential of a number of renewable energy technologies has been assessed: solar, wind, cogeneration, geothermal energy, and heating and cooling with surface water. For further details see 10.11.

6.10.12 Shared company building Veurne

For the shared company building on a new business park in Veurne (Belgium), different technologies for space heating/cooling have been considered: ground source heat pump with vertical geothermal probes, an air source heat pump, a condensing gas boiler and condensing air heaters. Also the potential and feasibility of a PV system has been analysed. More information can be found in 10.12.

6.11 Sources

Websites	
Solar potential maps	re.jrc.ec.europa.eu/pvgis
PR PV systems	www.photon.info/photon_lab_modul_ertragsm_cert_en.photon www.greenrhinoenergy.com/solar/technologies/pv_energy_yield.php
Small wind turbines	www.windkracht13.be www.swtfieldlab.ugent.be
Wind turbine categorisation UK	www.renewableuk.com/en/publications/index.cfm/Small-and-Medium-Wind-UK-Market-Report-2013
Geothermal energy	www.terra-energy.be www.meeroverepb.be/pages/kdb.php?id=250 www.renewables-made-in-germany.com/en/start/geothermie.html
Fig. 58	en.wikipedia.org/wiki/Seasonal_thermal_energy_storage
Heat and cold storage	www.provincie.drenthe.nl/wko
Guarantees of origin	www.vreg.be/garantie-van-oorsprong
Green power suppliers test	www.greenpeace.org/belgium/nl/groene-stroom

Certificates	
Flanders	
Green power certificates	www.vreg.be/systeem-groenestroomcertificaten-en-garanties-van-oorsprong
CHP certificates	www.vreg.be/systeem-warmte-krachtcertificaten www.vreg.be/hoe-wordt-het-aantal-toe-te-kennen-gsc-berekend
Calculation green power and CHP certificates	www.vreg.be/hoe-wordt-het-aantal-toe-te-kennen-gsc-berekend www.vreg.be/hoe-wordt-het-aantal-warmte-krachtcertificaten-berekend
Banding factors	www.energiesparen.be/monitoring_evaluatie
Green power certificates PV	www.vreg.be/uitbetaling-groenestroomcertificaten
Brussels	
Green power certificates	www.leefmilieubrussel.be/Templates/Professionnels/informer.aspx?id=32621
Minimum prices	www.elia.be/nl/producten-en-diensten/groenestroomcertificaten/Minimumprice-legalframe
Calculation green power certificates	documentatie.leefmilieubrussel.be/documents/IF_Energie_berekening_GSC_NL_juni2012.PDF?langtype=2067
Wallonia	
Green certificates	energie.wallonie.be/nl/systeme-d-octroi-de-certificats-verts.html?IDC=6384&IDD=12277
France	
Energy saving certificates	www2.ademe.fr/servlet/KBaseShow?sort=-1&cid=96&m=3&catid=25007 www.developpement-durable.gouv.fr/-Certificats-d-economies-d-energie,188-.html www.eceee.org/events/eceee_events/energy-efficiency-obligations/2_ademe
UK	
Renewables Obligation Certificates	www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/the-renewables-obligation-ro

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VREG 2013. Mededeling van de Vlaamse Regulator van de Elektriciteits- en Gasmarkt van 28 mei 2013. Brussels.

LOW CARBON BUSINESS PARK MANUAL

Chapter 7

Energy clustering

7 Energy clustering

7.1 Industrial ecology concepts

Industrial ecology is a multidisciplinary approach in which the energy, water and resource streams running through industrial systems, such as industrial parks, are mapped and analysed. Its aim is to detect profitable synergies between companies, that enhance sustainable use of resources and reduce environmental impacts. Emphasis is put on shifting from open to closed loop systems, in which residual (waste) streams are reintegrated into the system. The implementation of such synergies is referred to as industrial symbiosis, which is also the main objective of eco-industrial parks (Konz and van den Thillart, 2002, Roberts, 2004). A worldwide known example is the eco-industrial complex in Kalundburg, Denmark (see 3.2.2).

Energy clustering on industrial parks refers to all forms of inter-firm cooperation that exploit synergies within the park's energy system (presented in chapter 4). It is an effective strategy to reduce environmental emissions and costs at the same time. Physical realisations of energy clustering are collective energy production, local energy distribution networks, exchange of heat between companies and exchange of resources. Besides physical energy clustering, also services (related to energy) can be clustered, such as the purchase and sale of energy, energy monitoring and management, and maintenance of utilities. When seeing energy clustering from a business perspective, financial profit is the stimulus, while reducing environmental impacts is the advantage. As an example, without industrial symbiosis, CO_2 emissions from the Kymi Eco-industrial Park in Finland, would be 40 to 75% higher (see 3.2.2). In addition, energy clustering can be extended beyond the business park boundaries, to include synergies with the surrounding region.

Industrial ecology – energy perspective

Energy clustering = Energy synergies

- ***Physical clustering***
  - Collective energy production
  - Local energy networks
  - Exchange of heat
  - Exchange of resources
- ***Physical clustering***
  - Collective energy purchase/sale
  - Collective procurement energy monitoring/management system
  - Collective maintenance

7.2 Physical energy clustering

7.2.1 Collective energy production

Collective energy production refers to collectively or third party owned energy production installations tuned to the cumulative energy demand. More specifically, in this context energy includes heat, electricity and fuels. Collective energy production can be applied for a group of companies or for the entire business park and can even be extended to district level. It has several advantages compared to individual energy production. Firstly, the cumulative energy demand profile is more stable than the individual profiles, and peaks are flattened. This reduces the required maximum capacity and thus the overall costs of installations. Economy of scale reduces the investment and operation and maintenance costs. Additionally, larger installations exhibit higher efficiencies than smaller ones, leading to lower operation or fuel costs and related emissions. For the same capacity, a collective installation may have a smaller spatial footprint than a number of individual ones. Alternative low carbon energy production technologies that are too expensive on smaller scale, may become economically viable at larger scales. Large investments, such as geothermal installations, may not be financially feasible for one company, but may become feasible for a cluster of companies. Smaller companies and even parties located outside the business park are able to participate in collective energy production. The organisational burden is taken away from individual businesses, as collective energy production is managed by a collective corporation (see 7.5) or a third party (see 7.6). Such corporations contractually guarantee security of supply. As an alternative to large installations, a collective energy system can also be conceived as an array of smaller units.

For example, a collective ground heat source pump for a group of buildings could be more economically viable than individual ones. Companies with primarily electricity demand could be combined with companies that mainly need heat to efficiently use a CHP installation.

In the context of this paragraph, virtual power plants are virtual clusters of distributed energy production installations, extending beyond geographical boundaries, that are centrally controlled in order to jointly sell the energy produced or deliver stability or other ancillary services to the grid.

7.2.2 Local energy networks

Local energy networks are essential to distribute energy from collective energy production installations to the individual businesses. Alternatively, such networks can be used to connect individual energy production installations so that (temporary) excess capacity of one company can be made available for and sold to other companies. Energy networks are described in more detail in 7.7 and 7.8.

7.2.3 Exchange of heat

Waste heat from industrial processes and excess heat from energy production installations can be exchanged between different companies via direct heat links or via heat networks (steam or water). However, economically feasible opportunities for energy integration at company level should be focussed on first (see 5.5). Total Site Analysis provides a practical tool to detect possibilities for energy integration at cluster or business park level, taking into account the existing heat network infrastructure. The method calculates the theoretical potential of heat exchange between companies or processes via one or more heat transfer networks. For a more detailed description see 5.6.

The chemical cluster of Stenungsund in Sweden exists of five large chemical companies that strongly exploit symbiotic relations in terms of resources and energy (Hackl et al., 2010). At the heart of the cluster, a steam cracker produces olefins and fuels from saturated hydrocarbons. The olefins serve as feedstock for the other processes in the cluster, while the fuels are combusted for heat generation (see Fig. 61). Heat recovery is optimised on plant level, using individual heat networks (steam, hot oil). A Total Site Analysis has been carried out to calculate the energy savings that could be achieved by connecting (integrating) the existing steam systems of the individual plants. It was found that the use of fuel for heat generation could theoretically be avoided, provided that a hot water loop is integrated.

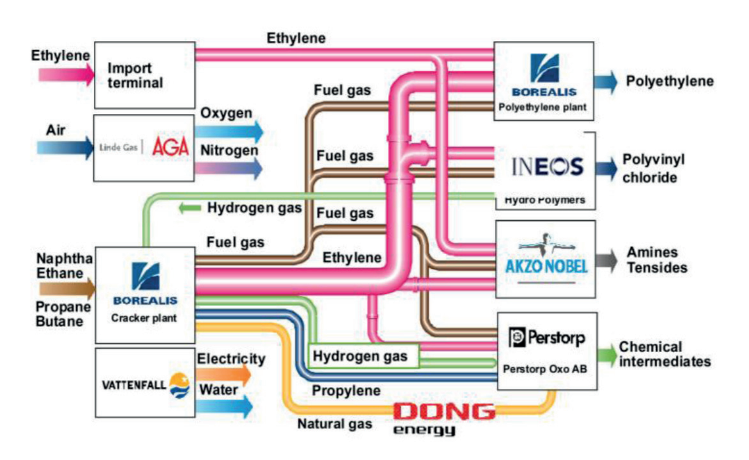

Fig. 61: Chemical cluster at Stenungsund, Sweden (Hackl et al., 2010)

7.2.4 Exchange of resources

Next to heat, also resources, such as waste, biomass, biofuels or hydrogen, can be exchanged between companies and used as a fuel. This also requires direct connections or networks. As an example, biological residues from food industry, manure, or sludge from sewers can be converted to biogas by fermentation in waste treatment plants. This biogas could be used in a CHP installation of a nearby company. Also wood chips from wood manufacturing industry or pruning waste could be used as fuel in a CHP.

7.3 Clustering of services related to energy

Joint purchase or sale of energy (electricity, fuel, heat), collective procurement of energy monitoring and energy management systems, joint maintenance of utilities, etc., can generate significant cost reductions. It strengthens the negotiating position with regard to the possible suppliers of these services. Service clustering can be facilitated by the park management or by the local business association. When companies jointly purchase electricity from an electricity supplier, the cumulative demand is more stable and shows less peaks than their individual demands. In this way, taxes related to peak demands can be decreased. Demand response could even actively avoid peaks by shifting demands in time (load shifting) or by capping them (peak shaving) (see 8.3.1.3). Alternatively, part of the demand could be temporarily supplied from a local energy generator. Demand response is illustrated in the Dutch Agrogas project, where the gas consumption of different greenhouse companies is controlled by a manager (van Gastel, 2002).

7.4 Complementary energy profiles

Company energy profiles are called complementary if they show opportunities for energy synergies that can be exploited through energy clustering. More specifically, energy functions (see 5.2.1) within different companies can be complementary in nature and/or time profile. For example, waste heat originating from cooling in warehouses (refrigerators) or datacentres could be used for space heating of adjacent buildings in colder seasons. When space heating is not required e.g. in warmer seasons, it can be stored in the ground or released to the environment. As another example, the heat that needs to be evacuated from greenhouses in summer could be stored in the ground (Borehole Energy Storage) to be used in colder seasons for low temperature space heating of adjacent buildings. Time profiles of both electricity and heat demand in offices and homes could also be complementary. As a consequence, the combined demand profile is more continuous than the separate profiles, which is advantageous for a collective CHP for example.

Complementarity of energy services can be enhanced by energy storage. For example, in greenhouse companies without assimilation lighting, demands for CO_2 fertilisation and space heating do not coincide in time. CO_2 fertilisation is needed during daytime to promote crop growth and space heating is required mostly during night-time (Vansteenbrugge et al., 2014). Both demands can be generated by a CHP. However, the CHP needs to operate during daytime, as CO_2 is provided instantaneously to the crops, while excess electricity can be sold to the grid during daytime peak demands. By storing the heat produced during daytime as hot water, and using it for space heating at night, complementarity of energy services is enhanced. For greenhouses with assimilation lighting, however, CHP operation will be tuned to the lighting schedule.

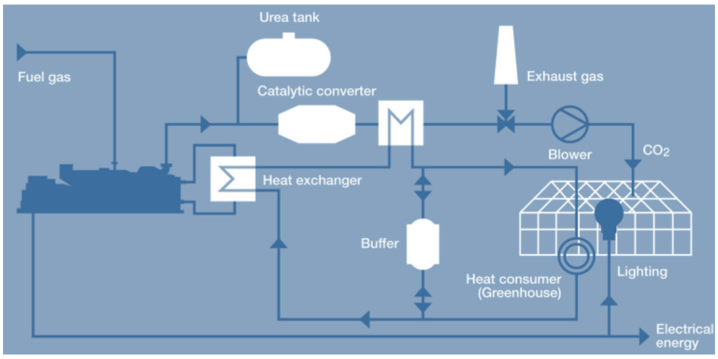

Fig. 62: CHP for complementary energy services in greenhouses (www.clarke-energy.com)

7.5 Business plans collective energy production

Different business models for collective renewable energy production can be drawn (Maes, 2011). In a first model, a unique corporation finances construction and operation of the installation, and sells the produced energy to the costumers (e.g. companies on a business park). The corporation may involve companies, but also third parties, such as energy companies, banks, park developers, government, individuals, etc., which participate by buying stocks or granting credits. An example of this corporation form is Ecopower cvba (www.ecopower.be). In a second corporate form, construction and operation of the installation are separated from the sale of the produced energy, in a production and a supply corporation respectively. Businesses can participate in one or both corporations. The production corporation either sells the produced energy to the supply corporation or rents its installation. In turn, the supply corporation sells the energy to a large number of individual companies or a to a business park. An example thereof is the tandem Fortech bvba (www.fortech.be) and Wase Wind cvba (www.wasewind.be). A third business model concerns a production corporation, similar to above and a purchasing corporation. The latter purchases energy from the production corporation and other market participants. Companies can participate in one or both corporations. The effective delivery to the end consumers is handled by an energy supplier.

7.6 Energy Service Companies

Alternatively to the business models described above for collective energy production, in which companies take part in the corporation, energy projects can also entirely be outsourced to a third party. An energy service company (ESCO) provides energy services, implements energy efficiency measures, or performs energy audits in a final customer's facility or premises. ESCO projects can include design, construction, operation and maintenance of energy production installations (CHP, wind, solar) and installations or equipment to deliver energy services (space heating, space cooling, lighting,...), next to energy auditing, monitoring or management. As the organisation and coordination of energy projects is transferred to the ESCO, customers (businesses) can stay focussed on their core activities.

The ESCO finances or arranges financing for energy projects and their remuneration is partly or entirely linked to the energy produced or the energy savings achieved. The customer gradually repays, corresponding to the energy cost savings created by the project. ESCOs will use their expertise to identify energy synergies to implement the project in the most cost-effective way and install accurate energy monitoring. On business parks, they will try to exploit synergies between companies (=energy clustering) to supply energy services to their customers in the most efficient way. In order to promote the introduction of ESCOs on low carbon business parks, they need to be incentivised towards carbon neutrality. Financing of projects can be done by the ESCO, the final costumer, a third party, or a combination thereof. An international market study of ESCOs has been performed by Marino et al. (2010). Note that ESCOs can assist in energy production as well as energy efficiency projects, at company scale (see 5.4) as well as at company cluster scale.

Public ESCOs focus on public buildings, while private ones also operate in the industrial, commercial, housing sectors, etc. In Belgium, for example, public ESCOs have been established by the federal (Fedesco) and the Flemish governments (Vlaams Energie Bedrijf), and as new departments of energy distribution grid operators. Internationally, also large energy suppliers, are starting to offer ESCO services and therefore try to exploit local energy synergies. The working of private ESCOs is based on Energy Performance Contracts (EPCs), in which payment is based on a contractually agreed energy performance criterion that is verified and monitored during the full term of the contract.

7.7 District and local heat networks

Within a business park, heat can be exchanged between companies by means of **direct heat links** or through a **local heat network**. In addition, excess heat from the business park could be injected into the **regional district heating network**. Hence, it can be used for space heating in the nearby city centre, hospital or sport complex, for heating a public swimming pool, or for heating greenhouses. Vice versa, the business park heat network can be connected to an external heat supplier, such as a waste incinerator or a power plant. Connecting the local heat network to the district heating network provides extra security of heat supply and demand.

Traditional district heating networks have a top-down structure, in which heat is centrally generated and distributed to the individual consumers. Similar to electricity networks, a shift towards smart thermal networks will support the integration of decentralised and renewable heat producers. A strategy could be to start local thermal networks and eventually connect them to form a regional heat network. District heating may in a first phase be provided by CHP and waste heat, to be supplemented or replaced in a later phase by renewable heat sources. Heat losses and costs related to heating networks are proportional with the network length. For a heat network with a supply temperature of 100°C, the heat losses could amount 1 to 1.5 °C/km. Therefore, demand and supply of heat must be **geographically clustered**. District heating networks entail high investment costs and long payback times, and therefore long term supply and demand contracts are demanded. Because of the long lifetimes of such networks, short payback times are not considered reasonable. Flexibility and robustness are of paramount importance so that those networks can be easily adapted to changing energy demands and emerging opportunities, while guaranteeing security of supply and demand. Robustness can be achieved by installing backup installations and storage facilities. A comprehensive district heating manual is composed by Frederiksen and Werner (2013).

7.8 Smart microgrids

The traditional electricity grid has a strong hierarchic top-down architecture. Electricity is produced centrally and subsequently transported through the transmission network to the local distribution grids that deliver it to the consumers. However, this one-way structure is inappropriate for large scale integration of decentralised electricity production. Therefore, a new bottom-up bidirectional approach better suited for the integration of prosumers (energy consumers that also produce energy) is required. Smart microgrids with intelligent control are able to balance local energy consumption with local energy production and storage, while exporting the electricity excess to or importing the deficit from the public electrical distribution network. Microgrids can provide ancillary services and benefits for both electrical distribution network operator and microgrid participants (Vandoorn et al., 2013). Unlike heat networks, electricity networks exhibit limited energy losses. Business parks offer a good geographical scope for the implementation of smart microgrids. The concept of virtual power plants even allows to extend the concept of microgrids beyond the geographical boundaries of business parks (Zwaenepoel et al., 2014, Vandoorn et al., 2012).

7.9 Feasibility of energy clustering

The feasibility of energy cluster projects is subject to technical, spatial, economical, legal and social constraints (Van Eetvelde et al., 2005). First of all, the theoretical potential of renewable resources is narrowed to the technical potential by the available conversion technologies, spatial planning restrictions and environmental emission bounds. Also different technologies can influence, hinder or exclude each other. Furthermore, economic viability expressed in return on investment, payback period or net present value has to be guaranteed for the investing parties. So different scenarios have to be selected and compared, further limiting the potential. This economic potential has to be checked with legal aspects, such as permits for installations, networks and connections to regional grids, legal structure and business model. Also the parties involved need to be committed to achieve a successful energy clustering project.

7.10 Role of business park developer in energy clustering

The role of the business park developer/manager in energy clustering can exist in attracting businesses with complementary energy profiles in the issuance phase, assisting companies to identify possibilities for inter-firm energy cooperation and eliminate barriers for the realisation of these energy synergies. Also, the park developer can reserve space in the spatial design for collective energy production, networks or direct connections between businesses (Maes et al., 2011). If feasible, the developer could also start up a collective energy production corporation, or act as an ESCO. Of course the objective is always carbon neutral energy (electricity) production.

7.11 Barriers and solutions for energy clustering

For investments at company level concerning energy efficiency in buildings or optimisation and integration of processes, companies expect short payback periods (< 2 max 3 year) and high IRRs (see 5.4.6 and 5.4.7). In this way profitable investments on slightly longer term are missed. In addition, net present value (NPV), discounted payback period or internal rate of return (IRR) are more accurate investment performance indicators (see 5.4.6). These remarks are also valid for energy clustering projects involving different companies.

In collective energy production or heat exchange projects, quality, security and continuity of supply is of key importance and is a contractual obligation, which puts extra stress on the individual companies involved. ESCOs can offer a solution, as they take over these responsibilities and provide backup installations, so that energy synergies are facilitated.

Unfortunately, energy clustering projects are sometimes obstructed by inadequate legislation. In Flanders, for example, direct electricity or gas links and closed electricity or gas distribution networks are allowed, as long as they are contained within one industrial site. However, when gas or electricity is exchanged between different industrial sites, currently, the Flemish energy regulator (VREG) decides whether to allow the project or not, based on the advice of the local grid operator. As the interests of the grid operator (maximise distribution to costumers, security of supply), differ from the interests of industrial energy producers and consumers (optimisation, cost savings), this advice is often negative. To solve this issue and pave the way for profitable exploitation of energy synergies between companies, a constructive dialogue between companies, government end grid operators needs to be initiated.

7.12 Case studies

7.12.1 The Loop

The city of Ghent has performed a feasibility study concerning collective energy production on business park 'The Loop' to fulfil electricity and/or space heating and cooling demands. Various systems have been investigated, including collective CHPs and boilers on natural gas, wood or bio-oil, and also a heat network supplied with heat from the waste incinerator of waste management company IVAGO. Alternative to these options, the feasibility of a water loop connected to the nearby channel has been analysed. This water circuit would provide free chilling in intermediate seasons, space cooling in summer, in combination with a compression chiller, and space heating in winter, in combination with a central or individual heat pumps and a backup gas boiler. For further details see 10.4.

7.12.2 Gent Zuid 1

The potential for energy clustering on business park Gent Zuid 1 has been analysed by the city of Ghent. Firstly, the feasibility of running an existing fermentation plant on locally available biomass and biological waste, combined with a CHP installation to convert the produced biogas into electricity and heat, has been assessed. Subsequently, the focus was on the feasibility of a steam network or steam link from IVAGO to companies with a sufficient heat requirement. A steam link would be possible with one specific company, provided that the system is supplemented with a backup installation for steam generation. A description of this case study is given in 10.2.

7.12.3 Roeselare West

Wvi investigated the feasibility of extending an existing heat network, currently supplying 22 public and commercial customers, to the business park development Roeselare West nearby, and additionally to a future housing development at greater distance. The heat network is fed by the waste incinerator of the waste management company MIROM. At Roeselare West, the supplied heat would primarily be used for space heating, with 1 company requiring higher temperatures for its processes. For further details see 10.5.

7.12.4 Heat exchange between waste incinerator and greenhouse area

Wvi assessed the feasibility of utilising low-temperature heat from the MIROM waste incinerator to fulfil space heating demands of the adjacent future greenhouse area. In periods of peak demand backup would be provided by a CHP installation on natural gas, while the carbon dioxide resulting from combustion could be used for crop fertilisation. For further details see 10.6.

7.12.5 Heat map and spread sheet model for heat networks

Wvi developed a heat map that inventories sources of waste heat in its working area, and a basic spreadsheet model to assess the feasibility of heat networks. For more information, see 10.7.

7.12.6 Veurne Sugar Factory

The redevelopment of the brownfield 'Sugar Factory" in Veurne will contain housing, recreation and businesses. Wvi estimated future heat demands of the new business area and identified potential waste heat sources on the adjacent existing business park "Veurne Industrial Park 1". The feasibility of a heat network supplied either by the available waste heat in combination with a gas boiler or by a CHP on natural gas and an additional gas boiler. was investigated. For further details see 10.8.

