CODE2

Cogeneration Observatory and Dissemination Europe

D5.1 Final Cogeneration Roadmap non pilot Member State: ***France***

July 2014

Leading CODE2 Partner: **FAST – Federazione delle associazioni scientifiche e tecniche**

France is part of non-pilot Member States of the South-West CODE2 Region.
The CODE2 Region 'South-West' comprises the following Member States:
France, Italy, Malta, Portugal, Spain

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

Introduction

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 is part of 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 expressed 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 France is written by CODE2 partner FAST – Federazione delle associazioni scientifiche e tecniche, based on a range of studies and consultation.

It has been developed through a process of discussion and exchange with experts.

Acknowledgement

FAST and the CODE2 team would like to thank all experts and policy-makers who on different level have been asked to give their valuable contribution to this roadmap.
It has to be stressed anyway that the statements and proposals in this paper do not necessarily reflect those of the consulted experts.

N.B.

The roadmap was written over the period April 2013 – March 2014. The national policy framework around CHP has continued to evolve in France and this should be taken into account when using the material in the roadmap.

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

TABLE OF CONTENTS

1. Executive Summary

The total installed electrical output from cogeneration in France in 2008 was 6.336 MWe, including gas and vapour as primary energies. In the period 2008 to 2014, the energy produced by cogeneration has decreased reaching about 4.555 MW for gas fired cogenerations in 2014[2]. The CHP capacity is mainly located in industrial plants and district heating. In the residential sector, micro-CHP is still non developed.
Under the EU Effort Sharing Decision[3], France has set a target to divide by four by 2050[4] the 1990 greenhouse gas emissions. A new national law regarding energy transition for green growth (LTECV) has been submitted end of July 2014. This new law would support the government effort in achieving energy efficiency and CHP targets.
A decline in CHP production and capacity is expected during the coming years, due to the lack of appropriate government support, market conditions, a clear long-term vision and unfavourable CHP clean spark spread (CSS) due to gas prices increase. CHP is today supported by purchase obligation and capacity prize. Residential micro-CHP get tax credit support and eventually eco-interest loans, whilst bio-energy CHP benefits from feed-in-premium and if applicable, from additional subsidies for use of agricultural slurries.
France had not historically been a very active CHP market, because of hard competition from other energy production technologies. This situation is also represented by a medium-to-low awareness among most of the market players and customers. Even in the presence of an active market environment, policy and administrative barriers do not encourage the full exploitation of CHP potential.
By a financial and business point of view French CHP initiative (in particular for large plants, district heating and biomass) have a potential margin of profit under the present market condition. However in a scenario of rapid policy changes, negative fallouts are expected on volume of investments, in particular for small and medium size plants.
A large government policy effort in the area of energy is today in place for bio-CHP, with a target of 2,3 GW by 2020 against the 877 MW 2008 figure, even if the actual trend projections indicate this target will not probably be respected within this horizon.

The energy structure and choices of France have not so far required significant recourse to cogeneration. If we consider total electricity production, cogeneration remains underdeveloped in France compared to its European neighbours, which is explained by the French choice to develop nuclear energy enabling the production of low price electricity with low carbon dioxide emissions. The electricity production of cogeneration facilities does, however, represent a significant share of conventional French thermal electricity production (thermal power stations).

French cogeneration output is at a turning point in its development: after the decade 2000-2010 which has seen the output of plants increase very rapidly (from 1 to 6 GWe) thanks to a policy of support for gas cogeneration, the reorientation of this support policy, in particular towards biomass cogeneration, should profoundly modify the conditions for cogeneration in France and transform the existing sector.
In current conditions, and assuming a certain number of economic hypotheses, while the cogeneration output, currently primarily supplied by gas, should partially convert to biomass, it does not seem inclined to increase its overall capacity for electricity production, which will probably regress by 2020 by 5 to 15%, depending on the hypotheses made.
According the calculations carried out in this study the implementation of CHP roadmap in France estimates a PES value equal to 83 TWh per year corresponding to 3% and CO2 emission reduction of 34 mio tons by 2030.

[2] Souce : ATEE "Journee micro/mini cogénérations" proceedings – January 23rd 2014 – Intervention of Patrick Canal – ATEE ("Etat des lieux des filières micro & mini cogénérations en France - Préconisations du Club Cogénération de l'ATEE pour le déploiement de ces filières")
[3] Source: http://ec.europa.eu/clima/policies/brief/eu/index_en.htm
[4] Source: POPE law of 13 July 2005

2. Where are we now? Background and situation of cogeneration in Member State

2.1. Current status: Summary of currently installed cogeneration

The total installed CHP electrical capacity in France in 2008 was 6.336 MWe, or 15.052 MWth[5], but installed capacity decreased to 4.555 MWe in 2014. The CHP capacity is mainly located in industrial plants and district heating systems.

In 2012, the total gross electricity generation was 564.275,00 GWh[6]. Today in France[7], cogeneration covers around 2 to 3 % of national electrical production (close to photovoltaic capacity), against the 78% of nuclear and the 20% of hydro plants. In 2010, the French CHP heat capacity was 13,3 GW and the CHP heat production was 173,9 PJ[8]. Thus, cogeneration does not represent a key segment of the French energy market.

Large power cogeneration plants (more than 12 MWe) represent roughly half of the total installed electrical capacity, mainly fed by natural gas (table 1). The CHP capacity is mainly located in industrial plants and district heating systems. The number of sites of mini and micro-CHP[9] is currently about 150.

Cogeneration segment	micro < 36 kW	mini 36 to 250 kW	small 250 to 1000 kW	Medium 1 to 12 MW	large >12 MW
Micro-engine or micro turbine (Stirling / Ranking cycle)	from 1 kW to 50 kW				
Module with gas engine		from 50 kW to 1 MW			
Gas or biogas ICE			from 1 MW to 6 MW		
Gas turbine				from 5 MW to 125 MW	
Installed capacity (MW)	< 0,20	~ 10	~ 45	~ 2300	~ 2200
Number of sites	< 100 sites	< 50 sites	~ 100 sites	650 sites	~ 35 sites

Table 1: Current installed cogeneration in France (2014)[10]

In 2013 the installed capacity and the number of sites of the large CHP plants (> 12 MW) remains stable, despite the large CHP plants have had a period of doubts, regarding the feed-in tariff, related to the end of the obligation to purchase contract with EDF mainly in the 2013 (table 1 and 2).

Cogeneration segment	Installed capacity	Number of engines/turbines	Number of sites
< 12 MW	2.390 MW	1.000	743
> 12 MW	2.176 MW	48	36
Total	4.566 MW	1.048	779

Table 2: Repartition of the installed capacity, of the number of CHP engines and of the number of CHP site in function of the CHP segment in November 2013[11]

[5] Source: Annual survey of electricity production by the SOeS (French Observation and Statistics Office) in 2008
[6] Source : Eurostat data - http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/main_tables
[7] Source: RTE (Réseau de transport d'électricité) – "Bilan Electrique Français 2013", January 2014 - www.rte-france.com/fr/
[8] Source : Eurostat – CHP data 2011
[9] In France the following market segmentation applies: microCHP <36 kW, miniCHP 36 to 250 kW
[10] Souce : ATEE "Journee micro/mini cogénérations" proceedings – January 23rd 2014 – Intervention of Patrick Canal – ATEE ("Etat des lieux des filières micro & mini cogénérations en France - Préconisations du Club Cogénération de l'ATEE pour le déploiement de ces filières")

The gas turbine is currently the dominant technology in terms of the installed electrical power (table 3). It represents more than half of the cogeneration output.

Technology	Installed capacity	Number of plants	Number of sites
Gas engine	1466 MWe	946	610
Gas turbine	3100 MW	102	169
Total	4566 MW	1048	779

Table 3: Breakdown of CHP plants by technology, November 2013[3]

Apart from large installations managed by major utility companies, in terms of decentralized installation grid connected, according to ERDF[12], which manage the electricity network of approximately 95 % of the French territory, in March 2014, there were 514 CHP plants which were connected to the electricity network managed by ERDF, with a total installed electrical capacity of 1.701 MWe. Within in the same period, 271 biogas CHP plants were connected, for an installed capacity of 270 MWe. The difference between the total installed capacity of 4.555 MWe and the figures of ERDF shows that the main part of the energy produced by cogeneration is used as self-consumption probably in the industrial sector.

Trends of decentralized cogeneration, over the period march 2013-march 2014, show a decreasing of connected installation installed power (- 1 MWe or 1%) but a growth of plant number (+ 6 plants or 1%). So the new plants do not belong to the large CHP segment. Biogas grows faster in the same period, with + 54 new plants connected to the grid for an additional capacity of 29 MWe (+11.%), which is an indication of the actual and future trend regarding bio-CHP, as it is reported in the final chapters of this report.

2.2. Energy and climate Strategy

Under the EU Effort Sharing Decision, France has set a target to quarter 1990's greenhouse gases emissions by 2050[13]. The National Climate Change Adaptation Plan (PNACC), released on 2010, contains concrete measures for the period 2011 - 2015, to address climate change, but does not mention to CHP. New regulations and measures in the energy field are under development at the time of writing and expected to be implemented by 2015.

The third French Energy Efficiency National plan[14], released on 2014 in the framework of implementation of EU directive 2012/27/CE, established within an horizon 2020 a double objective: to reduce its energy consumption to 1,53 TWh of final energy and to 2,75 TWh of primary energy in 2020 (excluding international air transport). At the same time France is engaged in the EU "20-20-20" strategy. The expected savings to be achieved by 2020 are principally concentrated on the residential and tertiary sector, with a target of savings of 38 % and on the transport sector, following by the industry and agriculture sectors.

