Current Issues

Energy and climate change

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Combined heat and power generation

A pillar of Germany's integrated energy and climate programme

Europe is a world leader in modern energy and climate policy. And Germany is the *primus inter pares* in the drive to promote climate protection, new energy technologies and energy efficiency. In Germany's new integrated energy and climate programme, combined heat and power generation (CHP), also known as cogeneration, tops the list of the key elements.

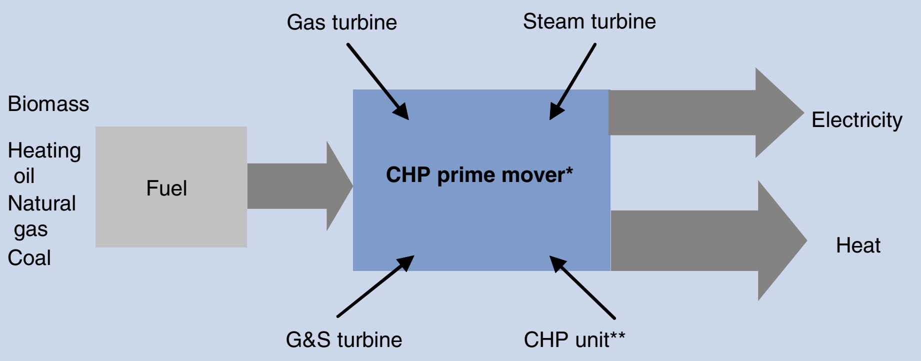
CHP technologies can pay "double dividends". State-of-the-art plants for the combined generation of heat and power utilise 90% of the input energy. CHP's exceptionally high efficiency saves primary energy and eases the burden on the global climate.

Government sprucing up Cinderella of the energy industry. It is crucial that the laws to promote CHP continue to be developed in the right direction. The proposed amendments to Germany's Renewable Energy Sources Act (EEG) and Combined Heat and Power Act (KWKG) will further enhance the appeal of this efficiency champion. The EEG 2009 will be a major driving force in the future spread of CHP fired by biomass.

Opportunities for agriculture, industry, trade and the public sector. The growing use of CHP technology helps to increase the decentralisation and boost the security of energy supply. Pilot projects with virtual power stations show that the former visionaries' playground has also started to fascinate pragmatic academics. In future, virtual power stations might save us having to build new conventional plants.

Doubling of CHP generation thanks to variety of instruments. The government's approach to raising the share of CHP generation is typically German and marked by a multitude of instruments, plant types and size categories. Going forward, the EU emissions trading regime is likely to put a question mark over the future of Germany's promotion laws.

Alternative approaches to cogeneration of heat and power



*Usually with a generator
**Petrol and diesel engines, Stirling engines, small gas turbines, fuel cells

Source: DB Research. For an alternative depiction refer to Krautkremer (2005). p. 61.

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Germany is the *primus inter pares* in Europe

In 2007 at the latest, Europe assumed the leading role worldwide for drafting a new approach to energy and environmental policy. The "3 times 20 by 2020" decision of the European Union marks the dawning of a new age and underpins Europe's claim to be a global leader on energy and climate issues. After all, the aim is to reduce emissions of greenhouse gases by (at least) 20% in the EU, raise the share of renewable sources in overall primary energy consumption to 20% (2005: 6.6%) and raise fuel efficiency through energy savings by 20%.

Germany is now regarded as the *primus inter pares* among the major countries of Europe in terms of commitment to climate protection, alternative energy technologies and energy efficiency. Of course, Germany is still far from being the European leader in the (proportional) use of renewable energies – partly because of the once very low starting basis due to the relatively low potential for hydropower. From this perspective, the 29 key elements of an ambitious energy and climate programme approved in Meseberg in August 2007 were by no means a miracle, but instead the logical outcome of converting a forward-looking sustainable strategy into practical measures. Germany's integrated energy and climate programme will be implemented in two stages: the first instalment consists of 14 laws and ordinances and was tabled on December 5, 2007. A second, smaller instalment is to follow on May 21, 2008.

In the context of the key elements agreed at Meseberg, the German government will attach particular significance to combined heat and power generation (CHP), also known as cogeneration. To use fuels more efficiently in future the share of CHP-based power production is to be raised from around 12% in overall electricity generation in Germany at present to about 25% by 2020. These are the targets of the proposals to amend the CHP Act (KWKG) passed in 2002 and to adjust the Renewable Energy Sources Act (EEG) in 2009.

