# CODE2

**Cogeneration Observatory and Dissemination Europe**

# *D5.1 - Final Cogeneration Roadmap*

## Member State: **United Kingdom**

**Date: July 2014**

Leading CODE 2 Partner: COGEN Vlaanderen

*The United Kingdom is part of the non-pilot Member States of the North-Western Europe CODE2 Region.*

*The CODE2 Region 'North-Western Europe' comprises the following Member States: Belgium, Ireland, Luxembourg, Netherlands and United Kingdom*

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

**The CODE2 project**[1]

This roadmap has been developed in the frame of the CODE2 project, which is co-funded by the European Commission (Intelligent Energy Europe – IEE) and will launch and structure an important market consultation for developing 27 National Cogeneration Roadmaps and one European Cogeneration Roadmap. These roadmaps are built on the experience of the previous CODE project (www.code-project.eu) and in close interaction with the policy-makers, industry and civil society through research and workshops.

The input of all experts has informed these roadmaps . The content of the roadmaps, and opinions of the roadmaps presented reflect the conclusions of the CODE2 project only.

The project aims to provide a better understanding of key markets, policy interactions around cogeneration and acceleration of cogeneration penetration into industry. By adding a bio-energy CHP and micro-CHP analysis to the Member State projections for cogeneration to 2020, the project consortium is proposing a concrete route to realise Europe's cogeneration potential.

**Draft roadmap methodology**

This roadmap for CHP in the United Kingdom is written by CODE2 partner COGEN Vlaanderen based on a range of studies and consultations (see Annex 8). It has been developed through a process of discussion and exchanges with experts.[2]

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

[2] First discussions with policy authorities and experts took place in 2013. The first draft roadmap has been discussed on a webex workshop on 16 May 2014 with 7 experts from the UK.

## Table of contents

# 1 Executive Summary

**In general, the UK CHP market has been stable for several years. Nevertheless, the market segment with CHP units between 100 kWe and 1 MWe has experiencing a strong growth last years, mainly in the in services sectors which have a large hot water demand such as leisure centres, hotels and health centres. Furthermore, the share of renewables used in CHP plants doubled to 8% last years. In 2012, 6 GWe electrical CHP installed capacity, which is mainly located in the industry, generated 6.5% of the total generated power in the UK.**

**Several actions are considered necessary to realise the CHP potential in the UK. The most important longer-term action is to strengthen the EU emission trading system (ETS) so that CHP will be rewarded for his CO2-emission savings.**

**At the UK Policy level, the government should develop a coordinated approach to energy delivery, which includes CHP. It should also perform, under the EED implementation 2014/2015 a comprehensive assessment of the high-efficiency CHP and efficient district heating potential. Based on this potential ambitious targets for CHP can be set together with a bespoke CHP policy to achieve those targets. The government should keep encouraging the development of heat networks, as they have been doing. At last, information campaigns should be launched for the less-informed actors.**

**If all actions in the roadmap are realised, we expect that the CHP capacity could grow up to 15 GWe in 2030. This will result in a primary energy savings of 86 TWh per year and estimated CO2 savings between 10 and 14 Million tons per year in 2030.**

# 2 Where are we now?: Background and situation in the United Kingdom

## *2.1* Current status: Summary of currently installed cogeneration in the United Kingdom

**In 2012, the total installed electrical CHP capacity was 6110 $MW_e$ (1880 units), which generated 6.47% of the total generated power in the UK. Most of it is installed in the industry and is fired by natural gas. The UK CHP market has been generally stable for several years except for a strong growth in the segment between 100 kWe and 1 MWe. Furthermore, over the last years, the share of renewables used in CHP plants doubled to 8.29%.**

Table 1 shows the Eurostat data[3] for combined heat and power in the United Kingdom in 2008. According to DUKES 2013[4], the UK CHP market has been stable for several years. In 2012, the installed electrical CHP capacity stood at 6.14 GWe. The generated electricity amounted to 23.36 TWh, representing 6.47% of the total generated power in the UK.

[3] Combined Heat and Power (CHP) in the EU, Turkey, and Norway - 2008 Data. (Eurostat, 2010)

[4] Digest of United Kingdom energy statistics chapter 7: Combined heat and power (DECC, 2013)

**Table 1: Eurostat data for CHP in the United Kingdom in 2008**

| | Installed capacity electricity (GW) | Total cogenerated electricity generated (GWh) | Total heat supplied (GWh) | Total share on electricity |
|---|---|---|---|---|
| 2008 | 5.53 | 25,000 | 44,889 | 6.4% |

Most (89%) of the installed electrical CHP capacity is located in industry, with mainly large CHP plants (> 10 MWe). A strong growth occurs in the segment of installations with a capacity between 100 kWe and 1 MWe with an average growth of 11% for the last four years.

69% of all the generated electricity in CHP plants in the UK is based on gas, mainly in plants with combined cycle gas turbines. In recent years, the share of renewables used in CHP plants has shown a strong growth from 3.87% in 2008 to 8.29% in 2012. This growth was mostly caused by an increase in sewage gas and wood fuels. With the introduction of the Renewable Heat Incentive in 2011, which will complement the Renewable Obligation in the power sector, the share of renewable fuels in cogenerated heat and electricity is expected to further increase.

Given the Government's commitment to improve the energy efficiency of buildings, the number and capacity of CHP units installed in buildings has been increasing. CHP used in the commercial, residential and public sectors represented 72% of the total number of CHP units installed in 2012. The installed capacity amounted to 433.1 MWe.

Indicative data suggests that there are around 2000 known district heating (DH) networks, most of them are relatively small, providing heat to approximately 210,000 dwellings and 1,700 commercial and public buildings across the UK non-domestic buildings. Based on the available data only 15% of the heat networks are using a CHP system, with a penetration rate of 65% for the large networks compared with 5% of the small networks[5]. An overview is given in the District Heating Installation Map[6].

## *2.2* Energy and Climate Strategy of the United Kingdom

**The UK has an indicative target to achieve an 18% energy reduction from UK's 2007 business as usual projection for 2020. The UK has also a legally binding target to reduce greenhouse gas emissions by 80% compared to 1990 levels by 2050. A legally binding system of five-year carbon budgets specify the amount of greenhouse gases that can be emitted over each budgetary period. The fourth carbon budget (2023–27) requires a 50% emission reduction on 1990 levels. Energy efficiency is indicated as a cost-effective way to achieve this target. Furthermore, heat for buildings and industry is recognised as a major target for energy reduction. DECC recognize the energy and carbon emission savings delivered by CHP and the significant potential for additional CHP capacity.**

In the context of the EU 2020 climate and energy package, the UK has to reduce non-ETS CO2 emissions by 16% with respect to 2005 levels, increase its share of renewables to 15% of the final energy consumption, and it has recently committed to an 18% reduction in energy consumption by 2020 as its indicative energy savings target under the Energy Efficiency Directive (2012/27/EU).

[5] Summary evidence on District Heating Networks in the UK (DECC,2013)

[6] District Heating Installation Map (CHPA)

The **Climate Change Act 2008** set a legally binding target for the United Kingdom to reduce greenhouse gas emissions by 80% compared to 1990 levels by 2050. The Act sets up a legal binding system of five-year carbon budgets, beginning in 2008. These specify the total amount of greenhouse gases that can be emitted over each budgetary period as shown in Table 2. An emission reduction of 34% and 50% below 1990 levels is required in 2020 and 2030 respectively.

**Table 2: Carbon budget periods**

| Carbon budget | First period (2008–2012) | Second period (2013–17) | Third period (2018–22) | Fourth period (2023–27) |
|---|---|---|---|---|
| Million tonnes $CO_2$ equivalent | 3,018 | 2,782 | 2,544 | 1,950 |
| $CO_2$ reduction below 1990 levels | 23% | 29% | 35% | 50% |

The **Low Carbon Transition Plan**[7] and its successor, **The Carbon plan**[8]**,** plan the actions the UK needs to take to meet those carbon budgets. The Carbon plan sets out four scenarios through which the UK could meet its legally binding target to reduce greenhouse gas (GHG) emissions. Energy efficiency is pointed out as an effective option. Depending on the scenario, between 21% and 47% final energy savings per capita is required between 2011 and 2050.[9] The UK is well on course to achieve this trajectory in the short term but without further policy action energy consumption is expected to rise again in the 2020s.

Heat for buildings and industry, which represent half of UKs natural gas consumption, is recognised as a major target for energy reduction. The Future of Heating[10] sets a framework for a transition to affordable and secure low carbon heating. Different DECC reports recognize the energy and carbon emission savings delivered by CHP and the significant potential for additional CHP capacity.