France is one of the industrial countries that emits the least GHG, both in terms of emissions per capita and emissions per unit of GDP. It represents 1,2% of the world's GHG emissions although it contributes 4,2% to world GDP. For metropolitan France and the overseas departments, the 2011 emissions are 13% lower than those of 1990 (14% lower than the emissions ceiling set by the Kyoto protocol), falling from 556 to 486 Mt $CO_2^{-eq.}$, whilst over the same period GDP increased by almost 40%. These excellent results are explained by the low use of coal and gas to generate energy. The results benefit from the high proportion of electricity

[11] Souce : ATEE "Conférence de l'Alec" proceedings – November 28th 2013 – Intervention of Jacques Besnault – ATEE ("Situation de la cogénération en France sur les segments de moins et de plus de 12 MW à debut nov 2013")
[12] Source: www.erdf.fr/panorama_des_installations_de_production, update March 2014.
[13] Source: POPE law of 13 July 2005
[14] Source: "Plan d'action de la France en matière d'efficacité énergétique", 2014 - www.developpement-durable.gouv.fr/IMG/pdf/0378_Annexe_1_PNAEE_.pdf

generated using nuclear or hydraulic power used in France and also from France's good performance in terms of energy efficiency. Following two decades of growth, final energy consumption has been almost stable since 2000, at around 1,86 TWh per year; demonstrating the efficacy of public policies to promote improving energy efficiency. Final energy intensity (corrected for variations in year-to-year winter temperatures) decreased by 1,7% in 2010 and 1,6% in 2011. Since 2005, it has decreased by 1,3% per year on average, when France already has one of the lowest levels of final energy intensity in the European Union.

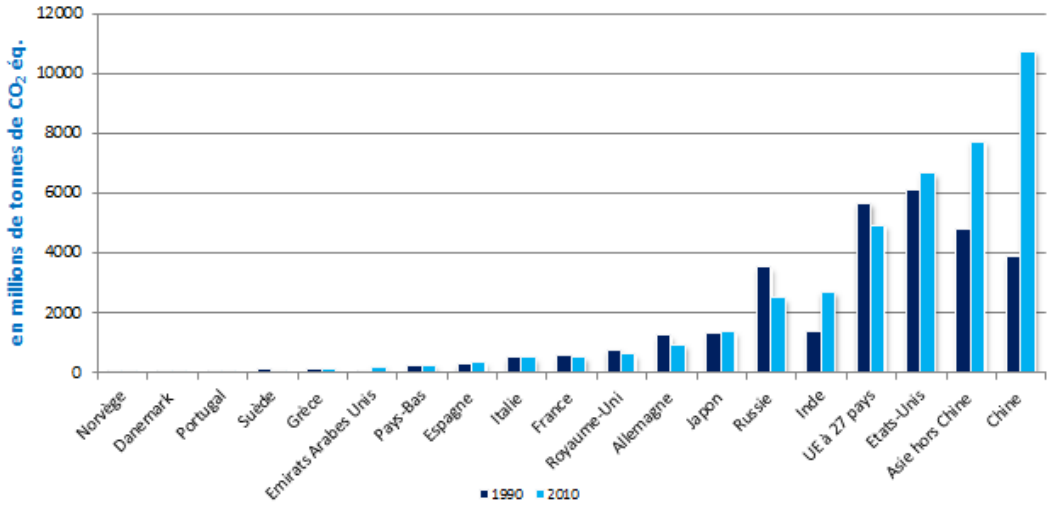


Figure 1 – Trend of the greenhouse effect gases emissions in the world since 1990 to 2010[15]

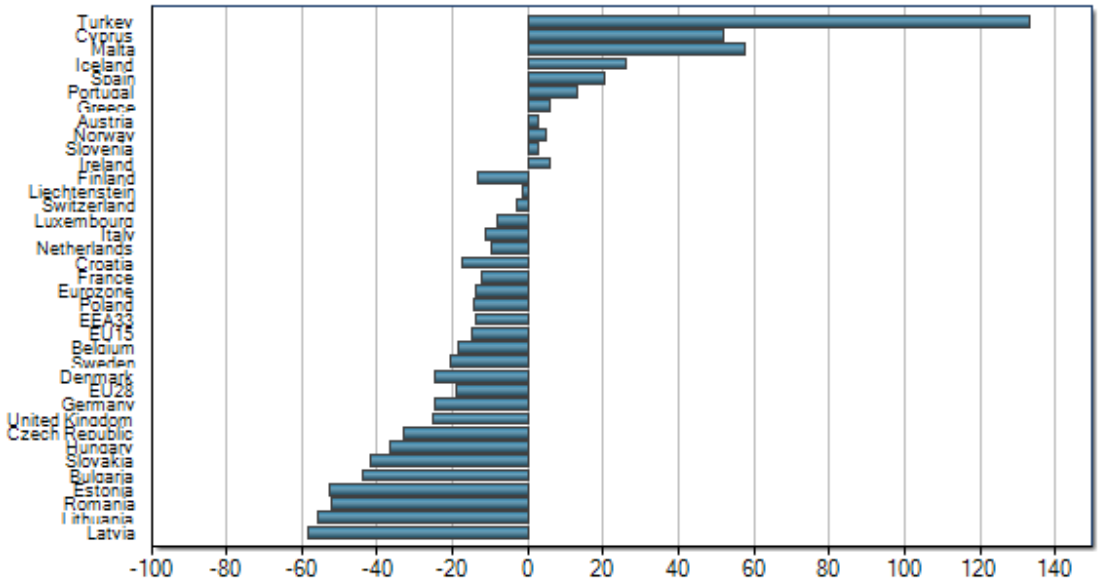


Figure 2 – Trend of the greenhouse effect gases emissions in the UE countries since 1990 to 2012[16]

Although good, these results are not yet at the target level written into the Programme Law of 13 July 2005 setting the directions for the energy policy (POPE law). This law set a target of a 2% per year reduction in final energy intensity as of 2015 and then 2,5% per year by 2030 (article 3 of the POPE law). The same has been observed for GHG emissions: they have decreased by 2% per year on average since 2005 whereas the

[15] Source: www.observatoire-electricite.fr/Les-emissions-de-gaz-a-effet-de

[16] Source: European Environment Agency, 2011

average fall would need to be 3% per year to reach the national target, which is to cut emissions to a quarter of their 1990 level by 2050.

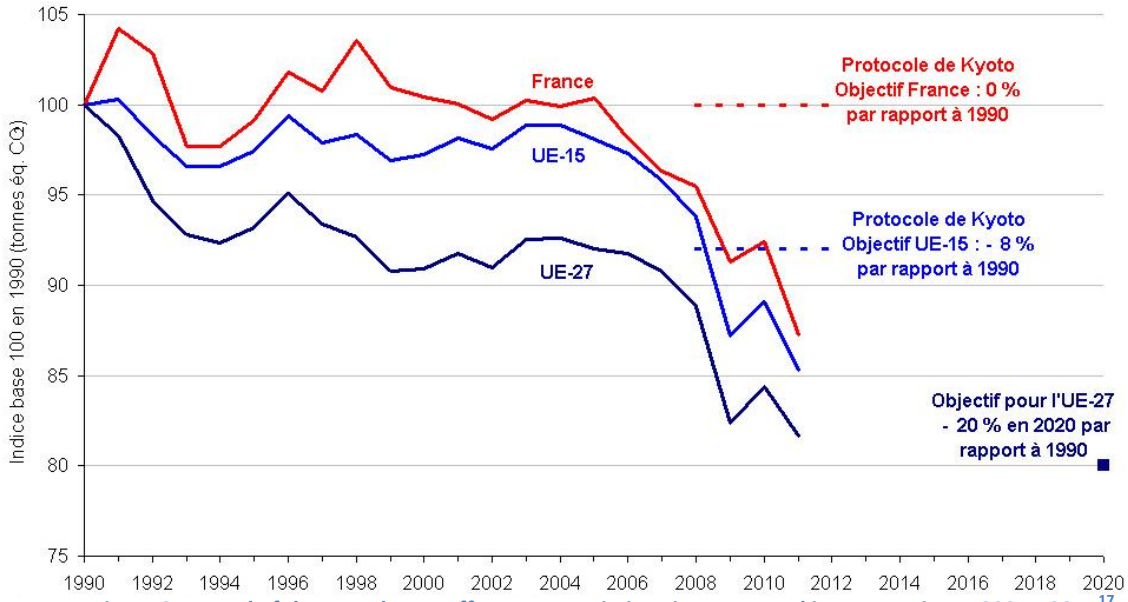


Figure 3 – Trend of the greenhouse effect gases emissions in France and in Europe since 1990 to 2011[17]

Cogeneration technology enables greater energy efficiencies to be achieved overall than those from technologies which produce heat and electricity separately, and is one of the solutions to be implemented to achieve these energy saving targets. Primary energies savings compared to separated productions can achieve 20 to 25% with the newest technologies of gas engines.

Consequently, policies support the development of CHP since it may be linked with the two other targets in this area, the reduction of CO_2 emissions (through cogeneration electricity production replacing more carbon-intensive electricity production), and the increase in the share of REs in the French energy mix (through the mobilization of biomass as fuel). The French context of an electricity production system which is on average low carbon, together with a biomass sector still in the process of being structured, is an element to take into account in the policy for the support of cogeneration.

During the 1990s and 2000s, gas cogeneration expanded rapidly in France under the influence of a policy of support via regulated tariffs for the power feeding-in. Since the late 2000s, this policy of support for cogeneration has been reoriented towards biomass cogeneration through successive calls for tender by the CRE (Energy Regulatory Commission), and by the implementation from 2002 of a tariff for the obligation to purchase electricity produced from biomass which encourages cogeneration; a feed-in tariff which was re-evaluated several times since 2009 and lastly in end of 2013 with the C13 contract, bases on real gas spot prices for the proportional remuneration.