Key elements of the integrated energy and climate programme

- Doubling of share of electricity from CHP generation to 25% by 2020.
- Boosting the share of renewable energies in electricity generation from 12% in 2006 to 25-30% by 2020.
- Increasing the share of renewables in the heat consumption segment from 6% in 2006 to 14% by 2020.
- Providing evidence of the technological, ecological and economic feasibility of low-CO_2 power plant technologies.
- Incentive programmes for climate protection and energy efficiency outside buildings.
- Promotion of energy-efficient products by setting equipment standards (e.g. eco-design).
- Upgrading and consolidating the existing building refurbishment programme to bring the energy efficiency of residential buildings up to date.
- Incentives to reduce CO_2 emissions in traffic. The German government says it wants to work towards the competition-neutral inclusion of air and naval traffic in emissions trading.
- Reduction of emissions of extremely harmful fluorocarbon gases which have up to 20,000 times the greenhouse gas potential of CO_2.

Source: The integrated energy and climate programme of the German government.

CHP: Cinderella of the energy industry for a long time

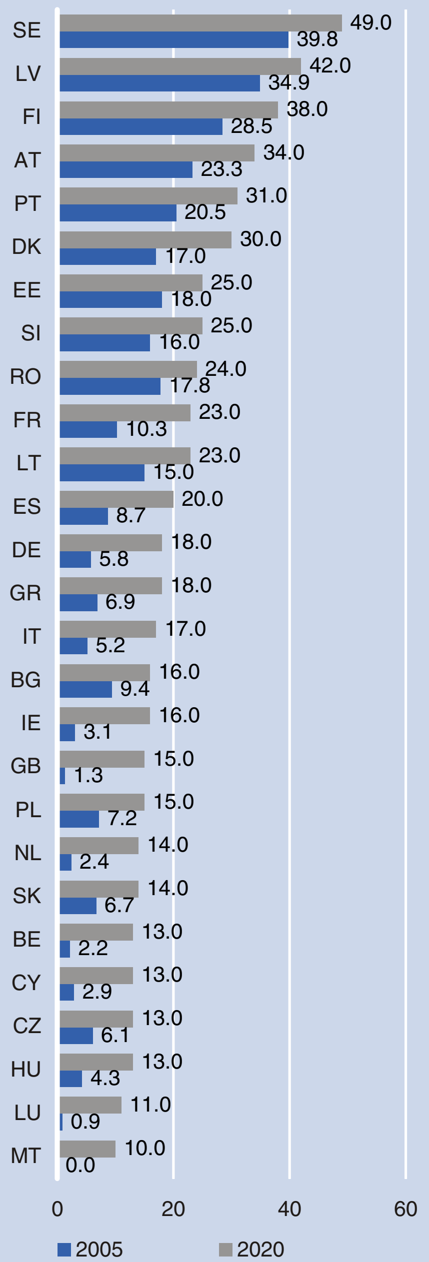
Probably only experts equate CHP generation with particularly efficient energy consumption. Lay people, by contrast, often find the term itself such a mouthful that they lose any interest in the technology. In addition, the diverse CHP technologies work their charm less spectacularly than other energy forms such as photovoltaics or wind power. CHP tends to reveal its appeal in a more down-to-earth way, i.e. it seems to be less "sexy". But it is precisely the minutely calculating investors and academics who ultimately find it important to see what the bottom line is on the energy balance sheet. And from an efficiency point of view, CHP technologies are virtually unbeatable.

CHP can pay "double dividend"

The term CHP covers all the processes for the generation of electrical energy which – at least partially – also use the heat released during the process. The CHP principle, i.e. the co-generation of power and heat, is by no means an invention of modern man. In natural processes it has always been an integral component in the genesis and development of life. Every cell in the body works according to this principle. Since the fuel of life, food, continually became scarce for temporary periods during the evolutionary process, it was vital to make particularly efficient use of it in order to survive. That is why cells generate power and heat from

EU expansion targets for renewables up to 2020

Renewable energies as % of total energy consumption



Source: European Commission

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the fuelling food supply in a combined and thus efficient process, satisfying elementary needs of living things. It was not until about 200 years ago that human inventiveness caught up with nature, the basic innovation being the development of engines. For the first time, engines allowed a "recycling" of the heat released during electricity generation, which up to then had gone unused. Thanks to more intelligent technologies it has since been possible to exploit the energy potential of fuels to an ever greater degree.