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LOW CARBON BUSINESS PARK MANUAL

Chapter 8

Smart energy management

8 Smart energy management

8.1 Introduction

Clustering distributed energy resources (DER) and energy consumers forms the guiding concept of the development of smart energy networks. Especially on industrial parks, smart energy networks become more prevalent and energy clustering can be integrated into the physical infrastructure of the area. This chapter is dedicated to smart energy management systems and focuses on the planning and management of energy within the domain of industrial parks.

8.2 Microgrids

8.2.1 Re-inventing the grid

Distributed generation (DG) and storage, become part of the modern energy structure. Unfortunately, classical energy grids are not designed for the subsequent bidirectional power flows in the distribution networks. Moreover, the distribution networks are not actively managed, i.e., they are conceived as passive facilities of the transmission network in which the control and stability is achieved. The increasing growth of decentralised electricity production and the unpredictability of electricity consumption creates even more instability. Ensuring a reliable and sustainable electricity supply drives the need for technology improvements in electricity networks. The implementation of smart electricity networks into the main grid is an essential part of this innovation.

8.2.2 From business park to microgrid

The main objectives of a microgrid are a coordinated integration and cooperation of DG units in the main electricity grid, in order to allow a more efficient use of energy, improve the reliability of energy supply, and become a controllable entity in the main electricity network. These small-scale grids can deliver power to a wide range of customers including residential properties, colleges, hospitals, commercial entities, industrial sites, military bases and even communities located away from the electricity grid, such as drilling platforms. Industrial parks can be managed as microgrids, e.g. to decrease the energy dependency, to increase the economic competiveness and to operate as a low carbon business park (Vandoorn, 2013).

8.2.2.1 Microgrid applications

Like many others in remote locations and island communities, North Kohala farmers have found an alternative to the polluting, expensive diesel to generate electricity. This microgrid project, known as SkyGrid Energy, has been fully operational since April 2013 (see Fig. 63). The system includes an NPS 100 wind turbine, which is the primary source of energy production, a battery bank and solar panels. With this system it is possible to pump annually enough water to irrigate 400 acres of agricultural land and support 14 participating farms and agricultural businesses.

Fig. 63: SkyGrid Energy microgrid - North Kohala, Hawaii

Fig. 64: Akademie Mont-Cenis, Herne, Germany

An elegant example of a prototype microgrid can be found at the site of a former Mont-Cenis coal mine in Germany's Nordheim-Westfalen (see Fig. 64). A 12.000 m² building, which houses a training academy, is powered by a 1MW photovoltaic array integrated into the roof and façade of the glass envelope structure, and by a CHP generator which is fuelled by methane escaping from the disused coal mine. A 1.2MWh battery ensures smooth integration into the local electricity supply, and the heat is used for the academy, surrounding housing and a nearby hospital

8.2.3 Structure and characteristics

Fig. 65 shows a schematic representation of a microgrid. A microgrid is a small-scale network, which is connected to the main electricity grid through a substation transformer. It includes DER units and different types of end users of electricity and/or heat. DER units, including distributed generation (DG) and distributed storage (DS), have different capacities and characteristics (Jayawardena et al., 2012). The electrical connection point between the main electricity grid and microgrid forms the point of common coupling (PCC) and makes the microgrid behave like a controllable entity that can operate either connected or isolated from the main electricity grid (Chowdhury and Crossley, 2009).

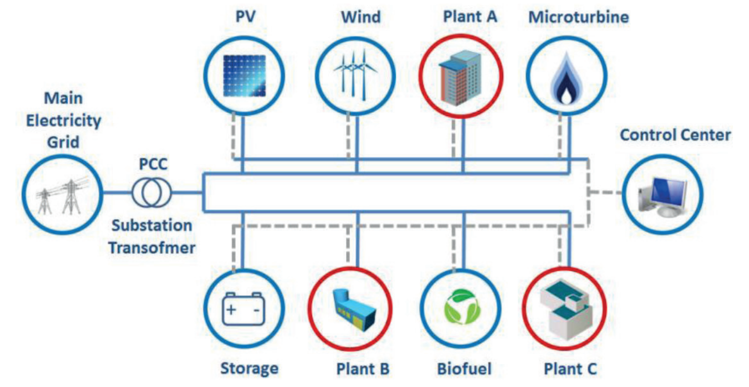

Fig. 65: Microgrid structure

From a spatial point of view, three types of microgrids can be distinguished, i.e. single-parcel or single-owner campuses, multi-parcel or multi-owner campuses, and remote off-grid sites. From the viewpoint of electrical power systems, microgrids can be distinguished by their interaction with the main electricity grid, i.e. grid-connected, off-grid (islanded) and hybrid. Via the substation transformer, the microgrid can operate in a grid-connected mode. When disconnected from the main electricity grid, the microgrid remains operationally autonomous as an islanded entity and it should provide sufficient production capacity to serve the critical loads.

8.2.4 Distributed energy resources

Distributed energy sources can be connected to the microgrid through rotary units or electronically coupled devices. Most types of DG and DS units are interfaced via power electronic converters with different control strategies and characteristics as compared to the conventional rotary units. For this reason, the control strategies and the dynamic behavior of a microgrid differs from the conventional power system (main electricity grid). A DER unit includes a primary energy source, an interface medium and switchgear at the unit point of connection (PC), and is presented in figure 2.

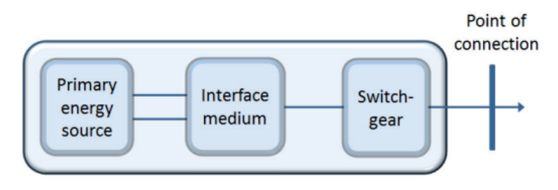

Fig. 66: DER unit

For a conventional DG unit, the rotating machine acts as an interface medium between the source and the microgrid and converts the power from the primary energy source to electrical power. An example of a conventional DG unit is an induction generator driven by a fixed-speed wind turbine, whereby the generator is the interface medium and the wind is the primary energy source. The interface medium of an electronically coupled DG unit is formed by a coupling converter which provides another layer of conversion and control. At the source side of the converter, the input power can be AC (alternating current) at fixed or variable frequency or DC (direct current). The microgrid side of the converter is at the frequency of 50Hz. For storage units, the primary energy sources should be replaced by a storage medium.

The controllability of the DG output power depends on the type of unit, and therefore a distinction can be made between dispatchable and non-dispatchable units. The output power of a dispatchable DG unit can be turned on or off, or can be adjusted on demand. Fuel-based thermal generators, i.e. diesel generators, gas micro turbines, biomass power plants and fuel cells, are dispatchable. For non-dispatchable renewable energy technologies, such as PV panels and wind turbines, the output power depends on the optimal operating condition. For example, a wind turbine is operated based on the maximum power tracking technique to extract the maximum possible power from the wind. As a result, the output power of a non-dispatchable DG unit varies according to the wind conditions.

8.2.5 Electricity demand

Microgrids include thermal and electrical energy demand. The energy demand can be divided into sensitive and non-sensitive loads. A sensitive load, such as critical business processes, requires a continuous supply of energy. Non-sensitive loads can be considered as controllable loads. They can be shifted or reduced to lower peak loads and smooth out the load profile. The microgrid electricity demand can also be scheduled according to the power delivered by intermittent renewable energy sources.

8.3 Energy management

Fast load changes and changes in the output power of non-controllable electronically coupled DER can affect the voltage and power stability when appropriate provisions are not in place. The insecure behavior of demand and supply of electrical energy requires a high update rate of the dispatch commands within the microgrid control architecture. To control and manage the energy within a microgrid, an energy management system (EnMS) can be used. An EnMS dynamically fits the consumption to the production, and vice versa, in combination with storage. A schematic representation of an EnMS on business park level is shown in Fig. 67.

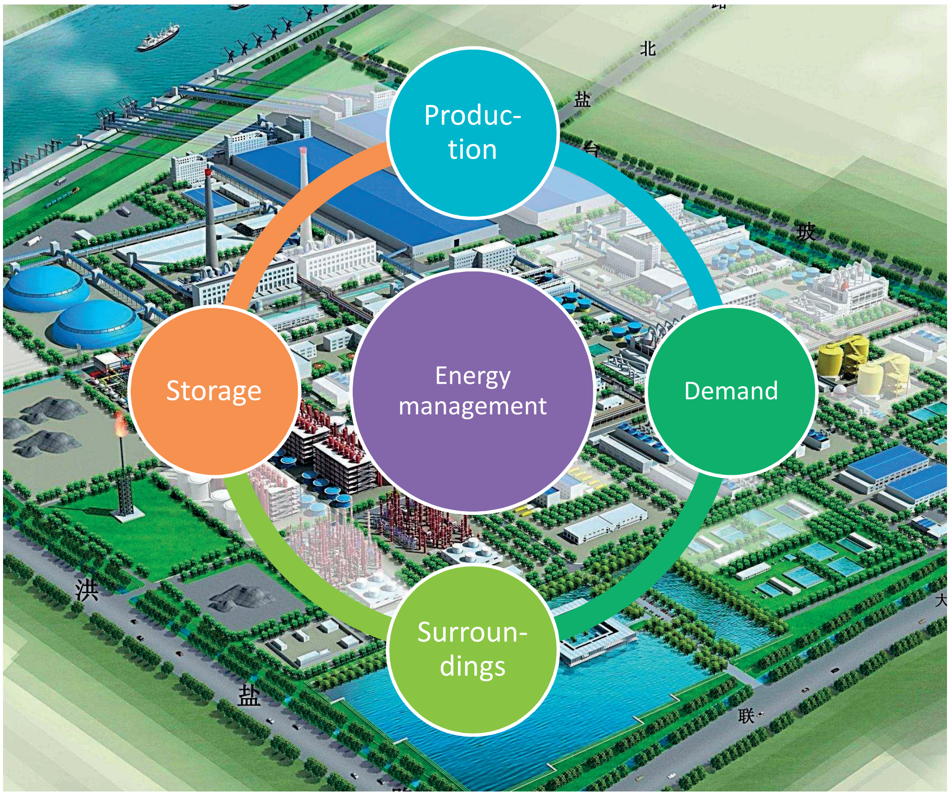

Fig. 67: Energy management on business parks

8.3.1 Energy management system

A diagram of a microgrid EnMS is presented in figure 5. The real-time management block receives the present and forecasted data of the different loads, DER units, and market information. Once the information is collected, the management block imposes an appropriate control on power flow, output generation, consumption level of the main electricity grid, dispatchable sources, and controllable loads (Katiraei et al., 2008).

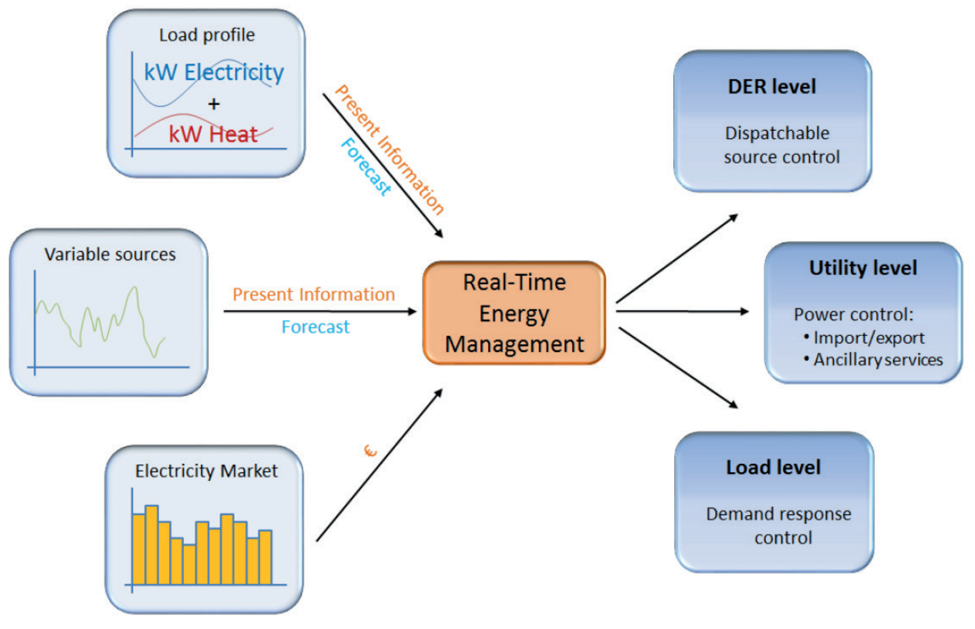

Fig. 68: Real-Time Energy Management diagram

The services provided by the EnMS can be categorized in three levels:

8.3.1.1 DER level

The EnMS dispatches the power among the different DER units in order to follow the energy demand profile and to control the voltage and frequency. When temporary microgrid instabilities occur, the EnMS activates dynamic response and voltage/frequency restoration. According to the microgrid control strategy, the output power of the RES will be maximised and the cost and CO_2 emissions related to local fuel-based energy production will be minimised. Therefore, several limitations should be taken into account, such as DER output power limitations, maintenance intervals, start-up time, etc.

After all, the efficiency of the microgrid operation strongly depends on the storage scheduling process. Extracting the maximum renewable energy during their availability and using them for both available and unavailable periods using storage units, will help to reduce both cost and emission by reducing the energy produced by fuel-based thermal generators. Storage can also be used to flatten the peak demand or in the case of a profit-based microgrid operation, energy can be purchased (and stored) from the main electricity grid when the tariff is favorable.

8.3.1.2 Utility level

In grid-connected mode, the main electricity grid is expected to absorb or deliver the difference in the power supply and demand within the microgrid. When the power exchange between the main electricity grid and microgrid is limited by operational strategies or contractual obligations, load or generation scheduling within the microgrid can be applied. In order to control the power import or export from and to the main electricity grid, each DER operates at a power level predetermined by the EnMS. By minimising the power import, microgrid peak usage will be avoided (peak shaving) and as a result, significant cost savings can be achieved. The microgrid EnMS provides also ancillary services, such as power balancing and voltage regulation.

Load level

In autonomous mode, when no main electricity grid is available, the output power of the DER units must meet the total electricity demand (load) of the microgrid. When local generation is insufficient to cover the total demand, a demand-side management strategy must be performed. The microgrid EnMs provides demand-side management (DSM), which includes demand response (DR). DR involves activities and methods to reduce, flatten or shift peak demand. DSM includes all modifications to demand profiles that are intended to alter the timing, level of instantaneous demand, or the total electricity consumption (Palensky and Dietrich, 2011). There are many methods of load management which can be followed by an industry or a utility.

Load shedding

When there is a shortfall in the microgrid electricity supply, the total microgrid demand has to be reduced very quickly to avoid that the entire microgrid becomes unstable. Load shedding is the deliberate disconnection of the power supply to certain parts of the microgrid. This method is very direct, but it is an important part of the emergency management within microgrids.

Load shifting

In this technique, the loads are rescheduled in such a way that loads are diverted from peak period to off-peak periods. Shifting the loads in a period of time does not change the amount of energy demand. Instead it allows to increase or reduce the amount of demand at a certain time period while the total energy consumption during the total time period is unchanged. Depending on the type of load, sensitive or non-sensitive, it is not possible to reschedule or shift every load. Figure 3 shows an example whereby peaks can be flattened by shifting the demand in time.

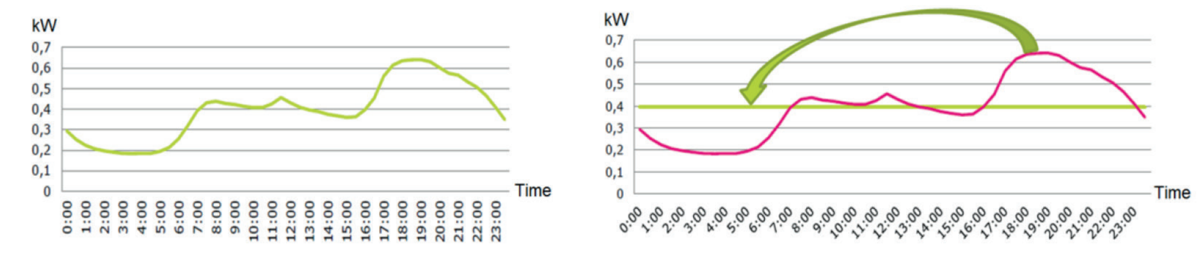

Fig. 69: Peak shaving

Active load control

In order to meet the local electricity demand, the microgrid loads will be adjusted to the local generated power. The active load control method adjusts the level of the non-sensitive loads.

8.3.2 Control architecture

Within the architecture of microgrid energy management systems, two different control systems exist, namely, centralised control and distributed or decentralised control (Katiraei et al., 2008). Both include three hierarchical levels and are presented in figure 3.

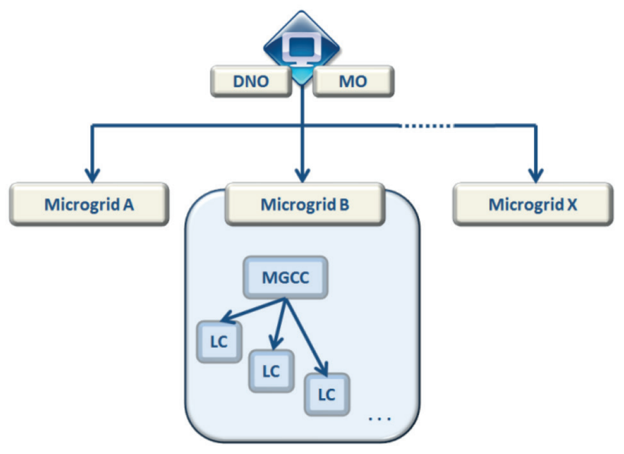

Fig. 70: Control architecture of a microgrid

1) distribution network operator (DNO) and market operator (MO)
2) microgrid central controller (MCC)
3) local controllers (LCs) associated with each DER and/or load

The distribution network operator (DNO) is responsible for the electricity distribution in a medium and low voltage area, where more than one microgrid can exist. The market operator (MO) takes place at the same level and is responsible for the market functions. Both the DNO and the MO belong to the main electricity grid and not to the microgrid. The microgrid central controller (MGCC) forms the link between the DNO/MO and the microgrid and is responsible for the optimisation of the microgrid operation by coordinating the local controllers (LC). The LC has a certain level of intelligence and controls the DER units and the controllable loads within the microgrid. In a centralised operation, each LC receives set-points from the corresponding MCC and in a decentralised operation, decisions are taken locally (Dimeas and Hatziargyriou, 2005). Figure 7 presents a centralised an decentralised control architecture.

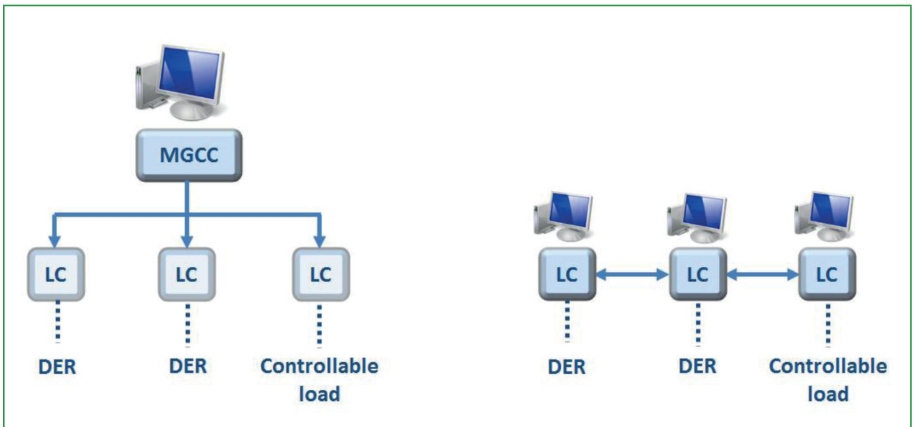

Fig. 71: Centralised versus distributed EnMS

In both applications, some decisions are made only locally, e.g., the voltage regulation. Centralised EnMS have the advantage of high efficiency, but it has the problem of a single point of failure. This system requires a very powerful central controller and has a laborious communication infrastructure with connections between the MCC and each unit in the network (Olivares et al., 2011). This single point of failure can be avoided by a decentralised EnMS. The communication infrastructure of a decentralised EnMS is easier by the plug-and-play nature of the DG units and loads. Within the domain of industrial parks, the local loads and DER units have different owners and decisions are taken locally and independently. Therefore, a decentralised control provides effective solutions for business parks.

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LOW CARBON BUSINESS PARK MANUAL

Chapter 9

New park development and retrofit

9 New park development and retrofit

9.1 Development of new low carbon business park

This chapter describes the different phases in the development of a new business park and the systematic integration of low carbon energy measures throughout these phases.

9.1.1 Development phases

Once the location for a new business park has been chosen, five subsequent phases can be distinguished in the development process (see Fig. 72). The first phase is the **preparation phase** and includes defining the role of the business park in the surrounding region, mapping the socio-economic potentials of the terrain and the financial analysis of the project. Meanwhile, a partnership is created and tasks and responsibilities are allocated to the different partners. This phase is followed by the **design phase,** in which infrastructure and business lots are spatially planned, taking into account physical and regulatory constraints, planned low carbon energy measures and expected economic activities. Next, the **realisation phase** comprises the building and follow up of the infrastructure and the preparation of the lots. In this phase, shared company buildings can be constructed. During the **issuance phase**, building lots and business modules are sold, leased or rented to selected candidate businesses, under conditions and guidelines that express the quality objectives of the business park. Once businesses are in operation in the **exploitation phase**, an effective park management has to guarantee that quality objectives are achieved and maintained, by continuous evaluation and adjustment and concrete actions. This phase is also characterised by a repetition of previous phases every time new businesses come in, the infrastructure is expanded or renewed or quality objectives are altered (Maes, 2011).

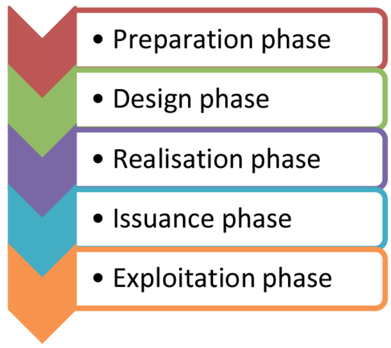

Fig. 72: Development phases

9.1.2 Integration of low carbon energy measures in business park development

The low carbon energy measures identified throughout this document need to be integrated during the organisational phases of the business park development. Necessary actions to achieve this are described for each development phase in following paragraphs. An overview is provided in Table 19 and Table 20. The development of a low carbon business park requires intense interaction between different stakeholders (business park developer, business park manager, energy consultant, authority, business, contractor and architect). The park developer plays an important role in the preparation, design, realisation and issuance phase, whereas the park manager plays an important role in the exploitation phase.

9.1.2.1 Preparation phase

Project initiation

In the preparation phase, the park developer establishes a stakeholder network and initiates the development process. The developer defines the economic focus (type of economic activities and company size) or theme of the park, in alignment with the guidelines and visions outlined in the regional and local spatial structure plans. A market analysis is performed to identify which types of companies will most likely be attracted. Ambitions and targets in terms of energy efficiency, renewable energy production and carbon emission reduction are set out, in line with European, national and local climate and energy policies. Throughout the entire development process, the park developer and manager will verify if these ambition levels are achieved. A decision is made about the issuance method that will be used: selling or leasing of either lots, company buildings or building modules. To technically follow up and assist the development process an energy consultant should be appointed. Furthermore, application procedures for possible subsidies are started up (see 3.7 for subsidies for low business park development in Flanders).

Terrain analysis
Prevailing spatial planning regulations and plans of existing infrastructure are consulted, and a first estimate is made of the total area available for company buildings.