## *2.3* Policy development in the United Kingdom

**Policy in place allows CHP to attract fiscal benefits and exemptions on energy taxes. There are different support schemes for renewable heat and electricity production. Furthermore, micro-CHP is eligible for a financing mechanism and micro-CHP units up to two 2 kWe can get support with a feed-in tariff. Some measures exist to support district heating grids.**

The UK Government has in place several measures to promote highly efficient CHP installations registered under the **CHP Quality Assurance** (**CHPQA**) program. Good Quality CHP plants are eligible to apply for **Enhanced Capital Allowances** (**ECA**), a fiscal benefit, which enable a business to write off 100% of investment in new CHP plants in the first year after investment. Good Quality CHP benefits also from a **preferential business rates** regime.[11]

[7] The UK Low Carbon Transition Plan: National strategy for climate and energy (DECC, 2009)

[8] The carbon plan: Delivering our low carbon future (HM Government, 2011)

[9] The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK (DECC, 2011)

[10] The Future of Heating: A strategic framework for low carbon heat (DECC, 2012)
The Future of Heating: Meeting the challenge (DECC, 2013)

[11] Source: http://chp.decc.gov.uk/cms/business-rating-exemption/

The **Climate Change Levy** (**CCL**) is a tax charged on the supply of energy products in the non-domestic sector. The CCL is made up of two rates: the main rates and the carbon price support (CPS) rates. The **main rates of CCL** tax the supply of energy products for use as fuels for lighting, heating and power by business consumers. Good Quality CHP installations are exempted from paying the levy. Until April 2013, for electricity supplied indirectly, operators of Good Quality CHP plants could apply for CHP **Levy Exemption Certificates** (**CHP LEC**s), which can be sold to energy suppliers. From April 2013, the **Carbon Prices Support** (**CPS**) **rates of CCL** tax the supply of energy products to generate electricity. The CPS rates of CCL will contribute to meeting the Carbon Price Floor, a yearly increasing $CO_2$ tax to compensate the low price of an emission allowance in the Emission Trading System (ETS). Currently, fuel used in CHP for generating heat is exempt and from April 2015, electricity produced by CHP for onsite use will be exempted from the levy.

Electricity produced from renewable sources is eligible for **Renewable Obligation Certificates**[12] (ROCs). ROCs can be traded and are used by the UK electricity suppliers to comply with a renewable energy quota obligation scheme. A biomass or bioliquid CHP registered under the CHP Quality Assurance scheme is eligible for ROC uplift. The Feed-in Tariffs with Contracts for Difference (FiT CfD), placed into law in the Energy Act 2013, "tops-up" any shortfall between the amount the generator receives per unit of electricity and a pre-defined "strike price" in the long-term Contract for Difference. Once the strike price is exceeded, the generator is required to pay the surplus back. The result is that generators neither suffer nor benefit from price volatility. The CfDs will start late 2014, and replace ROCs completely in April 2017.

Useful heat produced by a renewable fuel fired CHP installation is eligible for the **Renewable Heat Incentive**[13] (**RHI**) if the ROC uplift for GQCHP is not claimed. Biogas CHP plants with anaerobic digestion below 5 MWe and gas fired micro CHP units up to 2 kWe receive financial support under the **Feed-in tariff**s[14] (**FiT**s) scheme.

Micro-CHP is eligible under the **Green Deal**, a financing mechanism for energy investments. The loan repayments are financed through a charge on the electricity meter. Furthermore, domestic micro-CHP installations benefit from a **reduced VAT** of 5% (down from 20%).

District heating will be eligible under the **Carbon Savings Community Target** programme. This is a part of the **Energy Companies Obligation** (**ECO**), which places legal obligations on the larger energy suppliers to deliver energy efficiency measures to domestic energy users. A Heat Networks Delivery Unit has been established within the DECC to support local authorities in developing plans for heat networks and providing funding for feasibility studies.

Support is given to local authorities in developing heat networks by establishing a Heat Networks Delivery Unit (HNDU) within the Department that will work closely with individual authorities' project teams in England and Wales.

The Energy Act 2013 introduced also the Capacity Market. The Capacity Market set up a market for providers that are willing to contract capacity. This could be a big opportunity for larger CHP plants.

[12] Source: http://chp.decc.gov.uk/cms/renewables-obligation-2/

[13] Source: http://chp.decc.gov.uk/cms/renewable-heat-incentive/

[14] Source: http://chp.decc.gov.uk/cms/feed-in-tariff/

## 2.4 Exchange of information and awareness in the United Kingdom

**CHP is well known in the several industrial sectors and is experiencing strong growth in services sectors with a large hot water demand such as leisure centres, hotels and health centres. Although improvements are possible, the most important actors in the market and policy are familiar with CHP.**

Good awareness about the benefits of cogeneration, among the different actors, is one of the basic conditions to create an active CHP market. This is necessary to achieve the full potential of CHP. Good awareness corresponds with well-informed customers, enough qualified market players, policy makers that provide the correct framework for a functioning market and influencers that inform and advise the other groups. The actors on the CHP market, classified into four economic-socials groups, are show in Figure 1. The level of awareness was assessed for each of the actors and rated 1-5, (1 poor and 5 Active market), as shown below. The detailed comments on each group are described in ANNEXES

1.

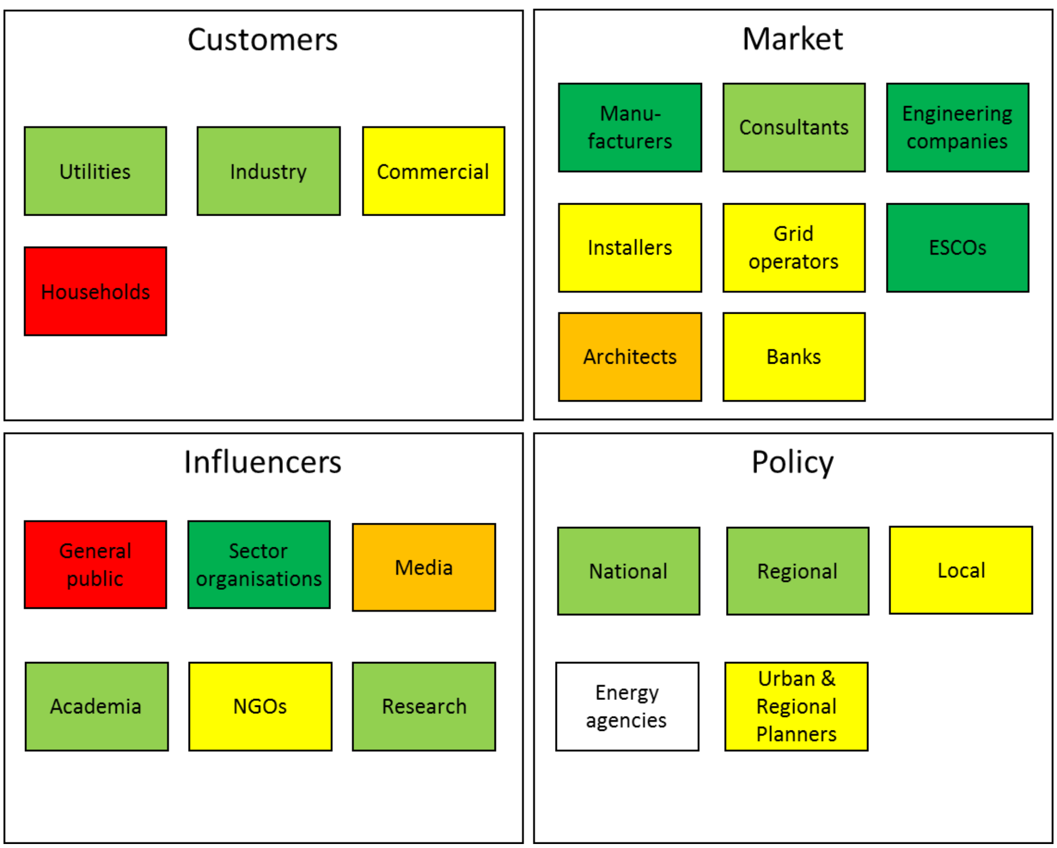


**Figure 1: Level of awareness among key actors under the 4 socio-economic groups**

1 Poor

2 Low

3 Early awareness

4 Interest

5 Active market

***Customers***

The main big industrial companies have been aware of cogeneration for some time and have a lot of experience. On the other hand, the awareness of industrial SMEs is relatively small. This is similar for commercial premises except in the sectors with a large demand for hot water like leisure centres, hotels and health centres. The utilities are aware of the aspects of cogeneration as far as they are related to electricity generation and their network. Households lack knowledge of CHP.

***Market players***

The CHP manufacturers are active in every segment of the CHP market, from micro-CHP to large scale CHP. Energy consultants specialised in CHP have enough knowledge and experience. This is less the case for the other energy consultants. Over a quarter of UK CHP schemes are owned or operated by ESCOs. The (small) installation companies do not always succeed in correctly installing and configuring a CHP unit. Engineering companies have enough knowledge and experience with cogeneration. The willingness to quickly connect new decentralized production capacity on the network is highly dependent on the responsible system operator. Many architects have little knowledge of cogeneration and the same is true for banks.