The French carbon tax[18] (or "Climate – Energy Contribution") is an environmental tax on carbon dioxide emissions, that aims to limit CO_2 production and was implemented in France on 1st April 2014, in order to control global warming. This tax discourages emissions by making polluters pay in proportion to their emissions. The impact of the tax on final products increases their price in proportion to their CO_2 emissions, promoting products which induce less carbon dioxide. A gradual increase and planned tax can help guide long term investments, giving the necessary time for consumers and businesses to adapt. In particular, the gas price will gradually increase through this carbon tax. The tax will especially influence on industries using natural gas and households using micro-CHP.

[17] Source: SOeS, Citepa aggregation, CCNUCC inventory of February 2013, European Environment Agency, 2013

[18] Source : www.actu-environnement.com/ae/news/taxe-gaz-naturel-menages-contribution-climat-energie-21234.php4

2.3. Policy development

A decline in CHP production and capacity is expected in the coming years due to an uncertain long-term policy vision, notably regarding the large plants (> 12 MW). CHP is today supported by an obligation to purchase tariff and a "capacity premium", but for large plants the capacity premium is guaranteed until 2016 only. Residential micro-CHP gets tax credit support and possibly an eco-interest loan. Bio-CHP attracts a feed-in-premium. Moreover, when agricultural slurries are used in the biological process, Bio-CHP, can benefit of a additional premium. Starting from June 2014 a new energy law proposal (POPE2) is under discussion, that could have negative impacts on the CHP sector.

Today the French CHP market is supported by several government measures:

- **Decree of 27.02.2013 related** to conditions of purchase of the **electricity produced by biogas plants**: regulatory framework dedicated to support biogas production and its **valorisation both through bio-methane injection into the natural gas networks and electricity production** and its injection into the network. This Decree is expected to increase the number of CHP plants, but experts already considers that tariffs for small plants are not sufficient to ensure a successful development of activity. This system allows producers to benefit for the first time from both the existing support mechanisms for the electricity production from biogas (obligation to purchase tariff) and from the bio-methane injected production (guaranteed purchase price up to 80 €/MWh). Previously, biogas producers were obliged to choose one of the two valorisation forms, which had the effect of preventing the realization of several biogas production projects or to limit their size.
- **Decrees of 9.10.2013 and of 11.10.2013** related to conditions of purchase of the electricity produced by cogeneration plants : these decrees established a new contract which regulate the tariff of the energy produced for **cogeneration plant of less than 12 MW capacity**. Both news plants (after October 2013) and existing ones are affected by these decrees, but not in the same way:
    - For existing contracts: only the gas remuneration and the energy efficiency premium are modified
    - For new contracts: the fixed premium reflects a energy efficiency coefficient with a primary energy savings increased from 5% to 10% (in reference to high efficiency electricity production promoted by EE Directive) and a new definition of the average availability

  Practically these new schemes introduce the following issues:

    - The reference electric yield, used to calculate the provided electricity remuneration, which was 54 %, has been increased to 56 % for the new contracts and is not changed for ongoing contracts.
    - A more plant running flexibility, with the possibility to choose among three operating modes : continuous mode "full week", continuous mode "working days" or availability for the electrical system, and can change monthly. The introduction of the continuous mode "working days" will allow the plant to stop during the week end without losing electric capacity availability. Moreover, the definition of winter season becomes: from the 1st November to the 1st of April and it is now possible to start or stop the winter season in November or in March.
    - The "remuneration based on spot market gas prices" component, for the electricity price calculation, is now capped, in order to have a better regulation of the CSPE (Contribution to public service for electricity) tax.

- There is now the possibility of summer running, with a production compensation equal to the settlement price of the positive electrical spread, which is generally 80 to 90% of the spot price[19].

- **Decree of 19.12.2013** related to **large cogeneration plants** (> 12 MW) covers industrial facilities as well as district heating systems. Under this scheme, eligible facilities can benefit, **until 31 December 2016,** from a remuneration for an availability commitment for the power system, subjected to a contract with EDF. The maximum **annual premium** is **45 k€/MW**. The decree is a transposition of the Article L. 314-1-1 of the Code of Energy. This article was introduced by the "Ddadue" Act of 16 July 2013 in an economic environment in which the decrease of market prices of electricity, the increase of the gas prices and a low level of CO_2 prices, have created unfavourable conditions for the operation of plants generating electricity from gas.

The additional costs resulting from the support policies for cogeneration and renewable energy and transient capacity premium for cogeneration plants over 12 MW are covered by the Contribution to public service for electricity (CSPE) tax. The CSPE tax is proposed each year by CRE (Energy Regulatory Commission) to Ministry in charge of Energy. The CSPE tax is paid by all electricity consumers in proportion with the kWh consumed. In 2014, CSPE tax is 16,5 €/MWh and 7,4 % of CSPE tax cover the cogeneration costs[20]. It would be around 20 €/MWh in 2015. In Germany, such tax is around 51 €/MWh[21].

- For micro-cogeneration (< 36 kW), the incentives of 2014 are the following: **income tax credit of 15 %** in case of implementation of **only a cogeneration system** in an existing building and **25 %** in case of implementation of a **cogeneration system in the framework of other works dedicated to improve the energy efficiency** of an existing building. It is also possible to benefit from an eco-interest loan, implemented in order to support individuals to finance improvements of the building energy performance.

A **new national law proposal regarding energy transition for green growth (LTECV)** - new POPE law[22] - has been presented on the **18th of June 2014**. This new law project will probably support the last effort of the government in the frame of energy efficiency and the existing CHP plants. Some macro-objectives for 2025 of this text are the decrease of the nuclear energy to a level of 50 % of the total electricity production of France and the development of renewable energy to a level of 32 % of French final energy consumption. According to the first draft of the proposal, no specific changes for CHP should be expected from its entry into force, but, at the same time, there are not specific mentions supporting the development of CHP market in France.

[19] Source: www.green-law-avocat.fr and Energie Plus – 18/10/2013 on www.atee.fr
[20] Source : http://www.cre.fr/operateurs/service-public-de-l-electricite-cspe/mecanisme
[21] Source : Patrick Canal - ATEE
[22] Source: www.developpement-durable.gouv.fr/IMG/pdf/140622_projet_de_loi_texte.pdf

2.4. Awareness

France had historically been a quite active CHP market, moreover because of hard competition for CHP from other energy production technologies and particularly large share of nuclear power. This situation is also represented by a medium-to-low awareness among most of the market players and customers. Even in the presence of an active market environment, policy and administrative barriers do not encourage the full exploitation of CHP potential, evaluated in 2010 to 30 electrical GW by the french administration (DGEC – Direction Générale de l'Energie et du Climat – Ministère de l'Environnement, du Développement Durable et de l'Energie).

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 social-economic groups, are show in Figure 4. 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 Annex 1.

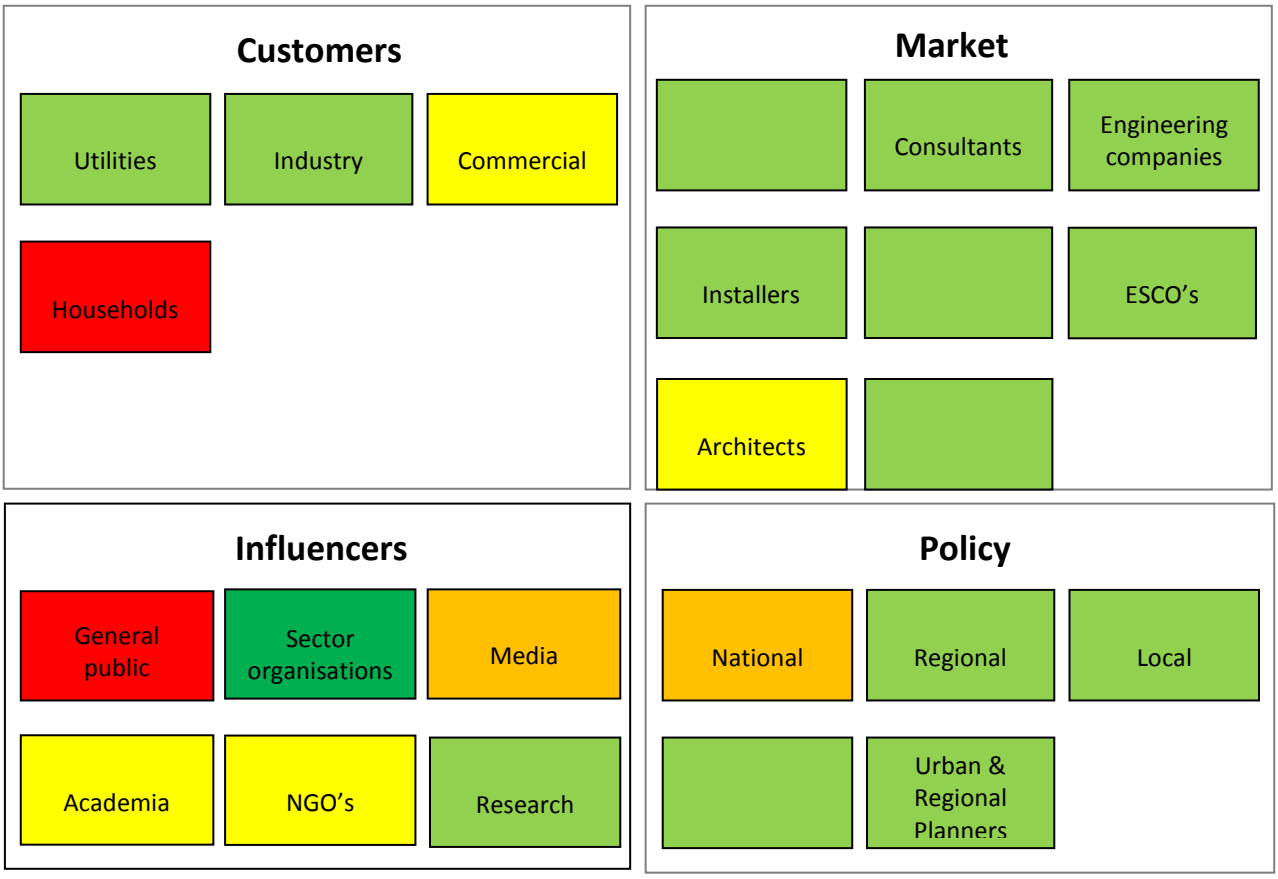


Figure 4: Level of awareness among key actors under the four socio-economic groups

1		Poor	4		Interest
2		Low	5		Active market
3		Early awareness			

Customers

Figures, discussed in Chapter 1.1, show us that there is an active market in the industrial sector. The penetration in commercial premises is only limited. Some manufacturers start to advertise domestic micro-CHP units to households, but during the last years, other systems like heat pumps have been promoted more than micro-CHP systems, so the awareness of the public and of the households of cogeneration technology is extremely low.