Estimation energy consumption
A rough estimation is made of the energy profiles of the company types identified during the market analysis.

Assessment of renewable energy potential
The availability of renewable energy sources (see 6.5) on the terrain is assessed, starting from climatic (insolation, wind speed) and geotechnical data. Next, the terrain-specific potential of renewable energy production is roughly estimated, taking into account the technical characteristics of energy technologies, and the spatial planning and building regulations that are valid for the business park area. For example, spatial planning regulations may not allow the installation of wind turbines on the terrain.

Assessment of energy clustering potential
Based on the estimated energy profiles, the potential of energy clustering between businesses and with the region is assessed. Energy clustering opportunities will be taken into account in the design phase. A detailed description of energy clustering is given in Chapter 7, including waste heat exchange via heat links or heat networks, exchange of resources, collective energy production and collective services related to energy.

9.1.2.2 Design phase

Energy performance of buildings: design requirements
In the design phase, guidelines and requirements concerning the energy performance of buildings are set out. Companies that settle on the business park will have to comply with these requirements by implementing a series of low carbon energy measures. These measures are related to spatial planning on the business park, building layout, building envelope and technical installations (see 5.4.1). Also the installation of individual renewable energy production technologies, such as PV systems, may be imposed. Therefore, building structure and technical installations must be adapted to accommodate these technologies. If a heat network will be installed, companies may be obliged to connect to the network and to install low temperature heating systems. These building design requirements also apply to buildings built by the park developer.

Energy performance of processes: design requirements
A set of guidelines and requirements related to energy efficiency in processes is composed. Candidate companies will have to comply with these requirements by implementing a series of low carbon energy measures related to processes (see 5.4.4). Measures include the evaluation of alternative production processes, intelligent and efficient thermodynamic process design, installing more efficient equipment, introducing a process control system to steer the dispatch of different process units, installing a monitoring system., etc.

Facilitation of energy clustering in business park layout plan
In the business park's spatial plan, the park developer has to provide corridors and reserve spaces for the realisation of energy clustering (see 7) projects, such as collective energy production, and exchange of waste heat between companies via heat links or heat networks. Also physical clustering (adjacent lots) of companies with complementary energy profiles (see 7.4) needs to be facilitated. Meanwhile, the layout plan has to provide enough flexibility for the energy system infrastructure to adapt to a varying business park occupancy, while taking into account building and spatial planning regulations.

Calculation renewable energy potential
The estimation of the terrain-specific potential for renewable energy production can be refined, taking into account the layout plan, the building design requirements, technical constraints and spatial planning restrictions. As an example of a technical constraint, the local capacity of the electrical grid could put a limit on the injection of locally generated renewable electricity. In addition, the potential for renewable energy production in the surroundings of the business park needs to be analysed.

Low carbon plan
The park developer creates a low carbon energy plan describing how low carbon energy measures related to buildings and processes will be implemented. In the context of Flemish subsidies, this is the carbon neutrality plan (see 3.7).

Energy system modelling
In the design phase, a rough pre-design of the business park energy system could be made by means of a techno-economic energy model (see 4.5). Therefore, energy consumption on the business park needs to be estimated, starting from the company types and economic activities identified during the market analysis, the available floor area within the business park, the building design prescriptions and the site-specific renewable energy potential. The model can be refined in the issuance phase when specific companies are selected.

9.1.2.3 Realisation phase
In the realisation phase, the infrastructure for collective energy production and distribution (gas, electricity, heat) is constructed, or provisions for future installations and for possible expansions are made. (Shared) Company buildings are constructed if they are provided by the business park developer and sold or leased to candidate companies. The park developer searches for investors, appoints an architect, screens and selects contractors, provides the necessary plans, and applies for permits and licences. A business plan for collective renewable energy production can be set up (see 7.5). In this phase, a business park manager is trained that will be responsible for the park management in the exploitation phase. To prepare for the issuance phase, the developer creates an issuance plan which includes the terms and conditions which candidate companies have to comply with during the issuance and exploitation phase (see 9.1.3).

9.1.2.4 Issuance phase
During the issuance phase, the developer organises workshops, meetings, information sessions and campaigns to attract candidate companies to settle on the business park. During these events, the low carbon ambition level and the issuance conditions are clearly communicated. Candidate companies are screened and if positively evaluated, lots are allocated. When allocating lots to companies, their energy profiles and the identified energy clustering opportunities are taken into account. For example, companies requiring space heating should be located on lots with a connection to the heat network, or alternatively on lots where a geothermal heat pump can be installed. Companies with residual process heat should be located nearby companies that require process heat. The park developer can also actively attract companies with complementary energy profiles, so that opportunities for energy clustering are enhanced and created. Company buildings are constructed during this phase, following the building and process design requirements (issuance conditions) described in the issuance plan. Compliance with these conditions is controlled from the moment a candidate company is selected. The park developer can provide an energy consultant offering guidance and assistance to companies.

9.1.2.5 Exploitation phase
The park manager organises information sessions about energy efficiency in buildings and processes and promotes energy audits or monitoring campaigns. Moreover, energy clustering opportunities are actively searched for and initiated, e.g. by organising workshops for companies with complementary energy profiles. Companies are incentivised to install an energy management system for active control of processes and their electricity consumption (see 5.3.4 and 8.3). During the exploitation phase, the park manager monitors whether each company complies with the issuance conditions and whether low carbon ambitions of the business park are met. Therefore, businesses need to monitor their energy consumption and related carbon emissions and submit the emission data to the business park manager.

In Flanders, the business park developer needs to guarantee carbon neutral electricity consumption on the entire business park in order to receive subsidies. This condition can be fulfilled by purchasing or producing green electricity or by compensating carbon emissions originating from the use of non-renewable electricity. Non-renewable electricity may also be labelled green by purchasing a corresponding amount of guarantees of origin (see 3.7). In some cases, the park manager can be responsible for the management of collective energy production installations. The park manager can be funded by revenues from energy production or by financial contributions of the companies.

9.1.3 Issuance conditions

The issuance policy followed by the park developer translates the low carbon energy ambition to the level of individual candidate companies. The issuance plan contains conditions and terms that have to be fulfilled by the companies on the business park. These issuance conditions may include obligations concerning:

- **Carbon neutral energy consumption:**
  In the Flemish subsidy context, carbon neutral electricity consumption is imposed in the exploitation phase to the individual companies on the business park (see 3.7). Annually, the business park manager or developer monitors whether companies fulfil this condition. Therefore, companies need to declare the electricity volume subject to carbon neutrality and demonstrate how the condition is fulfilled. Production of grey power by and purchase of grey power from installations on the business park are not allowed. Carbon neutrality could be extended to the generation and use of heat for space heating, sanitary water heating or process heating.

- **Design requirements for buildings and processes**:
  Targets for energy performance of buildings and processes are imposed as well as the measures to achieve them (see 9.1.2.2, 5.4.1 and 5.4.4). Stricter energy and insolation levels than demanded by the national or regional regulation can be imposed at business park level. The implementation of low carbon energy measures above a certain internal rate of return (IRR) or below a certain payback period could be imposed. There could also be a requirement to design the company building and its technical installations in such a way that renewable energy production technologies can be accommodated or that a connection can be made with a heat network.

- **Advice and control by means of energy scan**
  The park developer may require companies to apply for and to perform an energy scan in the design phase of their company building. This scan verifies if the design requirements are fulfilled and identifies low carbon energy measures to be implemented. Therefore, the company needs to provide plans of the building, the technical installation related to building use and the process installations. It can be required to review the scan when the company building is modified.

- **Energy monitoring system**
  An energy monitoring system facilitates control of energy consumption and carbon emissions and should therefore be a requirement.

- **Reporting**
  To enable the business park manager to evidence whether companies fulfil the issuance conditions, a number of reports have to be submitted by the companies, such as a report on the energy performance of the building (see 5.4.2), a description of the lighting installation, a carbon neutrality report, building plans, plans of technical installations and process installations.

- **Non-compliance**
  If companies do not comply with the issuance policy, a financial penalty can be claimed by the business park manager.

9.2 Low carbon retrofit of existing business park

The organisation of a low carbon retrofit is analogous to the development of a new carbon business park, but there is no issuance phase as it is assumed that no new businesses are allowed. In a retrofit situation the advantage is that the energy consumption profiles of the existing companies can be measured by energy audits or energy monitoring campaigns. Consequently, an energy system can be designed with more confidence. One disadvantage is that retrofitting existing company buildings may be more complex than building from scratch. It is also more difficult to adapt an existing energy infrastructure as companies must be able to continue their activities without disturbance. Alternatively, a new energy system could be realised, while keeping the existing one in operation, provided that companies will switch to the new one. The differences between retrofit and new development are listed in Table 19 and Table 20.

Table 19: Activity table low carbon business park development and low carbon retrofit existing business park (part 1)

		Development new low carbon business park	Level: business	cluster	business park	Stakeholders: E-consultant	Park developer	Park manager	Authorities	Company	Architect/contractor	Low carbon retrofit existing business park	Level: business	cluster	business park	Stakeholders: E-consultant	Park developer	Park manager	Authorities	Company	Architect/contractor
Preparation	***Project initiation***	set out stakeholder network set ambitions and targets (energy efficiency, renewable energy, carbon emission reduction) in line with policies determine economic focus business park, perform market analysis determine issuance method appoint energy consultant initiate subsidy application process										idem idem n.a. n.a. n.a. idem									
Preparation	***Terrain analysis***	consult spatial structure plans, spatial planning regulation, plans existing infrastructure estimate area available for new company buildings										idem n.a.									
Preparation	***Energy consumption***	rough estimation energy profiles expected company types										energy scan or monitoring consumption profile existing companies estimate future evolution energy consumption existing companies benchmarking energy performance existing company buildings and processes assessment of energy saving potential and carbon reduction at company and business park level analysis existing distributed energy generation									
Preparation	***Renewable energy***	gathering climatic and geotechnical data terrain-specific potential of renewable energy production										idem idem									
Preparation	***Eenrgy clustering***	assess energy clustering potential (collective energy production, heat exchange, heat network)										idem map waste heat availability and heat demand existing companies									
Design	***Energy performance buildings***	set design requirements related to energy performance of buildings (buidling envelope, technical installations, spatial planning) Application of building requirements in design buildings delivered by developer										idem check compliance existing company buidlings with design requirements									
Design	***Energy performance processes***	set design requirements related to energy performance of processes										check compliance existing company processes with requirements									
Design	***Energy clustering***	facilitate energy clustering in business park layout plan: reserve spaces and corridors for energy clustering projects, reserve adjacent lots for companies with complementary energy profiles										idem + facilitate energy clustering between existing and new companies									
Design	***Renewable energy***	calculate terrain-specific potential for renewable energy production , taking into account layout plan, building design requirements, technical constraints and spatial planning restrictions. potential renewable energy production in surroundings										calculate terrain-specific potential for renewable energy production , existing company buildings, technical constraints and spatial planning restrictions. idem									
Design	***Low carbon plan***	compose low carbon plan (or carbon neutrality plan) describing all low carbon energy measures										idem									
Design	***Energy system modelling***	set up techno-economic energy model for predesign business park energy system, based on estimated energy consumption profiles, site-specific renewable energy potential, carbon emission cap, calculate optimal system at minimum costs										set up techno-economic energy model for predesign business park energy system, based on measured energy consumption profiles existing companies, site-specific renewable energy potential, carbon emission cap, calculate optimal system at minimum costs									

Table 20: Activity table low carbon business park development and low carbon retrofit existing business park (part 2)

Phase	Activity	Development new low carbon business park	Level: business	Level: cluster	Level: business park	Stakeholders: E-consultant	Stakeholders: Park developer	Stakeholders: Park manager	Stakeholders: Authorities	Stakeholders: Company	Stakeholders: Architect/contractor	Low carbon retrofit existing business park	Level: business	Level: cluster	Level: business park	Stakeholders: E-consultant	Stakeholders: Park developer	Stakeholders: Park manager	Stakeholders: Authorities	Stakeholders: Company	Stakeholders: Architect/contractor
Realisation	***Energy infrastructure***	find investors, contractors, obtain permits and licences.										idem									
		construct energy distribution networks (electricity, gas , heat)										construct new or modify existing energy distribution networks (electricity, gas , heat), decomission obsolete installations									
		construct collective energy production installations or provisions for future installations										construct collective energy production installations									
		set up business plan collective renewable energy production										set up business plan collective renewable energy production									
	Company buildings	construction business park centre and company buidlings (if delivered by developer)										retrofit existing company buildings and business park centre									
	preparation issuance phase	compose issuance plan and issuance conditions																			
Issuance	***Candidate companies***	attract companies, communicate issuance conditions analyse energy profile candidate companies										n.a.									
	Allocation lots	allocate lots to new companies based on energy profile companies, following issuance plan										n.a.									
	Design and construction company buildings	verify compliance with building and process design requirements (issuance conditions) during design and construction new company buildings provide guidance and assistance to companies in low carbon design and construction of company buildings and processes (energy consultant, workshops, meetings, info sessions)										n.a.									
	Preparation exploitation phase	compose management plan										n.a.									
Exploitation	***Information***	provide information about and promote energy scan, monitoring, low carbon energy measures, workshops energy clustering for companies with complementary energy profiles										idem									
	Energy audit/ energy monitoring or management system	perform energy audit										idem									
		install monitoring/management system to monitor/control energy consumption and carbon emissions										idem									
	Controls issuance conditions	verify and enforce compliance with issuance conditions										n.a.									
	Collective energy production, selling, purchase	manage collective energy production if controled by park manager, clustered import/export renewable energy										idem									
	Park management	execute management plan, involve businesses										idem									

9.3 Combined low carbon retrofit existing business park and new low carbon expansion

In many cases, the low-carbon retrofit of an existing business park is combined with a low carbon extension of the park, or with the redevelopment of an obsolete part of the existing business park. In this case, the organisation includes a combination of both organisation sequences: for the development of the new business park area, the left part of Table 19 and Table 20 applies, whereas for the retrofit of the existing business park area, the right part applies. Of course the energy system supplies energy to the entire business park.

9.4 Monitoring sustainability of business park development

The city of Ghent developed the Sustainability Meter for Economic Sites. The term economic sites includes business parks, science parks, and zones for retail and leisure, for offices, or for transport and distribution. The Sustainability Meter is based on the BREEAM Communities methodology and has been adapted and extended to the local policy context. This instrument monitors the sustainability of the development of an economic site and offers guidance to the developer. Sustainability is monitored throughout the different development phases, by giving a score to more than 100 topics, divided in 10 thematic categories. One category evaluates **low carbon energy measures** on the site. Finally, the relative score for each category is presented in a bar chart. The development phases considered in the Sustainability Meter (see Table 21) show similarities with the preparation and design phases described in 9.1.1. More information about the Sustainability Meter for Economic Sites can be found in the matching explanatory document (Milieudienst Stad Gent, 2014).

Table 21: Development phases used in Sustainability Meter for Economic Sites

	Development phases		Sustainability Meter
1	**Development plan**		
	1.1	*Siting and site analysis / Collective strategies on macro scale*	
	1.2	*Site development plan*	
	1.3	*Issuance policy*	First evaluation
2	**Realisation collective parts of development plan**		
	2.1	*Sketch design*	
	2.2	*Predesign*	Second evaluation
	2.3	*Plan of implementation and technical specifications*	
	2.4	*Preliminary completion*	Final evaluation
	2.5	*Preparation of site management*	

9.5 Case studies

The low carbon business park developments in the ACE project are new developments, as the terrains that are being developed do not contain active company buildings.

- Business park Wiedauwkaai/Wondelgemse Meersen (see 10.3)
- The Loop (see 10.4)
- Business Park Roeselare West (see 10.5)
- Business park De Spie (see 10.11)
- Business park Veurne (see 10.12)
- Sugar Factory Veurne (see 10.8)

9.6 Sources

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LOW CARBON BUSINESS PARK MANUAL

Chapter 10

Case studies

10 Case studies

10.1 Guidance programme on energy management

10.1.1 Objective

The City of Ghent initiated a guidance programme on energy management for individual businesses, because of two important observations. Firstly, Energy Policy Agreements only incentivise energy efficiency measures in energy intensive companies with an annual primary energy consumption higher than 0.1 PJ. (see 5.4.5). As a consequence, a large number of companies with a lower, but still significant energy consumption get less incentive towards efficient energy management. Secondly, after an energy audit has been performed at a company, the proposed measures are often not implemented. The reason therefore is that energy is not a business's core activity, energy costs are underestimated, or because of a lack of time, staff or expertise. In this way, energy saving opportunities that could effectively generate profits are missed. The Guidance programme on energy management offers an energy audit to interested companies, followed by a continuous support of maximally one year. The aim is to actively detect and implement profitable energy measures and to permanently integrate energy management into the corporate policy.

10.1.2 Content and method

Fifteen companies have applied to participate in the program and are guided over a one year period by an expert energy consultant appointed by the City of Ghent. The value of the consultancy is € 5000, of which the company pays 10%. Each participant signed a declaration containing following commitments:

1. include the target of 20% reduction of primary energy consumption (relative to the start year of the guidance programme) by 2020 in the corporate mission.
2. endorse the objectives of the climate alliance of the city of Ghent by signing the charter
3. improving the energy accounting and transition to an energy monitoring system
4. exchange of energy consumption data in the framework of the ACE project
5. develop an energy plan and implement energy measures with a payback period ≤ 2 years
6. report implemented energy measures at request of the City of Ghent (up to 4 years after termination of the guidance programme)
7. appoint a (part-time) energy coordinator within the company

The guidance program comprises several key steps: First, an energy audit is performed, followed by an evaluation of the financial feasibility (payback period, IRR) and assessment of the carbon emission reduction related to the detected opportunities. Then, an energy plan is developed and validated by the managing board, and a helpdesk function is installed. Also, the energy accounting system is improved (as preparatory step to an ISO 50001 certified energy management system, see 5.3.1). The programme focusses on both building and process related energy measures.

10.1.3 Participating companies

All companies with an annual primary energy consumption of 1 to 27 GWh (on one site) in the greater Ghent area, including the port of Ghent, are targetted.

The 15 participating companies show an even distribution over the focussed area, and are active in following economic activities:

- automotive
- food/storage
- textile
- concrete
- steel construction
- engines
- animal food
- plastic processing
- printing
- hospital
- lubricants/storage
- research

It mainly concerns industrial buildings, and connected offices, for production, processing, storage or manipulation of products, but also some hospital buildings and labs. Jointly, they represent a primary energy consumption of 119 GWh and a carbon dioxide emission of 28 kton per year.

10.1.4 Detected energy efficiency measures

In the course of the guidance programme, various opportunities for energy efficiency have been identified. The most frequently detected measures are related to:

- compressed air (detection and repair of air leaks, transition to alternative concepts)
- relighting
- insulation (building envelope, steam and water pipes, heat storage tanks)
- heat recovery (from industrial waste water, drying kilns, condensate, cooling cycles)
- better management of opening and closing gates
- repairing damaged vapour traps
- (re)location of destratificators and air heaters

Also monitoring (compressed air, thermography, peak current), better maintenance and behavioural measures are frequently proposed. The largest carbon emission reductions result from installing economisers on boilers, recovering waste heat from compressors, adjusting set-up and location of air heaters and destratificators, closing gates when air heaters are in operation, correct use of rapid roll doors, insulation of storage tanks and reparation of roof cladding. Given the complexity of multiple measures, various recommendations were made for additional studies outside the scope of the guidance programme, such as detailed heat recovery studies.

10.1.5 Evaluation

It is estimated that energy savings resulting from the implementation of quick wins (with payback period ≤ 2y) detected by the guidance program are in the range of 10%. If also the less profitable measures would be implemented, this could increase to 20%. However, investments with payback periods between 2 and 6 years are often not implemented, as they are in competition with investments in production processes. The strength of the guidance programme on energy management is that it answers the demand of a lot of companies for customised support in technical and financial decisions. For several companies, the guidance was even an extra stimulus to achieve ISO 50001 certification. This pilot project shows that a large potential for energy savings exists in energy-intensive companies below the Energy Policy Agreement threshold.

10.1.6 Continuation

Based on the success of this pilot project, the City of Ghent is considering a further rollout of the concept of premiums for the guidance of companies. The intensity and way of guidance will probably depend on the company's size and energy consumption.

10.2 Business park Gent Zuid 1

10.2.1 Introduction

The potential for energy clustering on business park Gent Zuid 1 has been analysed by the city of Ghent.

10.2.2 Site description

Business park Gent Zuid I is situated in the south of Ghent (see Fig. 73 and consists of two parts with a total area of 100 ha. The larger part is enclosed by the E17 highway in the west, the R4 highway in the south, and the river Scheldt in the east, while the smaller part lies west of the E17 highway (see Fig. 74). The city of Ghent owns part of the business park and leases it to companies (leasehold estate). Gent Zuid I comprises mainly medium and large production companies, next to a number of hotels (see Fig. 75).

Fig. 73: Location business park Gent Zuid I

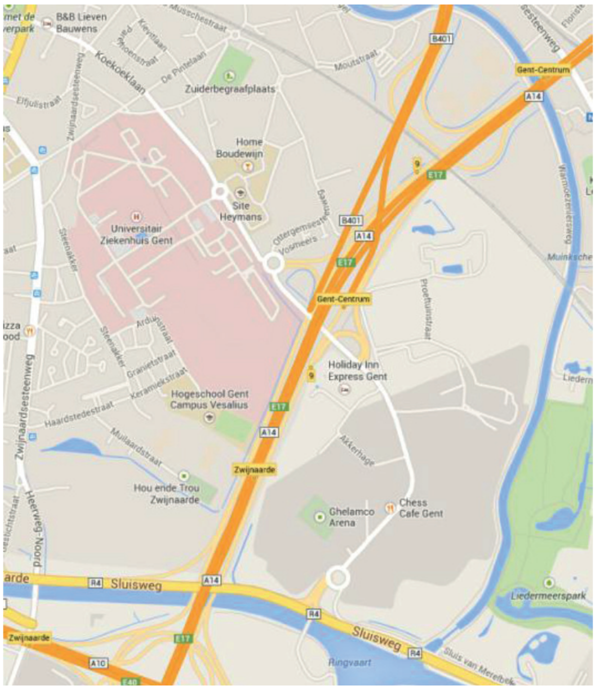


Fig. 74: Borders Gent Zuid I: A17, R4 and the river Scheldt

Fig. 75: Spatial plan of business park Gent Zuid I

10.2.3 Opportunities energy clustering

In order to identify opportunities for energy clustering on Gent Zuid I the city organised meetings with different stakeholders and carried out energy scans to assess the energy profiles of different companies. As Gent Zuid I contains relatively large and energy intensive companies, several opportunities were detected. The most important one consists in developing a steam network, fed by waste heat of the IVAGO waste incinerator, supplying heat to nearby companies. The waste incinerator already provides steam to the university hospital UZGent for space heating purposes, but there is still heat in excess.

The city of Ghent identified which companies show potential to participate in the heat network, based on information about economic activities obtained from the city's Department of Economy and from company websites. An inquiry showed that a number of companies are interested, provided that some financial and technical barriers could be solved.

10.2.4 Barriers energy clustering

A first barrier is that steam supply and steam or heat demand are not synchronised. The waste incinerator of IVAGO that supplies waste heat for steam generation is continuously in operation, while the heat or steam demands of the nearby companies fluctuate with time of the day, day of the week and season. A second problem is that IVAGO cannot guarantee a continuous steam supply, because of a two week maintenance stop two times a year. As a result, companies need to keep their boilers in operation to provide backup in these periods. Alternatively, a number of larger backup boilers could be connected to the steam net. The coordination between the steam from backup boilers and from the waste incinerator can be done by a regulator that keeps track of the amount of steam produced or consumed by each unit in the system.