***Policy makers***

The Department of Energy & Climate Change (DECC) sees CHP as a carbon emissions reduction measure. But they argue that since the impact of fossil fuel CHP on carbon emissions is highly sensitive to the rate of decarbonisation of power generation, they often see fossil fuel CHP as a transition technology. Due to the high return rates DECC are not convinced whether CHP is a cost-effective way of reducing carbon emission. Nevertheless, they provide adequate information about CHP on their website including calculations tools. Local authorities, such as the Greater London Authority, are currently forward thinking and promote district heating networks in combination with CHP. But these examples are limited.

***Influencers***

The Combined Heat and Power Association (CHPA) is an active sector organisation. The Association provides a lot of information for their members and the government in the form of seminars, weekly newsletters and a well-documented website. The general public on the other hand has a limited awareness of CHP or its benefits. CHP is mentioned very little in the media, except those who are specialised in energy. Academia knows what CHP is. Several colleges and universities have installed a CHP. Furthermore, there is research and modelling carried out around CHP. The fuel cell CHP research at the Centre for Hydrogen and Fuel Cell Research in the University of Birmingham is an example. While NGO's in general are not vocal on CHP, Greenpeace has a position and advocates in certain sectors.

## *2.5* The economics of CHP in the United Kingdom

**Under current policy and economic conditions (2014) the economic attractiveness of CHP varies by sector. For small-scale CHP units, with a capacity between 100 kWe and 1 MWe, a project can be financially feasible if most of the produced electricity is consumed on-site. Many industrial sectors demand such high internal rates of returns that the opportunity of finding interesting CHP project is small. It is hard to make a micro-CHP case, with an electrical capacity up to 50 kWe, financial attractive under current conditions. Renewable CHP projects are financially attractive due the financial support if the uncertainties of those support schemes can be removed.**

**The design of much of the currently installed large CHP installations means that they have to export much of their electricity to the grid, which may result in operational losses when the spark spread against eh wholesale price is low.**

A cogeneration plant is a large investment and its feasibility is often measured by its financial parameters, such as internal rate of return (IRR), return on investment (ROI) or payback period. An important factor is the capital cost of the cogeneration unit and its maintenance compared to a standard boiler. Another significant parameter is the spark spread. This is the theoretical gross margin of a gas-fired CHP from selling a unit of electricity, having bought the fuel required to produce this unit of electricity. The support systems described in Chapter 2.3 should improve the financial case for CHP installations.

An economic analysis is made for five standard CHP cases:

- a 50 kWe internal combustion engine (ICE) installed in a hotel
- a 1 MWe internal combustion engine (ICE) installed in an industrial plant
- a 10 MWe combined cycle (CC) cogeneration producing district heat and power in a public utility
- a 500 kWe biogas engine cogeneration placed at a farm, where the heat is sold to a client.

The details of this economic analysis can be found in 4. Assumptions used in the economics of CHP . The results are shown in **Error! Reference source not found.**.

The case with the 50 kWe ICE CHP installed in a hotel has a payback time of 17 years. This case shows it is not obvious to install micro-CHP units, even in an interesting sector such as the service sector with applications, which have a large hot water demand. Experience tells us that this sector is very interesting for bigger small-scale CHP units, with a range between 100 kWe and 1 MWe[15]. This is confirmed by our next case with a 1 MWe ICE CHP, which has a payback time of 4 years and an internal rate of return of 20%. Despite the low payback time, we notice that, currently, the interest of the energy intensive industry in CHP is very poor. This is the result of the high level of uncertainty in heat and electricity market, which make investment risk high due to uncertainty resulting in a requirement for a very short payback time on new non-core investment. For both cases, we assume that all the produced electricity is consumed on-site as the on-site spark spread, which is determined by the avoided electricity import price, is stronger than the export spark spread, determined by the wholesale price. The first reason is the currently low wholesale electricity price, and secondly small producers are not getting the full

[15] Digest of United Kingdom energy statistics chapter 7: Combined heat and power (DECC, 2013)

wholesale price. Depending on the profile and the volume of the injected power small producers would only obtain 80% of the wholesale price.

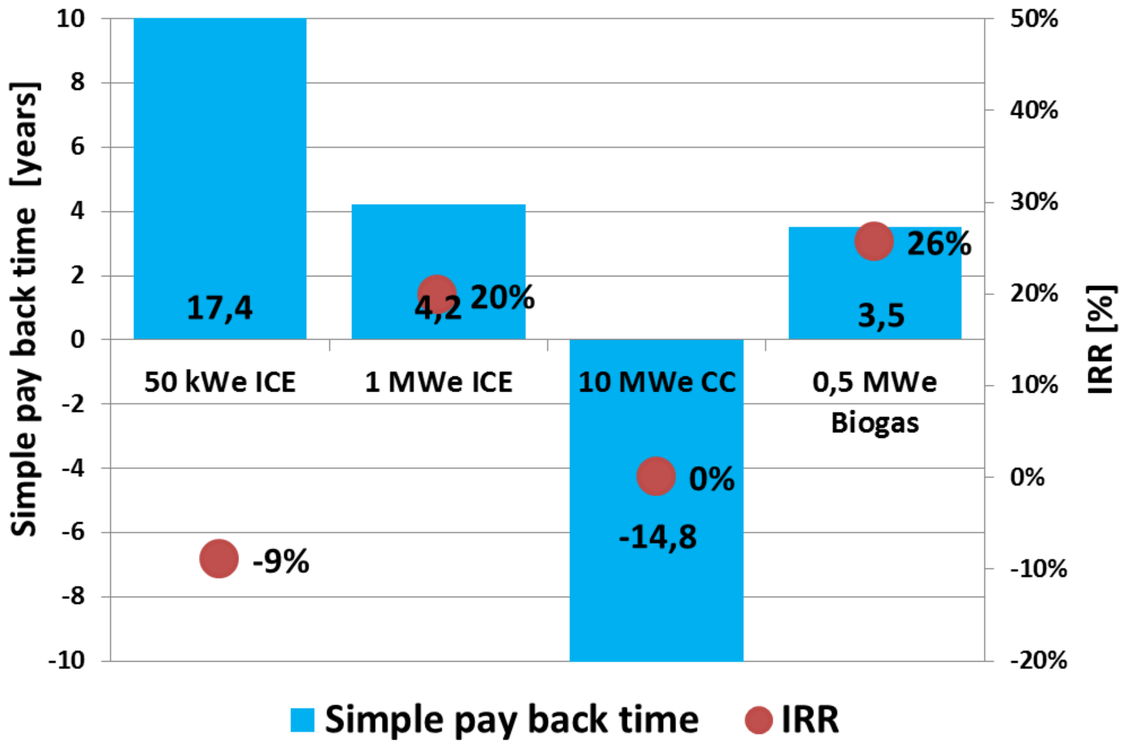


Figure 2: Economic calculations of four typical CHP plants

Our case with a 10 MWe combined cycle gas turbine CHP connected to a district heating network is unprofitable for the UK. The fuel and O&M costs are higher than the financial return of the exported heat and electricity. This is because the CHP has to export all the electricity to the grid at a low electricity price. We can say that the export spark spread is small, which is often the case for large (industrial) CHP plants. According to the DUKES statistics, the market of the large (industrial) CHP plants, with a capacity above 10 MWe, has stagnated. We can conclude that the profitability of a plant is currently largely dependent on the share of produced electricity that can be used on site in the current situation where the wholesale price of electricity is low.

The biogas CHP plant case has, as the result of the CfD and RHI support, an IRR of 26% and payback time of 3.5 years. Due the large investor uncertainties related to those support schemes, this high internal rate of return may not result in a large increase in renewable CHP plants investment.

The following matrix gives an overview of the economic situation of cogeneration in the several market segments. The matrix takes into account only the economic benefits of a CHP installation and ignores all other market barriers. Coal CHP plants, for example, benefit currently from a low coal and $CO_2$-emission price. Currently coal represents a 5% share of the CHP installations in the UK by fuel used. District heating networks are led by the public sector where lower rates of return and longer paybacks can be accepted due to public sector investment criteria and/or long-term heat supply contracts with commercial developers.

**Table 3: CHP economics matrix**

| United Kingdom | Micro | | Small & Medium | | Large | | |
|---|---|---|---|---|---|---|---|
| | *up to 50kW* | | *up to 10 MW* | | *more than 10 MW* | | |
| | NG | RES | NG | RES | NG | Coal | RES |
| **SME/Industry** | poor | inapplicable | modest | normal | poor | normal | normal |
| **District heating/cooling** | inapplicable | inapplicable | modest | normal | poor | normal | normal |
| **Services** | poor | inapplicable | normal | normal | inapplicable | inapplicable | inapplicable |
| **Households** | poor | inapplicable | inapplicable | inapplicable | inapplicable | inapplicable | inapplicable |

**Legend:**

**"normal"** Cogeneration Investment has **good economic benefits**, return on investment acceptable for the investors, **interest for new investment exists**; there are no significant economic barriers for the implementation.

