CODE2

Cogeneration Observatory

and Dissemination Europe

D2.3 First draft of final CHP roadmap

GERMANY

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Table of Contents

Summary and Conclusions

In Germany cogeneration has seen a positive development in the last 10 years. From 2003 to 2011 cogeneration power increased from 76 to 91 TWh/a. But the awareness of the opportunities of cogeneration is still not enough developed to accomplish a transformation of the heating markets towards a significant higher efficiency by using the available cogeneration technologies for all applications. This is considered as one of the main barriers, whereby other barriers as lack of knowhow at energy consultants, planners and installers are associated to this general deficit, which is typical for complex solutions.

The current low power prices at the power exchange EEX is an additional serious obstacle against reaching the cogeneration development target of 25% cogeneration share in total power production up to 2020 as incentives for new cogeneration investments are too weak. The cogeneration extension target should be combined with the aim to grant security of supply by further development of the cogeneration law with its next scheduled revision in 2014 to a capacity mechanism. Municipalities should be committed and enabled for additional energy efficiency and climate protection measures on the local level. Third party implementation and operation of cogeneration by energy service companies (ESCOs) should be strengthened. Political cogeneration support for households should be simplified.

It is estimated that implementing these measures would ensure the achieving of the legal fixed objective of increasing the cogeneration share in total power production from 15% in 2010 to 25% up to 2020 and enable a further increase of the cogeneration share to about one third, this development being in accordance with the aim to reaching a RES share in power production of 50% up to 2030. The development of cogeneration power would be based on a prospected rise of cogeneration share in end energy heat supply from 14% to 21% in 2020 and 25% in 2030.

This roadmap does not give any prediction or proposal regarding the future technology path of cogeneration development. To what extend it will be based either on heat grid or micro-CHP development should be decided in the frame of local heat concepts taking into consideration the probable prospects for energy efficiency and implementation cost development. The CODE2 micro-CHP study shows an enormous potential for decentralized cogeneration replacing heating boilers based on special assumptions amongst others for the prospective “learning curve”, which means production cost reduction with growing number of produced units.

It is assumed that up to 2030 the sustainable potentials for bio energy as shown in the CODE2 bio energy study will be completely exploited and that, in the heat and power market, they will be covered completely by cogeneration, thus covering 30% of the cogeneration heat production.

1. Where are we now? Background and situation of cogeneration in Germany

1.1. Current status: Summary of currently installed cogeneration

From 2003 to 2011 cogenerated power increased from 76 to 91 TWh. There was a significant growth in industry, small scale natural gas cogeneration and bio CHP, whereas the growth in the public supply[2] was rather moderate.

As described in more detail in the separate awareness study on Germany and in chapter 1.4, awareness and importance of cogeneration in the energy and environmental policies have seen a positive development in the last 5 to 10 years.

Due to different statistical methods and definitions the data base on cogeneration in Germany was homogenous in the past. According to the figures published by Eurostat 2010 for 2008, the installed electric capacity of cogeneration plants was 21.99 GW, the power cogeneration generated was 79.49 TWh and the heat produced 178.278 TWh.

	Installed CHP capacity el (GW)	Total CHP electricity gen. (TWh)	Total CHP heat supplied (TWh)	Total electricity generated (TWh)	Total CHP share on electricity
2008	21.99	79.49	178.278	635.9	12.5%

Table 1.1 - Eurostat CHP data for Germany published 7/2010

As part of the monitoring of the effects of the 2009 revision of the Cogeneration law, new figures were published 2011 in a study commissioned by the Federal government[1]. By including for the first time also the cogeneration heat and electricity from power plants which are working mainly but not exclusively in condensing mode, i.e. producing only low amounts of useful heat , the reported installed cogeneration capacity doubled to 40.736 GW in comparison to the Eurostat data. Even this higher number covers only the installations supported by the Cogeneration law. I.E. any devices supported by the Renewable Energy sources law (RES law) or any cogeneration plants not registered in any support system are not included in these numbers. The total net cogeneration power generation (including bio-fuel fired) was estimated 89.9 TWh in 2010. Its share in total electricity net production amounted 15.4 %.

A new calculation commissioned by the Federal Environment Agency was finalised in 2013. It shows the CHP electricity and heat (bio energy and small scale fossil cogeneration) in a consolidated time series from 2003 to 2011, making transparent a significant growth of cogenerated power in the

[1] Zwischenüberprüfung zum Gesetz zur Förderung der Kraft-Wärme-Kopplung; Prognos AG and Berliner Energieagentur, 2011.

sectors of: industry, small scale natural gas cogeneration ("Other fossil CHP") and bio CHP, whereas the growth in the public supply[2] was rather moderate. Conspicuous is a clear decline from 2010 to 2011 in the public supply and industry, indicating the worsened economic operating conditions resulting from decreasing power exchange prices which are identified as a serious barrier against cogeneration in chapter 1.6.

CHP power and heat production in Germany Source: Umweltbundesamt 2013[3]									
CHP electricity generation TWh	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Public supply	50,3	52,4	52,3	54,0	51,9	53,8	50,5	53,4	51,1
Industry	23,5	22,9	25,6	25,8	25,8	25,7	26,6	29,8	28,4
Other fossile CHP	1,8	2,0	2,1	2,2	2,4	2,7	2,9	3,3	3,8
Other bio CHP	0,0	0,0	0,0	0,5	2,5	4,0	5,5	6,6	7,6
Total	**75,6**	**77,2**	**80,0**	**82,5**	**82,6**	**86,2**	**85,4**	**93,1**	**91,0**
Bio CHP	1,1	1,8	2,4	3,3	5,2	6,9	9,1	10,5	11,7
Fossile CHP	74,6	75,5	77,6	79,2	77,4	79,3	76,3	82,6	79,3
CHP heat TWh	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Public supply	94	100	101	103	97	99	95	101	93
Industry	82	78	80	78	80	79	79	87	84
Other fossile CHP	3	3	3	3	4	4	4	5	6
Other bio CHP	0	0	0	1	4	6	8	9	10
Total	**179**	**181**	**185**	**186**	**184**	**188**	**187**	**202**	**194**

Table 1.2 - CHP power and heat production in Germany

[2] Supplied by public or private local utilities.

[3] Numbers on CHP are published by the Federal Environment Agency (UBA) on it´s website under http://www.umweltbundesamt-daten-zur-umwelt.de/umweltdaten/public/theme.do?nodeIdent=2323. The more detail numbers shown in this roadmap are not published but have been provided from UBA for the CODE2 project.

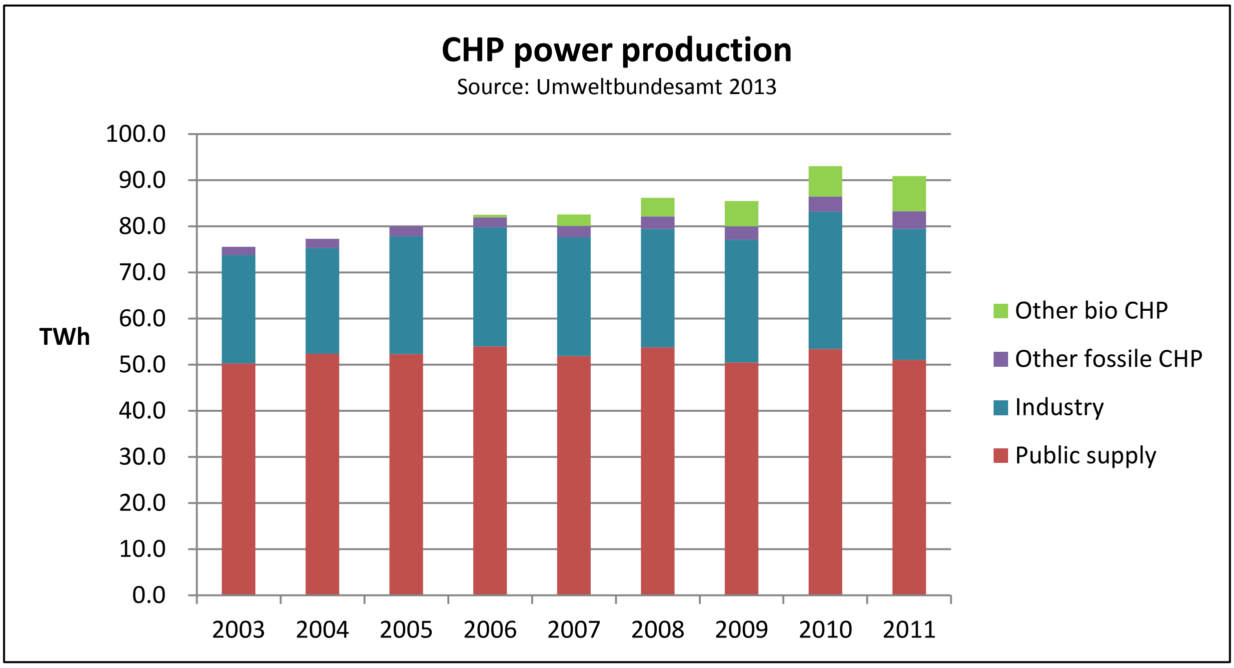

Figure 1.1 - CHP power production

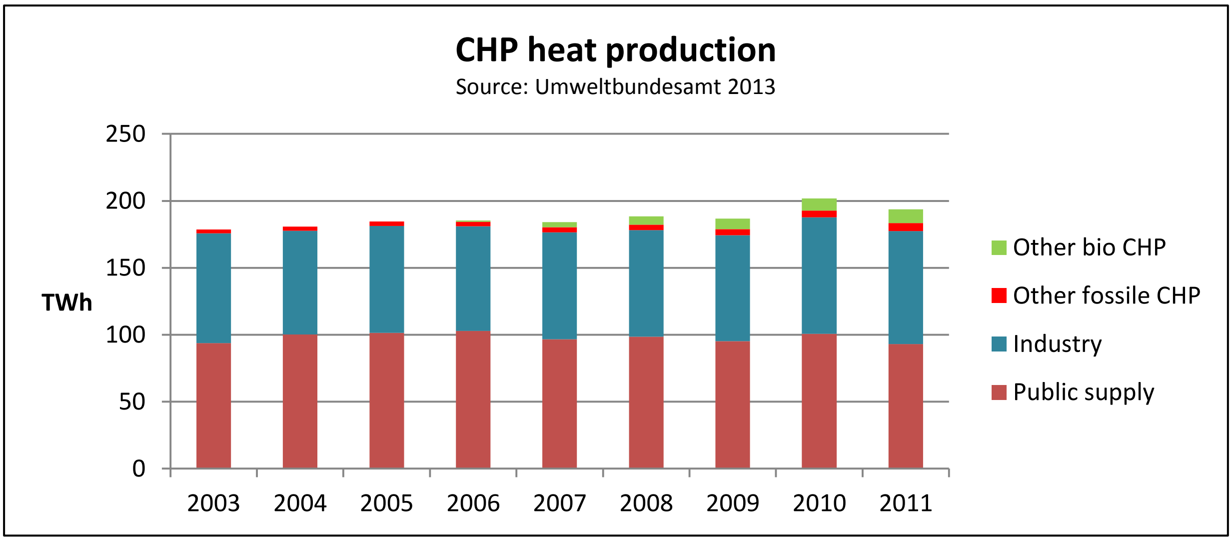

Figure 1.2 - CHP heat production

1.2. The German Energy and Climate Strategy

In the context of the "Energy transformation" with the planned phasing out of nuclear power by the end of 2022 the cogeneration share in power production shall rise from 15 % to 25 % by 2020, parallel to an increase of RES power production from 17% to 35%.

In 2011 following the Fukushima nuclear catastrophe in Japan, it became a broad consensus in politics and society to end the production of nuclear power, which delivered about 20% of electricity up to 2010. It was decided by the Government and Parliament to substitute nuclear power production by around 2022. The required transformation process is called the energy transformation ("Energiewende"). Additionally to the rejection of nuclear power in recent years a strong resistance against the construction of new coal-based power plants has emerged in Germany. This background accelerated the development of Renewable Energy and also raised the awareness of cogeneration as a complementary option of a combined strategy for phasing out nuclear energy and for decarbonisation of the energy system. The government energy targets are shown in table 1.3.

Energy and Climate Policy Objectives of the German government Source: BMU 2012			
	2010	**2020**	**2030**
Phasing out of nuclear power by the end of 2022			
Decreasing greenhouse gas emissions compared to 1990	23%	40%	55%
Renewable energy share of el. production	17%	35%	50%
CHP share of electricity Production (incl. Bio-CHP)	15%	25%	

Table 1.3 - Energy and Climate Policy Objectives of the German government

The objective of increasing the share of cogeneration in electricity production to 25% up to 2020, a target which had first been proposed in 2007 by the former government, was confirmed by its legal inclusion in the amended Cogeneration law of 2012, establishing 25% as the German target for cogeneration by 2020.

The plan for boosting cogeneration is related to electricity only and not to heat. There are no targets of the federal government concerning the share of cogeneration in the heating market, which would however be an implied result of the raising of the cogeneration power production role. Today heat plans exist only at a municipal level in Germany and only in a minority of cities.

1.3. Policy development

The first cogeneration supporting law was published in 2001 with three subsequent amendments the last in 2012. Since 2009 a bonus payment for the complete production of high efficient CHP electricity has been granted, the size and duration depending on the plant power capacity. A separate Complementary support mechanism for "Mini CHP" up to 20 kW_{el} was launched in 2012. In parallel power from bio energy has to be cogenerated in principle, but with important exemptions.