Market players

Most market players (manufacturers, consultants, engineering companies, installers and grid operators) are aware of cogeneration. Although some of the heating and electricity installers in the segment of the micro-installations lack the necessary knowledge. Some banks are really interested by cogeneration and follow with attention the development of the related technologies.

Influencers

The sector organisations (Cogeneration Club of ATEE – Technical Association Energy Environment, FEDENE – Federation of Energy Environment Services, UNIDEN – Union of Energy Using Industries) are very active to promote CHP at national and regional level. In the discussions about energy transition and energy efficiency measures and technologies, CHP is not mentioned by the popular media. Specialised media spend more time on cogeneration. NGOs do not mention CHP, they are more focused on energy efficiency system other than CHP. Consequently, the general public is not at all familiar with cogeneration.

Policy makers

The government knows the potential energy impacts of cogeneration but cogeneration is not seen as a priority technology to implement because of the energy mix of France where nuclear technology, covers a large part of the energy needs of the country (75 to 80% with 63 GW of installed electrical capacity). The government is not actively reforming nor compensating the market failures which relate to CHP. Despite the awareness of government that CHP is economically not feasible unless the market failures are addressed with unfavourable CHP clean spark spread (CSS) due to gas prices increase till 2005, this aspect is more or less ignored by the public decision makers.

2.5. The economics of CHP

There are still possibilities to run CHP projects in France thanks to the presence of incentives schemes and premiums. However the rapid evolution of support policies, the reduction of incentives schemes and fluctuation of power market prices made difficult to estimate the consequences in the short period on CHP investments trends, in particular for small and medium size plants.

An economic analysis have been carried out around four business cases, standardized within the CODE2 project, to enable comparison of different investment scenarios in present French market condition. The cases are:

- A 1 kWe Stirling engine household application
- A 200 kWe ICE installed in an industrial plant
- A 30 MWe Compressed gas turbine for district heating in north of France
- A 500 kWe biogas ICE at a farm, with use of animal slurries

In general, apart from the Household application, investment financial conditions are quite good, with a SPB estimated around 8 years and an internal rate of return on investment variable from 4% to 11%. However it's important to highlight that French support schemes to CHP are extremely variable, depending on technology, size and market geographical conditions and contract of natural gas supply. According to the contracts presently in force[23] for the purchasing of CHP power by the Grid Authority, prices and premiums are variable within the French Regional price of natural gas and the season of activities.

Thus, the conditions described below can be considered as average for French CHP market, but locally they could assume different trends and validations.

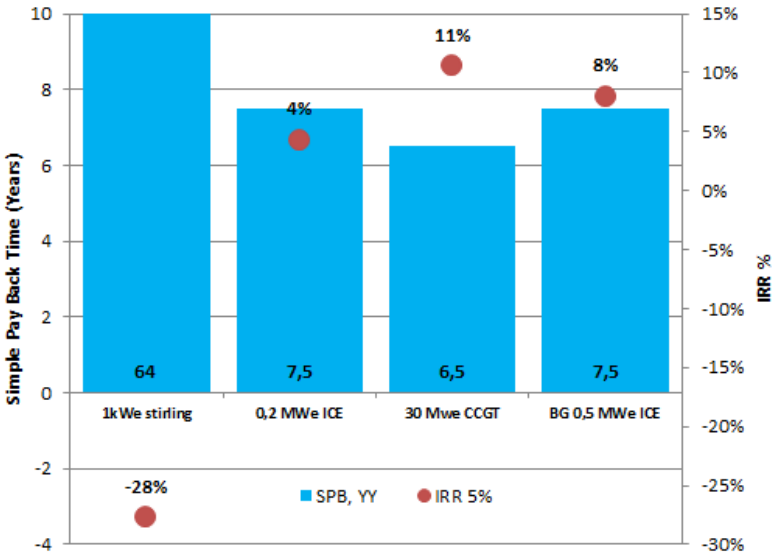


Figure 5: Economic calculations of four standard CHP plants

[23] Source : "Contrat d'achat de l'énergie électrique produit par les installations à biogaz et bénéficiant de l'obligation d'achat d'électricité – BG11 V01" and "Contrat d'achat de l'énergie électrique produite par les installations de cogénération et bénéficiant de l'obligation d'achat d'électricité - C10-13 V1" - www.edf.fr

Household micro appliances do not seem to have a viable potential exploitation at present market conditions. The main reason is linked to the absence of convenient feed in tariff for such installation and the high prices of these appliances on the French market. Despite the availability of investment incentives for their installation in the framework of energy renovation work in private homes[24], the ROI is extremely high (64 years) and they do not seem to be competitive considering present prices of grid power supplies.

In other EU countries, thanks to the involvement of utility companies[25] in promoting such appliances, these technologies are encountering a relative success, but in France so far this choice is not directly promoted by any programme[26].

For other technologies, in the modelled group, the impact of incentive schemes on return on investments is relatively high, in particular on biogas CHP. For these installation prizes for use of heat (minimum 35%) and use of animal slurries in biogas production could represent up to 19% of annual plant turnover. The expected reduction of incentive amounts for the coming years could affect the development of new investments.

The industry case , under present market conditions, shows an IRR of 4% versus a 5% reference rate for the calculation of net present value (NPV), in a scenario of full industrial valorisation of heat produced by CHP ("heat intensive processes"). Impact of incentives on payback period is relatively high. Considering the competiveness of grid power prices, in a scenario of expected reduction of incentives and increase of cost of grid connection and dispatching, in the short period is expected a reduction of investment of new plants and revamping of existing older ones.

Under present market conditions large CHP plant for District heating have the most favourable conditions for investment, because of the coupling of incentive of CHP power of the "C10-13" Contract and other incentives specific for heating distribution infrastructure ("Fond Chaleur"[27], not considered in present scenario) in particular for use of renewables. The price of heat is extremely variable in France with a spread from 35 to 85 Euros[28] per MWh, ensuring the sustainability of the district heating financial model. In addition the "capacity premium" for large scale application could play a relevant role.

Presently the conditions for CHP exploitation in France are quite favourable, thanks to the presence of policies and tariffs able to support small and large investments. Nevertheless the proposed reforming of the "obligation d'achat" and the elimination of "capacity premium" for large installations by 2016 could lead to a reduction of interest in investing in this energy sector. Policies trends seem to be more oriented to promote renewables and district heating than the wider use of CHP in the economy and industry.

If the present environmental support measures linked to CO_2 emissions (today part of C13 contract scheme) and the "capacity premium" would be maintained in future incentive schemes, this would maintain the economic convenience of CHP investment, in particular for in those installations and applications that use renewables sources and combustibles.

[24] Source : www.developpement-durable.gouv.fr/Comment-beneficier-du-taux-de-25.html

[25] http://www.britishgas.co.uk/products-and-services/boilers-and-central-heating/new-boilers/central-heating-and-boilers-explained/how-it-works/alternative-systems.html

[26] Source :ATEE - Journée micro/mini cogénérations - January 23rd, 2014

[27] "Fonds chaleur" is an incentive programme funded by national government supporting heat production from renewable sources (biomasses, geothermal, solar…) and the creation of district heating networks for civil, industrial and agricultural purposes. See http://www.ademe.fr/expertises/energies-renouvelables-reseaux-stockage/passer-a-laction/produire-chaleur/fonds-chaleur

[28] Source: "Enquête du prix de vente de la chaleur 2012" – ADEME Amorce (2014) - www.ademe.fr

2.6. Barriers to CHP

Today French government policy aims decided to maintain the level of cogeneration in France at the current 2014 level[29]. The barriers that hamper wider development and growth of CHP capacity in France are essentially economic reasons and their impact on the CSPE costs: There is no financial feasibility for CHP in France without subsidies.

As discussed in previous Chapters, France does not have a very active CHP market. Chapter 1.4 shows that many actors know the benefits of CHP, however the current outlook for CHP is not very promising. The barriers are ordered in descending order of importance.

Barrier 1: low grid power price on the whole sale market in France and low price of CO_2 on EU market make investments on CHP challenging

A component of National CHP Incentive scheme is linked to CO_2 market ETS prices. In addition CHP investments generate CO_2 credits, that can be traded on ETS platform, giving an additional income able to ameliorate economic investment figures. Today EU emission trading system (ETS) prices swing around 4-5 €/tCO_2[30] and projections estimate that the price in 2020 will be between 8 €/tCO_2 and 15 €/tCO_2[31]. The lower price of carbon combined with the availability of low cost grid energy generated by nuclear (today the main share in the national power energy mix) is an economic barrier for realization of new plants and revamping of existing ones. The low "spark spread[32]" is not only a barrier for the installation of new CHP plants but also for the operation of existing CHP plants.