**"modest"** Cogeneration Investment has **modest/limited economic benefits** and return on investment, **limited interest for new investments**.

**"poor"** Cogeneration Investment has **poor or negative return on investment or is not possible due to other limitations**, **no interest/possibilities for new investments**.

(hatched) Inapplicable, the technology is not used in this market segment.

**NG** **Natural Gas** or appropriate fossil fuel

**RES** **Renewable energy sources** (wood biomass, biogas, etc.)

## *2.6* Barriers to CHP in the United Kingdom[16]

**The most important barrier for gas CHP is the low spark spread comprising the low value for electricity exported to the grid and small CHP installations not receiving the full value in the electricity market. The major reason for the low wholesale prices is the current low price of coal and the low price of $CO_2$-emission allowances in the EU emission trading system. Appropriate support through policy for fossil fuel to achieve acceptable economic returns is not part of government policy. For Biomass CHP investments uncertainty related with certain support schemes are an important barrier for further investments.**

**The high level of uncertainty in the market for heat and electricity and the high costs and administrative burden of scaling up the electricity network connection are also experienced as barriers for CHP.**

***Barrier 1: Low electricity prices lead to lowered profitability against cost of basic fuel for the electricity exported. This results in a lowered profitability for existing plant, which is largely gas based, and a higher risk for investment in CHP. This is a barrier to the utilisation and wider deployment of CHP***

As discussed in Chapter 0, CHP plants injecting electricity into the grid receive a low electricity price relative to the price of the gas that was needed to produce this electricity. Currently, the electricity price is mainly determined by coal-fired power plants, which benefit from the current oversupply of coal in the world market (resulting in a low historical price) and the low price of CO2 emission allowances in the EU emission trading system (ETS). Small independently operated CHP schemes are also disadvantaged because they receive less than the wholesale price for the electricity they export to the grid. The price they receive depends on the volume and profile of the exported electricity.

A low spark spread is not only a barrier for investments in new CHP plants but also for the operation of existing CHP plants.

***Barrier 2: Lack of well-targeted and appropriate financial support for CHP to create an acceptable economic case for CHP operators in the context of wider energy and climate policy prevents the wider deployment of CHP***

Until 2013, CHP was exempted from the energy tax called Climate Change Levy (CCL). In April 2013, the rates of the CCL changed to the Carbon Price Support (CPS) rates, a carbon emission tax on power generation. CHP was no longer exempted from this tax. Recently, the government decided to exempt electricity produced by CHP for on-site consumption.[17] Nevertheless, this tax exemption for on-site consumption is not helpful for CHP plants exporting most of their electricity. Furthermore, the lack of targeted financial support prevents the UK from achieving its full potential primary energy savings from CHP.

***Barrier 3: The investor certainty issues related to CfD and RHI support is a significant barrier for biomass CHP investment opportunities resulting in a currently unattractively high investment risk.***

The budget for the Renewable Heat Incentive has been allocated until March 2016 when it will be reviewed under a new Government. The Government has expressed the intention to retain the RHI for

[16] Market Failures: Why does CHP not get built? (CHPA, 2013)

[17] Phew! Carbon tax scrapped for combined heat and power plants (CHPA, 2014)

new projects commencing operation post March 2016 but any certainty on the size and even existence of the RHI for new projects from April 2016 onwards is unlikely until after national elections in 2015.

The Contract for Difference (CfD) FiT will replace the Renewable Obligation (RO) and is set to start in 2015. Unlike the RO, there is currently no provision for any support for non-qualifying electricity output. As a result, should a CHP loose part of all of a heat load and cease to operate as good quality CHP, the CfD payments would cease altogether. The CfD will not support power-only biomass. This appears to be a result of the Government's interpretation of the Energy Efficiency Directive, which limits CHP support only to 'good-quality' CHP.

***Barrier 4: A high level of uncertainty as currently exists in both the market for heat and electricity in the UK deters new investment***

A CHP plant operator operates a plant primarily to meet the heat demand of the production process. The produced electricity will be used in the plant and surplus of power will be exported to the grid. This requires an active engagement with the electricity market rather than simply passive consumption. For a CHP operator electricity market interaction is a secondary activity and the electricity market is viewed as inherently risky and 'foreign' to business-as-usual.

The heat demand is important for the economic feasibility of the CHP project. Because of a high level of uncertainty of future industrial activities of the heat customer, caused by different factors like rapid changing product markets and high energy prices, there is a high risk of losing a part or all of the heat demand. This result in higher hurdle rates for investment pay back compared with power-only generation.

***Barrier 5: The cost and administrative burden of scaling up the network connection may result in interested parties choosing heat production by a boiler and purchase electricity from the grid.***

New CHP plants are sited based on heat demand, not on the present electricity grid infrastructure. Sites of new CHP plant may be in areas where the grid infrastructure is limited in its ability to accommodate new generation assets.  This increases the project complexity and costs, which give newly built CHP installations a competitive disadvantage to power generation stations, which are generally placed on sites where the infrastructure was developed for generation capacity and at a time before the UK electricity supply was privatised. Furthermore, depending on which distribution system operator is involved, scaling up the network connection can be difficult.

# 3 What is possible? Cogeneration potential and market opportunities in the United Kingdom

**The last DECC study estimates the projected total Good Quality CHP capacity will grow to 8.8 GWe in 2030. A study estimates the economic potential at 20 GWe in 2030 but according experts[18] this will be lower as result of a reduction of the technical potential by one quarter. There is a large market opportunity for CHP in the services sector with high and constant heat demand. In addition, domestic micro-CHP is interesting for households with a more than medium house. Furthermore, a further increasing share of renewable sources used in CHP is expected. Heat networks, fuelled by CHP have a large potential in cities.**

Article 6 of the Cogeneration Directive obliged Member States to analyse national potentials for high efficiency cogeneration and barriers to their realisation. In 2007, the UK Department for Environment, Food and Rural Affairs reported to the European Commission an economic potential for cogeneration in 2015 of 10.6 MWe.[19]

Ricardo-AEA (commissioned by the Department of Energy and Climate Change (DECC)) published in March 2013 a study about the CHP potential in 2030.[20] The study uses a bottom up economic model to assess the technical and economic potential of CHP across a range of sectors and sizes, representing all potential sites in the UK. To calculate the technical potential, the requirement to be more cost effective than conventional boilers and grid import is removed. The technical and economic potentials are calculated under existing policies and projected energy prices.

The technical potential for Good Quality CHP in the UK is estimated to be in the order of 29.3 GWe in 2013, representing a share of 29% of the total power capacity. A small growth of the technical potential is expected primarily as a result of growth in UK energy demands. In 2030, this results in a technical potential of 33.8 GWe or 29% of the total projected electricity production. Since the publication of the study, there are indications that the technical potential is reduced by a quarter. The economic potential is estimated at 18.1 GWe in 2020 and 20.1 GWe in 2030. The economic potential is calculated with the assumption that CHP projects with a minimum rate of return of 15% are implemented. In practice, however, industry will ask much higher rates of return for variety of reasons including risk aversion and risks related to heat customers. As a result, this “theoretical” economic potential is unlikely to be implemented.

The projected total Good Quality CHP capacity (conventional and renewable) in 2030 is estimated to be about 36% of the technical potential as shown in Table 4. The growth in CHP electrical capacity is mainly because of the increase of CHP in the service sector. The share of renewable CHP capacity is expected to rise from 7% in 2013 to 17%. This is mainly because of a fuel switch towards renewables in the chemical and food & drink sector.

[18] According a discussion with DECC

[19] Analysis of the UK potential for Combined Heat and Power (DEFRA, 2007)

[20] Projections of CHP capacity and use to 2030 (Ricardo-AEA, 2013)

Table 4: GQCHP electrical capacity

| Electrical capacity in CHP mode | 2020 | 2025 | 2030 |
|---|---|---|---|
| Renewable GQCHP (MWe) | 1,505 | 1,809 | 2,021 |
| Conventional GQCHP (MWe) | 8,893 | 9,837 | 10,107 |
| Total GQCHP (MWe) | 10,398 | 11,646 | 12,128 |
| Projection % of technical potential | 33% | 36% | 36% |
| Projected renewable share of GQCHP capacity | 14% | 16% | 17% |

The Update Energy and Emission Projection 2013[21] published by DECC predicts a slow growth of CHP capacity up to 2025 with a decrease of projected potential between 2025 and 2030, as show in Table 5. The main cause of this is the electricity price, which makes it more economic for some sites to import electricity from the grid than to invest in CHP. The effect of this is felt most in fossil fuelled sites in the EU ETS, whilst sites that are fuelled by bio-energy remain quite resilient.