Today, modern CHP technologies achieve efficiency ratings of around 90% on primary energy inputs. This has two advantages for, first, this can lower primary energy consumption by about 30-40% and, second, the amount of pollution from greenhouse gases is reduced accordingly. In this way, the combined generation of heat and power pays a "double dividend".

CHP comes in different forms – variety may be confusing

It is practical to apply a very broadly based definition to the term CHP. Besides the use of power processes, processes using fuel cells (i.e. without mechanical power) are also regarded as CHP generation – the prerequisite being the use of the waste heat. Basically, the heat may be used in a great variety of ways, e.g. for heating, refrigeration or as process energy. The more complex concept of combined heat, power and cold (CHPC) is more common if the waste heat is also used to drive a refrigeration process. The definition of CHP often even includes thermophotovoltaics, which is about the technical conversion of heat into electrical energy by photo cells (the buzzword is "lighting heat"[1]). Of course, this is essentially the cogeneration of heat and power in the opposite order.

The sometimes confusing variety of CHP technologies thus has to do with the processes being differentiated both according to the respective fuel input (whether fossil or renewable energies up to and including municipal waste) and also according to the specific type of engine or prime mover (gas, steam, gas and steam turbines (combined-cycle power plants) or also CHP units.)[2] Combined heat and power units (CHP units) are typically operated at the site of heat consumption. To produce electricity, CHP units use combustion engines, small gas-fired turbines (if output is less than 15 kW also called micro-CHP units) or fuel cells. While the electricity-generating capacity of a CHP unit is only between 5 kW and 5 MW, CHP technology in combined-cycle heating plants enables capacity output of several hundred megawatts. Of course, different temperature levels and ratios between electrical and thermal capacity are also part of the reason for the large variety.

On balance, the CHP concept unites many innovative technological approaches towards efficient use of very diverse energy sources. When assessing a specific form of CHP it is also vital to look at the right combination of technology and fuel. CHP efficiency and renewables are considered "Siamese twins" when it comes to changing the focus of the energy business towards greater security of supply and climate protection.[3] In the extreme case, when

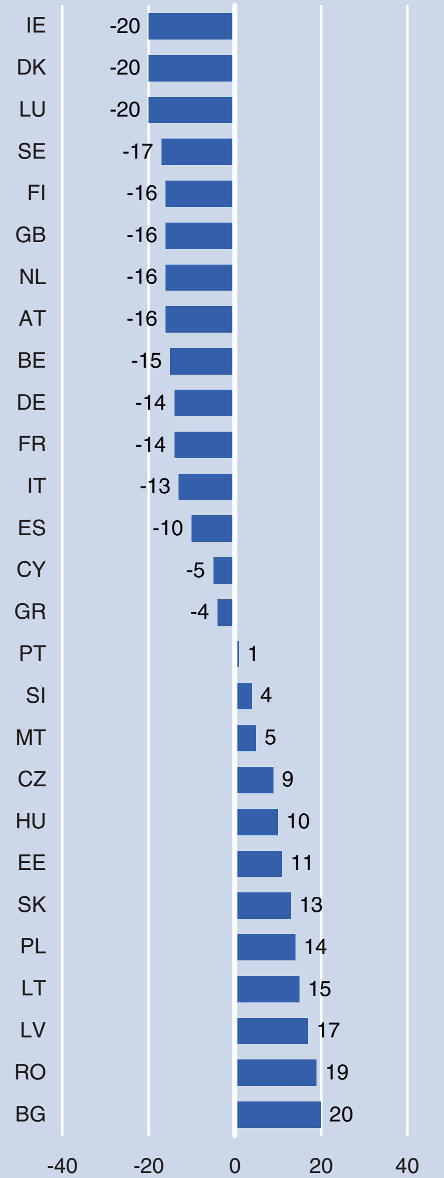
1 See energie.ch (http://www.energie.ch/themen/haustechnik/tpvoltaik/index.htm); accessed February 18, 2008.

2 For an overview of the common processes, modules, suppliers and costs see Arbeitsgemeinschaft für sparsamen und umweltfreundlichen Energieverbrauch (ASUE). BHKW-Kenndaten 2005. See also www.bhkw-info.de.