Historically the first support instrument for cogeneration was the exemption of cogeneration fuel input (under certain efficiency conditions) from the fuel tax on heating oil and natural gas in the context of the introduction of the "ecological tax reform" in 1999. Power delivered from small scale cogeneration up to 2 MW_{el} to users situated "nearby the cogeneration" was exempted from the electricity tax (2.05 Cent/kWh). In January 2013, due to a revised EU energy taxation exemption permission, the 100% fuel tax exemption (e.g. natural gas 5.5 €/MWh) had to be limited to the depreciation time of 10 years. Thereafter the EU-minimum fuel taxation is applied (e.g. natural gas 1.08 €/MWh).

In 2001 a preliminary law ("*KWK-Vorschaltgesetz*") was introduced. It supported power deliveries into the public grid by bonus payments and applied only to existing cogeneration plants. In 2002 the "Cogeneration modernisation law" was introduced. It supported again only power fed into the public grid, but included new cogeneration installations up to 2 MW_{el} and modernisation investments in cogeneration plants with higher capacity.

In 2004 an additional bonus payment for cogeneration electricity from bio energy was introduced into the Renewable energy law, supporting only electricity production from RES. This led in the following years to a substantial growth in bio energy cogeneration installations (see **TABLE 1.2**, **FIGURE 1.1** and **FIGURE 1.2**). This cogeneration bonus was abandoned with the last amendment of the RES law in 2012. Since then in principle the total electricity produced from bio energy must be cogenerated, but there are some important exemptions, leading in practise to a weakening of cogeneration with bio energy.

In 2009 by an amendment of the Cogeneration law new cogeneration plants bigger capacity above 2 MW_{el} were included in the support scheme and the bonus payments were extended to all high efficient cogeneration electricity produced including the part used directly on-site. Additionally investment grants for cogeneration heat grids were introduced.

In 2011 a monitoring of the effect of the law, was carried out, indicating that without further amendments of the law only a cogeneration share of maximum 20% would be possible by 2020. As a consequence and regarding the target of 25% declared on a more informal basis in 2007 the revised Cogeneration law 2012 provided some substantial improvements of the incentives for investments in new cogeneration plants and modernisation of old plants. Fig. 3 shows the bonuses paid for each produced kWh of cogeneration electricity for 10 years (this option applying only for micro-CHP up to 50 kW_{el}) or 30,000 full operating hours in the 2009 and 2012 law and the increase 2009 to 2012. Aiming to facilitate the support scheme for private cogeneration operators, for installations up to 2 kW_{el} the option of an immediate pay-out of the total support for 30,000 hours at the start of the operation was introduced.

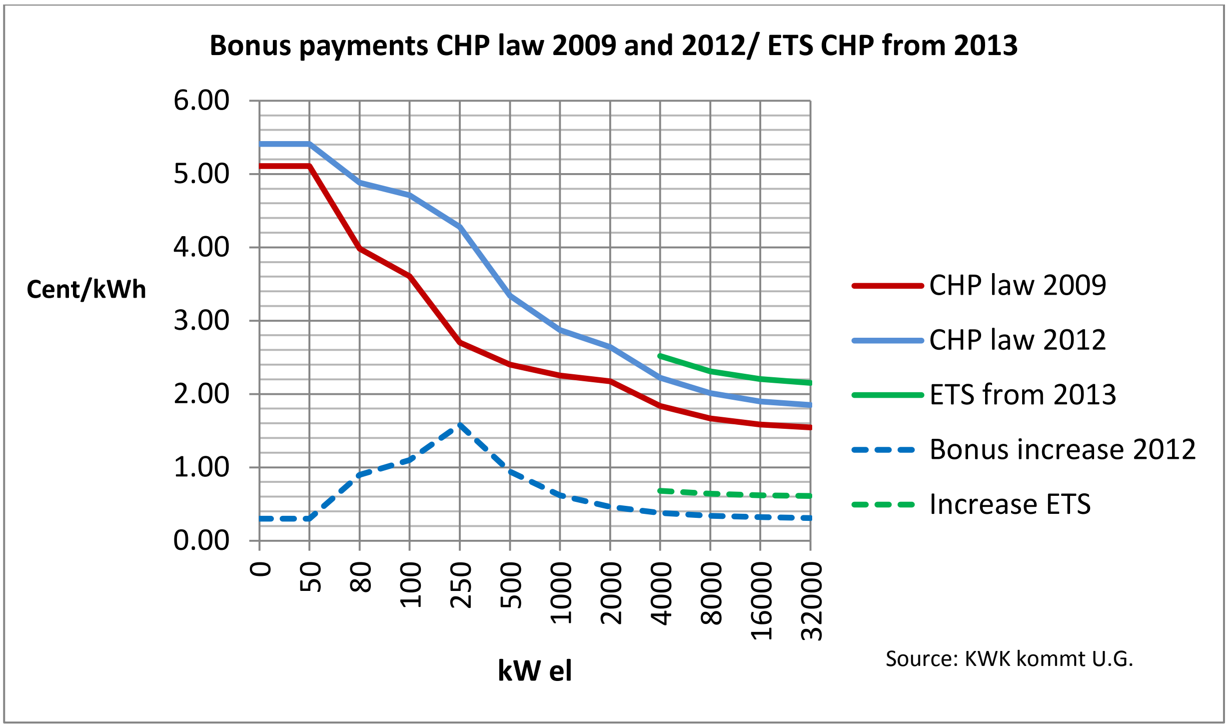

Figure 1.3 - Bonus payments CHP law 2009 and 2012/ ETS CHP from 2013[4]

Complementary to the Cogeneration law an additional support mechanism for "Mini CHP" up to 20 kW_{el} was launched in 2012, providing investment grants staggered by electric capacity between 1.500 and 3.500 € per installation.

1.4. Awareness[5]

Awareness of the importance of cogeneration in energy and environmental policy has seen a remarkable development in the last ten years. Cogeneration is now recognized at the most relevant government policy groups and throughout the power industry as an important element of the planned "energy transformation". But for important customer, market and influencer groups there is still a lack of awareness and information. This lack of awareness and information extends to relevant parts of the municipal policy administration.

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

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

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[4] Graph made by and based on own calculations from CODE2 project partner KWK kommt U.G.

[5] See also the more detailed case study on CHP awareness in Germany worked out in the CODE2 project.

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

Cogeneration is information sensitive. The recent successes in both the market and at the political level in Germany would not have been achieved without a substantial increase in awareness of cogeneration and its opportunities. However knowledge of the technical options of cogeneration and their economic and environmental advantages is currently not wide spread in many potential user groups.

One important attribute of cogeneration is its relative complexity in terms of technology, planning / design, approval and funding as well as in the resulting specific high standards of planning and information transfer. The know-how capabilities in these areas in the power industry as well as in general industry and the commercial sector are still low. This lack of awareness might be a limiting factor for an expansion of cogeneration. But a steadily increasing number of providers of energy systems and services is discovering cogeneration as a new economic business area because of the range of applications and favourable support mechanisms operating at present in Germany. This might be an important toe-hold for cogeneration development.

1.4.2. Cogeneration Awareness assessment in pilot Member States: Method

An assessment of awareness of cogeneration among key market actors has been developed. Qualitative interview techniques were used. A non-representative selection of sectoral experts and market participants, were addressed. Four groups of the socio-economic actors for cogeneration, **FIGURE 1.4**, were assessed. The list is not exhaustive but contains all the most relevant players.

1.4.3. Role of key actors

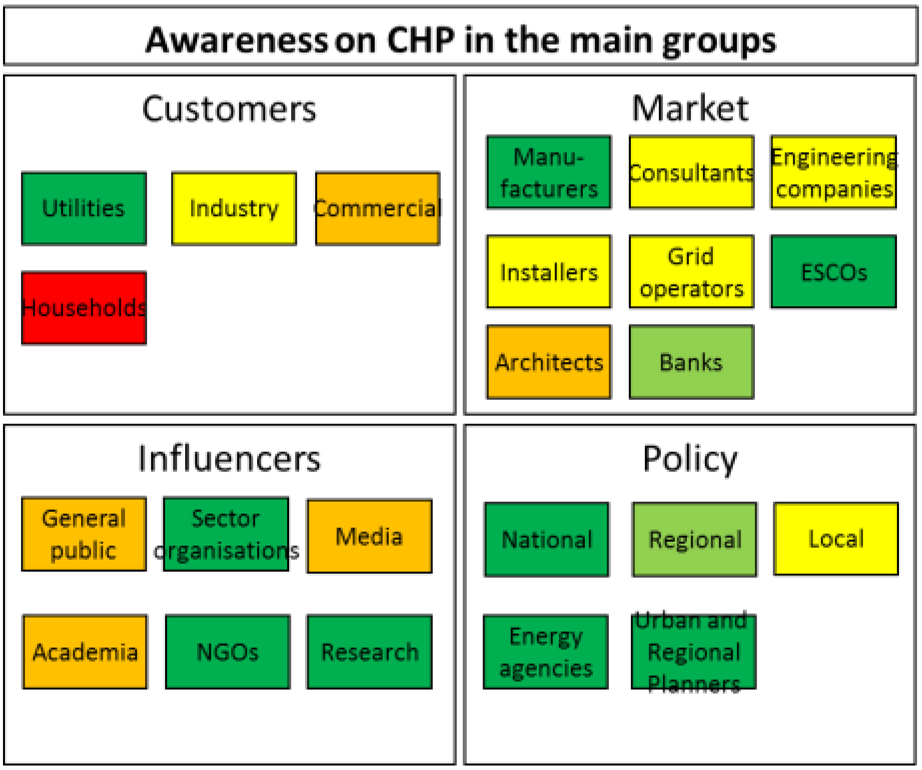

Figure 1.4 - Awareness of CHP in the main socio-economic groups

In the **area of customers** the Utilities in the energy sector are mainly well aware on the technological and economic opportunities of cogeneration, though old conceptions of central power production are still widespread. In the industry sector cogeneration is well known in principle, but there is a lack of technical, economic and legal know-how to implement projects despite an often good business case. Interest is growing. In the commercial and tertiary sector awareness of the opportunities of autoproduction with cogeneration is still low. Among households knowledge of heating with cogeneration devices is weak and micro-CHP for houses is still at an early market stage.

In the **area of market actors** the manufacturers have been the key actors for many years. It is the manufacturers who directly play the main role in promotion, distribution, customer contact and project completion. Many energy consultants and engineering companies know cogeneration only in principle, and often detailed knowhow is missing. The same is true for installers, but here some early awareness is visible as more experience is gained in projects. A knowledge and understanding by power grid operators of cogeneration is important for frictionless grid connection and power exports from on-site for cogeneration installations, but in practice barriers persist due to the historically centralized nature of the power grid. Energy service companies (ESCOs) tend to have a high awareness of cogeneration and the know-how in this group is steadily growing; in Germany they are currently playing a key role for cogeneration dissemination in industry, apartment houses, commercial organisations etc. Many architects have only a rather low knowledge of cogeneration details. Their focus is on solar thermal, heat pumps and pellets which fit more easily into traditional building design. Banks and leasing companies in Germany are informed on cogeneration and there are generally no major problems for financing; special credit programs with favourable terms are offered by the state owned KFW bank in cooperation with the local banks.

Besides the direct market actors a list of **influencers** can be identified. For the ordinary citizen in Germany cogeneration is mostly a technology which is out of his scope. With the introduction of micro-CHP devices for homes, certain sectors of the home market are becoming aware with the showcasing of cogeneration technologies as “power producing heating” for the first time. The relevant sector associations of the power industry, other industries and crafts are well aware of cogeneration and it´s opportunities. In the energy and environmental media cogeneration is meanwhile well known but in the popular media mentioning cogeneration is still rather rare. In the academic world only a minority of universities and technical colleges deal with cogeneration; and there is good knowledge, and a strong academic base, only in a few institutes.[6] Environmental NGOs and energy related research institutes are well informed about cogeneration and the image of cogeneration among the NGOs in Germany is good.

The **policy area** can be thought of as a special “influencer group” which interacts strongly with all other areas. On the national level against the background of the planned “Energy transformation” cogeneration currently has a good image and high priority in all parties in the German parliament and in the relevant Ministries and federal auxiliary institutions as well. On the regional level of *Länder* there is an increasing awareness of the important role of cogeneration with strong support for cogeneration in some Länder. Regarding the local government level there is a range of awareness of cogeneration, but in recent years a growing interest in communal climate protection concepts including cogeneration based district heating is reported. A federal funding program administrated by the Ministry of Environment started in 2008 and since then with a total funding of 13 Million Euro 227 communal climate protection concepts have been launched[7] for 2063 cities under the program. (The number of pre-existing climate protection concepts is not known). These concepts include heat supply concepts. Additionally a special funding program has been running since 2011 for “energetic city renovation” addressing only house block or quarter size solutions, i.e. no complete town solutions, in which 170 funding requests have been registered up to March 2013[8].

Regional energy agencies, often totally or partly funded by local or regional authorities, belong to the main actors in promoting CHP in Germany. These agencies in many cases perform conceptual and planning services for municipalities. Where the planning and conceptual work is done by private urban or regional planners, their knowledge on cogeneration and its image is good.