Table 5: updated CHP projection 2010-2030

| September 2013 projection | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|
| Capacity (GWe) | 6.0 | 7.7 | 8.4 | 9.2 | 8.8 |

***Micro-CHP***

A field test carried out by the Carbon Trust's Micro-CHP Accelerator[22] shows that Stirling engine micro-CHP in households with heat demands of more than 15,000 kWh/y results in an overall carbon emissions saving of 9%. This is equivalent to 400 kg $CO_2$/y for a 'typical' large house. Based on the UK housing stock and the boiler market, annual sales of micro-CHP units could be around 170,000. The study suggests that the initial markets for micro-CHP systems may be concentrated in the suburban areas of the major cities, due to their high proportion of larger gas-connected houses.

The Micro-CHP Accelerator also shows that existing Internal Combustion-engine (IC) micro-CHP systems, deployed as the lead boiler in a small commercial plant room, typically achieve an overall carbon savings of around 16%. The most attractive sectors for IC-engine micro-CHP are likely to be those in which the heat demand per building is typically high and consistent, such as nursing and care homes and leisure centres. With an overall carbon saving of 16% the potential carbon saving in those sectors is estimated to be greater than 100,000 tCO2/year in around 20,000-25,000 buildings. These sectors are also likely to be particularly attractive as they include a high proportion of buildings that are owned and occupied by local authorities. In other sectors such as offices and retail, landlord/tenant relationships are more common, and may act as a barrier to the installation of new low carbon heating systems such as micro-CHP. The large uptake of CHP units in the past three years with an electrical capacity between 100 $kW_e$ and 1 $MW_e$ confirms the large potential in the service sector.

[21] Updated energy and emissions projections 2013 (DECC, 2013)

[22] Micro-CHP Accelerator (Carbon Trust, 2011)

The CODE2 micro-CHP potential analysis expects a potential for 5,800,000  household micro-CHP units, with an electrical capacity of 1 kWe, installed in the UK in 2030. This will deliver a 75 PJ/year primary energy saving.  This level of micro-CHP penetration is compatible with  a strategy seeking to  support the electrical grid  at a DSO level during times of grid stress caused by a high electricity demand from heat pumps in cold periods and when intermittent renewable energy production capacity like wind or solar are unavailable.[23] The potential for micro-CHP in collective housing systems and SMEs is estimated at 61 000 units with 46 PJ primary energy savings a year. More information can be found in 2. Micro-CHP potential assessment.

***Bio-CHP***

The UK has set a target to reduce greenhouse gas emissions by 2050 by 80% compared to 1990 levels. This will result in a fuel-switching from natural gas to low carbon fuels such as waste, biomass and biogas. In 2030, 17% of the CHP capacity is estimated to be fueled by renewable sources like solid or liquid biomass or biogas as shown in Table 4.

According the CODE2 bio-energy CHP potential analysis, based on member states own projections for bio-based fuels in 2020 and 2030, bio-energy will have a share of respectively 14.1% and 18% of the CHP fuel consumption. More information can be found in Annex 4: Bio-CHP potential assessment.

***District heating***

The Pöyry report[24] suggests that residential heat networks become cost-effective in areas with heat demands at densities greater than 3 MW/km². It is estimated that 20% of the UK heat demand has at least this heat density. At the top end of Poyry's projections, where certain barriers are overcome, up to 14% of the national heat demand could be served by heat networks. The report looks mainly at the potential for gas CHP, and suggests that this would lead to a halving of carbon emissions from this heating and cooling, compared with current technologies. Studies conducted by UKDEA[25], Delta-EE[26] and ETI[27] confirm this potential.

DECC is developing a stand-alone heat networks model to understand the long-term potential for heat networks. Initial results from the modelling suggest that up to 20% of UK domestic heat demand might be served by heat networks by 2030.

A more general model of DECC, the pathways to 2050 modelling, suggests that heat networks could be an important part of the least cost mix of technologies needed by 2050. The potential is estimated at 7% (20 TWh) of domestic heating and hot water demand by 2030 rising to 14% (41 TWh) by 2050. Heat networks are also an important technology in non-domestic buildings, where they could supply up to 7% (7 TWh) of heating and hot water demand by 2030 and 9% (11 TWh) by 2050. The modelling suggests that heat networks are particularly important for helping decarbonise heating in older buildings in urban areas. In the period up to 2030, heat networks would predominantly be fuelled by gas CHP.[28]

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[23] The Future of Heating: Meeting the challenge (DECC, 2013)

[24] The potential and costs of district heating networks (Poyry, 2009)

[25] UKDEA Policy Paper (UKDEA, 2012)

[26] 2050 Pathways for Domestic Heat (Delta-EE, 2012)

[27] Macro Distributed Energy Project report (Energy Technologies Institute, 2013)

[28] The Future of Heating: meeting the challenge (Department of Energy & Climate Change, 2013)

# 4 How do we arrive there? The Roadmap

## *4.1* Overcoming existing barriers and creating a framework for action in the United Kingdom

**The following actions are considered necessary to realise the CHP potential:**
**- Strengthen the EU emission trading system (ETS)**
**- Develop a coordinated Government approach to total energy delivery .**
**- Perform an assessment of the high-efficiency CHP and efficient district heating potential**
**- Set ambitions for high efficiency CHP**
**- Implement a bespoke CHP policy**
**- Encourage the development of heat networks**
**- Information campaigns should be launched**

Chapter 1.6 gives an overview of the most important barriers for an optimal deployment of CHP. Currently, the most important barrier is the low electricity prices against cost of basic fuel for the electricity exported which lead to lowered profitability, as shown in Chapter 1.5. To achieve the energy and climate targets covered in Chapter 1.2, the full economic potential of CHP should be deployed. This Chapter treats the actions that are needed to deploy this full potential. The actions are ordered according to priority.

***Action 1: Strengthen the EU emission trading system (ETS)***

As discussed in Barrier 1 the low wholesale electricity price is partly the result of the low CO2 emission allowances price in the EU emission trading system (ETS). The EU emission trading system (ETS) was installed to combat climate change and reduce industrial greenhouse gas emissions cost-effectively. The low emission allowances price impedes a switch to low carbon technologies in the heat and electricity market. Actions should be taken at the EU level to strengthen the EU emission trading system, so it can achieve the objectives for which it was designed. The UK should push within the European Council for an ambitious CO2 target and ambitious EU ETS prices to drive energy efficiency investments.

CODE2 recognises that the current policy commitments under the ETS Directive limit what can be achieved up to 2020 and that the situation 2020-2030 is very much still to be analysed and addressed.

***Action 2: Develop a coordinated Government approach***

Combined Heat and Power is a technique, which often falls between the cracks, between heat and power, between demand side measures and generation, and between different elements of energy and climate policy. The Government needs to take a whole system approach to energy use, which takes into account generation and network costs, system balancing costs, environmental costs and security of supply. Within this overall approach the role of CHP will be clearer and the approach will show that CHP is more beneficial to the total system if a CHP plant is exporting electricity. The CHP industry through the UK CHPA can deliver the necessary input and feedback for this approach. Besides, the EED in Article 15 .5 contains elements specifically dealing with opening the balancing markets to CHP and a full implementation of this article along wich also includes requirements on regulators to pay due regard to efficiency of the electricity and gas networks in their regulation (Article 5.1 and .2) would trigger the necessary analysis which industry would readily support.

Furthermore, CHP should play an important role in the industrial roadmaps to decarbonise UK's most energy-intensive manufacturing processes.

***Action 3: Perform an assessment of the high-efficiency CHP and efficient district heating potential***

The Energy Efficiency Directive (EED) Article 14 paragraph 1 states that "*by 31 December 2015, Member States shall carry out and notify to the Commission a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling, [..]".* A thorough analysis of the potential of high-efficiency CHP (taking into account "***External benefits such as environmental and health benefits***", *EED Annex IX, part 1)* allows for defendable yet ambitious targets for primary energy savings through high efficiency CHP.

This comprehensive assessment will quantify the potential for CHP in general, and help government develop the necessary "adequate measures" Article 14.4 EED.

***Action 4: Set ambitions for high efficiency CHP***

At the moment, the UK has no published targets for high efficiency CHP. Targets are useful, however, for both policy makers and market players. Article 3 of the EED states that each Member State has to set indicative energy efficiency targets identifying total primary energy savings. An element of the target development under Article 3 should be explicitly linked to actions under articles 7, 14 and 15 for CHP.. The quantification of the CHP potential under Article 14 and the implementation of the measures under Article 15 is required to be reported by the member state under the NEEAP. Additionally the planned expansion of CHP should be explicitly linked back to the Article 3 target to create full clarity for policy makers, industry and investors. As cogeneration forms an important part of the EED, a vision should be formed on how cogeneration will contribute to energy efficiency targets of the UK.