Barrier 2: The current market failures are not addressed in today's CHP policy and support

The energy efficiency benefits of operating CHP are not sufficiently validated in the energy markets of today, notably in terms of gas and electricity networks and primary energies savings externalities, to allow the CHP operator to build an acceptable business case. The market takes little to no account of environmental costs, congestion in the network, additional network costs, energy storage, flexibility, networks reinforcements, vulnerability of large systems, both technical and political and the opportunities for heating/cooling. Energy savings and environmental benefits whether through ETS or otherwise are not financially rewarded in the energy market.

Barrier 3: The current micro-CHP market is not ready to be competitive on the French energy market

The investment required for micro-CHP units is currently (2014) too high to be economically profitable for a user, excepted maybe for small internal combustion packaged engines from 5 to 50 kWe (cogeneration modules). Moreover, the feed-in tariff encourages the individual to prefer auto-consumption of their electricity production rather than selling it (at a lower price than electricity purchased), the purchase price being around 13 c€/kWh (and feed-in tariff at 8,3 c€/kWh). Micro-cogeneration technology is in competition with other technologies which have already penetrated the market such as heat pumps and solar thermal. For micro-cogeneration, the obligation to purchase for electricity currently produced is not a sufficient incentive. Finally, the connection procedures for micro CHP are restrictive and may be prohibitive for project owners and project managers who may find these procedures too restrictive to decide to invest. The market is not yet ready, but should probably been pushed forwards by electricity prices increase (CRE expects a +15% by 2015 for residential uses).

[29] Source : ATEE
[30] Source: www.eex.com/en/Market%20Data/Trading%20Data/Emission%20Rights
[31] Source: www.icis.com/resources/news/2013/10/09/9713881/eu-2020-oversupply-forecast-exceeds-analyst-expectations/ ; www.icis.com/resources/news/2013/10/24/9718673/co2-price-for-coal-to-gas-switch-exceeds-2020-forecasts/
[32] The **spark spread** is the theoretical gross margin of a gas-fired power plant from selling a unit of electricity, having bought the fuel required to produce this unit of electricity, like in CHP plants.

Barrier 4: The French energy market is in overcapacity with the nuclear energy, which slows the CHP development

The huge share of nuclear in France's electricity supply system is currently seen, in combination with hydro RES, sufficient and economically effective for the national needs while the net demand tends to decrease[33]. From the perspective of the co-generators currently operating in France a consistent decline in support schemes for fossil based CHP since 2000 has been observed. Moreover, considering that the French market is mainly dominated by a supplier owned by the state, for all the other alternative energy sources operating as distributed generation, and so also for CHP, it is difficult to emerge in that context.

Barrier 5: The last constraints regarding high energy efficiency and renovation request for the existing plant can represent important barriers to overcome

The existing facilities have the possibility to obtain new contract under the condition of renovation of the plant, in order to increase the yield from 5 to 10 %, which often means the engine replacement. It represents an important investment (more than 400 EUR_{2014}/kWe indexed), which will not cover by the electricity purchase tariff.

Barrier 6: The bio-CHP sector is suffering of a lack of structure of the forest biomass market

The forest biomass offer is not sufficiently structured, the pricing signal is not sufficiently clear, the market lacks liquidity and long-term supply contracts are rare. In consequence, heat consumers not having favoured access to the forest resource have difficulty in securing their supply. Moreover, due in particular to the very divided structure of forest ownership in France, together with the recent rise of the biomass sector, the exploitation of forest biomass is still very little mechanised: productivity gains would enable control of forest biomass prices in a context of competing / high demand. This evolution towards greater productivity may today find itself in conflict with other uses for forest products, in particular in terms of cultural and biodiversity value.

Barrier 7: The recent implementation of the carbon tax (or "Climate – Energy Contribution") could became an additional barrier for the CHP development

Due partially to the implementation of the carbon tax since April 1st 2014, the gas price will gradually increase. This rise of the gas price will probably become an additional barrier, particularly for industrial CHP plant using natural gas and for the development of micro-CHP in the residential sector. The carbon tax, is designed to reduce fossil fuel use and under the same circumstances of presenting a barrier to gas based CHP could foster the development of CHP based on biogas production.

[33] Source : http://www.rte-france.com/uploads/Mediatheque_docs/vie_systeme/annuelles/bilan_previsionnel/bilan_actualisation_2013_v2.pdf

3. What is possible? Cogeneration potential and market opportunities

The estimation of technical market potential for CHP was developed by the French[34] Ministry of Ecology, Sustainable Development, Transports and Housing as part of a 2010 study. The analysis refers that national overall thermal needs are expected to significantly decrease in the next years, in particular because of the introduction of energy saving measures, of the change of economical paradigms and energy habits, and of the introduction of innovative technologies. the only sector in which heat demand is expected to grow is district heating. The French National Plan for renewable energies[35] highlights the role that biomasses will play in France's 2020 energy scenario, with a target of 3 GWe of installed power capacities to be achieved by bio energy to contribute to the accomplishment of the RES national target. Regarding micro-CHP, currently on the French market a few micro-CHP products are available and, even despite the existence of fiscal advantages set by national programmes, their economic viability has not been demonstrated.

The estimation of technical market potential for CHP was developed by the French[36] Ministry of Ecology, Sustainable Development, Transports and Housing as part of a 2010 study. The analysis was based on firstly establishing an estimation of potential French thermal energy needs at 2020, then deriving a technical potential for future CHP investments.

As shown in the following table, national overall thermal needs are expected to significantly decrease in the next years, in particular because of:

a) the introduction of energy saving measures,
b) the change of economical paradigms (tertiary vs manufacturing) and energy habits, and
c) the introduction of innovative technologies.

The study also estimates the CHP technical potential to cover the heat demand, purely based on technical feasibility of introducing cogeneration in the given sector. As shown in the table 4, the only sector in which heat demand is expected to grow is district heating, pushed by several government programmes and incentives set in the framework of national energy plans[37]. A significant decrease of heat demand is expected in the residential and tertiary sectors (-28% and -45% respectively), where energy efficiency interventions are expected to have significant impacts causing reduction of heat demand, whilst in industry it is assumed that there will not be major demand reductions by 2020 compared to 2008 figure.

[34] « *Analyse du potentiel national pour l'application de la cogénération à haut rendement* » October 20th, 2010, http://www.developpement-durable.gouv.fr/IMG/pdf/101015_Rapport_potentiel_coge_pour_UE-1.pdf
[35] Source: "Plan d'action national en faveur des énergies renouvelables - Période 2009-2020" – MEEDDM - July 2010 http://www.developpement-durable.gouv.fr/IMG/pdf/0825_plan_d_action_national_ENRversion_finale.pdf
[36] « *Analyse du potentiel national pour l'application de la cogénération à haut rendement* » October 20th, 2010, http://www.developpement-durable.gouv.fr/IMG/pdf/101015_Rapport_potentiel_coge_pour_UE-1.pdf
[37] http://www.developpement-durable.gouv.fr/IMG/pdf/0825_plan_d_action_national_ENRversion_finale.pdf

Sector	*Heat demand 2008 (TWh th)*	*Heat demand* 2020 (TWh th)	Heat demand 2008 vs 2020	Tech pot. CHP heat share, 2020	CHP pot. capacity 2020 (GWe)
Residential (no DH)	*280,2*	203	-28%	43%	12.1
Tertiary (no DH)	*75,6*	34,1	-55%	42%	3.7
District Heating	*25,2*	31,4	25%	45%	2.9
Industry (no DH)	*111,8*	111,8	0%	80%	8.9
Others (no DH)	*17,1*	17,1	0%	57%	2.5
Total	*2.517,9*	2.417,4	-4%	19%	30.1

Table 4: Expected evolution of Heat demand per sector (TWhth) and technical potential capacity for CHP plants (GWe)

When the impact of market competition and other factors are introduced to the analysis, the same study estimates the total "economical potential" of CHP for the mentioned sectors. The factors considered are:

- the attitude of investors to operate on free market out the present "obligation d'achat" incentive scheme,
- the opportunity for some sectors to shift from CHP system to boilers for heat production purchasing power from the grid,
- the willingness and opportunities to revamp present CHP systems at the end of their technical life,
- the potential to introduce CHP in not so far covered sectors like tri-generation in tertiary,
- the shifting to biomasses from natural gas and other fuels

Using the hypothetical technical potential analysed under the impact of these factors, the economic CHP potential for the French market has been estimated and is shown in table 5 for 2010 and 2020. The growth of CHP for the residential sector is expected to (43%) in particular for individual housing with introduction of micro-CHP. All other significant CHP sectors experience a decrease between 2010 and 2020. Industry is the sector in which the lowest decrease in CHP capacity is expected, in particular for the traditional large energy consumer sectors like the paper industry, with a little growth for agro-food. A growth is also expected for the "others" sectors, that includes agriculture and green house cultivations, in which biogas and biomass use are expected to play a prominent role.

For France as a whole it is expected that a minor part of overall 2020 heat demand will be covered by CHP (19%), with the largest share of this in industry (41%), due to the expected changes in subsidies programmes and the shifting to more subsidized heat-only technologies, in particular biomass in DH and residential.

Sector	2010 Mwe	2020 Mwe	2010-2020 trend	2020, % of CHP technical potential covered
Residential (no DH)	329	470	43%	4%
Tertiary (no DH)	449	370	-18%	10%
District Heating	1513	1035	-32%	35%
Industry (no DH)	3930	3635	-8%	41%
Others	114	160	40%	6%
Total	6335	5670	-10%	19%

Table 5: Expected evolution of CHP economical potential per sector , 2010 - 2020(GWe)

Focus
on bio-CHP

The French National Plan for renewable energies[38] highlights the role that biomasses will play in France's 2020 energy scenario. Policy targets set to around 3 GWe the installed power capacities to be achieved by bio energy to contribute to the accomplishment of the RES national target. All this capacity is expected to be under cogeneration mode and developed both at residential (DH) and industrial/agricultural level.

Following the "Grenelle Environment Round Table" the policy targets for cogeneration from biomass are described in table 6[39].