Overall, in Germany’s society the realization has grown that resource scarcity and climate change are forcing a restructuring of the energy supply system. Following the Fukushima nuclear catastrophe (2011) a broad consensus formed in politics and society to end the production of nuclear power. In recent years a strong resistance to new coal-based power plants has emerged. This background has increased the awareness of the value for the cogeneration option. In the energy and environmental

[6] According to an information received from Prof. Dr. Andreas Weiten, Fachhochschule Bingen, special study courses on CHP are offered only in two German university of applied sciences (Bingen and Münster), otherwise in a few engineering colleges it is covered in context with other topics.

[7] With support of the “Deutsches Institut für Urbanistik” the figure has been taken from the “Förderkatalog”, a database published by the Federal Government: http://foerderportal.bund.de/foekat/jsp/StartAction.do.

[8] Information provided by the state owned KfW Bank, phone call Adi Golbach with Kai Pöhler, 3 April 2013.

policy debate cogeneration is currently regarded as a low cost decentralized and environmentally friendly alternative to nuclear and coal fired power production.

The current positive image of cogeneration at the political level is in excess to that in the general public or at the level of multiplier and decision making groups. Although awareness among these latter groups has also grown, cogeneration as an important option for reducing total energy import costs and for climate protection, in comparison to renewable energy, is still relatively little known in the general population. Both the level of awareness and also the interaction between the various groups is important in achieving a mature market. Here some supportive developments have to be recognized particularly regarding the cooperation between policy and associations and the relevant associations with one another.

The existing awareness and knowledge deficits in some important groups have been identified as significant barriers against stronger cogeneration development. They will be taken up again in chapters 1.6 (Barriers to CH) and 3 (The roadmap).

1.5. The economics of CHP

In Germany completely different economic conditions are prevailing in the power industry on the one hand and at on-site installations in industry, commercial and housing on the other hand. Whilst the profitability in the on-site installations in many cases is excellent because cogeneration electricity currently competes against increasing end user prices, in the energy sector cogeneration power is competing immediately against decreasing power exchange prices with the result that profitability is currently depressed.

1.5.1. Main market areas

For fossil energy fuelled cogeneration there exist three market segments with fundamentally different decision criteria and parameters:

Main CHP markets		
User	**Criterion**	**CHP size**
1. Power industry	CHP electricity produced competes immediately and in each hour against the EEX spot market.	mostly big CHP plants > 10 MW_{el} (but partly also smaller CHP devices)
2. Industry and commercial	CHP electricity produced competes against the power taken from the grid whose price contains additionally to the commodity price the grid cost and taxes & levies, particularly the cost allocation fee from the renewable energy law.	small and medium scale CHP > 50 kW_{el} ≤ 10 MW_{el}
3. Housing and small scale commercial	CHP competes against other heating systems, mainly heat boilers. The relevant economic criterion is mostly the heating cost.	micro CHP ≤ 50 kW_{el}

Table 1.4 - Main CHP markets

In all market segments the value of the produced heat is linked to the heat market price level, determined mainly by the prices of natural gas and – with decreasing importance - heating oil.

1.5.2. CHP Economics Matrix

The following matrix gives an overview on the economic situation of cogeneration in the main market segments.

CHP Economics Matrix							
Germany	**Micro**		**Small & Medium**		**Large**		
	up to 50kW		***up to 10 MW***		***more than 10 MW***		
	NG	**RES**	**NG**	**RES**	**NG**	**Coal**	**RES**
Industry	[green]	[yellow]	[green]	[green]	[green]	[yellow]	[yellow]
District heating	[green]	[yellow]	[green]	[green]	[yellow]	[yellow]	[green]
Services	[green]	[yellow]	[green]	[green]	[grey]	[grey]	[grey]
Households	[yellow]	[red]	[grey]	[grey]	[grey]	[grey]	[grey]

Table 1.5 - CHP Economics Matrix

Legend:

[green]	**"normal"**	CHP 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.
[yellow]	**"modest"**	CHP Investment has **modest/limited economic benefits** and return on investment, **limited interest for new investments**.
[red]	**"poor"**	CHP Investment has **poor or negative return on investment or is not possible due to other limitations, no interest/possibilities for new investments**.
[grey]		**Not applicable** for the sector
NG		**Natural Gas** or appropriate fossil fuel
RES		**Renewable energy sources** (wood biomass, biogas, etc.)

1.5.3. Power industry

In the 1st market segment the cogeneration plant will run only in those hours when its operating cost are lower than the EEX power price. This is the only time when the cogeneration is generating positive capital cost contribution margins. As the gas purchase prices are mainly determined by the commodity price it can be reasonably assumed that costs are well correlated to the EEX gas prices. So the EEX gas and electricity prices and their relation are a good indicator of the economics of cogeneration in this segment.

FIGURE 1.5 shows the development of prices for natural gas (curve 1) and electricity EEX (curve 2) and the ratio between power and natural gas prices (curve a). The current power-to-gas price ratio of 1,7 is too low to induce new investment despite the increased bonus payments of the amended cogeneration law 2012. The most significant development is the decline of the EEX power prices since 2009. Its effect on the power-to-gas price ratio was temporarily overcompensated by low gas prices, which are increasing since then.

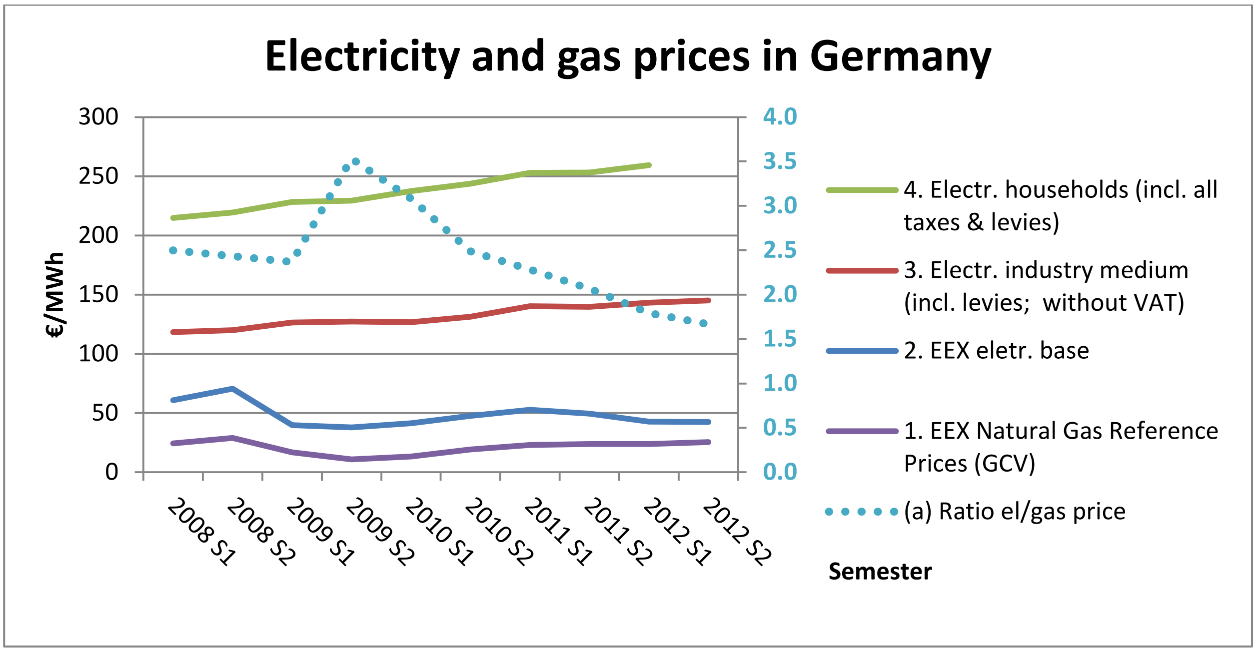

Figure 1.5- Electricity and gas prices in Germany

The reason for the decreasing EEX power prices is the fast rising share of fluctuating RES in the market in combination with the extremely low ETS carbon prices in the last years. EEX hourly prices are built according to the marginal cost and the derived merit order of power supply cost.

As the electricity from RES has to be taken off the grid (a legislative requirement) and paid for or grant-aided by legally fixed prices from the power grid operators these power amounts are sold on the EEX to even the lowest price level, their marginal cost as mentioned above being equal to zero. The political intention is that these rising RES electricity volumes should substitute carbon intensive power production, the low operation cost of coal fired power production against the background of a very low carbon price lead in the end that low carbon gas fuelled power production is substituted in first instance by RES and gasfired cogeneration in second instance instead of replacing the high carbon content coal as intended.

The amount of yearly hours, where the EEX electricity prices are high enough to generate contribution margins to the fixed costs of cogeneration, is decreasing. As a result, investments in big cogeneration plants are considered more and more to have an unattractive business case against the background of decreasing EEX average power prices.

New cogeneration plants benefit from the new 2012 Cogeneration law with its bonus payments for each produced kilowatt hour for 30,000 full operating hours, which reduces the marginal cost per kilowatt hour by roughly at least 2 to 2.3 cents depending on the plant size and whether or not it is subject to the emissions trading scheme. But this effect of reducing the marginal cost only works for the limited Cogeneration law support period of 30,000 hours and a business case will include a risk factor for the EEX future pricing.

1.5.4. Industry, commercial, housing

Contrary to the market situation for Cogeneration in the power industry the business case changes when talking about the industry, commercial, housing market segments. As curves 3 (el. prices industry) and 4 (el. prices households) show, the end user power prices increased steadily in the last years. Paradoxically in comparison with the EEX prices, these rises in electricity prices to the consumer and industry are induced by rising RES power supply, as the electricity consumers have to pay rising RES law cost allocation fees which are included in the power prices. This fee increased up to 3.6 Cent/kWh in 2012. A new dramatic increase up to 5.3 Cent/kWh in 2013 caused a political debate on possible measures of a "power price brake".

As the RES fee has to be paid only for electricity delivered from an "electricity supply company", the profitability of autoproduction has been changed by these developments. However a growing number of industry companies have been freed from the RES allocation fee, with the justification that this fee otherwise creates a competition disadvantages for exporting companies. It is important to note that power deliveries from ESCOs are included in the RES law allocation, if they carry the economic risks of investment and operation the cogeneration plant. This discrimination against energy service companies constitutes a serious barrier against cogeneration in this market segment (see chapter 1.6.4.3).

In the area of typical one-family houses micro-CHP devices of 1 or 2 kW_{el} are now available but without additional support not yet competitive against classic heating boiler solutions. This may change with rising number of units produced and accordingly decreasing production cost and sales price as discussed in the CODE2 study on micro-CHP.

1.5.5. Renewable Energy Sources

Cogeneration fuelled by bio energy is only a business case when support by the RES law is claimed. That means that the whole electricity produced is delivered into the public grid and sold either to the grid operator based on legally defined feed-in-tariffs or to a third party in the power market (direct market sales). In the latter case the cogeneration operator receives from the grid operator instead of a feed-in-tariff a so called market and management premium and, if operating the cogeneration flexibly according to the hourly development of the EEX prices, additionally a flexibility premium. So the economics of bio energy cogeneration depend next to the investment related costs mainly on the fuel cost and the value or price of the heat produced.

With the introduction of the revised RES law 2012 the conditions for bio energy have worsened substantially, which led to a crash of new installations of biogas plants by 74% in 2012[9]. Better conditions are still prevailing for biomethane, where a sufficient business case can be expected for cogeneration from about 50 kW_{el} onwards.[10]

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[9] Press release Fachverband Biogas from 17 May 2013.

[10] The mood in this sector is regularly checked in an industry barometer ("Branchenbarometer") published by "biogaspartner", an initiative launched by the German Energy Agency DENA, see http://www.biogaspartner.de/branchenbarometer/branchenbarometer-22012.html.