As the development of a site wide steam network is complex, the focus is first laid on a possible steam link between IVAGO and Induss. At the moment Induss generates its own steam by means of a natural gas boiler and supplies its excess steam to a neighbouring company. Instead Induss could be supplied with steam from IVAGO and use its own boiler as backup. This option is currently being investigated by IVAGO, but preliminary results are promising. With this project the major part of IVAGO's steam will be utilised. Consequently, for the development of a site-wide steam network, new investments in steam generation would be required. However, there is still low temperature waste heat available and currently it is being investigated if it can be used for space heating in nearby buildings.

10.2.5 Evaluation

The feasibility of a steam network or steam link from IVAGO to companies with a sufficient heat or steam demand has been investigated. A steam link would be possible with one specific company (Induss), provided that the system is supplemented with a backup installation for steam generation. It was found that complex contractual agreements form key barriers for energy clustering projects and more specifically for establishing a steam link or steam network. Moreover, as for investments related to a company's main activity, also for energy clustering projects payback periods of less than two years are expected by the company. However, this investment criterion is not suitable to establish inter-firm cooperation in terms of energy clustering.

10.3 Business park Wiedauwkaai/Wondelgemse Meersen

10.3.1 Introduction

The city of Ghent developed and analysed an ambitious low carbon energy issuance policy for business park Wiedauwkaai/Wondelgemse Meersen.

10.3.2 Site description

Wiedauwkaai/Wondelgemse Meersen, hereafter simply referred to as Wiedauwkaai, is an area situated in the north of Ghent (see Fig. 76). At the moment the area is not optimally exploited and the city of Ghent wants to transform it into a sustainable and qualitative local business park with green zone (see Fig. 77). The development consists of a new business park with an area of 14.5 ha for SMEs requiring lots below 5.000 m², and a green corridor of 4.5 ha along the Lieve channel.

Manufacturing companies are aimed at, including craftwork companies, while retail companies and autonomous offices are not allowed on the terrain. The city wants to attract company clusters that will exploit opportunities in industrial symbiosis (inter-firm cooperation in terms of resources, energy and waste).

Fig. 76: Location Wiedauwkaai

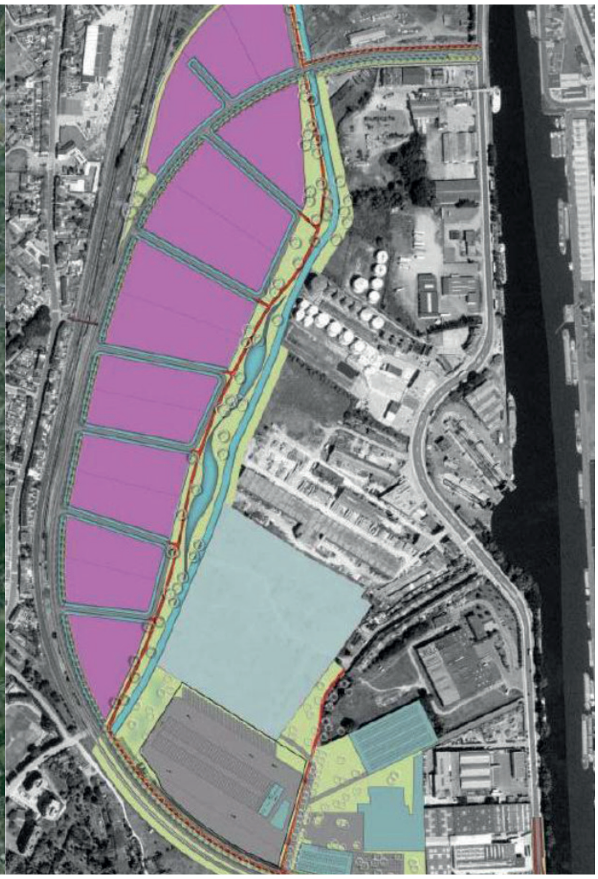
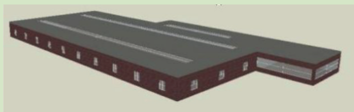


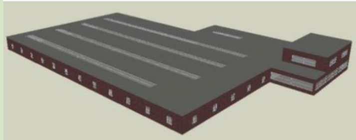
Fig. 77: Spatial plan Wiedauwkaai

10.3.3 Energy consumption

In order to assess the energy consumption on the new business park, EPB calculations were performed on small and medium sized SMEs (see Table 22). Using these types, the yearly energy consumption for a total built area of 72.770 m² has been calculated (see Table 23). The high electricity consumption results from the high share of floor space for industrial production halls adopted for the SME types.

Table 22: Company types used for EPB calculations		
Area [m²]	**Small**	**Medium**
Lot area	2500	5000
Built area	1625	3250
Housing	0	150
Office/show room	100	200
Production energy-extensive / storage with occupancy	1525	2900


Small SME


Medium SME

Carbon emissions related to electricity and heat consumption in the Business As Usual (BAU) scenario are calculated assuming an emission factor of 400 kg CO_2/MWh for electricity generation and of 181,4 kg CO_2/MWh for heat generation. The first figure corresponds to the average specific carbon emission of gas combustion-based electricity generation in Belgium (IEA, 2012). The second figure represents the carbon emissions from natural gas combustion (NG, lower heating value). However, since the new business park falls under the subsidy condition of carbon neutral electricity consumption (see 3.7), all electricity consumed on the business park is in theory free of carbon emissions.

Table 23: Estimation annual energy consumption new business park				
Total built area 72.770 m²	**Final energy consumption**		**CO_2 emissions**	
	BAU *annual* *GWh/year*	*kWh/y/m²*	*emission factor kg/MWh*	**BAU** *annual kton*
Electricity	25,6	→350	400 (0)	10,24 (0)
Heat	7,4	→100	181,4 NG	1,342
total	33	-	-	11,582

The potential for photovoltaic solar panels is estimated at 1,1 to 3,5 MWp, depending on the useable part of the final roof surface, and could cover 6-10% of the electricity consumption.

10.3.4 Low carbon energy guidance programme

10.3.4.1 Need for energy measures complementary to EPB requirements

A study carried out by Technum in 2013 ("Ambition level sustainability and energy") pointed out that the current EPB regulation only covers a low share of total final energy consumption on the new business park Wiedauwkaai, because it does not include specific business activities, such as industrial production halls, show rooms, workshops, etc. (see Table 24). Therefore, a low carbon approach of business park developers cannot be limited to EPB regulations.

10.3.4.2 Structural energy measures

The city of Ghent developed a guidance programme for businesses in order to promote profitable energy measures that cover a larger share of total energy consumption related to both building use and industrial processes (see 10.1). The programme consists of an energy audit and continued assistance and advice and will also be applied for business park Wiedauwkaai. To incite implementation of proposed energy measures, the city of Ghent opted for a rewarding system that links the repayment of a deposit (3€/m² in addition to the lot price) to the realisation of a number of structural measures listed below. Companies on Wiedauwkaai need to prove the implementation of these measures by means of certificates or invoices.

1. Extension of EPB regulation to small offices
In addition to the EPB requirements (see 5.4.2), an E-level of E60 and a K-level of K40 is required for company office space between 100 and 800 m² (see Table 24).

Table 24: Extended EPB requirements

EPB 2014	K level	E level
Housing unit	40	60
Office < 100 m³	40	
Office 100-800 m³	40	**60***
Office > 800 m³	40	60
Laboratory	40	
Showroom	40	
Storage	40	
Workshop	40	
Open hall		

* extended requirements Wiedauwkaai

2. Calculation of building nodes with method A or B
The K level of company buildings (see 5.4.2), needs to be calculated according to method A or B, to avoid that building nodes act as thermal bridges. Method A, B and C stand for very thorough, thorough and no analysis respectively.

3. Low temperature heating and high temperature cooling
In all non-industrial protected building volumes covered by the extended E-level requirements (incl. E60 for offices 100-800 m²) low temperature space heating and, if necessary, high temperature space cooling need to be provided (see 5.4.1 for a more detailed description). As such, the possibility to shift to renewable energy sources is structurally built in. For low temperature space heating, the supply temperature is below 45°C and for high temperature space cooling, above 15°C, while in both cases the temperature drop or gain over the heat emission or extraction equipment stays below 10°C. If laboratories require higher or lower room temperatures, additional installations can be installed to fulfil peak demands.

4. Blowerdoortest
For all protected building volumes covered by the extended K-level requirements for Wiedauwkaai a blowerdoortest needs to be carried out. Although no targets for test results are imposed, the leakage flow rate of the building envelope needs to be taken into account in the EPB calculation.

10.3.4.3 Energy audit

An energy consultant appointed by the city of Ghent is at the disposal of each individual company to perform an in-depth energy audit covering all energy services related to building use and production processes (see 5.2.1). In terms of building use energy services, the audit needs to evaluate lighting, ventilation, space heating and cooling (incl. assessment of potential for passive cooling), and the possible implementation of an energy management system. In terms of process related energy services, the audit needs to assess the potential for lowering process temperatures, and analyse the use of compressed air. Moreover, process installations with significant energy consumption need to be inventoried and the potential of rainwater use in processes and of recovery and reuse of waste, waste heat and waste water within the company or on the site needs to be mapped. Also the potential of frequency-controlled engines and pumps needs to be evaluated.

The audit consists of energy scans in different phases. A first scan can be carried out in the original company buildings in order to identify low carbon energy measures for the new company buildings. In a second scan, building plans are screened for further improvements. In this phase, information about the financial feasibility of energy measures is provided (payback periods). Moreover, the consultant will be available for guidance and support during the entire construction process of the building, although site visits during construction are not included.

Starting from the information provided in the application forms of the candidate companies, the auditor will (on short term) detect opportunities for energy clustering. Also a quick financial analysis of these opportunities will be performed. Based thereon, the auditor is able to set up recommendations for exploiting energy clustering opportunities between specific companies.

Necessary funding for these audits is raised by including a fee of 4€/m² in the selling price of the lots, which cannot be reclaimed by companies that do not make use of the offered audit. In addition to the lot price, companies need to submit a deposit of 3€/m² (when the authenticated act is completed), which can be recovered by implementing the 4 structural measures proposed by the guidance program.

10.3.4.4 Environmental and economic impact

The guidance program is expected to reduce final energy consumption with 10% against business as usual (BAU), provided that energy measures with a payback period of less than 3 years are implemented (S1). If all measures with a payback period of less than 6 years would be implemented (S2), reduction could rise to 20% or more (see Table 25). The economic impact of both scenarios is calculated in Table 26. As these calculations do not take into account any increase in specific energy costs, total energy costs will decrease even more than represented here.

Table 25: Environmental impact of guidance program Wiedauwkaai

	Final energy consumption			**CO_2 emissions**			
	BAU *annual GWh/year*	**S1 (10%)** *reduction GWh/year*	**S2 (20%)** *reduction GWh/year*	*emission factor kg/MWh*	**BAU** *annual kton*	**S1 (10%)** *reduction kton*	**S2 (20%)** *reduction kton*
Electricity	25,6	2,56	5,12	400 (0)	10,24 (0)	1,024 (0)	2,048 (0)
Heat	7,4	0,74	1,48	181,4 NG	1,342	0,134	0,269
total	33	3,3	6,6	-	11,582	1,158	2,317

Table 26: Economic impact of guidance program Wiedauwkaai

	Final energy consumption			**Energy costs**			
	BAU *annual GWh/year*	**S1 (10%)** *reduction GWh/year*	**S2 (20%)** *reduction GWh/year*	*c€/kWh*	**BAU** *annual €*	**S1 (10%)** *reduction €*	**S2 (20%)** *reduction €*
Electricity	25,6	2,56	5,12	15	3.840.000	384.000	768.000
Heat	7,4	0,74	1,48	6,5 NG*	481.000	48.100	96.200
total	33	3,3	6,6	-	4.321.000	432.100	864.200

* natural gas

10.3.5 Evaluation

The guidance programme should be initiated during the issuance phase, when new companies settle on the business park, in order to start from the full range of possible energy measures and energy clustering opportunities. The programme is an integrated approach that offers advice and guidance custom-tailored to the needs of each company. Instead of penalising companies that do not cooperate, companies that do participate in the low carbon strategy are rewarded.

The energy consultant needs to provide clear and illustrated evidence of the economic and environmental profits related to the energy measures he proposes in order to convince companies to actually implement them. In order to remove possible obstacles, the guidance team organises a consultation with each company, its architect and if necessary also external parties, such as AO-Enterprise Flanders and OVAM. The aim is to provide, in addition to the energy audit, information about energy measures and related financial support from the government (see 2.6.1). Furthermore, the guidance team can assist in the administrative process of applying for building permits and environmental permits.

Goodwill and smooth cooperation between companies, business park developer and energy consultant, are of key importance for the success of the program. All stakeholders need to propagate the sustainable and low carbon energy ambition and therefore clear communication between all parties during the issuance phase is necessary.

10.3.6 Continuation

The city of Ghent will accurately prepare and launch a tendering procedure to appoint a qualitative energy consultant. The energy consultant will verify if companies have implemented the structural measures proposed by the guidance program that are linked to the deposit restitution. In cooperation with the companies, the consultant will also measure the economic and environmental effects of the implemented energy measures. The city of Ghent will monitor and evaluate the overall economic and environmental effects of the guidance program in order to gain new insights, set up and refine policy recommendations and share knowledge with business park developers.

10.3.7 References

IEA 2012. CO_2 Emissions from Fuel Combustion Highlights - 2012 Edition.

10.4 Business park The Loop

10.4.1 Introduction

The city of Ghent investigated the potential of low carbon energy production to collectively fulfil space heating demands on business park "The Loop". The study builds on a report prepared in 2011 in the framework of "Master Plan Sustainability The Loop". In 2013, the feasibility of a space heating and cooling system existing of a cold water loop, connected to the nearby channel, in combination with bivalent heat pumps, was studied in more detail.

Fig. 78: Location of business park The Loop in Ghent

10.4.2 Site description

The Loop is a business park situated in the south-western part of Ghent (see Fig. 78 and Fig. 79). Its master plan includes office, leisure, retail and housing functions, and divides the site into 18 development areas that differ according to shape and targeted functions (see Fig. 81 and Fig. 82). The project offers more than 500.000 m² of floor space (see Fig. 80) and the development of the site will extend over several decades. In the first phase, mainly retail and leisure functions will be developed, while a second phase is dedicated to expansion of office area.

Fig. 79: Aerial view business park The Loop

Fig. 80: Spatial plan The Loop

Fig. 81: Functions on The Loop

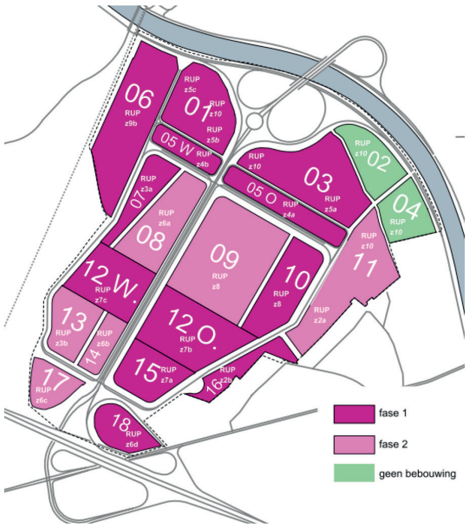


Fig. 82: Development areas and phases for The Loop

10.4.3 Energy consumption

In Table 27 the buildings foreseen in the master plan are categorised according to function, and floor areas are accumulated. Based on estimates for specific energy consumptions per floor area, derived from current building regulations, the total maximal loads and annual energy demands (space heating, space cooling, electricity) are estimated per category. For the entire site, the maximal total heat load is estimated at 32.7 MW and the total annual heat demand at 66.000 MWh/year. The maximal total cooling load is estimated at 14 MW, while the total annual (thermal) cooling demand is about 19.000 MWh/year. These predictions could differ from reality, as future more stringent regulation may reduce energy demands. Also, specific energy intensive companies are not included in these estimations. Datacenters, for example, may have a significantly larger demand for cooling and electricity than standard buildings.

Table 27: Estimated energy consumption The Loop

	Area	**Maximum Load**		**Energy consumption**		
		Heating	***Cooling***	***Heating***	***Cooling***	***Electricity***
Function	*m²*	*MW*	*MW*	*MWh/y*	*MWh/y*	*MWh/y*
Offices	309.500	13,9	6,2	18.600	9.300	15.500
Short term housing	23.500	1,1	0,4	3.300	600	2.400
Permanent housing	83.300	3,7	0,0	8.300	0	2.500
Leisure	145.000	5,8	2,2	14.500	3.600	43.500
Retail	69.000	2,8	1,0	6.900	1.700	10.400
Public hospital	60.000	5,4	4,2	14.100	4.200	8.700
Total	690.300	32,7	14,0	65.700	19.400	82.900

10.4.4 Low carbon energy production

10.4.4.1 Options for collective energy production

In 2011, a feasibility study for a collective space heating system was conducted in the framework of "Master Plan Sustainability The Loop" (report sustainable energy production, Ingenium 2011). More specifically, the feasibility of a heat network with central heat generation has been evaluated. The centralised generator(s) need(s) to be able to deliver the maximal total heat load of the site, equal to 32.7 MW and to annually produce 66.000 MWh of heat. Individual backup generators per building were not included in the calculations. The basement of development area 12 West is the most appropriate location for the generator(s). Different heat generation technologies are available, such as **boilers** and **CHP** installations on **gas**, **wood**, **wood pellets** or **bio-oil**. Alternatively, heat could be tapped from the waste incinerator of IVAGO.

Yet another explored alternative exists of a **cold water loop**, connected to the nearby channel, with decentralized heat pumps and backup gas boilers per building. This system can also provide free chilling in intermediate seasons and space cooling in summer.

10.4.4.2 Excluded options

In theory, energy production by combustion of bio-oil in boilers or CHP installations is carbon neutral, as it is the case for wood (pellets). However, the bio-oil option is not taken into consideration, due to the current uncertainty about its actual sustainability.

The waste incinerator of IVAGO supplies heat to the university hospital UZGent. Yet, the waste management company verified that no excess heat is available. As a consequence, an extra waste incinerator would be needed to additionally supply heat to a heat network on The Loop. Due to limits on the total number of waste incinerators, building a new installation is not considered to be realistic. However, if installations were put out of service, when obsolete or not compliant with more stringent regulations, IVAGO could possibly increase its capacity. In that case, the new waste incinerator could be linked to the heat network of The Loop, by means of a hot water pipe line of 5 km via the ring channel. The construction will require a number of underground drillings and permits. Considering that no excess heat is currently available and the relatively high length of the heat link, this scenario is not taken into consideration.

10.4.4.3 Evaluation of remaining options

In Table 28, the different options for collective heat production for space heating are evaluated, in terms of simple payback period (see 5.4.6) and carbon emission reduction, in comparison to decentralised heat production with individual gas boilers. The studied options for centralised combustion-based heat generation are: (1) gas boilers, (2) gas CHPs and (3) wood CHPs and pellet boilers. Also the water loop-based system, which provides both space heating and cooling is analysed.

The calculation assumes that all buildings on The Loop are connected to the heat network. In reality, however, this condition may not be fulfilled, resulting in lower cost savings and longer payback periods. Another assumption is that CHP installations can sell their excess power to the grid.

The highest carbon emission reduction is achieved with the wood (pellets) boilers and CHPs, as they are CO_2 neutral. The lowest payback period is achieved with the channel water loop.

Table 28: Comparison options collective energy production for space heating (and space cooling)

A. Heat network for space heating supplied by central heat generators:		
	Payback period (years)	CO_2 reduction (ton CO_2/year)
Gas boilers	19	0
Gas CHPs	13	3.553
Wood CHPs and pellet boilers	20	15.763
B. Channel water loop + individual heat pumps for space heating & cooling		
	Payback period (years)	CO_2 reduction (ton CO_2/year)
	7	6.007

10.4.4.4 Challenges

While the installation of gas boilers is straightforward, the integration of CHP installations poses extra difficulties due to the required connection to the electrical grid. Also for the case of the water loop system some difficulties arise. If, in warm seasons, the channel water temperature is too high for space cooling, the water loop temperature could be lowered by means of a centralised compression chiller. When, in cold seasons, the channel and loop water temperatures approach zero degrees, the heat pumps must be stopped (to prevent freezing of the evaporator heat exchangers). Alternatively, the water temperature in The Loop could be increased by a centralised air source heat pump or another heat source. Moreover, the water loop option requires the installation of low temperature heating and high temperature cooling systems in all buildings involved.

10.4.4.5 Water loop detailed study

The channel water loop option has been studied in more detail in the framework of "Master plan sustainability The Loop" (study channel water, Technum 2013). The study included an economic feasibility analysis from the water loop developer's side, as well as from the side of the final costumer. It was concluded that the project is not economically interesting from developer's side, because investment costs are almost as high as for a regular heating network, while revenues are much lower. Indeed, tariffs for selling low temperature water (10°C) are almost six times lower than for high temperature water. For the end customer, this option is not financially attractive, as he needs to invest in an individual bivalent heat pump.

10.4.4.6 Further options to be analysed

An alternative option to simultaneously provide space heating and cooling is by means of shallow geothermal systems (see 6.5.3.2). These systems allow to store heat from space cooling during warmer seasons in the ground, in order to use it in colder seasons. Also a heat network fed by a collective CHP installation should be reinvestigated.

10.4.5 Evaluation

A major obstacle for the realization of collective energy production on The Loop is the large number of stake holders (different building owners) and the lack of a project coordinator with an overall view on the project. Another difficulty is the variability of the conditions for such collective projects. For example, the hospital of Maria Middelares, represents a large share of the energy demand for space heating and cooling on The Loop. However, the hospital recently opted for an individual energy system. As detailed feasibility studies require a significant amount of time and conditions may change in a short time period, developers tend to continue business as usual. The City of Ghent has only limited power in steering the development of privately owned business parks.

Phase 2 of the project will only be realised when an adequate mobility plan is developed and after a certain share of phase 1 is realised, which may take several years. This phasing in time hinders the development of collective energy production and heat networks.

10.4.6 Continuation

In 2013, the City of Ghent appointed a project coordinator for the development of The Loop. This will facilitate further efforts towards collective energy systems. The largest opportunities lie probably within the development of Field 12, which contains an outlet centre, a cinema, large retail and offices (see www.takeoff-offices.be).

10.5 Business park Roeselare West

10.5.1 Introduction

Wvi investigated the feasibility of extending the existing heat network in Roeselare to the new business park development Roeselare West nearby and additionally to a future housing development at greater distance.

10.5.2 Project description

The existing heat network (hot water) is fed with residual heat from the waste incinerator of the intercommunal waste management company MIROM. It has a length of 15 km and currently supplies heat at a temperature of 110°C to 22 public and commercial customers: swimming pool, hospital, cultural centre, apartment building, boarding school, new housing development with 100 units, 7 schools, 4 nursing homes, and 5 companies. The new business park Roeselare West, is adjacent to the heat network trajectory and has a total area of 18 ha. The newly planned 43 ha housing area is located 3 km to the north and will offer space to 1.000 housing units. A comprehensive overview of the project is presented in Fig. 83 and Fig. 84.