Year	**2008**		**2010**		**2015***		**2020***	
Capacity / *energy*	MW	*GWh*	MW	*GWh*	MW	*GWh*	MW	*GWh*
Biomass	**877**	***4.331***	**1.052**	***5.441***	**1.895**	***10.496***	**3.007**	***17.171***
Solid biomass	755	*3.708*	888	*4.506*	1.531	*8.366*	2.382	*13.470*
Biogaz	122	*683*	164	*935*	363	*2.129*	625	*3.701*

Table 6: Evolution of the electricity production from biomass – scenario of the "Grenelle Environment Round Table"
*Trajectory of the "Grenelle Environment Round Table"

To achieve the goals set out a major incentive multi-programme has been launched based on tender system for the development of power plants.
In the period 2005-2011 around 280 plants have been bid, with a total capacity of 1,2 GWe; The last call under this process was been launched in 2011 for a capacity of 429 MWe. For several reasons (related mainly to biomass supply and project financing but also additional complexities), many projects have been abandoned. Only 9 projects of the 36 selected projects in the first two tenders (2005 and 2008) have effectively been realized, suggesting that additional barriers exist to a large realization of CHP biomass plants beyond the reach of this process. Currently, the launch of other calls for tenders is not expected.
The "heat fund" programme ("fonds chaleur")[40] is another incentive programme that is supporting the development of biomass plants (heating and CHP) founded by ADEME, public agency in charge of supporting the environmental and energy transition and particularly propose its expertise to companies, local authorities, public authorities and the general public in the fields of waste management, soil conservation, energy efficiency and renewable energy, air quality and fight against noise.
In particular, plants of renewable heat production through biomass and biogas, and heating districts can benefit from :

1. **National calls for tenders concerning the development of industrial plants providing energy** output of more than 1.000 toe/year from biomass. Five calls for tenders have been launched from 2009 to 2013 and a further call launched in January 2014 has an indicative target of 125.000 toe/year.
2. Support system, at the regional level, for collective installations of any size less than or equal to 1.000 toe/year. The subsidy is distributed through regional calls for projects, whose juries meet 1-3 time a year. Cases requiring a subsidy greater than 1,5 million €, are addressed through direct contracting.

[38] Source: "Plan d'action national en faveur des énergies renouvelables - Période 2009-2020" – MEEDDM - July 2010 http://www.developpement-durable.gouv.fr/IMG/pdf/0825_plan_d_action_national_ENRversion_finale.pdf
[39] Source : "Plan d'action national en faveur des énergies renouvelables - Période 2009-2020" – MEEDDM - July 2010 http://www.developpement-durable.gouv.fr/IMG/pdf/0825_plan_d_action_national_ENRversion_finale.pdf
[40] Source:Plaquette de présentation du fonds chaleur - www2.ademe.fr/servlet/KBaseShow?sort=-1&cid=96&m=3&catid=25130

The recent implementation of the carbon tax (April 1st 2014 see section 1.2), could be another incentive to foster the development of the CHP plants based on biogas production and, consequently the implementation of CHP installation.

Despite the measures described above and the ambitious biomass targets, the implementation of biomass based CHPs systems face additional challenges as outlined in the section 1.6 Barriers.

- Immature structure of wood supply value chain
- High operation and maintenance costs for biomass CHP plants
- Fluctuation of combustible prices
- Technology barriers, in particular for the performances of such cogeneration units and the emissions level from the combustion plants.

Micro CHP focus

In the framework of the National CHP analysis[41], the potential for market penetration of micro CHP have been investigated under two scenarios. Both cases hypothesise the presence of an incentive framework similar to the one currently (2014) operating for Heat Pumps (HP), and which addresses technology cost as the main factor :

- The first hypothesises a cost of micro-CHP systems close to the one of a heat pump. In this case CHP technologies should face the competition of HPs that are a well known technology, with a good reputation and already available on the French market. In this framework, the use of µCHP would be targeted towards social middle and upper class residential customers, with a potential share of 2,5% of the replacement of existing boilers market.
- The second case hypothesises a cost of micro-CHP positioned between the HP and the condensing boiler. In this case the market share could achieve 10% with if the programme is designed with a priority target group of individual house and small collective houses (from 5 to 10 flats per building)

At present on the French market a few micro-CHP products are available and, even despite the existence of fiscal advantages set by national programmes, their economic viability has not been demonstrated, in particular for small appliances up to 3 kWe that have an average cost of 10.000 – 15.000 Euros per kWe of capacity.

[41] Source : « *Analyse du potentiel national pour l'application de la cogénération à haut rendement* » October 20th, 2010, http://www.developpement-durable.gouv.fr/IMG/pdf/101015_Rapport_potentiel_coge_pour_UE-1.pdf

4. How do we arrive there? : The Roadmap

The main actions to implement in order to overcome the different barriers for the development of CHP are mainly: to support CHP in the new law design (for instance, in the new LTECV law) and to define a clear and stable national energy investment scenario for CHP. Despite the prediction of a decrease of installed CHP capacity in France, which will concern principally small CHP district heating and the industrial sector, a new market segment for residential appliances will emerge (micro-CHP), but this would be possible only at the time that technologies will be more mature and the cost comparable with competitor technologies, in particular of the heat pumps. Biogas CHP will represent a future promising market, together with solid biomasses having the highest growth rate, but to achieve this growth and associated targets it will be necessary to ensure a continuity of present incentive schemes and to innovate present biomass technology ensuring better performances in terms of power production and air emission impact.

4.1. Overcoming existing barriers and creating a framework for action

General policy actions

Action 1: Support CHP among key technologies inside new LTECV law

The proposal of the new LTECV law, as discussed in Chapter 1.3, does not specifically support CHP, but several policy targets (eg. the implementation of an additional compensation for electricity production plants, energy renovation obligation for public buildings, simplified procedures for decentralized power production plants) could give additional impulse to the CHP market, as energy efficiency is largely promoted. Actions should be put in place during the policy debate around the new LTECV law, both to support the present CHP support measures and to introduce further opportunities for realization of new installations within the PPE (Energy Production Planning). This approach will also help meet the requirements of the implementation of the new European Energy Efficiency Directive currently underway in all EU Member States.

At programme and authorization procedure level, and also as required by the EED it is important for CHP to ensure that the reduction in primary energy consumption factor is considered rather than an approach based on savings in final energy consumption. The EED requires that both approaches are used and reported. The primary energy factor approach records the significant contribution that CHP gives in achieving primary energy saving, and gross energy consumption at the national level and the impact on environmental targets.

Action 2 : Accelerate the definition of a clear and stable national energy investment scenario for CHP (grid connectivity, incentive schemes, taxation)

The French energy market is currently (2014) living through a phase of rapid transition in regulatory framework and this affects the possibility of attracting and developing investments in CHP. In particular investor concerns are related to the predictability and continuation of present capacity prizes (currently ensured only until 2016) and the potential impact of the "carbon tax" (see section 1.2) on fuel prices particularly natural gas for industrial CHP. The faster these and other energy policy measures can be defined, the clearer the potential of investment for the coming years will be and clearer any investment risk will become.

It is recommended that at national level within the EED implementation process and the other national policy frameworks related to CHP investment issues (Carbon Tax, New POPE law and others) a structure for deciding and reviewing both the capacity prize and the position of CHP under the carbon tax should put in place, allowing investors to satisfactorily assess their CHP investment risk.

Actions related to emissions reduction

Action 3: Improve the European emission trading system (ETS) as it relates to CHP.

CHP investments generate CO_2 credits, that can be traded on ETS platform, giving an additional income able to ameliorate economic investment figures. The French national emissions environmental and action plan[42] is closely linked to the evolution of the ETS at EU level. The restoring of ETS can support the exploitation of national energy transition plans, in particular for those technologies like CHP able to ensure a significant reduction in use of primary energy. As changes to the ETS-system have to be brought about on EU level, this action really requires adopting and defending a clear stance in the European parliament and council, rather than taking direct actions on member state level.

Action 4: Consider air pollution factors in the energy policies scenario

EU Environmental legislation such as the 7th Environment Action Programme (EAP)[43] and the French Regional Plans for Air Quality[44] stress air emissions as a priority to safeguard community health, in particular inside urban environments. Apart from greenhouse gases, other pollutant factors have to be considered in the elaboration of impact scenario of energy production, in particular for PM and NOx in densely populated areas. Technologies such as CHP can contribute to reducing the emission factors compared to condensing power production due to the significant efficiency in term of use of primary energy or, regarding innovative technology like fuel cells, minimize the emission of pollutants like NOx hard to be managed in combustion processes. Air Regional Plans should introduce support action in particular for all those CHP investments that can ensure the valorisation of heat production all along the year, such as in the industrial and tertiary sector.

Specific CHP related actions

Action 5: Update assessment of the high-efficiency CHP

The Energy Efficiency Directive (EED) Article 14 paragraph 1 states "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, [..]". The 2010 National CHP potential analysis should be updated, so to elaborate precise targets for the next decade and establish new target and expectations for CHP both in term of contribution to energy production scenario and achievement of energy saving and environmental target.

This CHP target should link explicitly to the French energy savings target, expressed in primary energy savings terms, set under Article 3 of the EED.

Action 6: Support renovation and revamping of present CHP installations

Revamping and renovation of already existing CHP plants is a primary leverage to maintain present French CHP capacity. Today it is estimated that there is CHP capacity of 630 MWe on 181 sites in France that require to be renovated by 2015. A barrier for the renovation of such installations is the uncertainty of policy scenario on support measures for CHP in the medium to long term. This is particularly the case for installations with a capacity under 12 MWe. A clear and committed policy framework for CHP is required in order to remove this barrier and support the activation of investment, with benefits on creation of workplaces and economic stimulus.