1.5.6. Example calculations

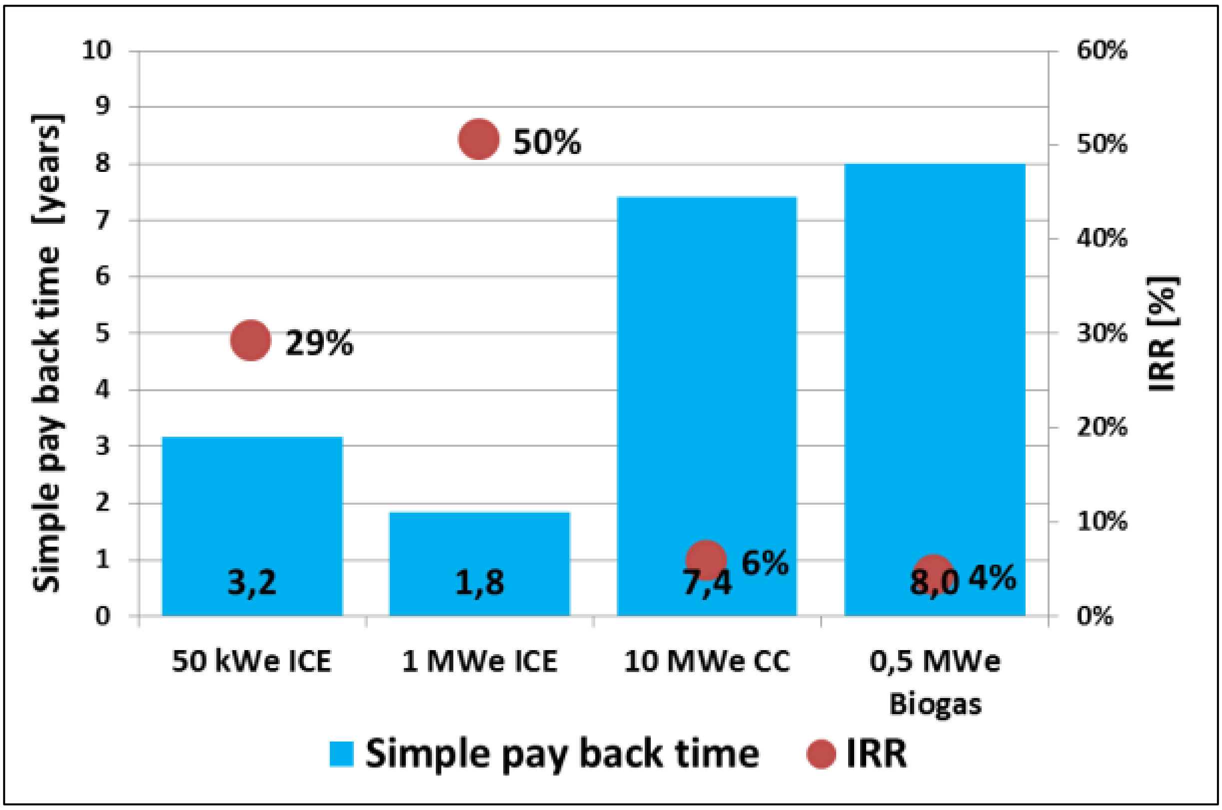

Figure 1.6 - Example calculations

Figure 1.6 shows the results of profitability calculations of four cogeneration devices: a 50 kWel internal combustion engine installed in a hotel, a 1 MWel internal combustion engine installed in an industrial plant, a 10 MWel combined cycle cogeneration producing district heat and power in a public utility and a 500 kWel biogas engine cogeneration placed at a farm, whereby the heat is sold to a client.

It should be noted that in praxis the profitability of a cogeneration investment may decrease because of additional investments that may be needed for integrating a new device into the existing infrastructure. In the industry case it is assumed that the power price includes full normal grid cost and full RES law cost allocation fees, but in practise many industry companies are completely or partly freed from these costs. In such cases the profitability of cogeneration is substantially reduced because cogeneration power has to compete against lower power purchase prices.

The profitability is indicated as internal rate of return (IRR) and Simple Payback time. The simple payback time is also called ROI (return on investment), whereby no interests are considered.

The calculation details are shown in Annex 2: Example profitability calculations.

1.6. Barriers to CHP

The lack of awareness of the benefits and availability of cogeneration solutions and the absence of awareness of the energy waste involved in conventional fuel based heating, and power generation systems compared to cogeneration impedes integrated consideration of heat and electricity supply. In utilities decreasing electricity market prices impede investments in new large cogeneration plants. The lack of know-how of planners, installers and architects means that several potential channels for getting cogeneration information and projects offered to customers are not active. The current cogeneration support scheme in Germany is too complicated for most private micro-CHP users.

1.6.1. Barriers noted in the 2007 report to the commission

The German 2007 report to the commission on potentials and barriers against cogeneration[11] highlighted a significant difference between the potential which can be realized as a result of success at a microeconomic level and the actual cogeneration potential which had been realized hitherto. Generally the report states, that "obviously, the yields which can be achieved by expanding cogeneration and district heating are regarded as being too low by many decision makers, both in industry and in the energy sector. ..."

In focusing on the main barrier issues of current relevance, taking into consideration new and additional barriers, many of the "old" barriers are seen to persist though some of them have a reduced importance. Other barriers have disappeared meanwhile. In particular the "inadequate obligation to accept and pay for electricity from cogeneration" noted in the 2000 survey has been removed by the Cogeneration law with its obligation for electricity network operators to connect and receive electricity from CHP as well as to pay the "usual price" for it. Only cogeneration installations up to 50 kW_{el} profit from this legal provision unrestricted and independent of the time of support payments. Meanwhile there are sufficient opportunities for larger systems to sell their surplus power on the market.

In more than 30 discussions and interviews in the research phase for this roadmap with experts and users[12], additionally based on long-standing personal experience in the cogeneration markets and their environment, almost 50 more or less detailed obstacles against cogeneration in all application areas have been identified.

[11] Report of the German Government to the EU commission determining the potentials for high-efficiency cogeneration in accordance with Article 6 of EU Directive 2004/8/EC. "Analyse des nationalen Potenzials für den Einsatz hocheffizienter KWK, einschließlich hocheffizienter Kleinst-KWK in Deutschland - Bericht entsprechend Artikel 6 Absätze 1 und 2 der Richtlinie 2004/8/EG über die Förderung einer am Nutzwärmebedarf orientierten Kraft-Wärme-Kopplung im europäischen Binnenmarkt." The report was based on a study carried out by Bremer Energie Institut and Deutsches Zentrum für Luft- und Raumfahrt (DLR), 2005.

[12] Amongst others an Internet discussion in the "BHKW-Forum" has been launched in November 2012, see http://www.bhkw-forum.de/board168-bhkw-forum-community/board183-allgemeines-zu-kwk-energie-umwelt-und-politik/p68410-code2-eine-kwk-roadmap-f%C3%BCr-deutschland-und-europa-die-potenziale-umsetzen/#post68410.

In the following only those barriers are listed, which are considered most important as base for proposed measures in chapter 3.

1.6.2. General barriers

1.6.2.1. General absence of awareness of the energy waste involved in conventional fuel based space heating systems compared to the high efficiency of CHP impedes integrated consideration of heat and electricity supply

Maybe the most important issue affecting the broader use of cogeneration is its relative complexity in terms of technology, planning, approval and funding opportunities, as well as in their specific resulting high standards of planning and information. And the advantages of cogeneration with regards to energy saving are not easy to understand for most people. The advantages are not as visible on the first evidence, as they are for solar and wind energy (low carbon) , and they need an explanation, more or less abstract, mostly presented as a graph comparing the energy input and output flows to those of separated production of heat and power.

With regards to a transformation of the energy supply system ("*Energiewende*") public and political awareness is limited to RES electricity, disregarding the enormous day-to-day energy waste in the traditional heating market. This tends to conserve an unbalanced policy steering system which is in all other aspects than RES consequently, setting poor market signals for potential CHP investors as described in the next chapter.[13]

1.6.2.2. Decreasing electricity market prices impede investments in new large CHP plants

Despite the improvement on the political cogeneration support with the 2009 and 2012 amendments of the Cogeneration law, the uncertainty for investments in big cogeneration plants has in the last years become even worse. As described chapter **1.5.3**. in more detail, this is due to the fast rising share of fluctuating RES in the market in combination with the extremely low ETS carbon prices in the last years. As a result, investments in big cogeneration plants are considered more and more to be no good business against the background of expectation on further decreasing EEX average power prices and persistently low ETS carbon prices.

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[13] The problems with the current RES law and possible solutions have been discussed in an experts workshop organized by Agora Energiewende in February 2013 titled "Die Zukunft des EEG – Evolution oder Systemwechsel? (http://www.agora-energiewende.de/fileadmin/downloads/publikationen/AGORA_EEG_Reader_130213_Web.pdf).

1.6.3. District heating (DH)

The 2007 German cogeneration potential analysis identified, related to 2005, economically feasible additional district heat potentials of between 133% and 188%. It must be underlined that this estimation did not take into account any political support.

But despite the political support from the Cogeneration law the supply of district heat has stagnated[14]. Obviously the support for investments in old cogeneration plant modernisation measures since 2002 as well as in densification and expansion measures since 2009 were not able to compensate the decline of specific heat demand resulting from measures for energetic amendments of the building stock.

The question must be raised, why the opportunities of district heating are not used much more in the German cities. Additionally to the general barrier noted in 1.6.2.2, which affect also big industrial cogeneration plants, the following specific barriers for district heating cogeneration have been identified.

1.6.3.1. Lack of information on the opportunities and advantages of DH/ CHP by most citizens, in communal policy, and in energy supply companies impedes the planning and growth of district heating.

Referring to reported experiences from cogeneration experts, there is still a lack of awareness of these business opportunities at the communal policy decision makers. Once a check of the economic feasibility of installing a heat grid in a city has been made, then it can be verified in many cases. The business case is reinforced since the 2012 increase of financial subsidies to up to 40% for heat networks with at least 60% cogeneration heat.

Nevertheless up to now only a small minority of cities have carried out a concrete investigation on the opportunities of DH/CHP or even developed plans to do so.

The local policy status of DH is linked with its general status in the public view. But from many local utilities there is no active base information and marketing for DH-CHP. Best practice cases show that interest and demand for DH connections increase significantly if appropriate information is offered to the public as part of a densification and expansion concept or if DH is newly introduced to a city.

It was reported in discussions with experts that even in many utilities the awareness of the opportunities arising from DH based on cogeneration is low and that the know-how resources are often still one-sided concentrated on selling electricity taken from the transmission grid and distributing gas into conventional boiler applications.

[14] According to AGFW-Hauptbericht 2011, the connected heat capacity in the reported companies has slightly decline from 2005 to 2011.

1.6.4. Industry Barriers

1.6.4.1. Buying electricity from the grid is easier than running a CHP and doesn´t bind any capital.

The general trend in the last decades towards concentrating on core business has, in the first instance, resulted in decreasing readiness to invest. Committing capital, which is scarce, over longer runtime than core business investments, is viewed as an encumbrance and not as support for the core business, and is in many industrial companies therefore preferably avoided by the management. The Return on investment (ROI) criterion for investments is in many companies 3 years, a value which is often not met by a cogeneration investment.

1.6.4.2. Lack of in-house know-how and similar lack among external planners and installers leads to possible CHP solutions being overlooked even when they are economically interesting

In many companies the necessary know-how regarding technical and legal issues is not available. Also external planners for industry installations are mostly not familiar with cogeneration technologies, resulting from a lack of adequate education in technical schools and high schools.

This barrier applies not only for industry but also for other potential cogeneration operators in the medium size range (hospitals, hotels, tertiary sector …).

1.6.4.3. A special rule defined in the Renewable Energy Law impedes CHP-solutions supplied by Energy Service Companies

In those cases where cogeneration solutions are not realized due to the barriers noted in 1.6.4.1 and 1.6.4.2, Energy Service Companies (ESCOs) are in many cases able to bring the cogeneration potentials into reality. As specialised experts on efficiency they do have the necessary know-how on technical and legal issues and many of them can offer cogeneration solutions by "contracting" even as a part of an integrated efficiency package including other energy saving measures regarding the supply of power, heat and cold.

Though cogeneration power deliveries to a factory by ESCOs are substitutes for autoproduction, they are treated in the German Renewable Energy Law (EEG) equal to conventional power supply from the power grid. As a consequence, the full EEG cost allocation fee (2013 5,3 Cent/ kWh) has to be paid for this electricity. Thus energy services, which include cogeneration and so cogeneration solutions as a whole, are hindered.

1.6.4.4. Lack of DH systems impedes use of industrial waste heat in local concepts

Nearly half of the heat used in industry is necessary for processes with temperatures of more than 500 °C. These temperatures cannot be provided by typical cogeneration technologies as engines and gas turbines. But waste heat from such processes can be used either as input in secondary cogeneration processes as e.g. ORC (which is supported by the Cogeneration law since 2009 but still barley practiced) or by delivering it into a DH network if any exists. Taking this fact into account the under development of DH infrastructure in Germany turns out also in this case to be a barrier against wider use of the large industrial waste heat potentials.

1.6.5. Barriers against in-house CHP (other CHP)

This chapter concerns all the potential cogeneration applications outside industry and where no DH supply is offered or officially announced by municipal development plans. That means installations in single businesses or domestic accommodation buildings or in small scale heat grids connecting some houses.

1.6.5.1. Lack of awareness among users about CHP solutions and their opportunities means that the market is underdeveloped

With regards to potential users the general lack of awareness noted in **1.6.2.1** applies.

1.6.5.2. Lack of know-how of planners, installers and architects means that the potential channels for getting CHP information and projects offered to customers are not active.

The know-how and capabilities concerning cogeneration of planners, installers and architects are still low[15]. In addition, any planner and consultant, who cannot adequately inform clients about cogeneration and work with cogeneration because of a low level of information may inadvertently advise against cogeneration installations simply by recommending conventional solutions, even if the user is interested in cogeneration. On the other hand, any expert for heat installations, who has become familiar with cogeneration, can be expected to be a multiplier.

1.6.5.3. The current German CHP support scheme is too complicated for most private micro CHP users.

The current cogeneration support scheme was designed for energy suppliers, industry companies and bigger commercial users, but not for small energy demand private users. It consists of energy tax exemptions and bonus payments from the Cogeneration law, which both require an annual calculation based on individual energy measurements and the result submitted to the state offices. Additionally the so called “avoided grid cost” for deliveries into the public grid, which have no support mechanisms, have to be administrated by contacting the power grid operators. For many potential micro-CHP users, who are home owners, this bureaucratic obligation acts as a deterrent to using cogeneration at all.