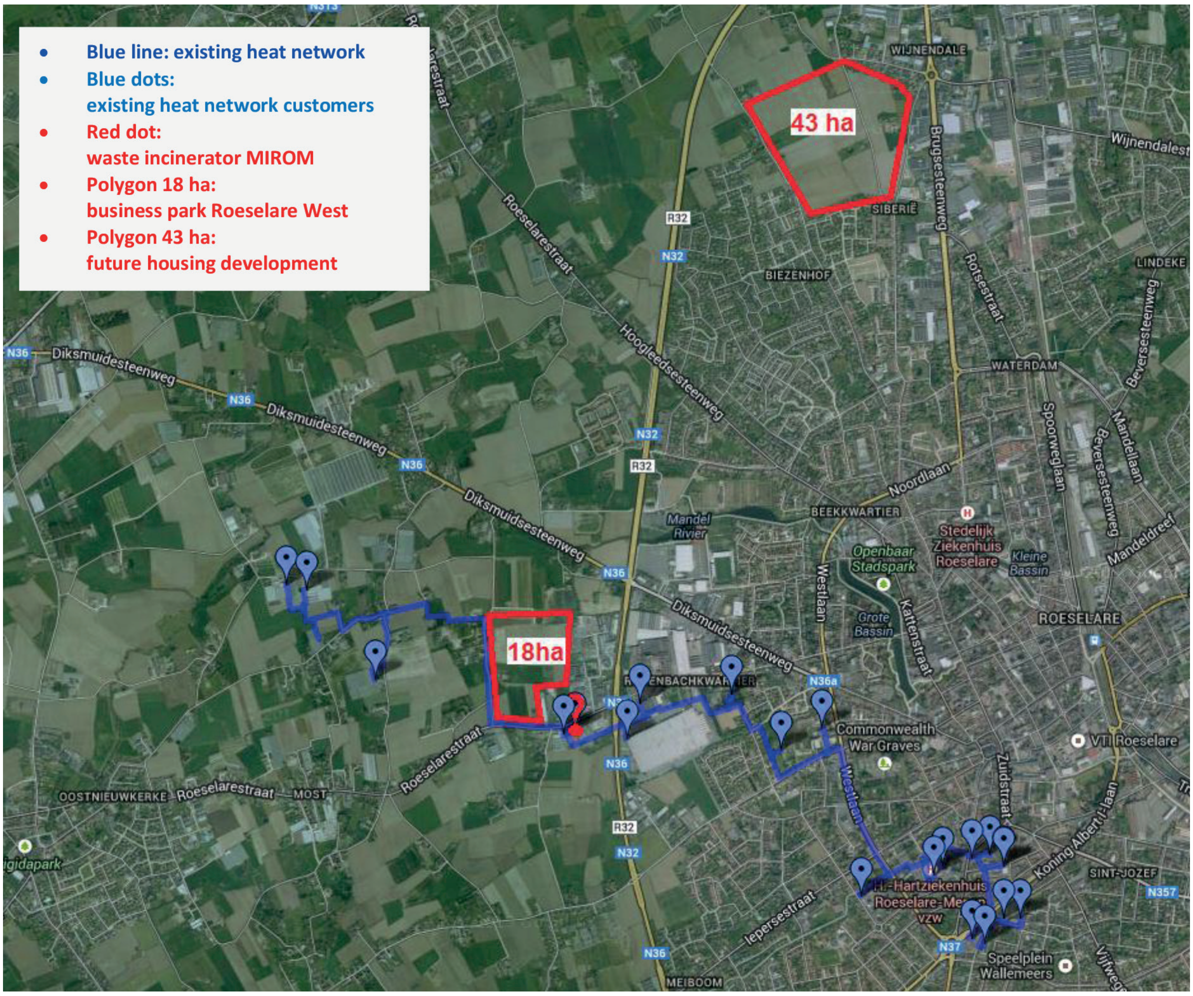


Fig. 83: Location existing heat network Roeselare, new business park Roeselare West and future housing development

10.5.3 Roeselare West

10.5.3.1 Business activities

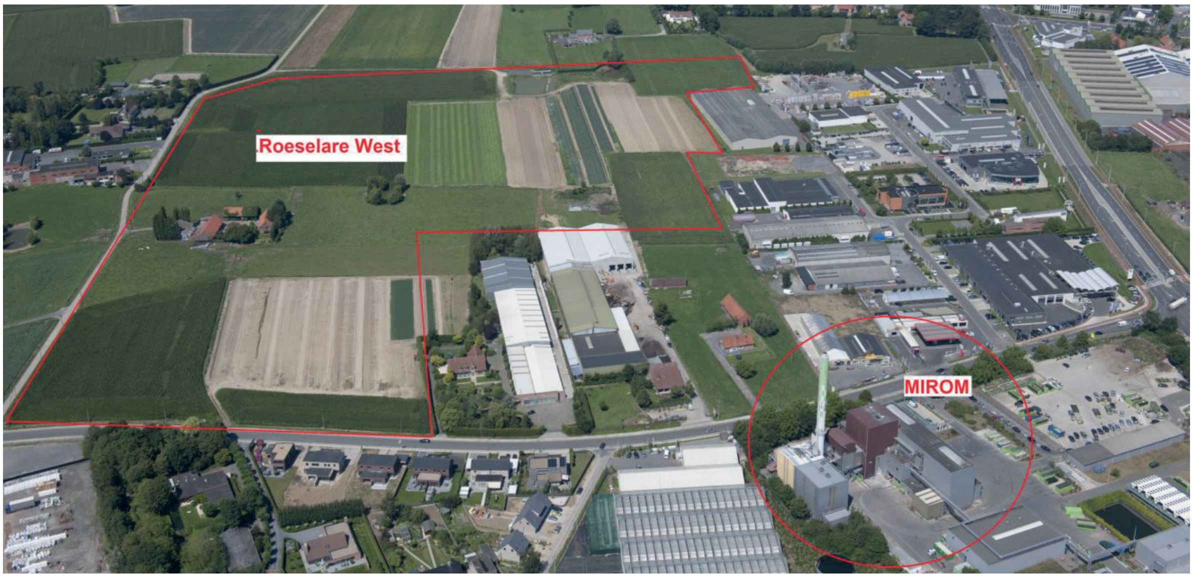


Fig. 84: Arial view business park Roeselare West and waste incinerator MIROM

Roeselare West is a mixed regional business park development dedicated to small, medium and large enterprises. The main business activities that are permitted include: production, storage and processing of products, energy production, and research and development. Fig. 85 provides a preliminary layout of the business lots and their sizes. The eventual layout, however, will be customized to the needs of the companies, in the course of the development process.

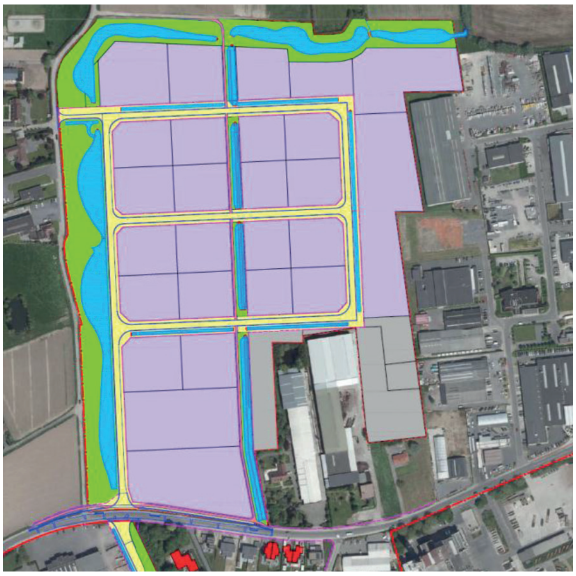


Fig. 85: Preliminary development plan Roeselare West

10.5.3.2 Heat demand

The candidate companies for buying lots on Roeselare West are listed in the wvi database. About half of them do not require any heat at all, while the other half requires heat for space heating. Only the catering company needs heat for its processes (cooking, baking) at temperatures of 180-220°C, which is higher than the supply temperature of the existing heat network. Additional heating could be supplied by a natural gas boiler or by an electric heater if no natural gas network is available. The latter could be the case if a heat network is opted for and if a gas network is not considered to be necessary on the site. In conclusion, at Roeselare West, the heat supplied by a heat network would primarily be used for space heating, with 1 company requiring higher temperatures for its processes.

10.5.3.3 Reduction of carbon emissions

Assuming that half of the businesses at Roeselare West (with a total heat demand of 620 MWh/year), will be connected to the heat network, and considering the use of waste heat as carbon neutral, the total emission reduction compared to BAU is estimated at 141ton CO_2 per year. In the business as usual (BAU) scenario, heat is generated by gas combustion with an efficiency of 11 kW/m³ gas and an emission rate of 2.5 kg CO_2/m³ gas

10.5.4 Economic feasibility heat network

10.5.4.1 Individual business perspective

Wvi analysed the economic feasibility of a heat network on business park Roeselare West, from individual business perspective. Therefore, the costs for connection to a heat network are compared to the costs for an individual gas boiler. The financial comparison is presented in Table 29 and cost savings related to the heat network are shown.

Table 29: Comparison individual costs in case of connection to district heating vs. costs of conventional system

	Natural gas		District heating			Cost savings
power	connection	installation	temp	connection	installation	district heating
50kW	€ 900	€ 7.000	85°C	€ 1.650	€ 3.100	€ 3.150
100kW	€ 1.050	€ 16.500	85°C 110°C	€ 2.100 € 2.550	€ 5.000 € 8.000	€ 10.450 € 7.000
200kW	€ 1.200	€ 30.000	110°C	€ 3.150	€ 13.000	€ 15.050

10.5.4.2 Heat network developer perspective

The investment costs for a heat network covering the entire business park will add up to around 1 million euro. Currently all possible funding channels are being researched. Operation and maintenance costs and the costs for a backup system should be further analysed.

It is not considered economically sound to install, by default, a heat network on a new business park, if it is not known a priori which companies will settle there, because:

- A large number of companies do not require heat.
- The installation costs of a heat network are 6 to 7 times higher than for a natural gas network.
- On industrial parks, a natural gas network often cannot completely be substituted by a heat network, as some companies might need heat at temperatures higher than the network's supply temperature. This heat could be generated by electric heaters, but this is 4 times more expensive than heat generation with gas boilers. So, even if a heat network is installed, a connection to the gas grid might still be necessary. Although, a wood or biomass boiler might offer a solution.

10.5.5 Evaluation

Strengths:

- MIROM has experience with district heating.
- The business park is adjacent to the main pipe of the existing heat network

Weaknesses:

- Company heat demands are not known a priori.
- Reserving the business park strictly for companies with a high heat demand is not possible under the city's spatial and economic policy.
- The current Flemish spatial economic policy still does not support heat networks, nor does it locate business parks nearby a potential waste heat source.

Opportunities:

- The connection of an individual company to the heat network is less expensive than to the natural gas grid.
- From 2014, construction permits for companies with integrated office or housing units require a minimum share of renewable energy production. This obligation can also be met by connecting to the district heating network.

Threats:

- The largest threat concerns the long term risk related to the continuity of the heat supply by the MIROM waste incinerator and the heat demanded by the companies.
- The majority of candidate companies in wvi's working area, are SMEs with little heat demand.

10.5.6 Continuation

Wvi is performing a detailed study together with MIROM to assess the feasibility of developing a heat network restricted to only part of business park Roeselare West. In the issuance phase, the list of candidate buyers will first be screened and filtered according to the requirements of the spatial economic policy of the city of Roeselare. Secondly, the heat demands of the selected companies will be analysed. Companies with a significant heat demand can then be located in the zone covered by the heat network. To enhance the feasibility of a heat network, Roeselare West will be promoted as a location for companies with large heat demands.

10.6 Greenhouse horticulture area Roeselare

10.6.1 Introduction

Wvi assessed the feasibility of using waste heat from the MIROM waste incinerator to fulfil space heating demands of the adjacent future greenhouse horticulture area.

10.6.2 Project description

The future greenhouse horticulture zone of 34 ha is located at a distance of merely 250 m of the waste incinerator of the intercommunal waste management company MIROM (see Fig. 83 and Fig. 86). The area is destined for the cultivation of energy-intensive crops, such as tomatoes, peppers, cucumbers, etc.

Assuming an annual specific heat demand of 450 kWh/m² to maintain the desired temperature for crop growth (e.g. tomatoes), and a net greenhouse area of 20 ha (= 200.000 m²), a total annual heat demand of 90.000 MWh is obtained. Likewise, considering an annual specific CO_2-demand of 35 kg/m² for crop fertilisation, the total annual CO_2-demand would be about 7000 ton.

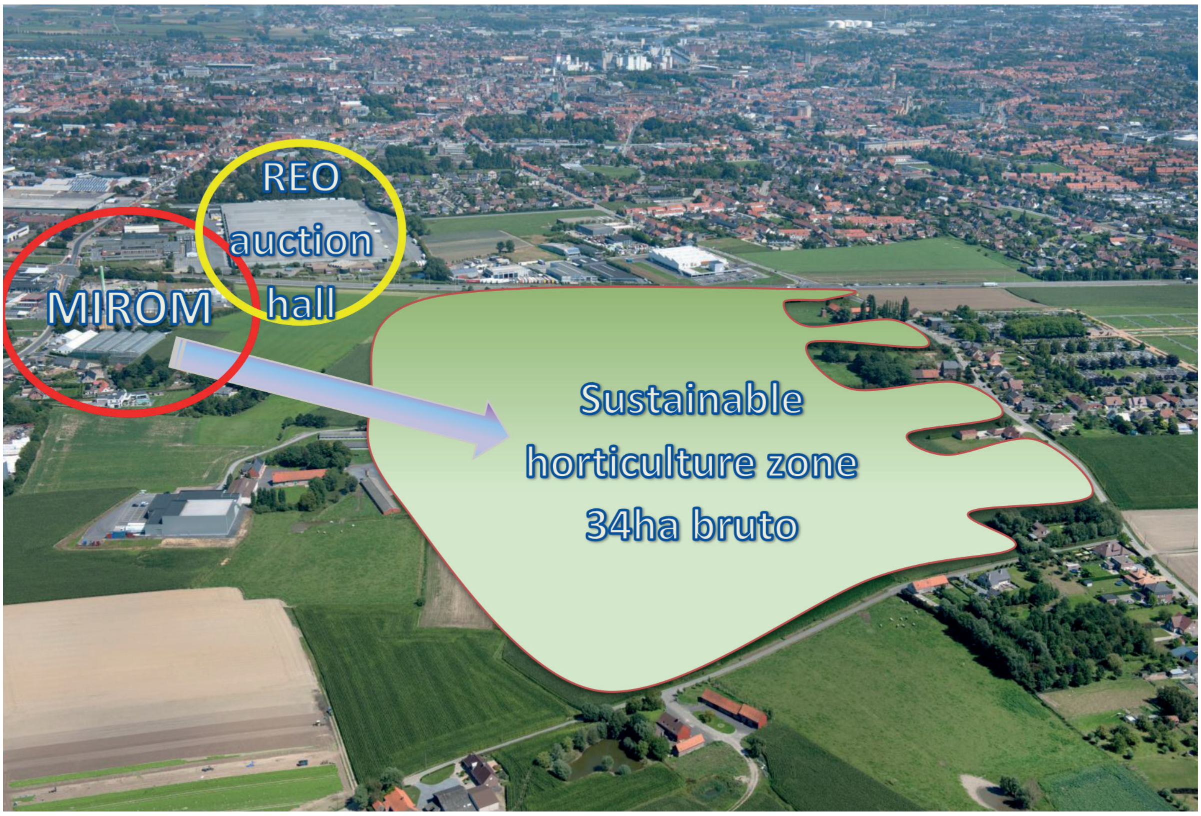


Fig. 86: Arial view of greenhouse horticulture area and MIROM waste incinerator

MIROM proposes to deliver low-temperature heat at 40° from the waste incinerator to the greenhouse horticulture area by means of a warm water loop. In periods of peak demand (e.g. in winter), if not enough waste heat is available, backup would be provided by a CHP installation on natural gas. The carbon dioxide resulting from combustion in this installation will be used for crop fertilisation. However, the CHP installation should best be dimensioned according to the CO_2-demand.

In Fig. 87 the annual shares of waste heat from MIROM (75%), and of heat generated by the CHP installation (25%) are compared. Part of the generated CHP heat (72%) corresponds to the CO_2 that is used in the greenhouses for crop fertilisation, while the remaining part (28%) is directly emitted without use.

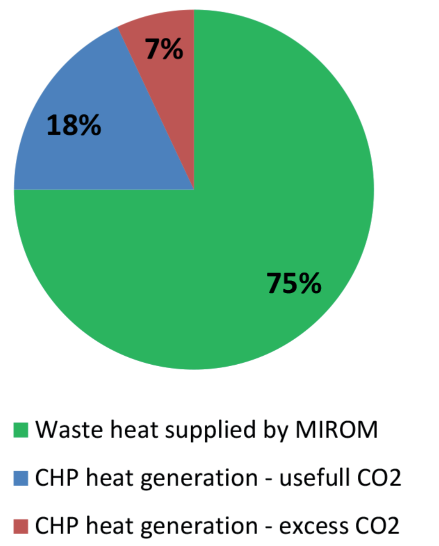


Fig. 87: Heat supply greenhouse area

10.6.3 Financial feasibility

Wvi will let the business lots based on a long lease instead of selling them. This issuance method ensures that this strategically located area will always be reserved for clustered, intensive greenhouse horticulture with heat supply from MIROM. Besides, leasing allows greenhouse companies to better spread investments in time.

A number of key aspects that influence the financial feasibility of this project have been identified:

- market conditions in horticulture (what are the costs of running a greenhouse company at other locations?)
- feasibility of waste heat delivery from the viewpoint of MIROM
- long term guarantee of a stable energy price
- advantageous scale effects connected to clustering
- costs of the lots
- costs of the park infrastructure (incl. archaeological research)

10.6.4 Evaluation and continuation

Additional financial support from the government is necessary to make this project feasible and competitive under the prevailing market conditions. At the moment, the use of renewable electricity and electricity from qualitative CHP is financially incentivised, but for the use of renewable or waste heat, no subsidy mechanisms are in place. MIROM converts waste heat into electricity by means of an Organic Rankine Cycle (ORC). As this type of energy production is financially supported, where the direct use of waste heat is not, a financial compensation to promote the use of waste heat over the production of electricity is necesarry. In cooperation with the steering committee, the potential subsidy channels are being mapped.

10.7 Waste heat map and calculation model for heat networks

10.7.1 Introduction

Wvi developed a heat map that inventories sources of waste heat in its working area in order to detect energy clustering opportunities for planned developments in the near future. In addition, a basic spreadsheet model has been developed to assess the feasibility of heat networks starting from a known (waste) heat source. The combination of these instruments allows to quickly evaluate the feasibility of a heat network for each new business park.

10.7.2 Project description

10.7.2.1 Waste heat map

For the development of the waste heat map, initially 157 existing companies with possible waste heat potential have been taken into account. 47 of these companies are located nearby a new wvi business park development. During a telephone survey 17 of them declared to effectively have waste heat available. Eventually, 8 companies were selected for an in-depth individual interview. The remainder of the companies will be analysed in the framework of other projects and there waste heat potentials can be added to the heat map in a later phase.

The companies identified as waste heat sources are, next to waste management companies, mainly those included in the Emission Trading System (EU-ETS, see 2.4.3) or covered by the Energy Policy Agreements (see 5.4.5). Companies identified as heat sinks have significant space heating or process heating demands (industrial laundries, coating companies, etc.)

Fig. 88 and Fig. 89 provide an overall and a zoomed in snapshot of the heat map, showing the 157 companies included in the study. Green dots indicate companies with waste heat potential, red dots indicate companies with no waste heat potential, and orange dots indicate companies with waste heat potential that have not been included in the study.

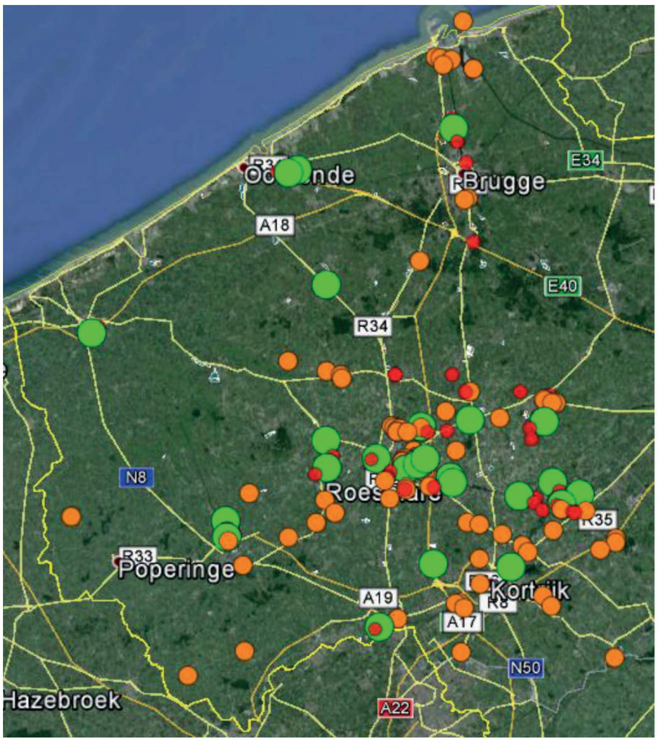


Fig. 88: Waste heat map

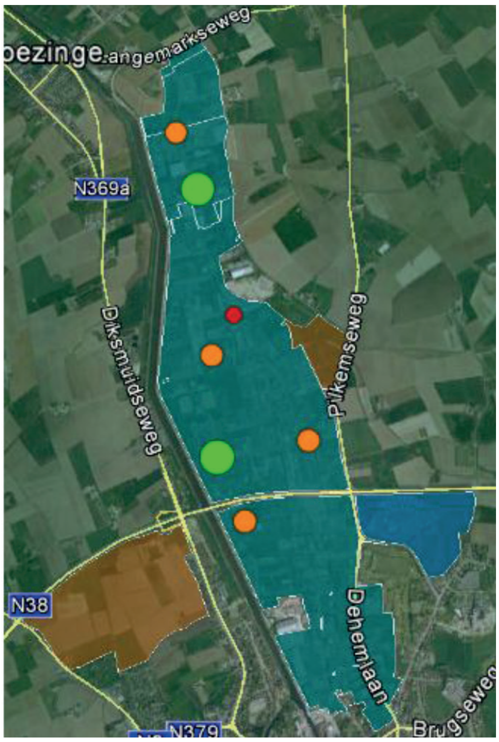


Fig. 89: Waste heat map detail

10.7.2.2 Heat network calculation tool

The tool is able to calculate the financial feasibility of heat networks on new business park developments. It takes into account the heat availability of a local heat source and the space or process heating demands of companies that will settle there. The tool is also applicable to existing business parks. In this case, possible costs for reparation of road infrastructure need to be included.

10.7.2.3 Methodology

Wvi takes up a role as facilitator for the realisation of heat networks at its new development sites (business parks, housing developments,...) using the heat map and the heat network calculation tool:

- The waste heat map is used to identify which new wvi sites are close to waste heat sources.
- Next, the feasibility of a heat network at such a site is analysed with the calculation tool
- If the realisation of a heat network is feasible, all possible funding channels at European and Flemish level are screened. Also potential partnerships with municipalities, distribution grid operators and waste heat suppliers are analysed. They may or may not lead to co-financing.