Such action would form a useful part of implementation of the EED under Article 14 and 15 which sets out a process for implementing consistent policy around CHP in the context of primary energy savings.

Action 7 : Simplify and to optimize procedures for grid connection

Today the procedural phases for grid connection of CHP plants can last from 3 to 6 month on average, and this uncertainty discourages investors in particular for small installations. Simplifying and accelerating procedures of connection to the public distribution network as well as requiring a systematic implementation of double counting meters in order to simplify the procedures for metering and invoicing of electricity sold to grid would benefit new CHP projects.

[42] www.developpement-durable.gouv.fr/IMG/pdf/140622_projet_de_loi_texte.pdf

[43] http://ec.europa.eu/environment/newprg/index.htm

[44] For instance Ile de France plans - http://ile-de-france.ademe.fr/-Le-cadre-reglementaire,26-.html

These changes should be made as part of the implementation of the EED. In particular, Article 15 requires an assessment of the energy efficiency potentials of their gas and electricity infrastructure, in particular regarding transmission, distribution, load management and interoperability, and connection to energy generating installations, including access possibilities for micro energy generators by 30 June 2015 and that member states may particularly facilitate the connection to the grid system of electricity produced from high-efficiency cogeneration from small-scale and micro-cogeneration units. Member States shall, where appropriate, take steps to encourage network operators to adopt a simple notification 'install and inform' process for the installation of micro-cogeneration units to simplify and shorten authorisation procedures for citizens and installers.

Action 8 : Support value chain: training, promotion, awareness, aggregation

CHP value chain is sometimes dispersed and involves several competences and skills. In particular for micro-CHP and for residential and small tertiary sectors, the supply chain is not adequately coordinated to develop a high quality product and services. Thus, it would be important to structure a value chain support programme including actions like the creation of synergies among value chain actors to decrease CAPEX and OPEX of CHP investments, training, exchange of experiences, quality standards labels, financial scheme, together with coordinated marketing actions aimed to promote CHP and facilitate the introduction inside national market of innovative and promised technologies and systems.

French Industrial and R&D Cluster policy is one of the most advanced in Europe and a specific action in support of CHP vale chain should be activated with the contribution of "Poles d'Innovations" and of "Poles de Competitivitès" operating on Energy issues, enforcing their present activities in support of CHP in the framework of a large more ambitious national dedicated programme.

Action 9 : Support research and innovation actions

In order to support the development of innovative solutions able to overcome present technical limitations in the use of CHP systems, the promotion of R&D programs focused on the external combustion engines (i.e. Stirling, ORC), fuel cells and hybrids, high efficiency turbines (as small ceramic types), in the EU Horizon 2020 framework is needed. European laboratories would increase the market penetration capacity of CHP solutions in a medium to long term perspective. To do so is necessary to increase the collaboration among industry and academies for research activity, together with agreement with Local authorities for the launch of demonstration action of early market CHP technologies and these are elements which can be achieved through the existing EU Horizon 2020 framework for collaboration and further supported through Articles 12,14,17, 19 and 25 of the EED on capacity building for energy efficiency measures.

Action 10: Support the growth of biomass CHP

In the framework of the elaboration of new national energy laws and environmental plans, biomass plays a relevant role for the achieving of targets. It should be important to respond to this policy approach with the consolidation of biomass to CHP value chain, in particular the forestry and agricultural sectors. Market consolidation actions, like the creation of a biomass price observatory would enable the emergence of average prices by forest basin as a reference for heat consumers. It would be also necessary to encourage productivity in the forestry sector, with dedicated measures supporting investment for forestry exploitation, in order to reduce and stabilize fuel prices as an indirect support for evaluation of CHP investment. Moreover, these actions should be integrated with present and future support measures for use of biomass inside district heating and large heat investments like, for instance, the "Fond Chaleur" programme[45], which has been doubled in the LTECV law.

[45] Source : ADEME - http://www.ademe.fr/expertises/energies-renouvelables-reseaux-stockage/passer-a-laction/produire-chaleur/fonds-chaleur

4.2. Possible paths to grow

The 2010 Ministry study **predicts a decrease of installed CHP capacity in France**, due to the concomitance of several market and economic factor, *in primis* the closing or restructuration of some incentive schemes for some installation categories and the competition of other source of energies, in particular grid power and biomass for heating purposes.

This trend will affect in particular small CHP district heating and the industrial sector (< 12 MWe) whilst **a new market segment for residential appliances will emerge** (micro-CHP), but this would be possible only at the time that **technologies will be more mature (Stirling, Fuel cells) and their cost comparable** with competitor technologies, in particular of the heat pumps.

Sectors/year	2010	2020	2020 trend
Industry, > 12MWe	1.601	1.323	-17%
Industrie <12MWe	391	361	-8%
Large DH >12 Mwe	691	518	-25%
Small DH < 12 Mwe	791	518	-35%
Tertiary > 36 kWe	768	636	-17%
Residential, < 36kWe	1	201	>1000%
Total	**6.253**	**5.577**	**-11%**

Table 7: Expected trend of CHP installations, MWE, 2010-2020, per sector

Besides the introduction of micro-CHP, the expected market evolution will also affect the business models that will be in use, due to the changes in incentives schemes and support measures to renewables. It's expected that 2020 **natural gas fed CHP will run out** of the "obligation d'achat" scheme, **so major effort in terms of technology and system development should be put in force to ensure economic viability** beyond that point, biogas CHP will represent a future promising market, together with solid biomasses having the highest growth rate, but to achieve this growth and associated targets it will be necessary **to ensure a continuity of present incentive schemes** and **to innovate present biomass technology** ensuring better performances in terms of power production and air emission impact.

MWe	2010	2020	Trend
NG, "Obligation Achat"	4.322	1.792	-59%
NG, no "Obligation Achat"	666	1.788	168%
Solid biomasses	10	1.048	>1000%
Biogas	19	137	621%
Others	1.235	812	-34%
Total	**6252**	**5577**	**-11%**

Table 8: Expected trend of CHP installations per fuels, 2010-2020

4.3. Saving of primary energy and CO_2 emissions by the CHP roadmap

Primary energy saving (PES) and CO_2 emissions saving projections resulting from increased use of CHP require assumptions about not just what types of fuel and technology are displaced, but also their operation on the market. Within CODE2 two approaches are developed. These represent two different analytic considerations which are summarised here and more fully explored in Annexe 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. According this methodology PES in France implementing the roadmap for CHP is estimated at 83 TWh per year corresponding to 3% and CO_2 emission reduction is estimated 34 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 CO_2 savings which can be anticipated. The CO_2 reduction achieved is due to both higher energy efficiency and fuel switching towards low carbon (natural gas) or non-carbon (bio energy) fuel, but CHP development and fuel switching are anticipated to be an integrated process driven by policy objectives.

2) **Substitution mix 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.

Table 6: Saving of primary energy and CO_2 emissions according EED methodology

Total CO_2 reduction, Mio. t/a	**-34**
Share in total energy-related CO_2 emissions	**8%**
Share in energy sector CO_2 emissions	**13%**
Primary Energy Saving, TWh/a	**-83**
Decrease of PE, %	**3%**
Bio Energy Share in CHP Fuels 2030	**66%**
Share of modernised and replaced CHP plants in CHP power growth up to 2030	**73%**

Table 7: Savings of primary energy and CO_2 emissions according Substitution mix methodology

Total CO_2 reduction, Mio. t/a	**-34**
Share in total energy-related CO_2 emissions	**8%**
Share in energy sector CO_2 emissions	**13%**
Primary Energy Saving, TWh/a	**-85**
Decrease of PE, %	**3%**
Bio Energy Share in CHP Fuels 2030	**66%**
Share of modernised and replaced CHP plants in CHP power growth up to 2030	**84%**

Annexes

1. **Stakeholder group awareness assessment**
2. **Micro CHP potential assessment**
3. **Bio CHP potential assessment**
4. **Assumption used in the market extrapolation**
5. **Methodologies used to calculate the saving of primary energy and CO_2 emissions**
6. **Sources and contacts**

Annex 1: Stakeholder group awareness assessment

1 Poor
2 Low
3 Early awareness
4 Interest
5 Active market

Group	Comment
Customers	
Industry	The industry is aware of CHP but with the current spark spread, they tend to switch to heat production with boilers.
Utilities	Utilities have several CHP plants in joint ventures with large industrial companies.
Commercial	The penetration in commercial premises is only limited.
Households	Some manufacturers start to advertise domestic micro-CHP cogeneration units to households, but during the last years, other systems have been promoted more than micro-CHP systems, so the awareness of the households on the cogeneration technology is extremely low.
Market and supply chain	
Manufacturers	There are sufficient manufactures of CHP units and CHP related equipment.
Installers	There is enough knowledge and experience among installers. Existing chain of 34.000 installation and maintenance companies.
Grid operators	Grid operators are convinced of the benefits of CHP.
Consultants	There is enough knowledge among installers.
Engineering companies	There is enough knowledge and experience among engineering companies.
Architects	Micro-CHP is not yet seen as a common heating option.
Banks	Some banks are really interested by cogeneration and follow with attention the development of the related technologies.
ESCOs	There is enough knowledge among ESCOs

Group	Comment
Policy	
National	The government knows cogeneration but it is not seen as a priority technology to implement because of the energy supplying of France by nuclear technology, which cover a large part of the energy needs of the country.
Regional	
Local	
Urban & Regional planners	CHP is not seen as a key technology for heat networks.
Energy agencies	The CHP technology is known but there is a lack of promotion of the related technologies.
Influencers	
Sector organisations	The sector organisations ATEE, FEDENE, UNIDEN are very active to promote CHP at national and regional level.
General public	General public does not know cogeneration.
Media	In the discussions about energy transition and energy efficiency measures and technologies, CHP is mentioned very briefly. Specialised media spend more time on cogeneration.
Academia	There are no CHP specific cogeneration courses or trainings.
Research	There are research centres and laboratories with good research programmes on the CHP issues.
NGOs	NGOs do not mention CHP, they are more focused on energy efficiency system other than CHP.