[15] As reported in the awareness case study on Germany, the first German distance learning course for installers on micro-CHP technology launched in 2010 was passed by mid-2012 by some 200 participants. This number has to be compared to totally existing 49,650 installation companies in Germany with 271,000 employees.

2. What is possible? Cogeneration potential and market opportunities

2.1. Potentials and market opportunities

Technically it is possible to cover the total power demand of Germany as a by-product of cogeneration heat production. The limits of what is economically feasible are shifting in the course of time towards cogeneration solutions. In the official German cogeneration potential study reported 2007 to the EU commission a cogeneration share in total power production of 57% was estimated to be economically feasible. A new cogeneration potential study carried out for the government of the *Land North Rhine Westphalia* underlines the message, that much more is possible than has been previously considered .

2.1.1. Technical potential of more than 100% of power demand

If the useful heat produced in conventional boilers for space heating, hot water and process heat up to 500 ° C would be generated in cogeneration with an average electrical efficiency, then the entire German power need could be covered by more than 100% as a by-product of heat. The technical potential for cogeneration is even higher as this does not include cooling [Approx. 10% of all electricity produced is used for industrial and commercial cooling processes in conventional compression machines. This cold could be generated far more efficient by combined heat, cooling and power (CHCP)] and the potential for electricity from industrial waste heat.

2.1.2. Potential analysis reported to the commission

The German CHP potential reported to the commission in 2007 is shown in table 2.1.

Total German economical CHP potential as reported to the Commission 2007[11]			
TWh/a	**CHP heat potential**	**CHP power potential**	**CHP power 2004**
DH CHP	219	245	75,5
Industry	85	90	58
Commercial and tertiary	23	16	n.a.
In-house micro CHP	1,2	0,4	n.a.
Bio energy	0	0	n.a.
Total	**328**	**351**	

Table 2.1 - Total German economical CHP potential

The analysis was based on the assumption that there was no political support for CHP and that in the cities with at least 20,000 inhabitants cogeneration based DH heat could be implemented in appropriate areas, i.e. where it would be competitive against conventional gas boilers. The study showed that the potentials of small scale and micro-CHP would be very low without political support. For Bio energy fuelled cogeneration there would be no potential under those conditions.

2.1.3. Political targets and lead study commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)

In 2008 the German government in the context of a climate protection policy concept declared the target of increasing the share of cogeneration electricity in total electricity production from the then estimated 12% to 25% in 2020. This aim was legally confirmed by reception into the Cogeneration law amendment 2009.Since 2007 on a yearly basis a so called "lead study" is carried out from some institutes commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) [16]. With this study the Ministry intends to present "sound and up-to-date scientific information as a basis for shaping energy and climate policy in the years to come". The presented long-term scenarios are declared to be neither predictions of the future development nor potential analyses of the energy system and to be based on the objectives of the "energy revolution" of the federal government. The last lead study was published in March 2012.

For 2020 in the medium lead scenario the prospect of cogeneration share in power production is about 25% according to the aim of the Governments planned "Energy transition" and it will stay on that level up to 2030. In parallel the cogeneration share in end energy heat will increase from 12% (2010) to 18% in 2020 and 19% in 2030.

Compared to the potential analysis reported to the commission, the lead study expects a lower cogeneration development mentioning the following reasons:

- dominance of fluctuating renewable energy share on power production;
- growing importance of the direct use of excess wind and PV energy for district heat production by electric heater and large heat pumps;
- significant decrease of heat demand;
- expansion of solar collector systems, hydrothermal heat recovery, heat from geothermal plants.

Cogeneration only a "bridge technology"?

The "lead study" states that "cogeneration is both a highly efficient and cost-effective "bridge technology" that should be developed as quickly as possible, but, on the other hand, it should be taken care that the long-term useful cogeneration base as it is required in an energy supply system largely based on RES in the medium term should not be exceeded significantly, so that the investment in cogeneration plants and heating networks can be written off sufficiently. From the perspective of infrastructure the grid-connected cogeneration is particularly suited to flexibly adjust to the new framework of the electricity market and to integrate in parallel heat from renewable sources (e.g. solar heat)."

From the point of view of developing a *cogeneration* ***roadmap this position seems to be not acceptable as it considers higher efficiency of energy transformation by*** *cogeneration* ***as an only secondary and temporary ("bridge") solution disregarding the long term persistent need of fuel use for heating in the existing building stock and in the industry.***

[16] Lead Study - Further development of the "Strategy to increase the use of renewable energies" within the context of the current climate protection goals of Germany and Europe.

2.1.4. Energy future 2050 – Scenario "Environmental Awareness"

2009 the FfE Research Center for Energy Economics (Forschungsstelle für Energiewirtschaft e.V.), Munich, published a comprehensive study titled „Energy future 2050"[17]. The study developed 3 scenarios. In the reference scenario (frame conditions develop according to the long-term trends and expectations) the cogeneration share in power production increases only up to 17% in 2020 and 18% in 2030 and staying then on that level. In the scenario "Increased technical efficiency" the cogeneration share moves up to 26% in 2020 and 32% in 2030. In the 3rd scenario "Environmental awareness" the share develops roughly equally, it's also 26% in 2020 and rises then to 33% in 2030. Regarding the corresponding development of CHP heat supply, despite increased efforts for building insulation it will rise up to a maximum of nearly 1,400 PJ (388 TWh) in 2030.

The results of the scenario "Environmental awareness" are used as a base for chapter **3.3** in this roadmap.

2.1.5. Market opportunities in the main use area

2.1.5.1. District heating

As shown in chapter 1.5., the current market opportunities for new cogeneration installation are disturbed by the low EEX power prices. Therefore in the local utility district heating area the propensity to start new investments in cogeneration plants (as in fossil power plants too) is currently low despite the amended support by the Cogeneration law. As without investments in new fossil fuelled power capacities on the medium run a capacity gap affecting security of supply is expected by most experts, there is a debate on establishing some kind of "capacity mechanism" to give incentives for investments in additional power capacities. The Cogeneration law 2012 and the RES law 2012 already contain such incentives by introducing new elements for supporting a more flexible operation mode of existing and new plants (e.g. by using large heat storage tanks for a temporary decoupling of heat and power production for some hours or even days). Some experts are supporting and expecting the introduction of capacity markets.

Based on the economic potentials as shown in the above cited study reported to the Commission and some more recent studies [16 / 17 / 18], a share of district heat of up 40% in the total low temperature heating market (room heating and hot water) could be possible up to 2030 compared to 17,5% in 2011[19].

2.1.5.2. Industry

A potential analysis carried out in 2011 for the biggest German Land, North Rhine Westphalia (NRW), estimates in comparison to the above cited potential report to the Commission an even bigger possible relative increase of industrial cogeneration electricity related to the status quo. The report

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

[18] Wärmebedarf und Fernwärmepotenzial der Haushalte in Deutschland, Dr. Markus Blesl, Institut für Energiewirtschaft und Rationelle Energieanwendung, Universität Stuttgart.

[19] Arbeitsgemeinschaft Energiebilanzen, Anwendungsbilanzen, Zusammenfassung.

to the commission, assuming no political support, calculated a possible increase of about 50%, whilst the NRW study, taking into account the support of the Cogeneration law, calculated a possible quadrupling. It identified a potential of raising industrial cogeneration electricity production per year from 6 TWh (2008) to 27 TWh by plant modernisation (+11 TWh) and the exploitation of additional heat sinks (+10 TWh). Table 8 shows for the most cogeneration suitable industries the cogeneration heat potentials once based on the 2007 status and additionally in a dynamic analysis, taking into account possible energy savings in two different energy price scenarios.

Industrial CHP heat potential in North Rhine Westphalia (NRW)					
GWh/a					
	Status 2007		Dynamic view until 2030		
	additional technical	econo-mical	additional technical	economical energy prices 1	economical energy prices 2
Chemical	897	514	-	-	-
Food	3.509	2.238	3.218	2.019	1.540
Paper	2.678	1.950	1.546	977	650
Metal products	1.809	1.129	1.611	1.005	839
Metal production	1.149	749	1.036	659	483
Rubber and plastics	1.277	633	1.198	594	362
Machine building	1.347	893	1.197	793	657
Vehicles	852	647	542	411	367
Textile	1.088	644	848	502	248
Glass, pit and quarry	754	308	773	316	172
Other	713	313	488	138	88
Total	16.073	10.018	12.456	7.315	5.405
Source: Potenzialerhebung von Kraft-Wärme-Kopplung in Nordrhein-Westfalen, 2011; study commissioned by the NRW-Ministry of Environment.					

Table 2.2 - Industrial CHP heat potential in North Rhine Westphalia (NRW)

Regarding the current market situation, industrial cogeneration is profiting from the rising electricity consumer prices noted in chapter 1.5. A new survey of the Association of German Chambers of Commerce and Industry [20] published in February 2013 showed that against the political background of the "Energy transformation" about one third of the 2307 companies responding (thereof 38% industry) are already installing or planning an electricity autoproduction. Thereof 8 % are planning an autoproduction with conventional energy, which may be interpreted as fossil cogeneration, 4 % are implementing measures and 3% have already such devices installed. Numbers related specifically to bio energy cogeneration have not been surveyed but this issue has still today a rather low relevance

[20] DIHK – Deutscher Industrie- und Handelskammertag, IHK-Energiewende-Barometer 2012

in German industry. The numbers suggest rising interest in autoproduction in cogeneration or with RES.

2.1.5.3. Small scale and micro-CHP

Regarding areas of the heating market outside district heating and industry, against the background of the new Cogeneration law 2012, there are excellent market conditions for installations from about 5 kW_{el} onwards. As described in more detail in CHAPTER 1.5, increasing electricity prices together with the amended political support constitute good economic conditions. In the market section of installations with 1 to3 kW el, targeting at one-family-houses, all major heating manufacturers are offering cogeneration solutions based on Stirling or Otto engines. Also some fuel cell producers are currently entering this market or in a final preparation phase. They all are profiting from a very well developed natural gas grid in Germany, resulting in a 49% share of natural gas in the heating of housing[21].

The question of how the space heating market could be divided between heat network based cogeneration and cogeneration supplying single houses, in 2011 there were 47 % of all dwellings in Germany situated in buildings with 1 or 2 dwellings, covering 59% of the total housing surface[22]. These are normally not suited for district heating, and so achievable for cogeneration technologies only by micro-CHP placed in each house or connected to small scale heat grids heated by small scale cogeneration devices.

In 2001 the study "EMSAITEK"[23] commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) investigated the possible contribution of micro-CHP systems up to 50 kW_{el} to achieving the goals of the "National Climate Initiative". One important result of the study was that micro-CHP from an electric performance of 16 to 25 kW onwards could be a business case for energy service companies. In addition to technological and economic aspects of market development in the study also the theoretical technical potential of micro-CHP was estimated, lying at nearly 400,000 units per year. Calculating the economic potential based on current price relations, the number drops to 17,000 units per year.

[21] Press release of the German Association of Energy and Water Industries, 2013 - http://www.stadtwerke-quedlinburg.de/index.php/92-startseite/startseite/338-unternehmen1.

[22] Statistisches Bundesamt, Fachserie 5 Reihe 3, Bautätigkeit und Wohnungen, 2011.

[23] Erschließung von Minderungspotenzialen spezifischer Akteure, Instrumente und Technologien zur Erreichung der Klimaschutzziele im Rahmen der Nationalen Klimaschutzinitiative (EMSAITEK) - Endbericht zu PART III: Beitrag von Mini-KWK-Anlagen zur Zielerreichung der Nationalen Klimaschutzinitiative; Bremer Energie Institut, Institut für Zukunftsenergiesysteme, 2011.

3 How do we arrive there? : The Roadmap

3.1. Preliminary remarks

This chapter, based on the facts & figures presented in the previews chapters, particularly on the most important barriers in chapter 1.6 and on discussions on possible accelerators, proposes concrete actions. The proposals have been, and are still being, developed in discussion with several experts.

The proposals are aiming to provide add-ons to “business as usual“ and it is necessary that they are more or less challenging. Regarding the “big surface” of the environment, in which cogeneration and its stakeholders are acting, it seems to be unavoidable that the opinions of the experts on certain proposals are more or less different. But supposing that there is a concord on the common objective to realize the cogeneration potentials as far as possible, then there should be a general readiness to agree even on extraordinary and challenging actions.

We propose the following common goals and criteria for actions under the roadmap:

Goals and criteria:

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

3.2. Overcoming existing barriers and creating a framework for action

A combination of the following main measures is considered necessary to activate the German cogeneration potentials:
1. Measures to strengthen awareness of cogeneration and knowhow of consultants, planners and installers; training and certification measures should be launched;
2. Further development of the capacity mechanism elements in the Cogeneration law and the RES law;
3. Municipalities should be authorized to set decreasing limits on the specific CO2 emissions for new heatings and they should be committed to carry out local heat concepts;
4. Strengthening third party implementation and operation of cogeneration by energy service companies (ESCOs);
5. Facing the rising number of private and small scale cogeneration users cogeneration political support should be adapted to their specific needs for simple and non-bureaucratic solutions.