Besides for new wvi business parks, also for existing ones, opportunities for participation in heat networks may arise, when e.g. linked to a new development nearby (business park, housing area). However, this may require cooperation with other partners, such as the Provincial Development Corporation (POM), or distribution grid operators. In this case wvi strongly requests to be involved, to be able to evaluate its possible role.

10.7.2.4 Environmental impact

If heat demands on a business park would be completely fulfilled via a heat network connected to a renewable or waste heat source, the heat supply on the business park could be considered carbon neutral. However, in most cases a backup system is required at peak demands or when no waste heat is available. Often, a gas boiler or CHP is used as backup, because it can be easily dispatched.

10.7.2.5 Costs

The cost of developing the heat map was about 30.000 EUR (VAT incl.). The calculation model was developed for an economical price of 7.000 EUR (VAT incl.), as this was part of a joint study towards the feasibility of a new heat network in Ostend and the extension of an existing one in Bruges (POM West Flanders –Eco2Profit).

10.7.3 Evaluation

From studies with the heat network calculation tool, it was learnt that the magnitude of the heat demand is a key factor for the feasibility of a heat network. It must be large enough to ensure that revenues from selling heat are larger than the annualized investment costs and the operation and maintenance costs of the heat network. Wvi concludes that developing a heat network is only feasible at a demanded heat load of 2MW/km and an annual heat demand of 2 GWh/km.

10.7.4 Continuation

Besides being a useful tool for wvi, the heat map can also serve as a communication tool for parties (policy makers, municipalities, companies) with waste heat and parties with heat demand. The heat map inventories opportunities and keeps track of which have been investigated (leading to a successful business plan or not). The heat map is continuously updated with new heat demands and will in a later phase also be available to other partners.

10.8 Site of Sugar Factory Veurne

10.8.1 Introduction

In Veurne, the "Sugar Factory" brownfield is being redeveloped by wvi. The feasibility of a heat network for the new residential area and the potential feed-in of waste heat from companies on the adjacent "Veurne Industrial Park 1" has been investigated

10.8.2 Site description

Since the Sugar Factory (see Fig. 90) closed end 2005, the 48 ha terrain has not been used and is degenerating. Within the project Manage+ a redevelopment master plan has been prepared, reorganising the area in a residential, a recreational, a green and a business zone (see Fig. 92). The residential area of 13,5 ha will be developed in two phases (5 ha in 2015 and 8.5 ha in 2017), with a minimum housing density of 25 houses per ha. The new business area will take up 8.6 ha, offering space to about 14 companies. It is adjacent to the existing business park Veurne Industrial park I and will be reserved for regional companies. This new business park will be developed in two equally sized phases in 2016 and 2020.

Fig. 90: The historic Sugar Factory in Veurne

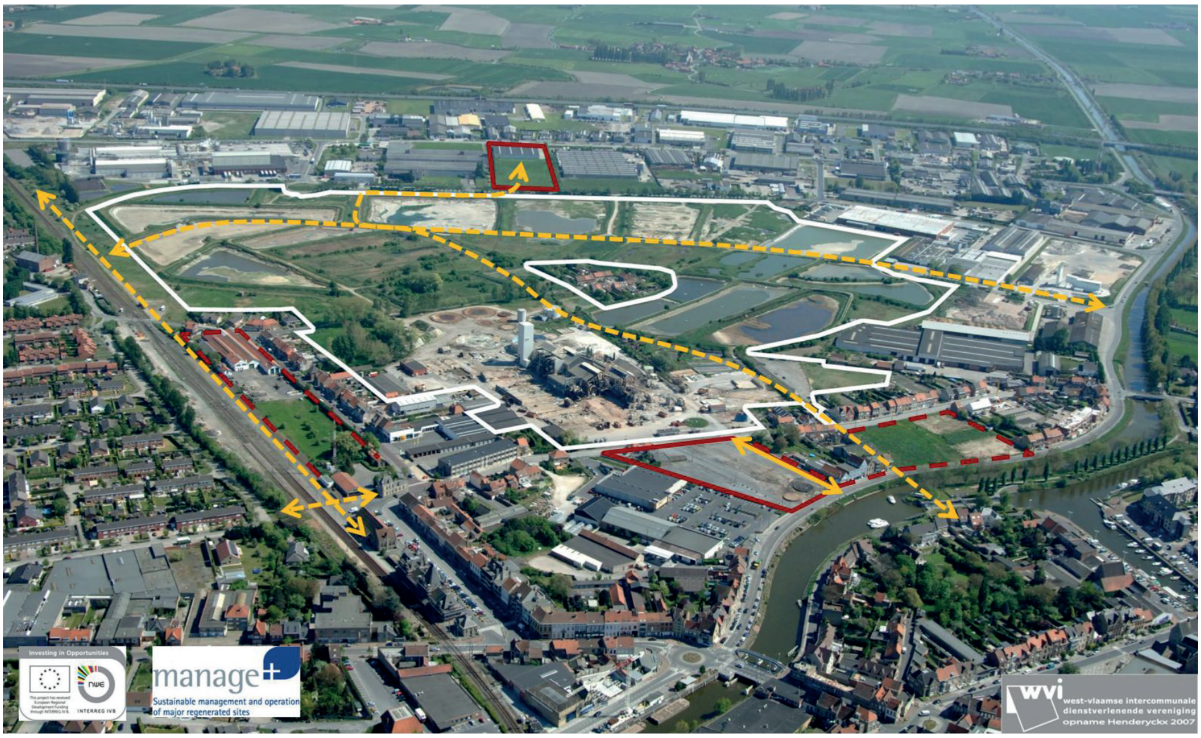


Fig. 91: Arial view of Sugar Factory brownfield

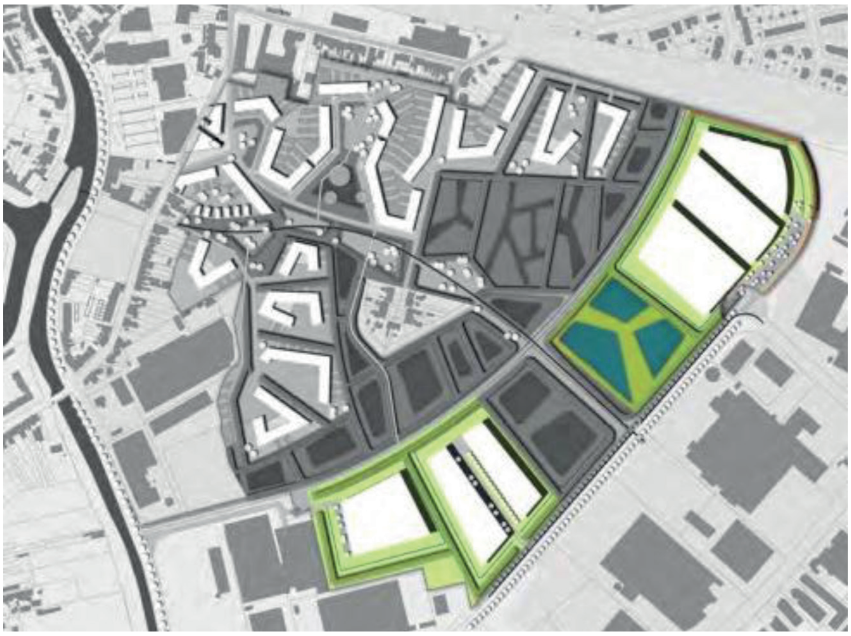


Fig. 92: Master plan redevelopment Sugar Factory brownfield

10.8.3 Energy consumption

The energy consumption of the new business park and the new housing area is estimated by the consultancy company 3e, based on projected building standards (see Table 30). The joint annual heating demand for the housing and business area is 4.424 MWh (phase 1 and 2).

Table 30: Space heating demand on business park and housing area Sugar Factory site

	13.5 ha	Phase 1 - 5 ha		Phase 2 - 8.5 ha		
Houses		**house**	**apartment**	**house**	**apartment**	**office**
space heating	kWh/m²/y	32	9	20	9	20
hot water	kWh/unit/y	2.967	2.967	2.967	2.967	0
total heat demand	MWh/y	972		2.002		
		2.974 for phase 1 and 2				

	8.6 ha	Phase 1 - 4.3 ha	Phase 2 - 4.3 ha
Companies		offices	offices
space heating offices	kWh/m²/y	40	20
total heat demand	MWh/y	min. 850 - max. 1.650	min. 600 - max. 1.200
		min. 1.450 – max. 2.850 for phase 1 and 2	

10.8.4 Low carbon energy production

During the first phase of the study, the waste heat potential at Veurne Industrial Park I was inventoried. Only two companies have available waste heat: company A produces food and drinks and company B processes by-products from the food industry. Company A has an available waste heat load of 1000 kW at a temperature of 40°C, which is too low for feeding a heat network. Company B does not apply waste heat recovery on its flue gasses and consequently, a heat load of 300 kW at 80°C is available. As the company's working schedule will be intensified from 5 to 6 days a week, even more waste heat will become available. In conclusion, only company B is a possible waste heat supplier for the heat network and is currently able to deliver heat during 5 days of the week.

In a second phase, the feasibility of a heat network that would provide space heating in the residential area of the Sugar Factory site has been studied. This network would be fed with waste heat from company B (base load), complemented by a gas boiler.

In the business as usual scenario, space heating for all housing units on the new site is provided by means of individual natural gas boilers (η=90%). This corresponds to a primary energy consumption of 2.974/0.9 = 3.304 MWh/year, and CO_2 emissions of 667 ton/year.

In the heat network scenario, the primary energy consumption is 2.911 MWh/year, corresponding to 588 ton CO_2/year. This implicates a primary energy saving of 393 MWh/year and an emission reduction of 79 ton CO_2/year (assuming 0,202 ton CO_2/MWh natural gas).

Table 31: Primary energy consumption and carbon emissions

	Primary energy consumption	Primary energy savings	CO_2-emissions*	CO_2-emission* reductions
Scenario BAU	3.304		667	
Heat network	2.911	399	588	79

*0,202 ton CO_2/MWh natural gas

10.8.5 Economic feasibility heat network

A financial analysis has been performed (see Table 32)

Table 32: Economic feasibility heat network

Total costs over a period of 20 years		Heat network
costs electricity	€	308.877
revenues electricity	€	-
costs gas	€	2.234.612
revenues heat	€	4.000.887
costs waste heat	€	377.531
revenues use heat network*	€	1.941.540
maintenance costs	€	620.479
revenues CHP certificates	€	-
operation costs	€	356.151
total operational revenues	€	2.044.776
total investment costs	€	1.759.529
avoided investments	€	190.560
connection charge	€	114.934
cashflow	€	590.740
NPV	**€**	**451.474**
IRR before taxes	**%**	**+3,22**
Optimisations		
Shorter transport grid & boiler closer	NPV	365.790 €
	IRR	3,90 %

*a one-off connection + the fixed rights for the use of the heat network over a 20 year period.

10.8.6 Evaluation

Strengths:

- The overall efficiency of a heat network can be improved by replacing or upgrading only the centralised heat generator or source, whereas the efficiency upgrade of all individual boilers and equipment in case of decentralised heat production is more time consuming.
- Waste heat is available within an acceptable distance of the heat network.

Weaknesses:

- Current and future building legislation imposes gradually reducing bounds to space heating demands. As a result, a heat network at the new residential area at the Sugar Factory site has a relatively low heat density (annual heat demand per m), which is disadvantageous for its economic feasibility.

Opportunities:

- Due to its size in comparison to the residential nucleus of Veurne, the Sugar Factory brownfield redevelopment will have an impact on the city. It is wvi's responsibility to turn this project into an example of liveability, comfort, sustainability and low-energy living and working. The installation of a heat network contributes to this objective.
- The project timing is favourable, because other cities are setting up similar project developments and experience can be shared.
- Since 2012, the obligation of providing access to the gas grid for every house has been cancelled, provided that the house is enclosed by a heat network.

The distribution grid operators Eandis and Infrax have recently decided to invest in heat networks, if the economic feasibility is guaranteed. They will be only involved in the construction of the heat network (tubing, sub-stations, individual heat exchangers), but not in the exploitation.

Threats:

- The rollout of a heat network requires decisions in an early phase of the project. The choice between an individual or a collective concept for space heating and sanitary water heating has an impact on the design of the housing units and companies. Also, it affects various steps in the development, starting from the application for the allotment permit (whether or not a natural gas network is necessary). On the other hand, the decision can only be made if the cost-effectiveness is ensured and if all stakeholders agree.
- The parties involved in the construction of a gas grid are known and experienced. However, this is not the case for the construction of a heat network.

10.8.7 Continuation

It was found that, even though more stringent energetic performance requirements for buildings lower the heat density of a possible heat network, it can still be economically viable if the project size is large enough. Yet, the economic feasibility of the project must be increased by applying for Flemish (strategic ecology support) or European subsidies. At the end of 2013, the distribution grid operator was contacted and is currently screening the heat network project (it will probably be positively evaluated).

10.9 Business model for collective renewable energy production

10.9.1 Introduction

Wvi develops low carbon business parks on which businesses are bound to carbon neutral electricity consumption (see 3.6 and 3.7).

Wvi wishes to facilitate business investments in collective renewable energy production. Therefore, a study has been commissioned to develop a business model for collective renewable energy production on business parks. The study takes into account legal, technical and economic aspects, and the municipalities covered by wvi and the province of West-Flanders should be able to participate.

10.9.2 Test case Sappenleen

The expansion (30 ha) of the existing business park Sappenleen (75 ha) in Poperinge serves as a test case. Four wind turbines with axis height 100 m, rotor diameter 92,5 m and nominal power 2,05 MW have been built, two within the business park extension and two on the adjacent agricultural zone (see Fig. 93). Their joint annual green electricity production is estimated at 23.3 GWh, which is sufficient to cover the electricity demand of the 100 businesses located within the existing business park.

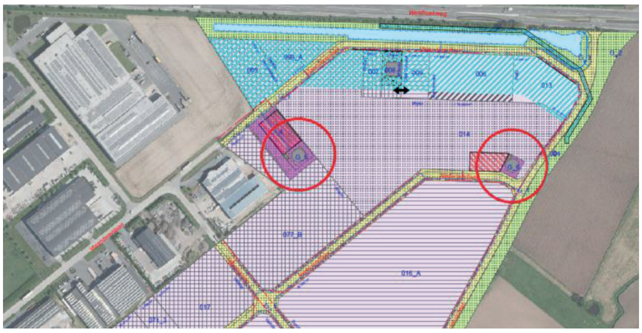


Fig. 93: 2 wind turbines on business park expansion Sappenleen

10.9.3 Business model

Different Belgian business structures are analysed within the study and advantages and disadvantages are identified (see Fig. 94). The most appropriate structure for all partners to work together is an affiliation of an autonomic company of one municipality or an affiliation of an autonomic company of the province.

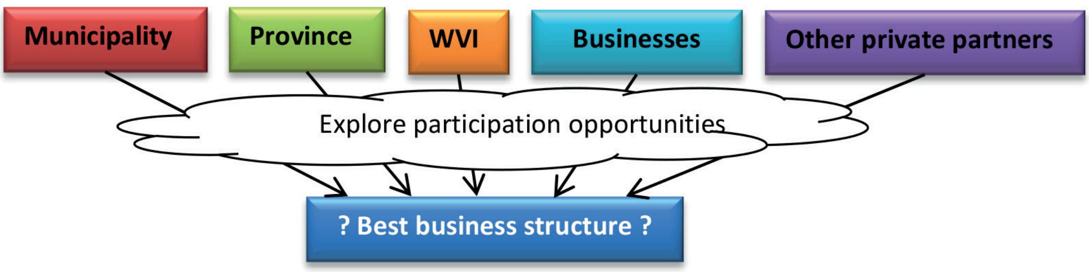


Fig. 94: Search for best business structure

The most appropriate legal corporate structure depends on the aim of the corporation (see also 7.5) and the role of its participants (see Fig. 95):

- Participation in renewable energy production and delivery (single, double or multiple structures)
- Participation in renewable energy production
- Participation in renewable energy delivery

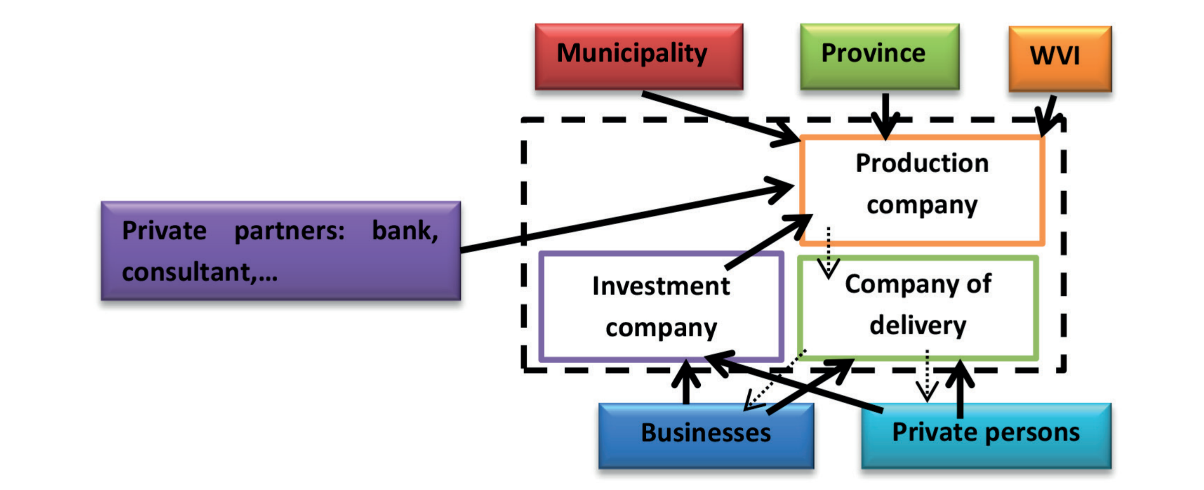


Fig. 95: Legal corporate structure collective renewable energy production

10.9.4 Financial feasibility

Table 33 gives an indication of costs and revenues generated by the 4 wind turbines at business park Sappenleen. In Flanders, subsidies for green electricity production by wind turbines are based on a complex formula in order to only subsidise the unprofitable part of the investment (see 6.9.2).

Table 33: Economic feasibility renewable energy production at Sappenleen

business case 20 years	best case	worst case
cost turbines*	€ 16.000.000	€ 16.000.000
maintenance costs per year	€ 200.000	€ 200.000
management, insurance and other costs per year	€ 145.000	€ 145.000
compensation fee ground occupation per year	€ 40.000	€ 40.000
loan cost (20 years 3-5%)	€ 5.100.000	€ 8.500.000
costs over 20 years	€ 21.485.000	€ 24.885.000
yearly production (MWh)	23.300	23.300
income of electricity sales (/MWh)	€ 50 + 2%/year	€ 50 + 0,5%/year
revenue in 20 years	€ 28.306.436	€ 24.440.669
profit after 20 years	**€ 6.821.436**	**€ - 444.331**

*incl. grid connection, building and electricity costs and consultant en engineering costs

10.9.5 Evaluation

Wvi decided not to invest by itself in wind energy (4 turbines) on business park Sappenleen. Instead, investments are made by EGPF WWE (Electrabel Green Projects Flanders Wind Werkt Echt), a private partner in which Poperinge municipality participates.

10.9.6 Continuation

Wvi will screen its future developments for renewable energy production opportunities. Once opportunities are detected the role of wvi as facilitator or participant will be evaluated.

10.10 Electrical charging stations

10.10.1 Introduction

In order to assess the economic feasibility of public charging stations for electric vehicles on its business parks wvi performed a market study.

10.10.2 Market study

The following companies are included in the **Belgian market** survey: Becharged, Nsolar, eNovates and Blue corner. Becharged develops its own aluminium charging poles and communication software, but in the future this will be done by two separate subsidiary companies. NSolar distributes the charging stations of GE Industrial Solutions. eNovates and Blue Corner are two subsidiary companies, of which the first one develops charging stations and software, and the second one is the service provider. Becharged and eNovates offer web-based, and NSolar stand-alone charging stations.

Electric charging infrastructure can be categorised according to the type of vehicles to be charged: bicycles and scooters, or cars.

10.10.2.1 Charging stations for electric bicycles and scooters

Electric bicycles can be charged via a standard power socket and plug, analogous to other electricity consuming equipment. Charging stations with multiple charging points are available on the market. Free electric bicycle charging can be offered to the public by municipalities or distribution grid operators or by companies to their staff.

10.10.2.2 Charging stations for electric cars

Charging stations for electric cars are more complex than for bicycles and different types and capacities are available. Generally, a charging station consists of a pole with two power plugs for two parking spaces, which can be single- or three phased, with a nominal current of 16A or 32A. Charging time depends on available power and car type.

Both **stand-alone** and **web-based** electrical charging stations are available. Stand-alone systems can be used for the charging of a company's electric fleet. Such a system can only be accessed with special charging cards handed out by the company itself, and is not available to the public. Web-based systems are more expensive to invest in than stand-alone systems. Moreover, the owner has to pay a yearly fee in order to get access to a charging station network (180-300 €/year). The user can buy charging time via one of the available networks, similar to mobile phone networks. If the charging station is connected to a different network as the user, the user needs to pay additional "roaming" costs. The owner of the charging station can also choose for payment with text message, which involves additional costs for the user (0,25 €/message), or for payment with bank-card. The last option is not economically attractive, because of the high monthly fee and transaction costs for the owner. To connect the charging station to the internet, a GPRS-connection (3G) can be used, which costs 5€/month (per SIM card).

10.10.3 Environmental impact

The reduction of carbon emissions caused by replacing the traditional fossil fuel driven car with the electrical car is a point of discussion. When only direct emissions are taken into account, the electrical car is carbon neutral, whereas the new traditional cars emits 100-150 g CO_2/km and some eco-models, hybrid models or models on compressed natural gas emit less than 100 g CO_2/km.

In case of the electric car, emissions are generated at the stage of electricity production. Assuming that the overall carbon intensity of electricity generation in Belgium is 220g CO_2/kWh (IEA, 2012) Table 1), and that an electrical car consumes between 0,15-0,3 kWh/km, the related carbon emissions amount 33-66 gCO_2/km.

The carbon intensity of electricity generation by gas-fired power plants and CHPs in Belgium is about 400 gCO_2/kWh (IEA, 2012). Based on this value, an electrical car emits 60-120 gCO_2/km.

10.10.4 Test case Veurne

The feasibility of charging stations for the collective company building in Veurne (Belgium) has been evaluated. The business park comprises mainly small companies with activities in construction, car service, sales and assembly and metal works.

10.10.5 Evaluation

To charge a company's electric vehicle fleet, stand-alone charging systems are best suited. For public places, a publically accessible web-based charging station is the best option. Availability of power supply and connection to the internet are required to avoid additional costs. Wvi will not install electric charging infrastructure, but can provide public parking spaces and take up the role of facilitator if companies are interested to invest.

10.10.6 Continuation

Due to the freeze of fiscal benefits in Belgium for private persons buying electrical vehicles, the demand has strongly decreased.

10.10.7 References

IEA 2012. CO_2 Emissions from Fuel Combustion Highlights - 2012 Edition.

10.11 Business park De Spie

10.11.1 Introduction

Wvi investigated how carbon neutrality principles could be incorporated in the design of new business parks. The study starts from the potential of local renewable energy production on the business park itself and the opportunities for energy exchange with the surrounding area. The new to develop business park De Spie in Brugge is taken as a test case.