3 See Hennicke, Peter (2005). Die siamesischen Zwillinge der Energie. In Petermann, Jürgen (ed.). Sichere Energie im 21. Jahrhundert. pp. 385-395.

EU climate protection targets for 2020

Savings targets for emissions versus 2005 (%)



Source: European Commission **2**

Energy flow with a decentralised CHP unit (%)

Primary energy (natural gas)	**100**
Power plant efficiency	90
-Conversion loss	**10**
- Transport loss	**3**
of which	
Electricity	*1*
Local heating	*2*
= Use of input energy	**87**
of which	
Electricity	*36*
Heat	*51*

Source: ASUE **3**

modern CHP technology meets renewable energies, the result is a highly efficient and sustainable mix – and this brings the vision of an energy era dominated by solar power even closer.

CHP efficiency is attractive

Energy supply in Germany still harbours considerable untapped potential for efficiency gains. According to estimates, as much as half of primary energy input goes unused. The lack of efficiency results in both primary energy consumption and thus the energy (import) bill being too high. If energy were used more efficiently, this could save costs and relieve environmental strains.

Considerable savings potential is thought to slumber in Germany's power generating stations. The bulk of electricity there is still generated in condensing power plants, typically fired by fossil fuels such as coal or natural gas (virtually no oil) or nuclear fuels. The current structure of generating plant capacity is deeply rooted in history. It reflects on the one hand the struggle to ensure a cheap and secure supply of energy, while on the other it is the result of structural policy decisions – that transcend actual energy policy itself (for example, incorporating regional policy considerations).

The energy flows of electricity generation in traditional condensing power plants and in centralised and decentralised CHP plants provide an informative look at the efficiency of different technologies and show what is possible. To this end, Germany's Association for the Efficient and Environmentally Friendly Use of Energy (*Arbeitsgemeinschaft für sparsamen und umweltfreundlichen Energieverbrauch, or* ASUE) examined three fundamentally different types of power plant as examples which allow a good – albeit rough – overview of existing options and implications:

CHP units even more efficient than conventional heating plants

From an efficiency standpoint, the decentralised gas-fired CHP unit achieves the best scores. 87% of the natural gas input arrives as energy at the customer's location, with 36% going into the electricity supply and 51% into heat. Thanks to CHP and the high efficiency of combustion engines the environmental losses are small (10%). Since CHP units are installed on a decentralised basis and thus close to the consumer, the transport losses (1% for electricity and 2% for heat) are limited. All in all, only 13% of the primary energy goes unused.

CHP central heating plants take up the waste heat produced in electricity generation and offer it to consumers for heating purposes. Since the heating plants are usually located away from built-up areas, there are significant losses not only on conversion (about 15%) but also on transmission. While the transmission of electricity "costs" merely 1% of the primary energy input, the transport of heating energy via district heating networks to consumers eats up around 5%. If the conversion losses incurred by the technology (15%) are added to the transport losses (6%), ultimately only 79% of the primary energy input arrives at the consumer level. This efficiency level is lower than that of decentralised CHP units (87%), but in comparison with conventional domestic condensing power plants, heating plants are about twice as efficient, as demonstrated by the following example.

Condensing power plants are less attractive

The efficiency record of condensing power plants is noticeably poorer in comparison with CHP units and conventional heating

Energy flow with centralised heating plant (%)

Primary energy (natural gas)	**100**
Power plant efficiency	85
- Conversion loss	**15**
- Transport loss	**6**
of which	
Electricity	*1*
District heating	*5*
= Use of input energy	**79**
of which	
Electricity	*29*
Heat	*50*

Source: ASUE 4

Energy flows with condensation power plant and oil heating (%)

	Cond. plant	Heating
Fuel	Coal	Oil
Primary energy	**100**	**57**
Efficiency	38	90
- Conversion loss	**62**	**6**
- Transport loss	**2**	**-**
of which		
Electricity	*2*	*-*
Heat	*-*	*-*
= Use of input energy	**36**	**51**
of which		
Electricity	*36*	*-*
Heat	*-*	*51*

Source: ASUE 5

plants. With coal-fired power plants (efficiency rating of 38%), only 36% of the primary energy input reaches consumers in the form of electricity on account of the sizeable losses incurred in conversion (62%) and transport (2%). As a consequence, the centralised power supply – often far away from built-up areas – generally releases the waste heat (and thus nearly two-thirds of the primary energy) into the environment unused – i.e. it impacts on the atmosphere or is partly responsible for warming up ambient bodies of water.