***Action 5: Implement a bespoke CHP policy***

As discussed in Action 2, CHP often falls between cracks when energy and climate policies are developed. Therefore DECC's commitment in 'The Future of Heating: Meeting the challenge'[29] to develop a bespoke CHP policy is a welcome initiative. DECC's apparent intention is for a policy to provide capital support with the aim of overcoming the barrier of higher capital cost and higher risk in CHP investment compared to alternatives. This policy should be implemented, with sufficient funding to meet the ambitious targets defined in Action 4. This action complies with Article 14.2 of the EED which states that "*Member States shall **adopt policies** which **encourage** the due taking into account at local and regional levels of the potential of using efficient heating and cooling systems, in particular those using **high-efficiency cogeneration**. [..]*"

***Action 6: Encourage the development of heat networks***

In 2030 and later there will still be a large amount of old-build buildings, however, which have a high heat demand. The easiest way to decarbonise those heat demands is to connect them to heat networks. According to DECC, the first generation low carbon heat production plants will be CHP installations. In 2012, UK CHPA on behalf of the industry presented seven key measures to boost heat networks in their "Big Offer"[30] to the Energy Secretary. Most of these measures are already implemented or underway. The Government has launched the Heat Networks Delivery Unit, which is a development support agency an also provides funding for feasibility studies. The industry's Independent Heat Customer Protection Scheme is in development and progressing, with delivery potentially by the end of the year. Lastly, the Green Investment Bank is considering loans to support District Heat investment. There are only two remaining measures of the "Big Offer" which have not been addressed:

[29] The Future of Heating: Meeting the challenge (Department of Energy & Climate Change, 2013)

[30] CHPA presents "Big Offer" to Energy Secretary to boost community district heating (CHPA, 2012)

- **District heating database of opportunity**, an extension of current England heat map, this database will indicate to local government areas to prioritise viable schemes.
- **Loan guarantees for district heating** will underwrite the capital borrowing from low-risk institutional investors (such as pension funds) to provide capital at low interest rates.

All those measures comply with the obligation of Article 14.2 of the EED which states that "*Member States shall* ***adopt policies which encourage*** *the due taking into account at local and regional levels of the potential of using* ***efficient heating and cooling systems****, in particular those using high-efficiency cogeneration. [..]*"

In implementing the EED the UK government should develop policy measures in co-operation with the industry to deliver these important enabling elements to expanding CHP and DH in the UK.

***Action 7: Information campaigns should be launched***

DECC already provides a lot of information about CHP on their website[31]. Nevertheless, as shown in the awareness study, several actors lack the necessary awareness about the benefits of CHP. In order to overcome this, targeted information campaigns on cogeneration and its advantages for consumers, the environment and the national economy should be launched in a partnership between the government and the industry. The main target groups will be clear as result of the development of a coordinated Government approach discussed in Action 2. With a relatively small financial sum spent in these measures the effectiveness of the financial incentives given by the CHP and RES law can be expected to be strongly amplified. The new campaign comply with Article 17.4 of the EED that states "*Member States shall, with the participation of stakeholders, including local and regional authorities, promote suitable information, awareness-raising and training initiatives to inform citizens of the benefits and practicalities of taking energy efficiency improvement measures.*"

[31] http://chp.decc.gov.uk/cms/

## 4.2 Possible paths to growth in the United Kingdom

**With the proposed roadmap, it is estimated that the CHP capacity could grow from the current 6.1 GWe up to 15 GWe in 2030. The business as usual scenario will result in an increase to 9.1 GWe in 2025, whereupon it will decline to 8.8 GWe in 2030.**

As discussed in Chapter 2 the CHP market in the UK has been stable for several years. In 2012, the installed CHP capacity was 6.1 GWe. The business as usual (BUA) scenario, as projected in the Update Energy and Emission Projection 2013[32], estimates a slow growth of installed CHP capacity until 2025, with a total of 9.1 GWe installed CHP capacity. From 2025 to 2030, a decrease is projected to 8.8 GWe, as shown in Figure 3.

The technical and economic potential of CHP, as estimated by Ricardo-AEA[33], are also shown. As discussed in Chapter **Error! Reference source not found.**, there are indications that the estimated technical potential will be reduced by 25%. Furthermore, the theoretic economic potential of CHP does not include risk aversion, stricter criteria of certain sectors, risks related to heat customers and lack of awareness in some sectors. Therefore we CHP capacity in 2030 will be lower than the economic potential. We expect that, if all actions in the roadmap are realised, the CHP capacity could grow up to 15 GWe in 2030. The corresponding growth path is shown in Figure 3.

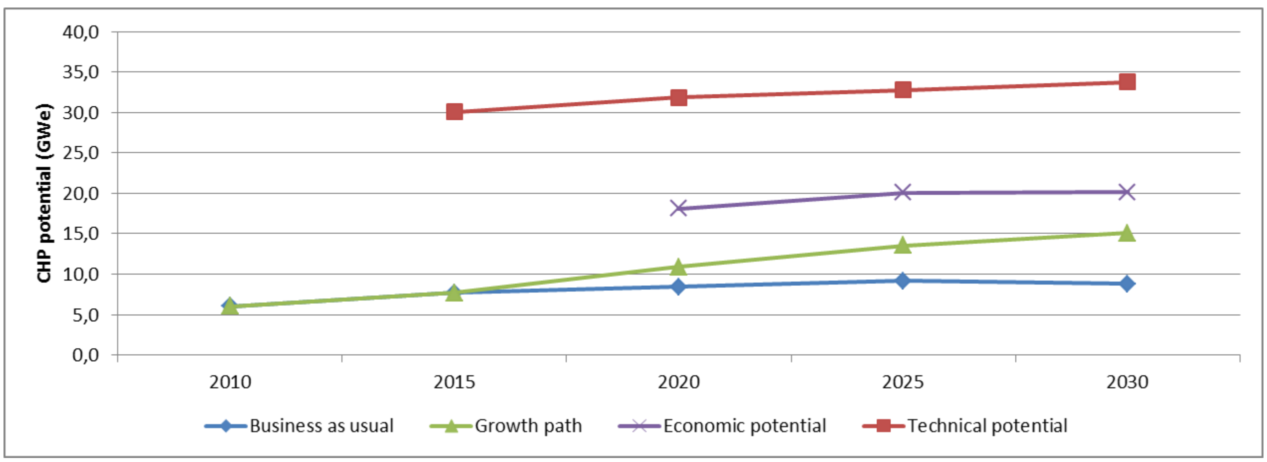



Figure 3: Growth path of CHP until 2030

[32] Updated energy and emissions projections 2013 (DECC, 2013)

[33] Projections of CHP capacity and use to 2030 (Ricardo-AEA, 2013)

## *4.3* Saving of primary energy and CO2 emissions by the CHP roadmap of the United Kingdom

Primary energy saving (PES) and CO2 emissions saving projections resulting from increased use of CHP require assumptions about not just what types of fuel and technology are displaced, but also their operation on the market. Within CODE2 two approaches are developed. These represent two different analytic considerations which are summarised here and more fully explored in Annexe 5.

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

2) **Substitution method.** This method has been developed within the project and estimates the amounts of electricity, heat and fuel which are actually replaced by additional new CHP based on a projection of the supply base changes in the member state supply over the period are calculated. The situation in 2030 is compared to the current status. With this method PES for the United Kingdom through implementing the roadmap for CHP is estimated at 86 TWh per year and CO2 savings are estimated to be between 10 and 14 Million tons per year in 2030. The actual saving is particularly dependent on the efficiency increase through upgrading both current power plant and CHP technology efficiencies. The final share of bio energy in additional CHP has a major impact on the CO2 savings which can be anticipated. The CO2 reduction achieved is due to both higher energy efficiency and fuel switching towards low carbon (natural gas) or non-carbon (bio energy) fuel, but CHP development and fuel switching are anticipated to be an integrated process driven by policy objectives.