10.11.2 Site description

Fig. 96: Location of De Spie

Fig. 97: Aerial view new development business park De Spie (source: wvi)

De Spie is a new to develop regional business park in the north of Brugge (see Fig. 96). It is a wedge-shaped area enclosed by the national road N31 in the north, the railroad to Zeebrugge in the east, and the railway to Blankenberge in the west (see Fig. 97). The area connects to the western part of the Port of Zeebrugge and the existing business parks Blauwe Toren and Herdersbrug. Given its location, De Spie is primarily suited for medium to large companies requiring lots of more than 5.000 m². From the total area of 42 ha, only about 30 ha can be used because of its inconvenient shape. According to the spatial implementation plan following economic activities are permitted: production, storage and processing of products, energy production, research and development, storage and transhipment, stock management, groupage, physical distribution and retail, waste processing (including recycling), processing and treatment of manure and silt, processing and treatment of resources including minerals. A possible layout of business park De Spie is presented in Fig. 98. The actual business lots will be determined in the issuance phase, customised to the need of the companies that want to settle here.

Fig. 98: layout proposition for business park De Spie (source: wvi)

10.11.3 Low carbon energy production

In cooperation with Power-Link, wvi performed a study to identify which technologies can contribute to carbon neutrality on business park De Spie and the implications thereof on its spatial layout.

Solar Energy: The potential of solar energy can be exploited at company level by means of roof-mounted photovoltaic and thermal solar panels or foils. An optimal orientation of the company roofs and a well-chosen layout of the business park will avoid shadow and will maximise electricity yield.

Wind energy: The practical potential of wind energy on business park De Spie has been studied. Possible locations for large wind turbines were identified, taking into account the spatial constraints related to housing, natural reserves, infrastructure and pipe networks (see Fig. 99). Moreover, also small or medium turbines can be installed, preferably at the west border of the park.

Fig. 99: Proposition layout wind turbines with axis height 90 m (source: wvi)

Fig. 100: Existing heat network Brugge (source: POM West-Vlaanderen)

Cogeneration: For the carbon neutral generation of electricity and heat a biomass driven CHP installation is an interesting option. It is still to be determined which partner could initiate such project.

Geothermal energy: The study showed that the underground is unsuitable for heat-cold storage, but the implementation of Borehole Energy Storage or energy poles is possible.

Heating and cooling with surface water: Heat could be extracted from the water buffers that are planned on the business park or from the Lisseweegse Vaart to provide space heating and cooling in companies. Moreover, the lots adjacent to the water buffers could be reserved for datacentres, which need significant space cooling.

Energy storage: The electricity grid in the region of De Spie suffers from congestion problems. As a result, in the past a biomass processing plant could not be established there, because it would have caused an overload of the local network. To cope with this problem, a project is running to extend the capacity of the electricity grid between Zomergem and Zeebrugge and on De Spie a lot for a transformer substation is reserved. This grid reinforcement will allow electricity producing companies to settle on De Spie.

Heat network: In case a biomass fuelled cogeneration plant would be installed on De Spie or on an adjacent business park, it is recommended to connect it to the existing heat network of Brugge. As the connection is at the south of the business park, companies with large heat demands should be concentrated there. The spatial plan of De Spie should provide the space needed for the realisation of a heat network. Additionally, If excess heat could not be fed to the heat network, it can be converted into electricity by an ORC (Organic Rankine Cycle).

Mobility: As De Spie is enclosed by railway tracks, companies with a potential for railroad transport of their resources or products could be encouraged to settle there. However, the railway infrastructure managing company still needs to be consulted about the possibilities thereof. Furthermore, to boost the transition from fossil fuels to hydrogen and biogas for transportation, a Greenpoint could be installed.

Energy efficiency: Wvi will promote and support the construction of sustainable and energy efficient buildings in the issuance phase. In the exploitation phase, opportunities for energy clustering will be investigated (see 7).

10.11.4 Economic feasibility

The economic feasibility of a heating network on a business park has been described in 10.4. When the destination and further development of the business park becomes more concrete, potential subsidy channels need to be analysed.

10.11.5 Evaluation

Low carbon energy production can be facilitated by smart spatial design of the business park. Spaces need to be reserved for wind turbines, geothermal installations, CHP installations, a heat network, etc. Also attached building and optimal building orientation need to be stimulated in the building and spatial planning prescriptions. This project indicates the importance of mapping the energy potentials of the business park and its surroundings, starting from the business park energy system superstructure described in 4.2.

10.11.6 Continuation

Wvi will keep its focus on opportunities towards carbon neutrality throughout the development of business park De Spie and, where possible, take up a role as facilitator or manager.

10.12 Shared company building Veurne

10.12.1 Introduction

In Veurne, a new business park for local companies will be developed, next to the existing business park "Industrieterrein II". Wvi carried out a study to identify which low carbon energy measures could be integrated in the design of shared company buildings on the business park.

10.12.2 Site description

The new to develop business park is located in the northwest of Veurne, adjacent to the existing business park "Industrieterrein II" (see Fig. 101). The park is destined for local companies with a maximum lot size of 5000 m² (see Fig. 102). In order to use the available space as efficient as possible and to offer a solution for companies with a limited need for space, two shared company buildings are constructed (see Fig. 103). The first one is situated along the Pannestraat and is reserved for businesses with offices, show rooms or housing units, that require a qualitative outside view. The second one is located on the inside of the business park and is reserved for businesses with storage or work space that do not have specific requirements in terms of view quality.

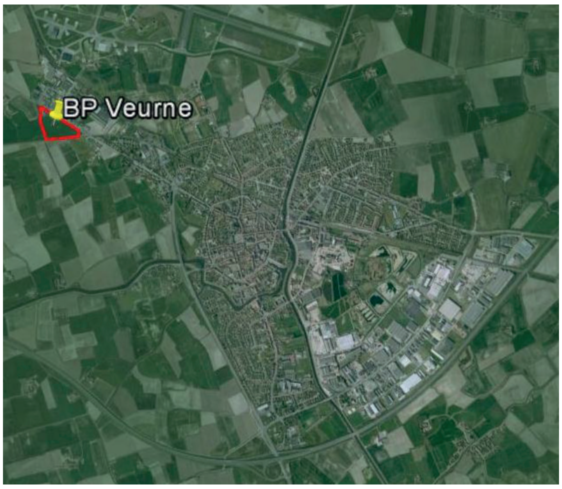


Fig. 101: Location new businesspark Veurne

Fig. 102: Arial view new business park and adjacent existing business park "Industrieterrein II" in Veurne

According to the spatial implementation plan, the following main economic activities are permitted: manufacturing, workshop, storage, wholesale and car repair. Additionally, company-related housing units or sales rooms with a limited surface can be allowed. However, commercial functions and retail and also office-only buildings or autonomous public restaurants are not permitted.

Fig. 103: Two shared company buildings on new to develop business park Veurne

10.12.3 Energy consumption

In order to reduce the building envelope area through which heat can be exchanged with the outside, the building modules are coupled. More specifically, for the semi-detached modules (at both ends) the heat loss area is lowered by 18%, whereas for the terraced (enclosed) ones, it is reduced by 31%. This results in a decreased space heating demand. The space heating demand of a building module can be estimated with following formula:

$$Q_{space\ heating} = U_{average} \times A_{heat\ loss} \times N_{dd} \times 24h$$

with:

$Q_{space\ heating}$	annual space heating demand [kWh]
$U_{average}$	average heat transfer coefficient [W/m²/K]
$A_{heat\ loss}$	heat loss area [m²]
N_{dd}	annual number of degree days [K]

A degree day is the positive difference between a fixed reference temperature and the average outside temperature of a certain day. This reference temperature T_{ref} marks the outside temperature below which space heating is required and depends on the required inside temperature (T_{ref}: 16,5°C for offices and houses, 13°C for workshops, 3°C for frost protection) Degree days are summed over all days of the year, resulting in the annual number of degree days. In Table 34, the annual space heating demand for a terraced (enclosed) module is calculated. This calculation does not take into account potential heat gains (e.g. from engines, lighting, etc.), nor potential heat losses (e.g. from ventilation, open gates, etc.).

Table 34: Calculation annual space heating demand 1terraced building module

Module parameters		Module space heating demand		
$U_{average}$	0,5 W/(m².K)	T_{ref}	kWh	kWh/m²
$A_{heat\ loss}$	794 m²	16,5°C	24.094	89
N_{dd} (2012) 16,5°C	2327 K	13°C	14.775	55
N_{dd} (2012) 13°C	1427 K	3°C	1.595	6
N_{dd} (2012) 3°C	154 K			
A_{floor}	265 m²			

10.12.4 Low carbon energy production

Ground source heat pump: Shallow geothermal energy can be used to provide low carbon space heating. Such an installation consists of vertical or horizontal ground heat exchangers, connected to a heat pump (water/water) that raises the temperature level of the extracted heat. Subsequently, this low-temperature heat is supplied to radiators in offices and radiating panels in work spaces and halls. The boreholes that need to be drilled for the realisation of the vertical ground heat exchangers are costly. In this project, 3 boreholes per building module are required. Vertical heat exchangers could also be integrated into the pile foundation of the shared company buildings, but the pile length (12 m) is not enough to extract a sufficient amount of heat.

Air source heat pump: In heating mode, an air source heat pump (air/air) extracts heat from the outside air and lifts it to a higher temperature level in order to heat up the indoor air. In cooling mode, the operation is reversed, so that heat from the indoor air is extracted, lifted to a higher temperature, and transferred to the outside air. Such system enables fast space heating or cooling. For the offices, a collective system could be designed. For industrial halls, the ventilation system and the heat pump could be integrated.

Condensing boiler on natural gas: Space heating in offices could also be provided by a condensing boiler on natural gas that supplies heat to radiators or to a floor heating system. Industrial halls can be heated with radiating panels connected to the centralised boiler, or alternatively by autonomous condensing air heaters. In industrial halls, floor heating might be inadequate because of large floor surfaces and the required flexibility towards changes in economic activities. The combination of a condensing boilers with a low temperature heating system does not reduce gas consumption. However, it facilitates the transition to low carbon technologies that generate heat at lower temperatures (solar boiler, ground source heat pump or heat network).

Photovoltaic solar panels: The roof of each building unit of the shared company building offers space for the installation of a 5kWpeak PV system.

10.12.5 Economic feasibility

Table 35 presents an economic comparison between a natural gas condensing boiler and a ground source heat pump with a heat load capacity of 10 kW. The difference in investment costs between the heat pump and the natural gas boiler is recovered by the savings in annual energy costs. The payback period is 25 years when the heat pump is driven by imported electricity from the grid and is 11 years when the heat pump runs on electricity generated by the local PV system. Heat pumps are subsidised by the Flemish government via the Ecology Premium (see 2.6.1) and by premiums issued by the distribution network operator. However, in this cost calculation, subsidies are not taken into consideration due to the current rapid evolution.

Table 35: Economic comparison heat pump and natural gas boiler

	Natural gas boiler	Heat pump (COP 4,4)	Difference	Payback period
Equipment	€ 3.700	€ 8.000		
Borehole		€ 7.000		
Natural gas hook-up	€ 2.150			
Total investment costs	€ 5.850	€ 15.000	€ + 9.150	
Annual energy consumption	24.000 kWh natural gas	5.459 kWh electricity		
Without PV				
Unit cost energy	0,0527 €/kWh	0,165 €/kWh (1)		
Annual energy costs	€ 1.265	€ 900	€ - 365	25 years
With PV				
Unit cost energy	0,0527 €/kWh	0,08 €/kWh (2)		
Annual energy costs	€ 1.265	€ 437	€ - 828	11 years

(1): 50% peak hours: 0,2 €/kWh, 50% off-peak hours: 0,13 €/kWh
(2): 0,08 €/kWh (investment € 7.900 over 20 years)

10.12.6 Evaluation

Due to the necessary flexibility towards the activities of companies that will settle in the shared company buildings, it is difficult to a priori fix a space heating system. As an example, floor heating might be inadequate for storage or cooling rooms. Therefore, wvi decided not to invest in a space heating system (individual or collective). However, wvi will install a 5kWp PV system on the roof of each building unit of the shared building along the Pannestraat.

The payback period of a ground source heat pump system in comparison with a traditional condensing boiler system is quite long. When cheap electricity is available, e.g. from an own PV installation, the payback time is shortened. Of course the investment in the PV installation has to be taken into account.

10.12.7 Continuation

If the business activities and the corresponding space heating demands of the companies that will settle in the shared buildings are known, wvi could install a collective heating installation.

10.13 Supporting businesses on low carbon business parks

10.13.1 Introduction

Wvi offers free guidance about energy efficiency in design, construction and exploitation of company buildings to all businesses settled on its low carbon business parks.

10.13.2 Low carbon business parks

Wvi develops low carbon business parks on which businesses need to ensure carbon neutral electricity consumption (see 3.6 and 3.7). Businesses settled on these business parks are offered free guidance concerning energy efficient design, construction and exploitation of their company buildings. An extensive list of energy efficiency measures is given in 5.4.1. With its low carbon strategy, wvi aims to increase the consumption and production of renewable energy on its business parks, promote sustainable building practise and detect opportunities for energy clustering (see 7) in an early phase, while at the same time lowering the energy bill.

Most of the business parks that are being developed by wvi (see Fig. 104) carry the label low carbon and nine of them are in the issuance phase. Four low carbon developments are regional business parks destined for companies requiring lots larger than 5000 m², one is reserved for car service and retail, and the rest are smaller business parks for SMEs needing lots below 5.000 m².

	Municipality	Business park
A	Alveringem	Hofstede
B	Brugge	Kazerne Lissewege
C	Ieper	Pilkem L.O.
D	Ingelmunster	Zandberg
E	Izegem	Autohandelzone
F	Koekelare	Ten Barne
G	Ledegem	Vierschaere Fase 3
H	Lichtervelde	Stegen Akker
I	Middelkerke	Kalkaert
J	Moorslede	AZ Uitbreiding
K	Oostrozebeke	De Gouden Appel
L	Pittem	Pittem L.O.
M	Poperinge	Sappenleen uitbr. III
N	Roeselare	West
O	Torhout	Torhout Noord Zone E
P	Veurne	Industrieterrein II (Slableedstraat)
Q	Zedelgem	Aartrijkestraat

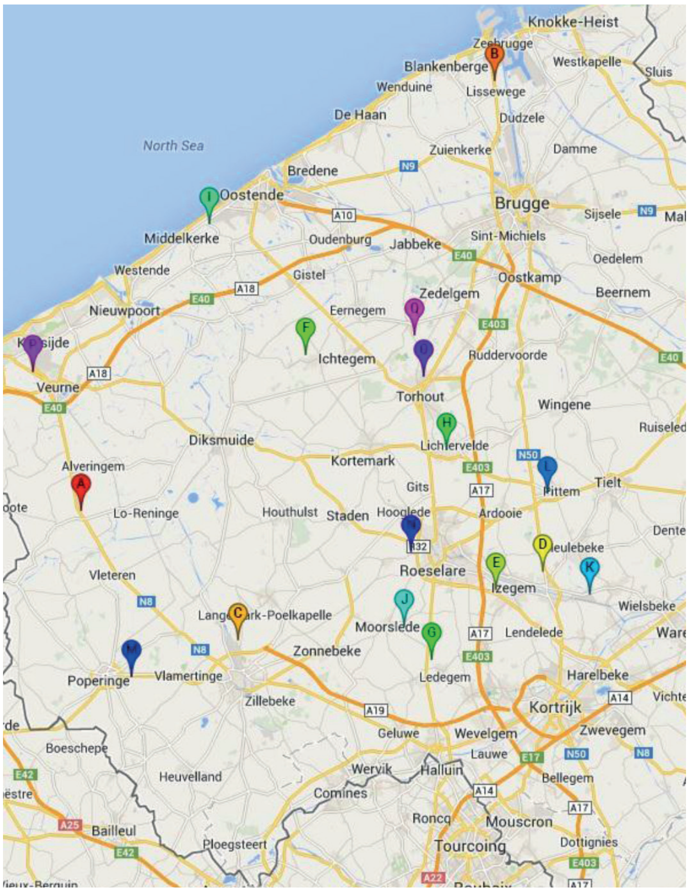


Fig. 104: Overview low carbon business park developments of wvi

10.13.3 Evaluation

Advice about energy efficient building practice is the most efficient when it is custom-tailored to the companies. wvi offers assistance to business in finding subsidies, applying for environmental permits, and finding experts.

10.13.4 Continuation

The companies will be surveyed to measure whether they are satisfied with the guidance offered, and whether they implemented the proposed energy measures. A website is under construction, which will provide information about energy efficient building practise.

10.14 Heat network industrial park "2 Synthe"

ECOPAL investigated the feasibility of waste heat exchange via a heat network on the industrial site "2 Synthe", in cooperation with the local authorities, the local business club and companies, ADEME, etc. Heat demands and waste heat availabilities on the site have been inventoried. Additional aims were to sensitise companies towards a sustainable Dunkirk region and to support companies in managing their energy costs.

The study identified the location of companies with waste heat availability and of companies with waste heat demand. The results were integrated into the plans for a district heating network in the city of Dunkirk (see Fig. 105). From the 160 companies located in the industrial zone, 35 show potential to participate in the heat network. 21 of these companies represent a total waste heat potential of 148.283 MWh per year and a final energy demand (mainly electricity) of 330.000 MWh per year.

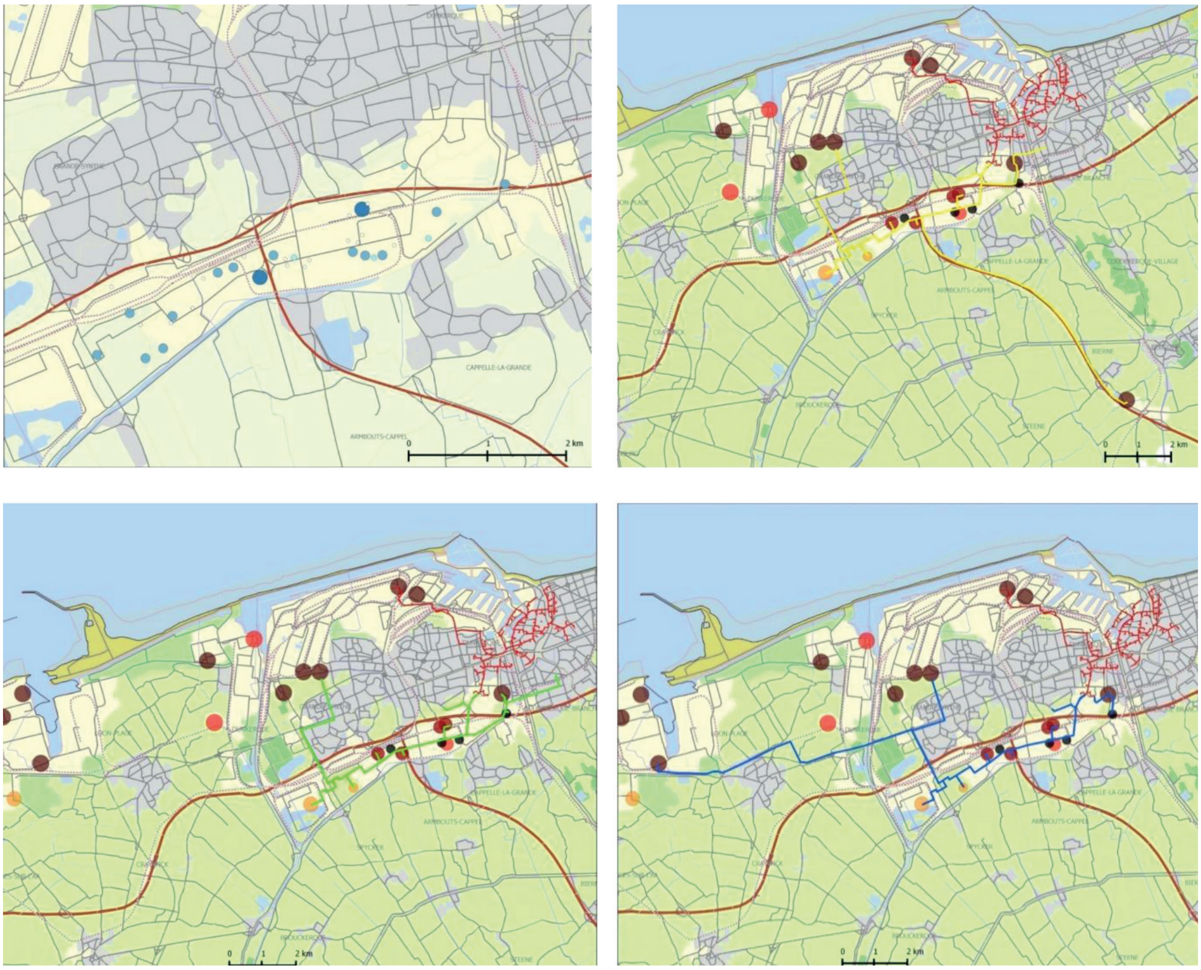


Fig. 105: Industrial zone 2 Synthe and 3 variants of heat network layouts

10.15 Collective waste collection and substitution

10.15.1 Introduction

Since 2001 Ecopal aims at establishing closed loops in the resource streams of the Dunkirk region. The activity area of ECOPAL is shown in Fig. 106. During the ACE project, the organisation has incited companies in its network to exchange information about their energy, resource, and water flows. Starting from this flow inventory, opportunities for industrial ecology between companies are identified, in terms of recovery and reuse of waste heat, waste, by-products or waste water, and clustering of services. The aim is to save energy and resources and to reduce both costs and environmental impacts.

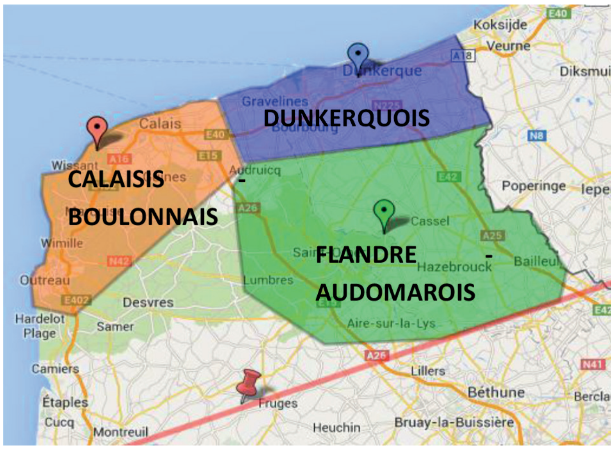


Fig. 106: Activity area ECOPAL

ECOPAL's member base comprises

- 30% very small businesses (restaurant, engineering, garage, construction, retail)
- 62% SMEs (steel processing, food, mechanical workshop)
- 5% large companies (steel production, refinery, power generation)
- 3% private persons

Firstly, ECOPAL organises clustering of services for companies, such as waste collection. Secondly, the focus is on substitution of primary by secondary resource streams (waste or by-products), substitution of fresh water by waste water, and substitution of fossil fuel combustion by waste combustion or use of waste heat When waste streams and by-products are reintegrated in the local system, the need for primary resources and the emissions related to extraction and transport thereof are avoided. Also the costs for treatment of the waste streams or by-products are decreased or avoided.