3.2.1 Proposed actions

3.2.1.1. General proposals independent of application area

In the following elements are included in all the proposals by main application areas

- proposed accelerating actions (if appropriate with reference to chapter **1.6**)
- proposed actors and who should take the initiative/ coordination
- proposed time scheduling

Blueprint RES campaign "Germany has endless energy"

The successful acting Renewable Energies Agency could serve as a blue print. Its campaign "Germany has endless energy" is supported by companies and associations in the renewable energy industry as well as the Federal Ministry for Environment, Nature Conservation and Nuclear Safety and the Federal Ministry of Food, Agriculture and Consumer Protection. The task of the agency is to communicate the most important advantages of a sustainable electricity supply on the basis of renewable energy. Above all, these are: Security of supply, innovations, increase in employment, export potential, permanent cost-cutting power supply, climate protection and conservation of resources.

3.2.1.1.1. A long-term Information campaign should be launched

In order to overcome the general lack of awareness of the low energy efficiency of conventional heating systems and condensing power production and the opportunities to overcome it by cogeneration (barrier 1.6.2.1) , a nationwide long-term information campaign on cogeneration and its advantages for consumers, the environment and the national economy should be launched. 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 could refer to Article 17 of the EED (Information und training).

It is proposed that the Federal Government initiates the project by commissioning a subsidiary body or an agency to develop a concept with appropriately detailed measures including the coordination of sector specific activities of the affected associations in a project working group. The project financing could be generated through a joint fund with a distribution between the involved associations and the Federal Government (e.g. 50%/50%) is proposed. Both industry and public participation are regarded to be valuable. Each association included in the project with its name and logo should contribute financially.

3.2.1.1.2. The capacity mechanism elements in the CHP law and the RES law should be further developed, in that way also increasing profitability of investments in big and bio-energy CHP

To address the problem (1.6.2.2.) of the discouragement of investments in big Cogeneration plants due to decreasing electricity prices it is proposed to link this with a solution of the evolving need for non-fluctuating secure power capacities.

The new 2012 Cogeneration law contains incentives for capacity oriented planning and operation of CHP plants. Such incentives aim to focus the electricity production of cogenerations to hours with high energy market value (high prices) and this approach should be further developed through suitable amendments. Of course, the capacity related payment to be developed must also guarantee an appropriate business case for investments in new CHP plants. In that way the German Cogeneration law would be further developed to include a capacity mechanism additionally to its role to raise total energy efficiency. A currently discussed alternative of a capacity mechanism to be introduced with strong priority to cogeneration power capacities seems to be less useful with regards to reaching the cogeneration extension goal and activating the cogeneration potentials. By aiming unilaterally to achieving the needed power capacities installed by e.g. auctioning the pre-calculated capacity needs it is not assured that also the target of 25% cogeneration share in total power production will be achieved. So it seems to be important, that the targets of cogeneration boosting and long term power supply security should be considered in an integrated approach. Only in that way both targets will be surly achieved.

It is out of the scope of this roadmap to propose a detailed capacity related investment and operation incentive mechanism, but for cogeneration the following elements appear essential:

- Capacity related payment (€/MW) only for flexible capacity (not base load capacity);
- Power related bonus payments (€/MWh) only in hours with EEX power prices higher than base load price;
- The expectable revenues must be in total high enough to encourage investments in new cogeneration plants and modernisation of all plants.
- There should be sufficient incentives not only to function as power supply back-up but to actually run also in hours with low EEX power prices and produce a share of heat in a DH system of at least 80% in a year (experiences in the last years show that otherwise the share of heat produced in the backup boiler increases).

In the energy debate it has been argued that the problem of a pending power capacity gap is not urgent and it would be early enough to decide on a solution to the capacity question after 2015[24]. But regarding the political target of raising the cogeneration share in power production up to 25% until 2020 and the currently insufficient cogeneration investments to reach the national objective, an amendment of the Cogeneration law or the introduction of a capacity mechanism with priority for cogeneration should be launched by the Federal Government in the context of the scheduled revision of the Cogeneration law in 2014.

The RES law 2012 with the "Market premium" and the "Flexibility premium" already contains capacity related incentives. These should be strengthened by the next revision of the law. Simultaneously the general attractiveness of bio energy investments as well as the incentives for

[24] See the documentation on a debate about "Kapazitätsmarkt oder strategische Reserve: Was ist der nächste Schritt?" organised from Agora Energiewende in March 2013: http://www.agora-energiewende.de/themen/strommarkt-versorgungssicherheit/detailansicht/article/kapazitaetsmarkt-oder-strategische-reserve/ .

cogenerated heat use should be substantially improved to meet the bio energy potentials and address the failure of the current law to mobilise this sector.

3.2.1.1.3. Municipalities should be authorized to set decreasing limits of the specific CO2 emissions for new heatings

A new clause in the Building Law Code (*Baugesetzbuch*) should create the possibility for municipalities to set linearly decreasing limits on the CO_2 emissions per kWh of heat for new heating plants. It should be expressed as a time schedule or curve for the development of the limit up to 2050. The time schedule or curve should be oriented on the 2050 GHG reduction target of 80 to 95%. The early scheduling will provide an important planning orientation for all affected decision makers at consumers or manufacturers.[25] Just for clarification, FIGURE shows a simplified example, in which the specific CO2 emissions by kWh heat produced are reduced by 50% up to 2050. The actually necessary start and end points would have to be calculated by taking into account the share of room heating in total GHG emissions reduction in comparison to other sectors as e.g. traffic and, inside the room heating area, the share of the heating system compared to reducing the specific heat demand of buildings e.g. by insolation measures (kWh/m²).

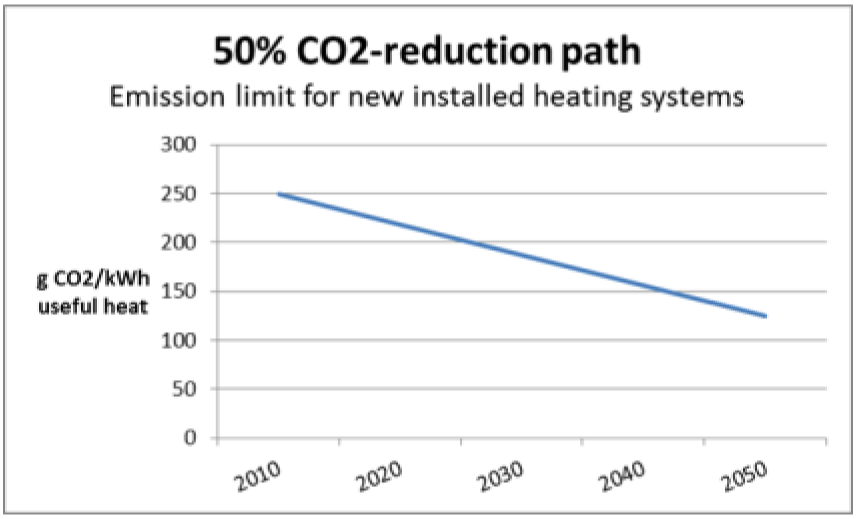

Figure 3.1 – Simplified model of a CO2 reduction path

Making use of this opportunity would also bolster the implementation of local heat concepts and cogeneration based on heat networks or on-site fuel use.

Adapting the Building Law Code is a Federal Government competence and should be implemented as soon as possible.

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[25] A somewhat similar proposal (without degression in time) has already been made the study of Ökoinstitut et.al. „Ergänzende Untersuchungen und vertiefende Analysen zum EEWärmeG (Folgevorhaben) – Endbericht, December 2010; chapter 7.2.

3.2.1.2. District heating (DH)

3.2.1.2.1. The municipalities should be obliged to carry out local heat concepts

Generally speaking, the momentum of the EED should be used for implementation of local heat plans including industrial waste heat. The degree of Interpretation allowed in implementing the EED should be used by the German government to increase "target oriented" action and to support additional commitment to developing sound plans and cogeneration.

Complementary to the amended support for investments in heat grids with the Cogeneration law 2012, it is proposed to introduce an obligation for cities to develop simplified standardized heat concepts. This obligation should overcome the statistically proven lack of activity on the communal level in Germany and identify the economically feasible cogeneration potentials based on DH, small scale heat grids and gas grids. Therefore a standardised planning tool should be developed to be used by the cities for this purpose and commissioned by the Federal Government. In these heat concepts also waste heat potentials from industry should be taken into consideration.

The legal obligations for the municipalities have to be decreed by the *Länder* governments. They should ideally be developed on a harmonized pattern in a joint Federal and *Länder* working group.

Complementary to this obligation, financial support for carrying out the heat concepts should be provided by the Federal Government.

With regards to social acceptance and political feasibility, efforts must be made on the local level to convince the citizens of the advantages of politically coordinated efforts to create an efficient and sustainable energy supply system, with cost advantages for each individual household.

Regarding social and political acceptance, a simultaneous development of different cogeneration solutions on a broad line is regarded to be useful, that means cogeneration expansion both, in heat grids and on-site-installations. In this way there will be no losers in the transformation towards a broader cogeneration use, e.g. installers of heatings, but, in connection with formation measures (see 3.2.1.3.1) only winners.

Engaging the public is crucial

"The social dimension of the energy roadmap is important. The transition will affect employment and jobs, requiring education and training and a more vigorous social dialogue. In order to efficiently manage change, involvement of social partners at all levels will be necessary in line with just transition and decent work principles. Mechanisms that help workers confronted with job transitions to develop their employability are needed."

- European Energy roadmap 2050 -

3.2.1.3. Industry

3.2.1.3.1. Certification and accreditation schemes including training programs for providers of energy services, energy audits, energy managers and installers should be launched, thereby explicitly including CHP

In order to overcome the lack of in-house know-how in the industry and among external industry device planners and installers noted in 1.6.4.2, the implementation of Article 16 EED is assessed particularly valuable with regards to overcome the barriers noted in 1.6.4.2 and 1.6.5.2. According to that EED Article the Member States have to "ensure that, by 31 December 2014, certification and/or accreditation schemes and/or equivalent qualification schemes, including, where necessary, suitable training programs, become or are available for providers of energy services, energy audits, energy managers and installers of energy-related building elements."

It is important to make sure that cogeneration is explicitly included during the transposition of the EED into German law.

3.2.1.3.2. Third party implementation and operation of CHP by energy service companies (ESCOs) should be strengthened

The implementation of Article 18 EED, requiring that "Member States shall promote the energy services market …" could be a core element for bringing the cogeneration potentials of the industry into the reality. The same is true for many other energy users e.g. in the commercial or housing sector who aren´t able or do not want to invest in and operate cogeneration devices themselves. It is important to make sure that cogeneration implementation by external ESCOs is explicitly supported.

Referring to the barrier noted in **1.6.4.3** the RES law should be changed by introducing a clarification that installing and operating a cogeneration by an ESCO must be treated equal to autoproduction of the electricity by the owner of the object to be supplied with heat and power from a cogeneration.

3.2.1.4. In-house CHP

3.2.1.4.1. Measures to raise awareness on CHP and know-how of planners, installers as well as to strengthen CHP related energy services should be launched

Here the proposals already noted in **3.2.1.1.1** (general information campaign), **3.2.1.3.1** (Certification and accreditation schemes), **3.2.1.3.2** (strengthening energy services).

3.2.1.4.2. CHP political support should be adapted to the rising number of private and small scale CHP users and their specific needs for simple and non-bureaucratic solutions

Referring to barrier **1.6.5.3** an appropriate simplified support mechanism for users of micro-CHP installations (up to 10 kW_{el}) should be considered in the context of the scheduled revision of the Cogeneration law in 2014. The revised support scheme should be adapted to the specific needs of private and small scale energy consumers. It should be easy to understand and simple to handle for the users. The possibility of concentrating different bureaucratic obligations (tax exemption, Cogeneration law support, receiving the "avoided grid cost") into a simplified administrative obligation should be considered.

3.2.1 Additional issues to be considered

The current power grid cost allocation system should be reviewed with regards to the changing challenges in the electricity supply. The current system was developed in an era when decentralised power production was just starting to become a new option. It was designed to deliver electricity from central power plants in one way to the consumers and contains only one single element which aims to take account of decentralised on-site power production, i.e. the so called "avoided grid cost". But even this element is not regulated adequately and consistently as it discriminates against small scale cogeneration feed-in without power performance measuring.[26] Meanwhile decentralised power production is generally accepted as an important element of a transformation towards a sustainable energy system with cogeneration, solar and wind power. A growing share of decentralised power production affords an efficient interaction between central and local power producers, consumers and grid operators. The cost allocation system needs to be revised in such a way, that it contains incentives for all parties to act towards a most cost effective system.

The EED in ANNEX XI lists "Energy efficiency criteria for energy network regulation and for electricity network tariffs". These have to be considered in a revision of the German grid cost system.

[26] See position paper of the German CHP Association (B.KWK), *Vermiedene Netznutzungsentgelte*, 2007.