**Table 6: Saving of primary energy and CO2 by the UK CHP roadmap**

| | Substitution method | | EED method | |
|---|---|---|---|---|
| | **low case** | **high case** | **low case** | **high case** |
| PE saving (TWh/a) | 85 | 86 | 64 | 71 |
| $CO_2$ saving (Mt/a) | 10 | 14 | 11 | 9 |
| - per kWh el* (kg/kWh el) | 0,77 | 0,87 | 0,25 | 0,22 |

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

# ANNEXES

## 1. Stakeholder group awareness assessment

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

| Group | Comment |
|---|---|
| **Customers** | |
| Industry | The main big industrial companies know CHP for a long time and have a lot of experience. On the other hand, the awareness of industrial SMEs is relatively small. |
| Utilities | The utilities are aware of the aspects of cogeneration as far as they are related to their network. |
| Commercial | In general, the awareness among commercial premises is relatively small. Exceptions are sectors with a large demand for hot water like leisure centres, hotels and health centres. |
| Households | Households lack knowledge of CHP. |
| **Market and supply chain** | |
| Manufacturers | The UK manufacturers are active in every segment CHP market, from micro-CHP to large scale CHP. |
| Installers | The (small) installation companies do not always succeed to correctly install and configure a CHP unit. |
| Grid operators | The willingness to quickly connect new decentralized production capacity on the network is highly dependent on the system operator. |
| Consultants | Energy consultants specialised in CHP have enough knowledge and experience. This is less the case for the other energy consultants. |

| | |
|---|---|
| Engineering companies | Engineering companies have enough knowledge and experience with cogeneration. |
| Architects | Many architects have little knowledge of cogeneration, so not many micro-CHP units are installed in houses. |
| Banks | Some banks are aware of CHP and commonly provide loans for investments in CHP. The new Government-backed Green Investment Bank has created an increased role for bank financing in CHP deployment. |
| ESCOs | Over a quarter of UK CHP schemes are owned or operated by ESCOs. |
| **Policy** | |
| National | The Department of Energy & Climate Change (DECC) sees CHP as a carbon emissions reduction measure. But as the impact of fossil fuel CHP on carbon emissions is highly sensitive to the rate of decarbonisation of power generation generally, they see fossil fuel CHP as a transition technology. Due to the high return rates currently required, they are not convinced whether CHP is a cost-effective way of reducing carbon emission. On their website, they provide information about the different aspects of CHP (project development, CHP technology, environmental, operation and maintenance, finance, incentives) including calculation tools. |
| Regional | |
| Local | Some local authorities, such as the Greater London Authority, are forward thinking and promote district heating networks in combination with CHP. But these examples are limited. |
| Urban & Regional planners | |
| Energy agencies | |
| **Influencers** | |
| Sector organisations | The Combined Heat and Power Association (CHPA) is an active sector organisation. They provide a lot of information to their members and the government in the form of seminars, weekly newsletters and a well-documented website. |
| General public | The general public does not understand the basic principles of CHP or its benefits. |
| Media | Cogeneration is mentioned very little in the media, except those who are specialised in energy. |
| Academia | Academia knows what CHP is. Several colleges and universities have installed a CHP |

| | |
|---|---|
| Research | There is research on fuel cell CHP is being done in the Centre for Hydrogen and Fuel Cell Research in the University of Birmingham. |
| NGOs | Greenpeace is promoting CHP. The other NGO’s are less well informed about CHP. |

## 2. Micro-CHP potential assessment

### *Country statistics*

Population: 62 300 000 (2010)
Number of households: 27 000 000 (2010)
GDP per capita: € 27 300 (2010)
Primary energy use: 143 000 ktoe/year (2010)
GHG-emissions: 590 Mton $CO_{2,eq}$/year (2010)

### *Household systems (±1 kWe)*
***Boiler replacement technology***

**Present market (2013)**
Boiler stock: 25 700 000 units
Boiler sales: 2 100 000 units/year

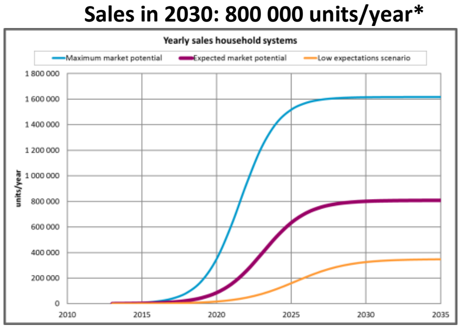
### *Potential estimation*

| *Indicator* | *Score* |
|---|---|
| Market alternatives | 2 |
| Global CBA | 2 |
| Legislation/support | 2 |
| Awareness | 0 |
| Purchasing power | 2 |
| **Total** | **6 out of 12** |

**Expected final market share: 38% of boiler sales in Household sector**

### *Yearly sales*

Sales in 2020: 86 000 units/year*
**Sales in 2030: 800 000 units/year***




### *Stock*

Stock in 2020: 180 000 units*
**Stock in 2030: 5 800 000 units***
Stock in 2040: 8 000 000 units*

### *Potential savings in 2030*

**Primary energy savings:**
75 PJ/year*
1 800 ktoe/year*
**GHG-emissions reduction:**
5.1 Mton $CO_{2,eq}$/year*

### *SME & Collective systems (±40 kWe)*
***Boiler add-on technology***

**Present market (2013)**
Boiler stock: 345 000 units
Boiler sales: 28 000 units/year

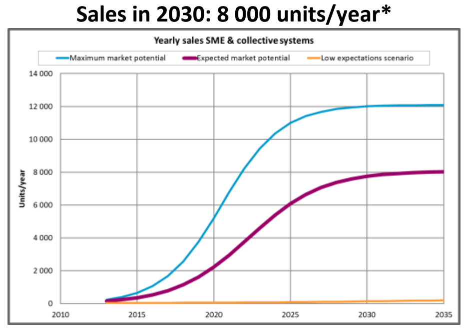
### *Potential estimation*

| *Indicator* | *Score* |
|---|---|
| Market alternatives | 2 |
| Global CBA | 4 |
| Legislation/support | 0 |
| Awareness | 2 |
| **Total** | **6 out of 9** |

**Expected final market share: 15% of boiler sales in SME & Coll. sector**

### *Yearly sales*

Sales in 2020: 2 200 units/year*
**Sales in 2030: 8 000 units/year***




### *Stock*

Stock in 2020: 14 000 units*
**Stock in 2030: 61 000 units***
Stock in 2040: 82 000 units*

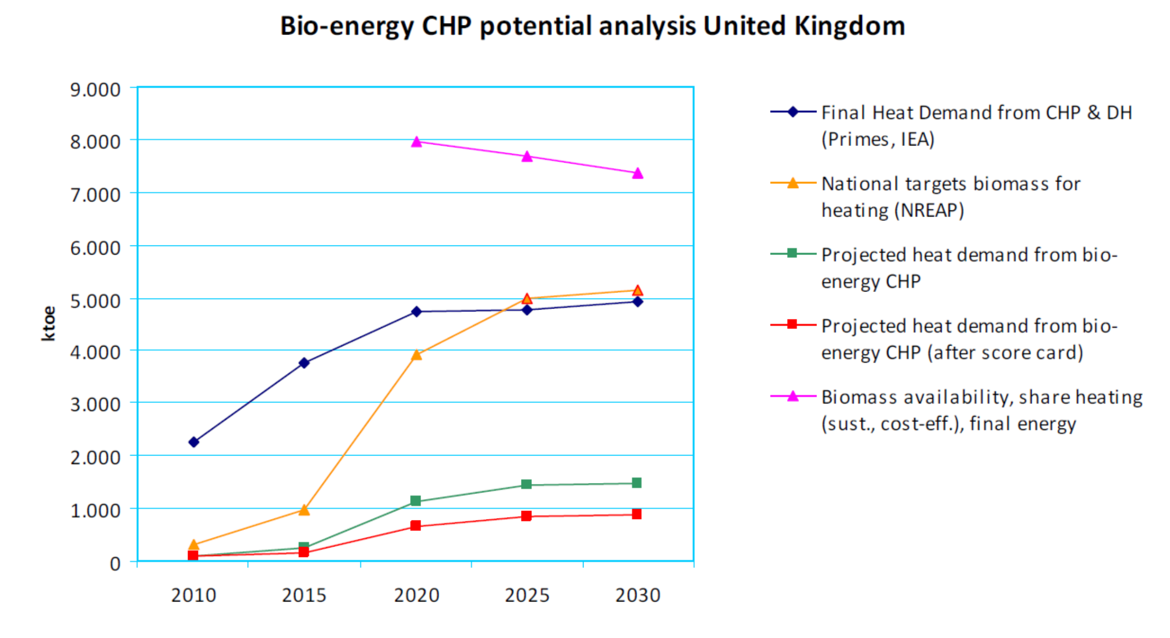
### *Potential savings in 2030*

**Primary energy savings:**
46 PJ/year*
1 100 ktoe/year*
**GHG-emissions reduction:**
3.1 Mton $CO_{2,eq}$/year*

*Corresponding to the expected potential scenario.