10.15.2 Collective waste collection

The collective collection of empty ink cartridges is taken as an example of service clustering. As a result of the lower number of vehicle-kilometres, the consumption of fossil fuels and related carbon emission are reduced compared to the situation where each company organises its own waste transport (see Table 36). For all collective waste collection projects, Table 37 summarises the CO_2 savings related to reduction of transport distance and the cost savings of collective collection compared to individual collection by waste management companies.

Table 36: CO_2 savings from collective collection of empty ink cartridge

	Feb.	April	June	Sept.	Oct.	Dec.	Total
Participants	11	9	9	7	9	11	56
Individual waste disposal							
km to waste disposal	1991	1629	1629	1267	1629	1991	10136
Collective waste collection							
km actually driven	211	205	205	200	205	211	1237
km avoided	1780	1424	1424	1067	1424	1780	8899
Tons of waste	0,46	0,5	0,3	0,36	0,22	0,26	2,1
km. x ton avoided	819	712	427	384	313	463	18688
kg CO_2/km/ton							0,175
ton CO_2 avoided							3,270

Table 37: CO_2 savings ECOPAL collective waste collection projects						
Waste type	**Waste company**	**# companies**	**Ton CO_2 avoided**	**# collections**	**Tons collected**	**Cost savings**
Paper, carton, plastic films	Baudelet	32	10,52	24	43	22.494
Paper	Veolia	43	8,07	12	18	9.832
Carton, plastic films	Veolia	74	9,39	24	82	49.727
Confidential archives	Van Ganse-winkel	21	5,31	6	16	1.630
DEEE	Envie2E	18	1,86	4	15	3.000
Hazardous waste	Chimirec Norec	46	5,39	12	66	11.727
Batteries & accumulators	-	42	-	12	1	-
Ink cartridges	Eeko	47	3,27	6	105	418
Oil separators	Astradec	8	0,92	2	20	2.230

10.15.3 Substitution of primary resources by secondary streams

Companies can substitute primary resources with waste or by-products originating from its own processes or from other companies and fossil fuels by waste or waste heat. ECOPAL has started an inventory of all in and outgoing material flows within the Dunkirk industrial area to identify opportunities for developing synergy projects.

A synergy between the steel company Arcelor Mittal and the cargo handling company Sea-bulk is taken as an example of resource substitution. Sea-bulk organises the delivery of iron ore and coal to Arcelor Mittal and consequently both companies have a strong historic relationship. The waste resulting from maintenance of Sea-bulk's infrastructure (roads, quays, conveyors,…) contains coal and various minerals, which can be used in the sinter process at Arcelor. However, to prevent distortions in the sinter process this waste stream needs to be pre-treated first in a homogenisation installation at the steel company. Due to the good relationship between the two companies, this synergy has been realised very quickly.

ECOPAL established a barter system in which companies can announce a request for or offer of materials (pallets, pallet spacers, wooden boxes, straps, battens) and equipment each month.

10.15.4 Evaluation

ECOPAL successfully facilitates the realisation of industrial symbiosis, due to the geographical proximity to its members, good contact with local stakeholders and knowledge of the area. Difficulties to establish synergies are given by technical barriers, such as large variation in waste types, small quantities and discontinuity of certain waste streams. The approach generates reductions in both costs and environmental impact of industry, and triggers economic development (new skills, techniques, technologies, processes, R&D). Also the development of new financial aids for industrial investments is promoted. By effectively realising profitable long-term synergies between companies, the idea of industrial symbiosis is promoted.

10.15.5 Continuation

ECOPAL continues its material stream inventory and synergy projects, and seeks to extend the approach over its entire working area and beyond.

10.16 Theaklen Drive Refurbishment Project

10.16.1 Introduction

HBC identified and evaluated the best low carbon energy measures for refurbishing four industrial units at Theaklen Drive in Ponswood Industrial Estate. This project can serve as a pilot for the modernisation and energy efficiency upgrade of the 62 industrial buildings of Ponswood industrial estate (see Fig. 107).

10.16.2 Site description

The Theaklen Drive Unit (ca. 1400m²) was built in 1989 and over its lifetime has accommodated a variety of tenants ranging from furniture storage to its current use as a motor repair garage. Langley Garage currently occupies three of the buildings, while the remaining unit is vacant. The building is a single detached rectangular 'Flex Building', constructed from steel portal frames with profile metal sheet sandwich cladding panels and glass quilt insulation (see Fig. 108). The concrete floor slabs were not insulated and the roof had a single ply PVC membrane roof finish with a suspected (not surveyed) 30-50mm polystyrene insulation layer. The units were lit by aluminium framed single glazed windows and by 48 polycarbonate rooflights. Roof membrane and rooflights were at the end of their serviceable life expectancy.

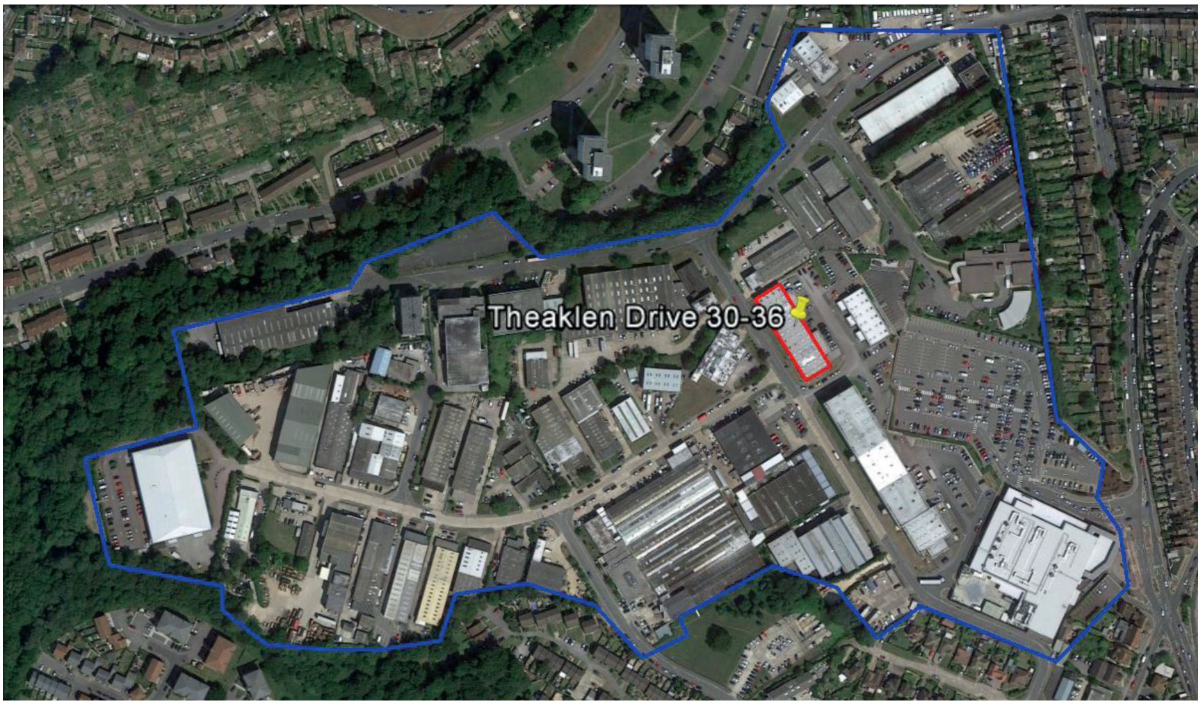


Fig. 107: Location 30 – 36 Theaklen Drive, Ponswood Industrial Estate, UK (2013)

Fig. 108: Location 30 – 36 Theaklen Drive, Ponswood Industrial Estate, UK (2013)

10.16.3 Low carbon measures

A study carried out by BBM Sustainable Design Limited (Dip Arch RIBA Ian McKay) identified energy measures that provide a good trade-off between CO_2 emission reductions and investment costs. Based on this, a top five of energy measures is set up. Following the Trias Energetica strategy (see 3.3), measures that reduce energy demand were investigated prior to renewable energy production.

1. Roof insulation:

Due to the size of industrial buildings, the roof corresponds to a significantly larger heat loss surface than the walls. Moreover, hot air accumulates below the roof as it rises inside the building. Therefore, to decrease heat losses a well-insulated roof is of paramount importance. In the constructional design of older industrial units little or no insulation has been included. As a consequence changes to the parapets and up stands might be required to fit in the roof insulation. At the same time, the weathering membrane should be replaced.

2. Wall insulation

Beside the roof, the exterior walls of industrial buildings are responsible for a significant part of heat loss to the environment (see Fig. 109). Many construction techniques use quilt insulation between profiled metal sandwich panels, which is prone to slumping. This problem can be detected by a thermal imaging camera, but results should be interpreted carefully, as the reflectance of the cladding may cause some disturbance. New deep fixing systems allow for the construction of wider cladding sections so that insulation thickness can be increased, while slumping is prevented. For buildings or building parts exposed to sunshine, space heating demands can be reduced by about 20% by applying metal profiled cladding systems with integrated air channels. Direct solar irradiation preheats the air in the corrugations, which is taken in by the ventilation system. The upgrade or replacement of insulation could be synchronised with the replacement of the wall cladding at the end of its lifetime.

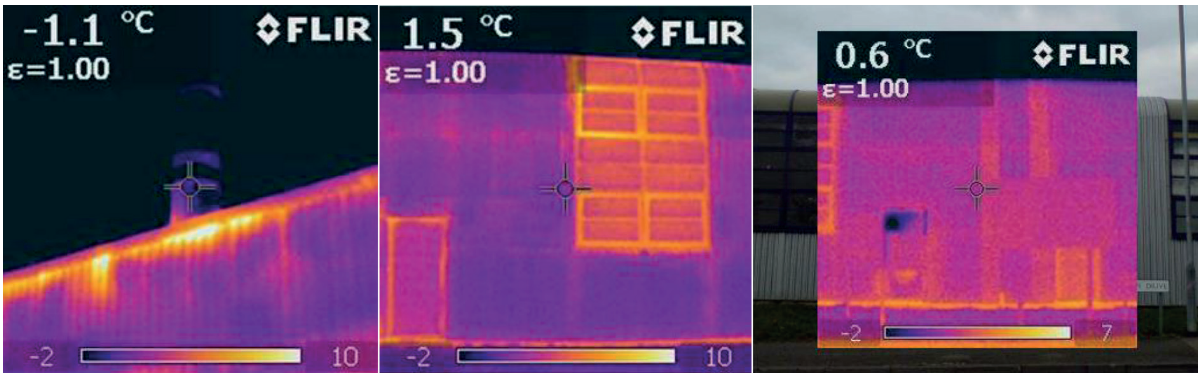


Fig. 109: Heat loss images at 34 Theaklen Drive

3. Upgrade perimeter insulation

Due to the large floor surface in industrial buildings, insulation of the entire floor is expensive. However, heat loss via the ground bearing floor slab is concentrated in a 2 m wide zone along its perimeter (see Fig. 108). As a result, heat loss can be significantly reduced by vertically insulating the outer border of the floor slab or the external wall plinth such that a thermal break is made. The insulated plinth can be taken into the ground and terminated at the top of the foundation.

4. Upgrade windows and doors

For industrial buildings the contribution of window and door area to the total heat loss area of the building envelope is significantly smaller than for residential buildings. Consequently, the relative reduction of heat demand resulting from replacing single by double glazed windows and installing insulated doors will be smaller for industrial than for residential units. When replacing doors and windows the air tightness at the junctions should be improved e.g. by means of adhesive tapes and mastics.

5. Upgrade roof lights

Many industrial halls are equipped with low quality polycarbonate roof lights. They offer poor thermal insulation and over time their transparency is deteriorated by UV-light. New light tube technologies and improved glazing material enhance daylight penetration and reduce the need for artificial lighting (see 5.4.1).

6. Additional energy measures

Additional energy measures are the application of radiant space heating systems instead of convection based ones (see 5.4.1), relighting and daylight steered artificial lighting (see 5.4.1), solar PV panels for electricity generation and solar thermal panels for hot sanitary water (see 6.5.1).

10.16.4 Economic feasibility

Refurbishment of the existing Theaklen Drive building was preferred over constructing a similar new one, as this would cost between £1.2m to £1.7m. The project was completed in February 2014 and received £450 000 of investment from the Council and EFRO. The implemented energy measures include: installation of solar tubes, rapid roll doors and double glazed doors and windows, roof and perimeter plinth insulation, roof structure reinforcement for PV, and office relighting. An overall efficiency improvement of 28% is expected, resulting in reduced energy bills. Moreover, the lifetime of these industrial units is extended by another 25 years.

The installation of PV systems would have approximately cost £15,000. However due to current feed in tariff schemes it was estimated that the yield from a £15,000 PV array on building unit 30 would be 3,648kWh/year. Based on a generational tariff of 13.9p/kWh the annual return would be £863, resulting in a payback period of approximately 17 years. Therefore it was decided to only make the roof PV ready to keep future options open for either landlord or tenant.

10.16.5 Evaluation

As a landlord, HBC is under pressure to lease the units in order to secure on-going revenue. As a result the realisation of the project depended on the willingness of the tenant to cooperate in a low carbon refurbishment. At the same time, this was also the key to success.

The choice between refurbishment and new build is central to this project and the decision depends on the return on investment (ROI). In this case, the analysis showed that the cost of eco-refurbishing units 30-36 at a cost of €5.5K and extending their life-time by a further 25 years produced an economic saving of €1 Million. In addition, the construction time and embodied carbon for refurbishment is significantly lower than for new build. Moreover tenants can be retained.

There is a need to build mutual benefits to reduce carbon emissions for both tenant and landlord. For this project HBC (the landlord) and Langley's (the tenant) understood that energy efficiency and waste management would have direct economic savings to the business and therefore increase the profitability and sustainability of the business ensuring continued and secure revenue for HBC.

10.16.6 Continuation

The impacts of the proposed works will be considered in the *Answers to the Carbon Economy – for the Theaklen Drive Refurbishment Project. Hastings Borough Council – Business Case: Part two (June 2014).*

Annex

Fig. 110 shows the different steps of the auditing process (Office of Energy Efficiency of Natural Resources Canada, 2002).

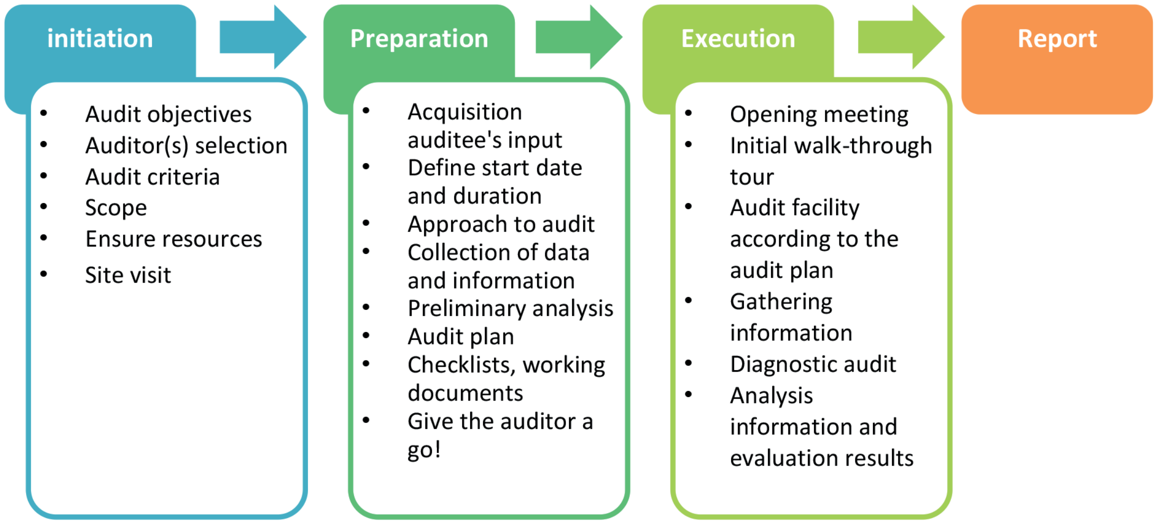


Fig. 110:Flow chart energy audit

1. Audit initiation

- **Performing an energy audit**
  In this early phase, it is important to prioritise facilities within the company for the energy audit. This can be done according to the energy consumption per problem area or per unit floor area.

- **Audit objectives**
  Objectives can range from identifying and qualifying energy losses through the building, follow-up the compliance with internal energy management policies to outline opportunities for energy efficiency.

- **Auditor(s) selection**
  The auditor will guide the audit in the determination of the audit scope and criteria and other audit preparations.

- **Audit criteria**
  The criteria of the energy audit includes the determination of policies, practices, procedures or requirements against which the auditor compares the collected audit evidence about the state of the energy system in the organization. The requirements may include standards, guidelines, specific organisational requirements and legal or regulatory requirements.

- **Scope**
  The scope describes the system's boundary of the physical location and organisational activities. It includes any energy-consuming building, processes and sub-processes, number of pieces of equipment or individual piece of equipment, etc.

- **Ensure resources**
  The allocation of resources should be consistent with its objectives and scope, including:
  ✓ access to the involved facilities, personnel and all relevant information
  ✓ records as requested by the auditor;
  ✓ facilitation of measurements and data collection;
  ✓ informing the auditor about the organization's safety and other requirements and potential risks

- **Site visit**
  A site visit gives a clear picture of the respective facility and the scope. Furthermore, issues may be clarified, resources can be identified and secured and adjustments to the planned audit scope, date and duration may be made.

2. Audit preparation

- **Acquire the auditee's input**
  Several relevant issues need to be clearly communicated, such as the scope of the audit, the proposed methodology and other tasks. Furthermore, information regarding areas of concern that need priority attention needs to be requested.

- **Commencement date and estimated duration**

- **Approach to the audit**
  The energy audit can be purely intended to outline potential energy management opportunities (EMO) or it can also be a more detailed, specific analysis to confirm and quantify the opportunities.

- **Collecting data and information**
  Energy flow data and other information of energy-consuming units within the boundary has to be collected. Starting with the verification of energy bills, gathering production and weather records, insight in historical information of different energy flows within the facility can be obtained. Additional, historical data can be supplemented with locally generated energy consumption data by direct measurement. In order to provide a reliable basis from which future energy consumption must be monitored, the data must represent the current activities of the facility. Besides energy flow data, information such as plans, drawings and switchboard panel schemes can be useful to locate energy-using units.

- **Preliminary analysis**
  In this phase, the alignment of the utility data with the facility operational information is carried out and the main areas of energy consumption will be identified. A work plan for gathering information of the audit site, and analysing the data and the delivery of an audit report will be established.
  After all, the energy balance of the facility can be plotted which gives the possibility to recognise areas where energy is consumed most and subareas to screen closely during subsequent phases of the energy audit.

- **Audit plan**
  An audit plan is a well-defined document, yet flexible enough for changes caused by unexpected information and unexpected circumstances. An energy audit plan contains:
  ✓ details of the organisational and functional units to be audited (including contact information)
  ✓ where and when the audit will be conducted
  ✓ audit objectives and criteria
  ✓ audit scope
  ✓ identification of high priority audit elements
  ✓ the timetable with the expected time and duration for major audit activities
  ✓ names of audit team members
  ✓ confidentiality requirements
  ✓ the format of the audit report, expected date of delivery and distribution

- **Checklists and working documents**
  The purpose of a checklist is to guide systematically the auditor and encourages the following energy audit steps:
  ✓ inventory of the existing measurement and control instruments
  ✓ investigate the function of the energy performance of the various systems and processes
  ✓ inventory of the missing information and the steps to be taken
  ✓ list of upgrades that would be useful and help the estimate costs
  ✓ estimation of the energy savings

- **Give the auditor a go!**
  When the three following essential conditions for conducting an audit are present:
  ✓ adequate resources are available
  ✓ sufficient information is available
  ✓ auditee's cooperation is secured

3. Perform the energy audit

- **Opening meeting**

- **Initial walk-through tour**

- **Audit facility according to the audit plan**

- **Gathering information**
  Both the supply and the consumption data can be extracted of determined based on billing information, hourly information received from the network operator, additional measurements, data from previous years, etc [www.ict4saveenergy.eu/wp-content/uploads/2011/12/save-energy-d23-energy-audit-methodologies-and-procedures.pdf)].

Energy and water supply
Collecting, tabulating and graphing information of the supply of energy and water:
✓ heat supply (district heat, oil boiler, natural gas boiler, etc.)
✓ rating of heating source (ordered power/ordered water flow, boiler effect, volume/power of electric storage heating, etc.)
✓ owner of the electricity network and the transfer or distribution costs
✓ supplier of electricity and the type of selling tariff
✓ electricity supply to tenants
✓ capacity of the power connection
✓ for water, the supply of water and waste water treatment

Energy and water consumption
Collecting, tabulating and graphing information of the consumption of energy and water:

Heat
✓ annual heat consumption compared with the average specific consumptions of similar buildings
✓ calculating the distribution of heat consumption for the normalised consumption of the previous year
✓ distributed heat consumption can be divided by heating, ventilation and domestic hot water
✓ heat energy charges of the building are divided into the basic charge and the energy charge

Electricity
✓ annual consumption of electricity compared with average specific consumptions of similar buildings
✓ calculating the distribution of electricity consumption by department within the facility, for example lighting, production, storage facility, offices and administration, etc.
✓ annual electricity consumption, divided by appliance group, can be divided into monthly and day/night consumptions so that the comparisons of annual costs of alternative tariffs can be made
✓ determining the peak power need of the building for the comparison of tariffs and for the estimated distribution of electricity consumption by appliance group
✓ electrical load variations are studied
✓ electricity charges from the previous year are presented and are divided into components according to the used tariffs (transfer/selling)

- ✓ ***Water***
- ✓ water consumption from the comparable time period and in a similar way with the heat consumption information
- ✓ determining the realised and specific water consumption
- ✓ annual water costs, divided into consumption charges (water and waste water) and fixed charges (basic charges, sprinkler charges, and meter rents)

- **Diagnostic audit**
  The detailed diagnostic audit helps the auditor to detect and declare operational variances, transients and other irregularities. This detailed data gathering includes also requests for demonstrations and taking additional measurements and recordings. With this collected information, the achievable energy utilisation per energy consuming unit can be calculated and shows the possibilities for the implementation of changes in order to improve energy efficiency.

- **Analysing information and evaluate the audit results**
  - ✓ verification of collected information
  - ✓ formulation of findings and observations
  - ✓ recommendations
  - ✓ EMO's
  - ✓ quantification of the expected energy savings efficiency

4. Audit report

The energy audit report provides an overview of the energy efficiency condition of the facility and the arguments related to the high energy costs. With the audit report, the auditee understands the grounds of the energy saving proposals and the measures with which the savings are achieved.

The audit reports describes calculations and analysis including:

- energy services with the most potential for direct improvement.
- a cost-benefit analysis on the future energy costs
- the payback time of the project to evaluate a potential energy project
- the energy intensity ratio (i.e. energy used per unit of product)
- selection of the EMOs
- conclusions and recommendations

References

OFFICE OF ENERGY EFFICIENCY OF NATURAL RESOURCES CANADA 2002. Energy Efficiency Planning and Management Guide.

Answers to the Carbon Economy (ACE) is a project in the INTERREG IVA 2 Seas programme. The low carbon business park manual is an important deliverable of the ACE project. It combines the experience from the six project partners in three EU member states, and incorporates the lessons learnt during the 3 year project period. The manual serves as a guide to low carbon energy measures for companies and business park developers and also provides in-depth background information.

WWW.ACE-LOW-CARBON-ECONOMY.EU

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