Main strategic elements	Proposed concrete actions	Initiator/ Protagonists	Application areas where impulses are expected		
			District heating	Industry	In-house CHP (commercial & tertiary housing)
1. Organize systematic Information and Knowhow transfer	3.2.1.1.1 A long-term Information campaign should be launched (Reference to EED Article 17)	Federal government / Associations	X	X	X
	3.2.1.3.1 Certification and accreditation schemes including training programs for providers of energy services, energy audits, energy managers and installers should be launched	Federal government / Associations		X	X
2. Restructure political CHP support towards capacity mechanism incentives.	3.2.1.1.2 The capacity mechanism elements in the CHP law and the RES law should be further developed. Additional incentives for CHP installations for flexibility and security of supply contribution.	Federal government and *Länder*	X	X	X
3. Commit and enable municipalities to address energy efficiency and climate protection	3.2.1.1.3. Municipalities should be authorized to set decreasing limits of the specific CO2 emissions for new heatings	Federal government and *Länder*	X		X
	3.2.1.2.1. The municipalities should be obliged to carry out local heat concepts	Federal government and *Länder*	X	X	X
4. Strengthen CHP implementation by ESCOs	3.2.1.3.2 Third party implementation and operation of CHP by energy service companies (ESCOs) should be strengthened	Federal government Association		X	X
5. Simplify political CHP support for households	3.2.1.4.2 CHP political support should be adapted to the rising number of private and small scale CHP users and their specific needs for simple and non-bureaucratic solutions	Federal government, Associations			X

Table 3.1 - Overview on the German CHP roadmap

3.3. The roadmap path in numbers

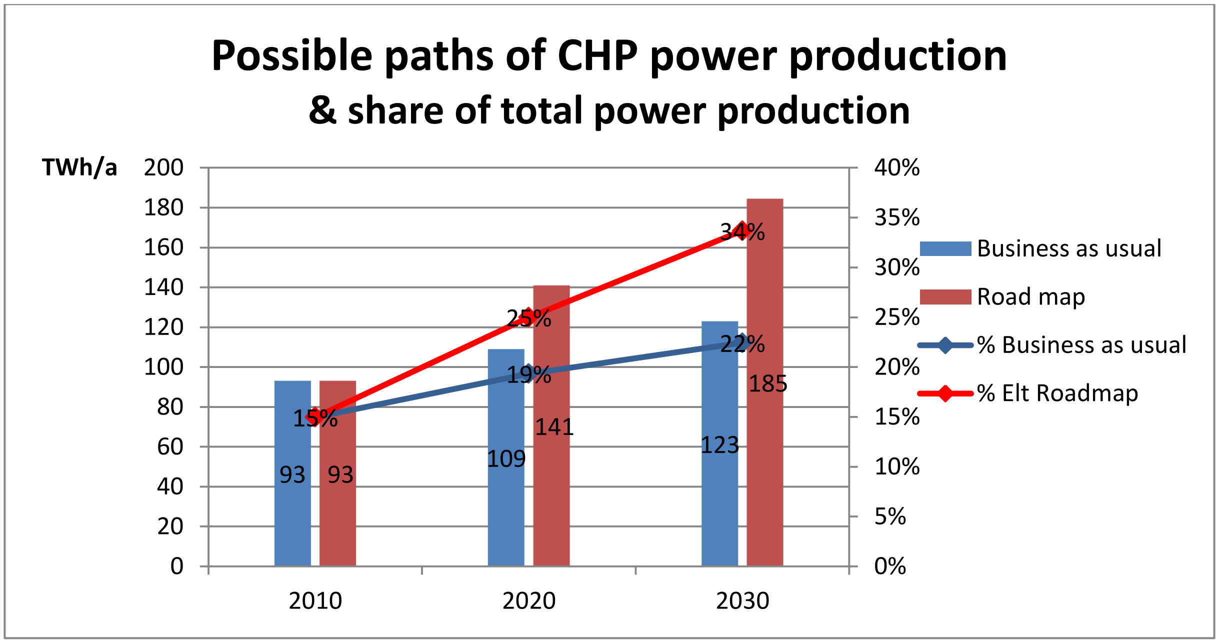

Figure 3.2 - Possible paths of CHP power production

Due to the already existing support mechanisms, the cogeneration share of total power production will further grow if no additional measures are implemented, but the potentials will probably be far away from getting completely used. For in principle the total heat demand could be covered by cogeneration solutions, reduced only by economic restrictions, but these will be lowered with future cogeneration technology development and cost reduction as assumed in the CODE2 micro-CHP study.

Based on the business-as-usual-scenario of the FfE[17] and taking account of the opinions of consulted cogeneration experts the official target of 25% share of power production up to 2020 will be achieved not even 2030: just 19% in 2020 and 22% in 2030.

With the proposed roadmap the official target of 25% until 2025 is estimated to be attainable and in 2030 the cogeneration share could arrive at roughly one third (34%). This would be compatible with the government target of 50% electricity from RES at that time. According to the prospect of 30% bio energy share of cogeneration input estimated for Germany in the PRIMES model and confirmed in the CODE2 Report on potential of bio-energy, the share of bio energy cogeneration in the total power production could amount to roughly 11%, leaving for fossil cogeneration a share of 23% and for the other RES of 39%. Electricity production from cogeneration and RES would add up to 73%. Only a rest of 27% would still be covered by fossil condensing power plants.

With the proposed measures cogeneration heat production will substantially increase in all application areas: district heating, industry and in-house cogeneration (small scale and micro). Inside the area of low temperature heat production by cogeneration, the shares of district heating and in-house cogeneration will mainly depend on the efforts to expand local heat grids (as proposed in 3.2.1.2) on the one hand and the further technical and economic development of micro-CHP as analysed in the micro-CHP study of the CODE2 project on the other hand.

Generally the share of heat covered by cogeneration at a given heat sink will rise with changing planning and operating attitudes, which are already beginning to respond to the new capacity task of cogeneration as an instrument for securing electricity supply against the background of rising shares of fluctuating wind and solar power amounts.[27]

In the business-as-usual path the cogeneration heat production and its share in the end energy heat use will decrease after 2020.

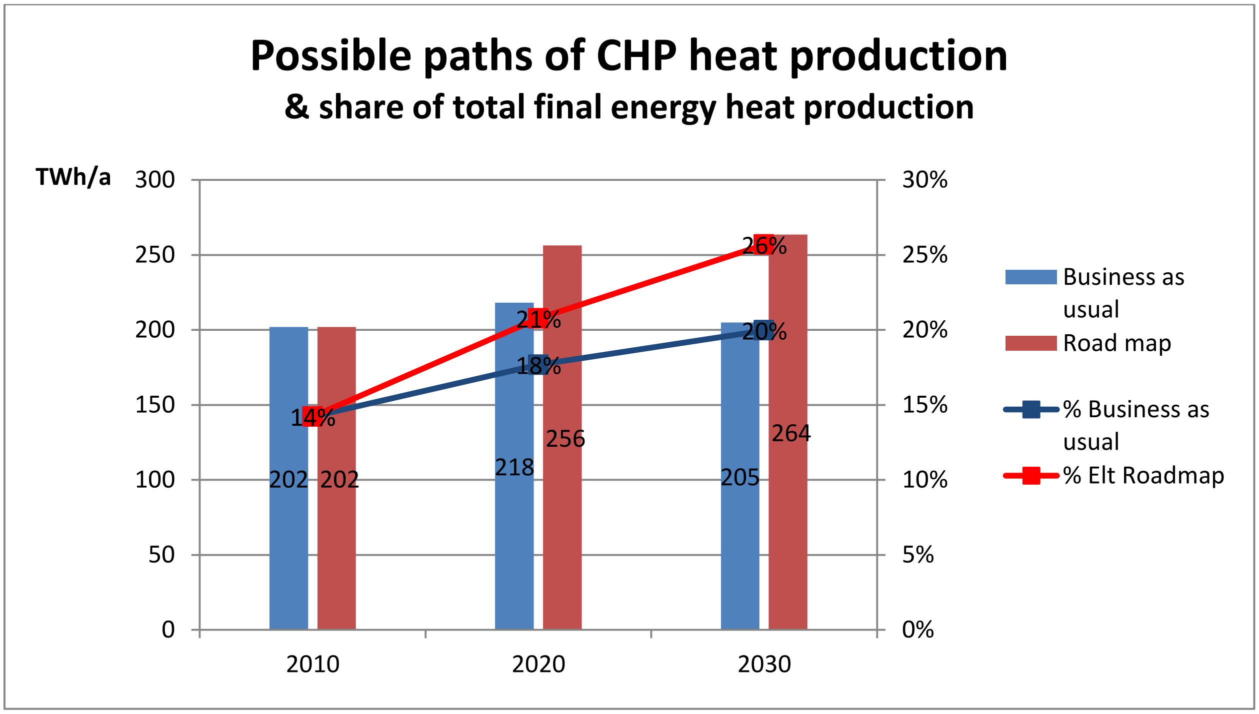

Figure 3.3 - Possible paths of CHP heat production

Regarding the fuels used there will be a development towards low carbon fuels as natural gas, LPG, Biogas, Biomethan, solid bio mass and in the medium term additionally methane produced from wind and solar power ("power to gas").

According to the cited "lead study" [16] and as also shown in the CODE2 bio-energy study, the estimated amount of biogas and solid biomass in Germany, which could be disposable in 2030 for heating and power production and classified as sustainable, amount 229 TWh/a. From this input a possible heat

[27] New big heat storage tanks designed to meet the arising business cases linked to the expected EEX market development are currently being constructed in several utilities, e.g. in Halle/Salle, Schwerin, Düsseldorf.

production of 173 TWh/a is projected. Thereof only 68 TWh are allocated to cogeneration and 105 to individual heatings and heating plants, the latter number being 25% higher than 2010. It is estimated, that a consequent energy efficiency policy should have to lead to a rather decreasing use of scarce biofuel in inefficient heat-only firing devices. It is assumed that the share of heat production in individual heatings and heating plants will decrease between 2020 and 2030 to the level of 2015 again. .

Applied to the projected total cogeneration heat, a bio-energy share of 30 % in cogeneration heat production is assumed. However this roadmap path supposes an adequate amendment of the bio CHP support provided by the RES law, as mentioned in chapter 3.2.1.1.2.

Regarding the business-as-usual path, the current national frameworks for investments in biomass fuelled cogeneration is crucial, i.e. without substantial change of the framework for bio-energy cogeneration. Based on the scorecard method used in the bio-energy study the prospected share of bioenergy in cogeneration fuels is estimated to amount at 27% in 2030, representing a significant lower level in absolute terms.

Additional to bio energy also “power gas” produced from surplus wind and solar power which cannot be used just in time because the supply exceeds the demand. It is expected from experts that significant amounts of power gas will be taken into the gas grid after 2020. With regard to the possible size till now only few considerations have been made. In a projection calculated by the magazine Photon designed to demonstrate a scenario with total electricity production from wind and solar energy in 2030, from totally 655 TWh power produced 241 TWh are intermediately transformed and stored as power gas in the gas network and then retransformed into 115 TWh power an 100 TWh heat.[28] It should be noted that this scenario is of course not compatible with the CODE2 cogeneration road map, but it shows, that even in the extreme case of a energy future without any fuels from fossil and biogenic resources cogeneration could play still an important role.

The assumptions used in the market extrapolation of this roadmap are described in the **Annex 5**: Assumptions used in market extrapolations

[28] Photon October 2012, „Herr Altmaier, so geht´s“.

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Annex 1: Stakeholder group awareness assessment

This annex referres to chapter 1.4.

Customers	
Utilities	Increasingly high priority for cogeneration, mostly good image, some opposition from traditional central power station owners. Gas industry is an important driver for micro-CHP.
Industry	Cogeneration is well known in principle, but there is a lack of technical, economic and legal know-how to implement it despite good business case. Moving to interest.
Commercial	In the commercial and tertiary sector awareness on the opportunities of autoproduction with cogeneration is still low.
Households	Knowledge on heating with cogeneration devices is weak as the micro chp market for houses is still at an early stage.
Market and supply chain	
Manufacturers	Key actors since many years.
Energy consultants	Cogeneration is known in principle, but often detailed know-how is missing.
Engineering companies	Cogeneration is known in principle, but often detailed know-how is missing.
Installation companies	Cogeneration is known in principle, but often detailed know-how is missing.
Grid operators	Knowledge on cogeneration of power grid operators is important for frictionless grid connection and power exports from on-site cogeneration , but here in practice often still some barriers to exist.
ESCOs	High awareness, growing know-how. ESCOs are playing a key role for cogeneration dissemination in industry, apartment houses , commercial etc.
Architects	Cogeneration solutions are mostly known only superficially. Focus on solar thermal, .heat pumps and pellets.
Banks - leasing	No major problems for cogeneration financing are reported; special credit programs with favourable terms are offered from the state KFW bank
Influencers	
general public	For the ordinary citizen cogeneration was and is mostly still a “far-away- technology” except for micro-CHP.
Sector organisations	Good awareness on cogeneration .
Media	In the energy and environmental media meanwhile well known. Popular media mentioning cogeneration is still little known.

Academic area	Only a minority of universities and technical colleges deals with cogeneration; good knowledge only in a few institutes.
Environment NGOs	Good image: decentralized, environmentally friendly, citizen close.
Research	Good image and awareness
Policy	
Federal	Against the background of the "Energy turn" good cogeneration image. high priority for all parties in the parliament
Länder	Increasing awareness on and support for cogeneration in the Länder
Local	In many cities and communes there is still a lack of awareness on CHP and DH opportunities
Energy agencies	They belong to the main actors in promoting cogeneration.
Urban and regional Planners	Knowledge on cogeneration and its image are good

Table 5.1 - Ratings of CHP awareness of different influential groupings

Legend:

- Active CHP market (green)
- Interest in CHP (light green)
- Early CHP awareness (yellow)
- Low CHP awareness (orange)
- Poor CHP awareness (red)

Annex 2: Example profitability calculations

This annex referrers to chapter 1.5.6.