If – as in the case of the CHP unit – the aim is not only to supply electricity but also heat, then a boiler must be deployed locally, too. And this requires additional primary energy. Assuming the consumer is to receive the same amounts of electricity and heating as in the case of the CHP unit (i.e. 36% and 51%, respectively), the overall calculations are as follows: all the data pertaining to the power supply remain the same. But to deliver 51% heat energy, an oil heater (90% efficiency) requires an energy input of roughly 57% (if 6 percentage points are factored in as conversion losses). The separate generation of electricity and heat by means of a condensing plant for electricity and additional oil-fired plant for heat thus – given a total of 157% input – requires a 57% higher input of primary energy than a decentralised CHP unit. And separate generation (55% efficiency) trails far behind the efficiency of the CHP unit (87%).

On balance, the CHP unit achieves a 36% saving on primary energy in comparison with separate energy supplies. But this still isn't all. In addition, the CHP facility can significantly ease strains on the environment, reducing dust (by 99%), SO_2 (98.5%), NO_x (29%) and CO_2 (58%).[4]

The examples show the fundamentally different implications of the individual types of technology. Of course, this is only at first blush. And there are many new types on the market and in research projects – also mixed forms and technologies that use other fuels. While different types of power plant (e.g. with higher efficiency ratings or alternative energy inputs) naturally also have different efficiency results, this casts no doubts on the general superiority of the combined use of the primary energy.

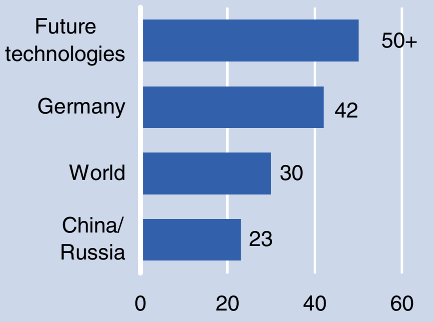
Potential for more efficiency in power stations

Analysis of different types of power plant in particular shows that higher energy efficiency can be an important stepping stone in reducing energy consumption. Data for hard-coal power plants suggest that there is considerable potential for boosting efficiency in Germany and the rest of the world.[5] Germany still has a number of coal-fired condensing power stations that are less than 35% efficient. On average, Germany's hard-coal generating stations are about 42% efficient. Nonetheless, this is still much higher than the global average (30%), or that of China and Russia in particular (each about 23%). Technological advances will pave the way for noticeable efficiency gains. The efficiency of coal-fired power stations rose by one-third on average in the EU over the past three decades. Future technologies could perhaps even achieve readings of 50% or more. This would be nearly equal to the efficiency achieved today by modern alternatives such as combined cycle gas-fired and steam-turbine power stations used exclusively to generate

4 See ASUE (2007). Energie Erdgas: Effiziente Technik und Erneuerbare Energien. P. 15.

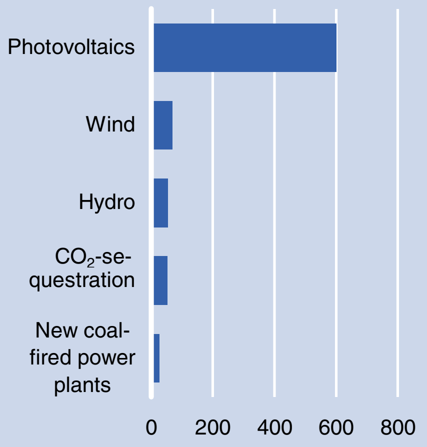
5 See also Auer, Josef (2007). Technology to clean up coal for the post-oil era. Deutsche Bank Research. Current Issues. Frankfurt am Main. February 6, 2007.

Efficiency of hard-coal plants
%



Sources: Euracoal, GVSt 6

Specific costs of CO_2 avoidance
EUR/t CO_2



Sources: Euracoal, RWE 7

electricity (57% efficient). Precisely the gas and steam-fired examples underscore that even state-of-the-art condensing plants are still a long way from delivering the efficiency ratings of current CHP plants. Besides, the latter generate the double dividend discussed above. The energy savings are an important additional benefit in the security context given the heavy dependency on imports.