## 3. Bio-CHP potential assessment

| Figures (projections) | 2010 | 2020 | 2030 |
|---|---|---|---|
| Final heat demand from CHP and DH (PRIMES, IEA), ktoe | 2.265 | 4.749 | 4.918 |
| (Projected) heat demand from bio-energy CHP and DH (after score card), ktoe | 83 | 671 | 885 |
| Bio-energy penetration rate in CHP markets (2009: EEA, Eurostat) | 3,6% (2009) | 14,1% | 18,0% |
| Biomass availability, share heating (sust., cost-eff.), final energy (Biom. Futures), ktoe | | 7.976 | 7.366 |




| Framework Assessment (Score card) | Score | Short analysis |
|---|---|---|
| Legislative environment | + 2 (of 3) | - New Heat Strategy helping to create positive investment environment<br>- No DH-specific subsidy support<br>- Ambitious renewable and emissions targets<br>- Strong bio-energy support, especially for bioenergy CHP but limited visibility of future funding. |
| Suitability of heat market for switch to bio-energy CHP | ++ 3 (of 3) | - Good industrial opportunity<br>- Challenge overcoming relatively low gas prices<br>- Challenge banking renewable heat |

| | | |
|---|---|---|
| | | incentives for investment decisions and long-term build (>5 years)<br>- Significant new renewable CHP deployment expected by 2020 |
| Share of Citizens served by DH | - 0 (of 3) | - Low current DH deployment<br>- Promise to consider support for bioenergy used on heat networks in 2014.<br>- New heat strategy to help spur DH penetration |
| National supply chain for biomass for energy | + 2 (of 3) | - Few biomass supply chain difficulties but limited Indigenous biomass production so import dependent<br>- Growing environmental stakeholder concern about impact of imported biomass<br>- Some conflict for wood feedstocks between generators and the wood products, paper and panel industries |
| Awareness for DH and CHP | + 2 (of 3) | - Strong government and environmental stakeholder support that bioenergy should be CHP<br>- Some environmental stakeholder concerns about biomass for larger-scale (>50MW) use |

## 4. Assumptions used in the economics of CHP

| Sector | | Heating in services with large hot water demand | Industry and service process heat and heating supply | District heating | Bio gas CHP (agriculture, waste, industrial wastewater or sewage treatment) |
|---|---|---|---|---|---|
| | | 50 kWe ICE | 1 MWe ICE | 10 MWe CC | 0,5 MWe Biogas |
| **Technology** | | **ICE** | **ICE** | **CC** | **ICE** |
| **Power** | **$MW_{El}$** | **0.05** | **1** | **10** | **0.5** |
| **Efficiency-el.** | $Eff_{EL}$ | 34% | 40% | 30% | 38% |
| **Efficiency-th.** | $Eff_{H}$ | 53% | 45% | 50% | 37% |
| **Efficiency-sum.** | $Eff_{SUM}$ | 87% | 85% | 80% | 75% |
| **Operation** | **h/a** | **5,500** | **6,500** | **6,500** | **7,000** |
| Fuel | MWh | 809 | 16,250 | 216,667 | 9,211 |
| Electricty | MWh | 275 | 6,500 | 65,000 | 3,500 |
| Heat | MWh | 429 | 7,313 | 108,333 | 3,408 |
| | | | | | |
| **Investment** | **£** | **125,000** | **1,000,000** | **10,000,000** | **2,800,000** |
| | **£/kWel** | 2,500 | 1,000 | 1,000 | 5,600 |
| **O&M costs** | % of Inv. | 8% | 8% | 7% | 7% |
| | £/MWh | 36.36 | 12.31 | 10.77 | 56.00 |
| **Price of fuel** | £/MWh HHV | 32 | 28 | 27 | 0 |
| **Value of electrcity** | £/MWh | 100 | 80 | 47 | 89 |
| **Other market revenues** | £/MWh | | | | |
| **Value of heat** | £/MWh | 40 | 35 | 33 | 30 |
| **Support** | | | | | |
| Electricity | £/$MWh_{El}$ | | | | 140.2 |
| Other support or benefits | £/a | | | | 90,757 |
| Tax reduction | £ | 26,250 | 210,000 | 2,100,000 | |
| **Costs & revenues** | | | | | |
| Fuel | £/a | -28,758 | -505,556 | -6,500,000 | 0 |
| Electricty | £/a | 27,500 | 520,000 | 3,055,000 | 312,480 |
| Heat | £/a | 16,935 | 252,778 | 3,611,111 | 102,237 |
| Support | £/a | 0 | 0 | 0 | 581,457 |
| Other market revenues | £/a | 0 | 0 | 0 | 0 |
| O&M costs | £/a | -10,000 | -80,000 | -700,000 | -196,000 |
| **TOTAL** | **£/a** | **5,677** | **187,222** | **-533,889** | **800,174** |
| **SPB** | **years** | **17.4** | **4.2** | **-14.8** | **3.5** |
| **IRR** | **%** | **-9%** | **20%** | **#GETAL!** | **26%** |

# 5. Methodologies used to calculate the saving of primary energy and CO2 emissions under the roadmap

**Substitution method**

This method has been developed in the CODE2 project. In doing this, two other approaches have been considered: 1) the "replacement mix method[34]" from the Munich FfE institute, which however cannot be used directly for a long term comparison as needed in CODE2; 2) a method used to calculate the $CO_2$ saving resulting from a voluntary commitment of the German industry for $CO_2$ reduction[35], however this method has been considered as too simple. Therefor the following more differentiated approach has been developed:

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

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

b) of electricity in power plants

c) of heat in boilers.

The savings result from a combination of three effects:

- CHP effect

- Technology effect (improved CHP technologies)

- Fuel switching (e.g. lower carbon content of natural gas compared to coal, $CO_2$ neutrality of bioenergy)

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

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

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

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

- replacement of separate generation by cogeneration

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

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

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

can be usefully seen only as an integrated process.

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

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

**EED method**

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

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

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

## 6. Sources

**AEA** Interaction between different incentives to support renewable energy and their effect on CHP [Report]. - [s.l.] : DECC, 2010.
**Carbon Trust** Micro-CHP Accelerator [Report]. - 2011.
**CHPA** CHPA cited in parliamentary energy bill debate [Online]. - 31 07 2013. - http://www.chpa.co.uk/chpa-cited-in-parliamentary-energy-bill-debate_1564.html.
**CHPA** CHPA presents "Big Offer" to Energy Secretary to boost community district heating [Online]. - 15 11 2012. - http://www.chpa.co.uk/chpa-presents-big-offer-to-energy-secretary-to-boost-community-district-heating_1054.html.
**CHPA** District Heating Installation Map [Online]. - http://www.chpa.co.uk/district-heating-installation-map_790.html.
**CHPA** Phew! Carbon tax scrapped for combined heat and power plants [Online]. - 20 March 2014. - http://www.chpa.co.uk/phew-carbon-tax-scrapped-for-combined-heat-and-power-plants--_2111.html.
Climate Change Act 2008. - 2008.
**Cogen Europe** European Cogeneration Review - United Kingdom [Report]. - 2012.
**Defra** Analysis of the UK potential for Combined Heat and Power [Report]. - [s.l.] : Department for Environment, Food and Rural Affairs, 2007.
**Department for Environment, Food and Rural Affairs** Anaerobic digestion strategy and action plan [Report]. - 2011.
**Department of Energy & Climate Change** [Online] // DECC's Free resource supporting the development of CHP. - http://chp.decc.gov.uk/cms/.
**Department of Energy & Climate Change** CHP Incentives: Renewable Obligation [Report]. - 2012.
**Department of Energy & Climate Change** Digest of United Kingdom energy statistics chapter 7: Combined heat and power [Report]. - 2013.
**Department of Energy & Climate Change** Energy efficiency strategy: The Energy Efficiency Opportunity in the UK [Report] = Energy efficiency strategy. - 2012.
**Department of Energy & Climate Change** Meeting energy demand: Combined Heat and Power [Report]. - 2012.
**Department of Energy & Climate Change** Summary evidence on District Heating Networks in the UK [Report]. - 2013.
**Department of Energy & Climate Change** The Future of Heating: A strategic framework for low carbon heat [Report]. - 2012.
**Department of Energy & Climate Change** The Future of Heating: meeting the challenge [Report]. - 2013.
**Department of Energy & Climate Change** The Future of Heating:Meeting the challenge Evidence Annex [Report]. - 2013.
**Department of Energy & Climate Change** The UK Low Carbon Transition Plan: National strategy for climate and energy [Report] = Low Carbon Transition Plan. - 2009.
**Department of Energy & Climate Change** Updated energy and emissions projections 2013 [Report]. - 2013.
**Department of Energy and Climate Change** Homeowners' willingness to take up more efficient heating systems [Report]. - 2013.
**Eurostat** Combined Heat and Power (CHP) in the EU, Turkey, and Norway - 2008 Data. [Report]. - 2010.
**Greenpeace** Combined heat and power [Online]. - http://www.greenpeace.org.uk/climate/solutions/combined-heat-and-power-chp.
**HM Government** The carbon plan: Delivering our low carbon future [Report]. - 2011.
**Major Energy Users' Council** Powercut Britain: Are the lights about to go out for UK Business? [Report]. - 2013.
**Ofgem** FiT installations Report [Report]. - UK : [s.n.], 2012.

**Pöyry** The potential and costs of district heating networks [Report]. - 2009.
**Ricardo-AEA** CHPA Sales Database - Report 10: April to December 2013 [Report]. - 2014.
**Ricardo-AEA** Projections of CHP capacity and use to 2030 [Report]. - 2013.
UK's indicative national energy efficiency target for 2020 under Article 3 of the Energy Efficiency Directive [Report]. - 2013.

# 7. Contacts

## Project partners

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

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