Sector		Heating in a hotel	Industry	District heating	Bio gas CHP (agriculture)
		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}	35%	42%	46%	38%
Efficiency-th.	Eff_{H}	56%	41%	42%	37%
Efficiency-sum.	Eff_{SUM}	91%	83%	88%	75%
Operation	**h/a**	**5.000**	**6.500**	**3.200**	**7.500**
Fuel	MWh	714	15.476	69.565	9.868
Electricty	MWh	250	6.500	32.000	3.750
Heat	MWh	400	6.345	29.217	3.651
Investment	**EUR**	**115.000**	**1.100.000**	**6.000.000**	**2.200.000**
	€/kWel	2.300	1.100	1.000	4.400
O&M costs	€/MWh	33 €	23 €	16 €	7,5%
Price of fuel	€/MWh	57	53	40	30
Value of electrcity	€/MWh	187	160	42	
Other market revenues	€/MWh				
Value of heat	€/MWh	72	66	50	30
Support					
Electricty	$€/MWh_{El}$	54,1	28,7	22,7	167,09
Other support or benefits	€/a				
Investment subsidy	€				
Costs & revenues					
Fuel	€/a	-45.163	-896.133	-3.060.870	-296.053
Electricty	€/a	46.750	1.040.000	1.344.000	0
Heat	€/a	28.740	417.517	1.460.870	109.539
Support	€/a	13.525	186.550	726.400	626.588
Other market revenues	€/a	750	0	850.000	0
O&M costs	€/a	-8.250	-149.500	-512.000	-165.000
TOTAL	**€/a**	**36.352**	**598.433**	**808.400**	**275.074**
SPB	**years**	**3,2**	**1,8**	**7,4**	**8,0**
IRR	**%**	**29%**	**50%**	**6%**	**4%**

SPB = Simple payback time; IRR = Internal rate of return.

It should be noted that in praxis the profitability of a cogeneration investment may decrease because of additional expenditures that may be needed for integrating a new device into the existing infrastructure.

Annex 3: Micro CHP potential assessment

micro-CHP potential summary Germany

Country statistics

Population: 81 800 000 (2010)
Number of households: 38 950 000 (2010)
GDP per capita: € 30 300 (2010)
Primary energy use: 217 000 ktoe/year (2010)
GHG-emissions: 937 Mton $CO_{2,eq}$/year (2010)

Household systems (±1 kWe)

Boiler replacement technology

Present market (2013)

Boiler stock: 11 800 000 units
Boiler sales: 550 000 units/year

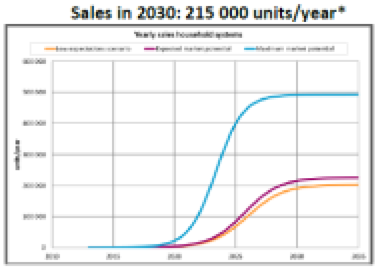
Potential estimation

Indicator	Score
Market alternatives	0
Global CBA	4
Legislation/support	2
Awareness	1
Purchasing power	3
Total	**10 out of 12**

Market share in 2030: 41% of boiler sales in Household sector

Yearly sales

Sales in 2020: 3 800 units/year*
Sales in 2030: 215 000 units/year*



Stock

Stock in 2020: 7 500 units*
Stock in 2030: 1 070 000 units*
Stock in 2040: 2 250 000 units*

Potential savings in 2030

Primary energy savings:
22 PJ/year*
530 ktoe/year*
GHG-emissions reduction:
1.6 Mton $CO_{2,eq}$/year*

SME & Collective systems (±40 kWe)

Boiler add-on technology

Present market (2013)

Boiler stock: 2 140 000 units
Boiler sales: 99 000 units/year

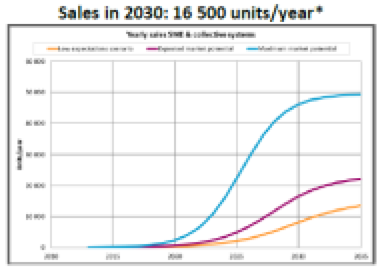
Potential estimation

Indicator	Score
Market alternatives	1
Global CBA	2
Legislation/support	3
Awareness	1
Total	**6 out of 9**

Market share in 2030: 23% of boiler sales in SME & Coll. sector

Yearly sales

Sales in 2020: 640 units/year*
Sales in 2030: 16 500 units/year*



Stock

Stock in 2020: 4 200 units*
Stock in 2030: 71 000 units*
Stock in 2040: 217 000 units*

Potential savings in 2030

Primary energy savings:
59 PJ/year*
1 400 ktoe/year*
GHG-emissions reduction:
4.1 Mton $CO_{2,eq}$/year*

*Corresponding to the expected potential scenario.

micro-CHP score card
Argumentation

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

±1 kWe systems (Households)

Boiler replacement technology

Scorecard

Indicator	Score
Market alternatives	0
Global CBA	4
Legislation/support	2
Awareness	1
Purchasing power	3
Total	**10 out of 12**

Market alternatives

Alternatives at decentralized heating solutions at least currently are very strong, see attached graph of heat producer statistics of BDH (association of heat systems industry). Micro-CHP in new buildings is not supported (as the energy demand is very low). Additionally it has to be considered that according to my draft of a CHP roadmap the share of DH in the heat market will grow substantially. Micro-CHP in DH areas is not supported.

Global CBA

SPOT: ***2.8 years***

Legislation/support

The booster effect of the political support for mCHP < 5 kW is still not sufficient

Awareness

Purchasing power

GDP: ***€ 30 300 per year***

±40 kWe systems (SME & Collective systems)

Boiler add-on technology

Scorecard

Indicator	Score
Market alternatives	1
Global CBA	2
Legislation/support	3
Awareness	1
Total	**6 out of 9**

Market alternatives

Global CBA

SPOT: ***9 years***

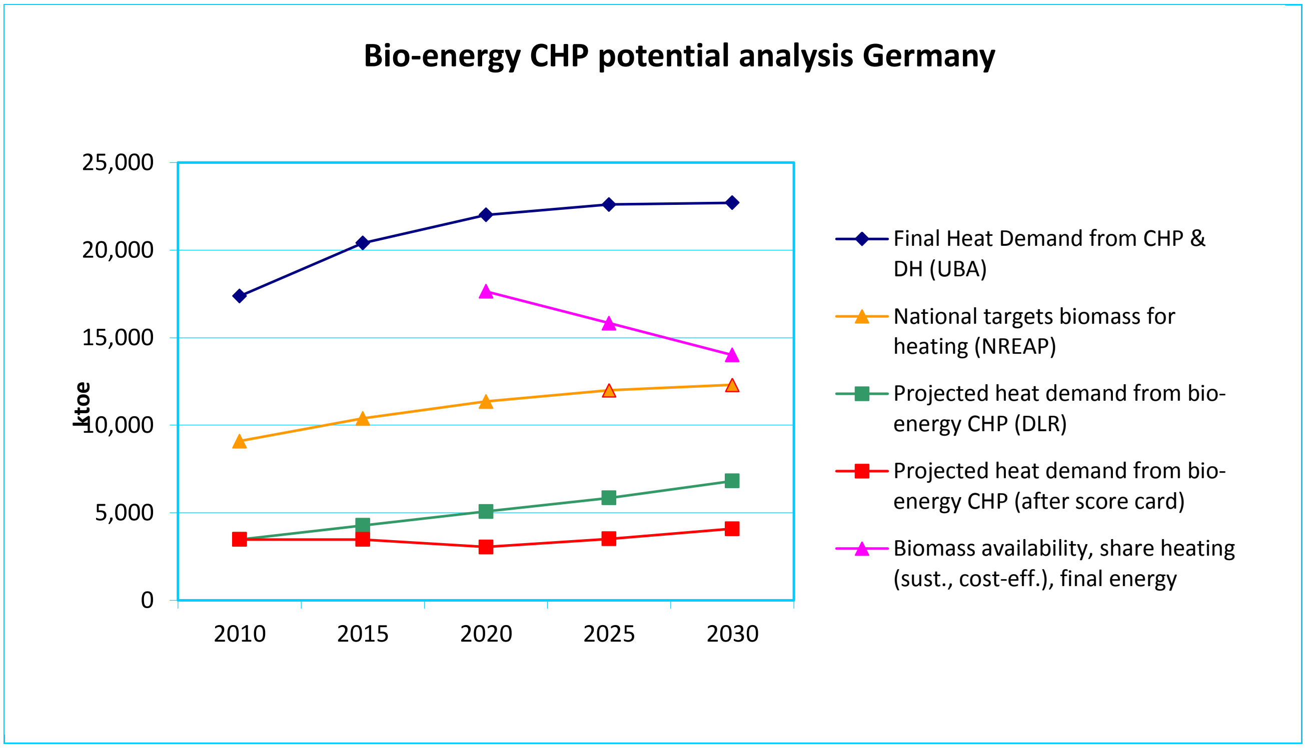
Legislation/support

Awareness

Annex 4: Bio CHP potential assessment

Bio-energy CHP potential analysis Germany

Figures (projections)	2010	2020	2030
Final heat demand from CHP and DH (UBA), ktoe	17.369	22.012	22.700
(Projected) heat demand from bio-energy CHP and DH (after score card), ktoe	3.474	3.044	4.086
Bio-energy penetration rate in CHP markets (DLR)	20,0%	13,8%	18,0%
Biomass availability, share heating (sust., cost-eff.), final energy (Biom. Futures), ktoe		17.643	14.014



Framework Assessment (Score card)	Score	Short analysis
Legislative environment	o 1 (of 3)	After long time favourable conditions with a strong increase of bio CHP since 2004, the conditions have substantially worsened with the new RES law 2012 with the effect of a sharp decrease in investments.
Suitability of heat market for switch to bio-energy CHP	++ 3 (of 3)	High interest on bio fuels in all market segments
Share of Citizens served by DH	o 1 (of 3)	14% of End Energy Heat consumption
National supply chain for biomass for energy	o 1 (of 3)	High population density.
Awareness for DH and CHP	++ 3 (of 3)	

Annex 5: Assumptions used in market extrapolations

This annex refers to chapter 3.3.

Business as usual path

Assumptions:

- The positive effects of the Cogeneration law revision 2012 in the small and medium size markets are compensated by the negative effects of the low EEX power prices and the persisting low power-to-gas price relation.
- The 2014 Cogeneration law revision leads to no substantial new impulses for new big cogeneration installations and plant modernisation.
- The RES law gets no new amelioration for bio energy; new investments stay weak.
- The EED is transposed unambitious following the guideline of doing not more than what must be done.
- A power capacity mechanism is introduced not before 2020 and without advantages for cogeneration related to condensing power plants.

Derivation of numbers:

As already mentioned in chapter 2.1.4 the prospected numbers used are based on the reference scenario of the cited FfE-study. Though meanwhile the political support of fossil cogeneration have been improved by the Cogeneration law revisions 2009 and 2012, these positive effects are currently affecting mainly the small and medium size markets as shown in chapter 1.5.3. Overall they are compensated by the negative effects of the low EEX power prices, the persisting low power-to-gas price relation and the worsened conditions for bio energy cogeneration resulting from the RES law revision 2012. The electricity production figures of the reference scenario have not been taken directly but only the prospected increases compared to 2010. The data base for 2010 has meanwhile improved with the result that the number of cogeneration power production with 93 TWh has been calculated 12 TWh higher than supposed 2009 in the FfE-study. To avoid distortions, the difference of 12 TWh has been added to the prospected values of the reference scenario.

The heat values have been derived from the power values by using assumptions on the development of the average power-to-heat ratio considered as plausible. Considering the high efficiency of new installations, it is assumed that the average power-to-heat ratio will increase from 46% in 2010 to 50% in 2020 and 60% in 2030.

Roadmap path

Assumptions:

The proposed actions presented in Chapter **3.2.1** or equivalent measures will be implemented.

Derivation of numbers:

For 2020 the 25% cogeneration share in electricity production according to the political targets of the “energy transformation” is taken as anchor point. Applied to the prospected total electricity production in the “lead study 2011” (see chapter **2.1.3**) the cogeneration power production in TWh is calculated. The cogeneration power production in 2030 is based on the Scenario “Environmental Awareness” of the FfE-study described in chapter **2.1.4.** As explained above for the business-as-usual path, the figure has been adapted to the meanwhile revised cogeneration power production value 2011, i.e. the difference of 12 TWh was added. It should be mentioned that the Scenario “Environmental Awareness” was explicitly characterized by the authors as possible but rather improbable. As most probable they assessed the reference scenario. But it has to be taken into account that the study was made two years before the Fukushima catastrophe and the German government’s decision to shut down nuclear power production.

Again the cogeneration share in electricity was calculated with reference to the total electricity production as expected in the “lead study”.

The cogenerated heat produced in 2020 and 2030 respectively have been derived from the power production values by using the following power-to-heat ratios: 55% in 2020 and 70% in 2030. These ratios are higher compared to the business-as-usual path, taking into account the faster rising share of new or modernised cogeneration installations with high power-to-heat ratios of more than 1 at medium and big motor and gas turbine cogeneration plants and even up to 2 with fuel cells in the micro-CHP market.

Inside the cogeneration growth path the shares of district heating and micro-CHP will pan out depending on the technology and cost development of micro-CHP and the decisions on the municipal level with regards to the orientation of heat concepts, i.e. rather DH or micro-CHP.