This assessment has been made on the basis of articles and interviews with different local actors.

Annex 2: Micro CHP potential assessment

Country statistics

Population: 65 350 000 (2010)
Number of households: 28 400 000 (2010)
GDP per capita: € 27 200 (2010)
Primary energy use: 159 000 ktoe/year (2010)
GHG-emissions: 522 Mton $CO_{2,eq}$/year (2010)

Household systems (±1 kWe)
Boiler replacement technology

Present market (2013)
Boiler stock: 15 800 000 units
Boiler sales: 990 000 units/year

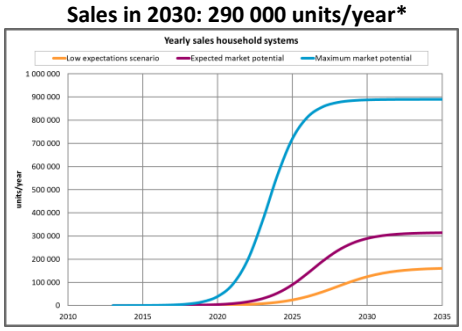
Potential estimation

Indicator	*Score*
Market alternatives	2
Global CBA	1
Legislation/support	2
Awareness	0
Purchasing power	2
Total	**5 out of 12**

Expected final market share: 32% of boiler sales in Household sector

Yearly sales

Sales in 2020: 4 400 units/year*
Sales in 2030: 290 000 units/year*



Stock

Stock in 2020: 9 000 units*
Stock in 2030: 1 300 000 units*
Stock in 2040: 3 100 000 units*

Potential savings in 2030

Primary energy savings:
27 PJ/year*
650 ktoe/year*
GHG-emissions reduction:
-1.4 Mton $CO_{2,eq}$/year*

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

Present market (2013)
Boiler stock: 1 070 000 units
Boiler sales: 66 800 units/year

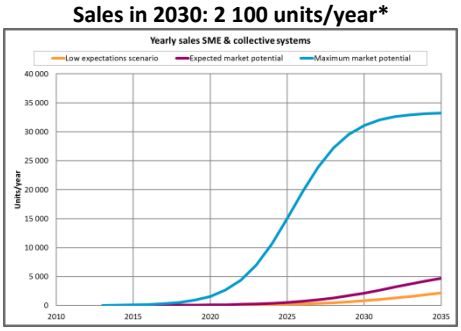
Potential estimation

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

Expected final market share: 9% of boiler sales in SME & Coll. sector

Yearly sales

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



Stock

Stock in 2020: 700 units*
Stock in 2030: 8 400 units*
Stock in 2040: 46 000 units*

Potential savings in 2030

Primary energy savings:
7 PJ/year*
165 ktoe/year*
GHG-emissions reduction:
-0.3 Mton $CO_{2,eq}$/year*

*Corresponding to the expected potential scenario.

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

±1 kWe systems (Households) Boiler replacement technology	±40 kWe systems (SME & Collective systems) Boiler add-on technology
Scorecard	Scorecard

Indicator	Score
Market alternatives	2
Global CBA	1
Legislation/support	2
Awareness	0
Purchasing power	2
Total	**5 out of 12**

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

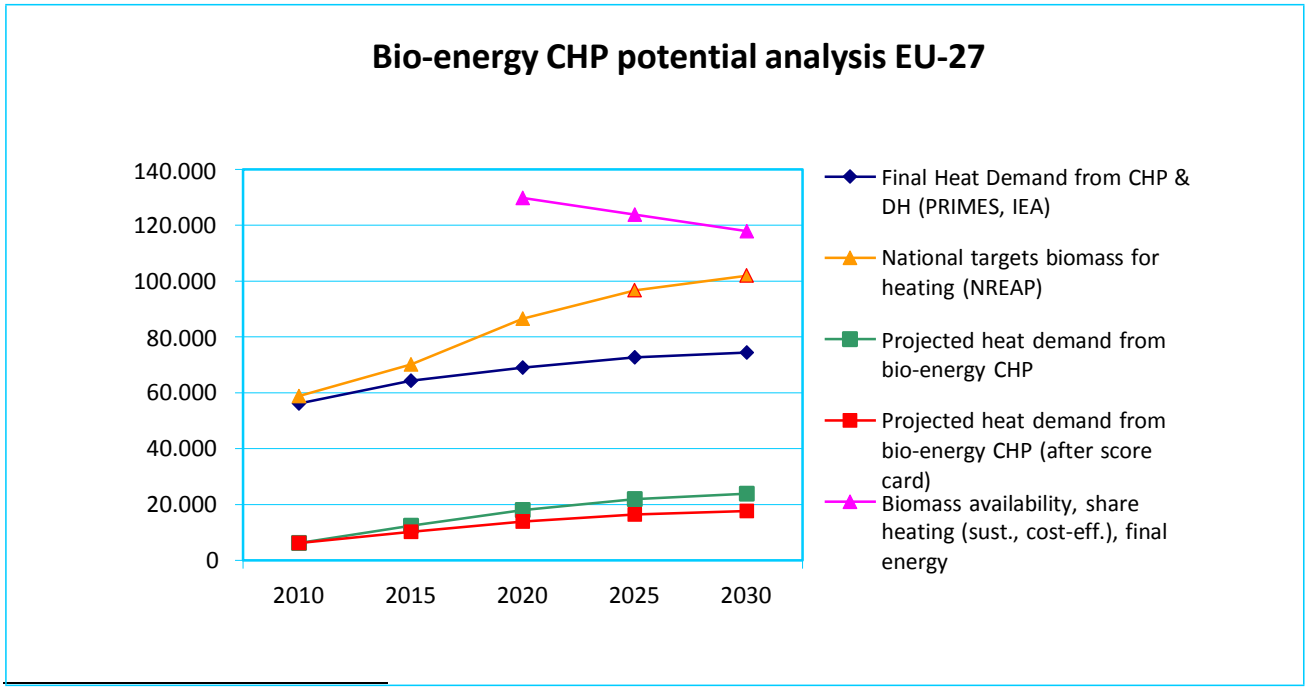
Market alternatives	Market alternatives
Global CBA	**Global CBA**
SPOT: ***12 years***	*SPOT:* ***70 years***
Legislation/support	**Legislation/support**
Awareness	**Awareness**
Purchasing power	
GDP: ***€ 27 200 per year***	

Annex 3: Bio-CHP potential assessment[46]

In the context of the CODE2 project, a potential analysis for bio-CHP was elaborated for the EU-27 countries in aggregate and per member state.
The national bio-CHP potential analysis is based on figures from the PRIMES database, Eurostat, the National Renewable Energy Action Plan (NREAP), and the project Biomass Futures. The analysis has been discussed and, where necessary, refined in consultations with national energy experts.
The complete EU-27 analysis is found at
http://www.code2-project.eu/wp-content/uploads/CODE2-D2.6-European-report-on-potential-of-bio-energy-CHP.pdf

Bio-energy CHP potential analysis France

Figures (projections)	2010	2020	2030
Final heat demand from CHP and DH (PRIMES, IEA), ktoe	1.606,8	3.789,8	4.063,5
(Projected) heat demand from bio-energy CHP and DH (after score card), ktoe	411,8	667,7	745,0
Bio-energy penetration rate in CHP markets (2009: EEA, Eurostat)	25,6% (2009)	17,6%	18,3%
Biomass availability, share heating (sust., cost-eff.), final energy (Biom. Futures), ktoe		22.211	21.695



[46] The national bio-CHP potential analysis is based on figures from the PRIMES database, Eurostat, the National Renewable Energy Action Plan (NREAP), and the project Biomass Futures. The analysis has been discussed and, where necessary, refined in consultations with national energy experts (see Annex for the detailed bio-CHP potential analysis).

		Article 6 of Directive 2004/8/EC of the European Union – p15
National supply chain for biomass for energy	+ 2 (of 3)	France NREAP 2014, “Analysis of the national potential for the application of high efficiency cogeneration”; In accordance with Article 6 of Directive 2004/8/EC of the European Union
Awareness for DH and CHP	o 1 (of 3)	

Annex 4: Assumptions used in market extrapolation

Detailed economic analysis of four standard CHP cases was implemented in all pilot roadmaps and optionally in non-pilot roadmaps.
As requested detailed economic data for economic analysis of four standard CHP cases were not available or are not sufficiently reliable for making objective conclusions about the CHP profitability and comparison of economics with other member states, detailed calculation table is not included in this report.

Annex 5: Methodologies used to calculate the saving of primary energy and CO_2 emissions.

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.

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[47]" 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[48], 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)
- Fuelswitching (e.g. lower carbon content of natural gas compared to coal, CO_2 neutrality of bioenergy)

[47] 10. FfE Forschungsstelle für Energiewirtschaft e.V., Energiezukunft 2050; http://www.ffe.de/die-themen/erzeugung-und-markt/257
[48] The calculation has been made by the VIK Verband der Industriellen Energie- und Kraftwirtschaft e.V., 2010, Unpublished.

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
- 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.

Annex 6: Sources and contacts

Sources

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Contacts

- ADEME
- ATEE – Club de la cogénération
- EDF
- EEX
- ERDF
- European Environment Agency
- GreenLAW Avocat
- ICIS
- International Energy Agency - Energy Technology Policy Division
- Ministère de l'Écologie, du Développement durable et de l'Énergie - Direction Générale de l'Énergie et du Climat - Économies d'énergie et Chaleur renouvelable
- Observatoire de l'Industrie Electrique
- Pole de compétitivité Tennerdis
- RTE (Réseau de transport d'électricité)
- SOeS (French Observation and Statistics Office)
- Université de Franche-Comté - Département Energie
- Université de Lorraine

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