CHP is not practical everywhere

The superior efficiency of CHP does not automatically make it spread like wildfire. For investors looking at a decentralised CHP plant, comparatively high specific costs of investment will rapidly become a business problem because of the lack of economies of scale. The problem of high initial investment does not ease until volume markets emerge, since mass production then offsets the investment costs. Unlike the high investment costs, the relatively low running fuel costs can only be recouped over time. Therefore, financial analysis of the investment will not necessarily always be positive. Obviously, the interest rate environment plays a major role when decisions have to be taken.

In addition, CHP faces competition from alternative efficiency strategies. For example, better heat insulation in existing buildings can curb energy consumption and thus tap savings potential. In the new-build segment, strategies range from regional planning through to construction planning and traffic policy.

CHP should mainly be used at locations or for supply facilities where there is a predictably high demand for thermal power all year round if possible. If the heat generated cannot be taken up in the summer months, this may put profitability at risk or result in losses. If the heat also has to be transformed into cooling, further costs are incurred.

Typically, the optimum size of a CHP plant is a compromise between meeting as much demand as possible and achieving the highest capacity utilisation possible (normally more than 4,000 full load hours).[6] In this case, it may make sense to buy electricity in the market to satisfy peak demand.

CHP is an option for, say, public buildings such as city halls, schools, senior citizens' homes, long-term care facilities, hospitals, and indoor and outdoor swimming pools linked to the same energy supply. Furthermore, CHP can be used for public housing developments, industrial plants and private home or office complexes. Micro-CHP units are an interesting option for private homes, farms and isolated buildings such as log cabins in the mountains.

CHP could replace conventional home heating systems

Micro-CHP units for single-family dwellings

Today, German households typically obtain the electricity they need from a power utility, while they usually have a gas or oil-fired heating system to keep them warm in winter. The cogeneration of electricity and heating by a small CHP unit could revolutionise the way house-holds obtain energy. In the past, there only used to be small-scale power stations with output of between 100 KW and several MW, which were only interesting for fairly large companies and buildings. Today, thanks to innovative engineers there are even micro-power plants for single-family dwellings. The small CHP units represent a

[6] See Bard, Jochen (2001). Dezentrale Kraftwärmekopplung - Konversionstechnologien und Einsatzmöglichkeiten. In ForschungsVerbund Sonnenenergie (FVS). Integration erneuerbarer Energien. pp. 73-81, here p. 73.

serious challenge to what has been the most efficient type of heating technology up to now: the condensing boiler. Of the 17 million heating units in Germany roughly one-tenth have a condensing boiler. The micro-CHP plants are state of the art and thus attractive. They only take up as much space as a wall cupboard or a washing machine. The German association for CHP says that micro-CHP units represent the future for home heating.

Fuel cells still need time

However, time marches on. Not only the fuel cell but especially gas-driven steam turbines with a generator or with a Stirling engine powered by natural gas or liquefied gas are considered to be future competitors on the market for home heating systems that generate electricity. While pilot plants based on steam turbines and Stirling engines are already in operation, fuel cells – especially in combination with hydrogen – will still need a fairly long time to achieve a market breakthrough.[7]

Decentralisation raises security of supply

Decentralisation offers protection against power failures

Increasing use of CHP technologies in public facilities, private households, the distributive trade, small and medium-sized businesses and industry can make a positive contribution to the security of the energy supply. By becoming energy producers themselves, traditional energy users can lower their vulnerability to exogenous supply shocks. A more decentralised energy supply is less susceptible to blackouts, for instance. For one thing, the traditional customers produce their electricity themselves, so they are transformed from consumers into generators. For another, the reduced volumes drawn ensure that, all in all, less electricity is transported via the established networks. This in turn lowers the risk of power surges and blackouts.

Virtual power plants rather than new conventional power plants

CHP has enormous potential for supplying homes with electricity and heating. In Germany there are around 40 million homes in approximately 17 million residential buildings. And about two-fifths of the electricity generated in Germany is ultimately taken up by private households.

Playground for new energy models

These figures not only offer visionaries a playground for revolutionary ideas. Pragmatic academics are also starting to put on their thinking caps and ponder new ways of securing the energy supply. The electrifying buzzword is decentralisation. And the ultimate expression of decentralisation is considered to be the gradual development of virtual power stations. In essence, the idea is to achieve central coordination and optimisation of decentralised power generating systems.

A home-heating facility that also produces electricity is surely desirable from an efficiency standpoint. But this doesn't really fire anyone's imagination until you transcend the singular event and factor other size parameters into the calculations. Let us assume that, in the course of 25 years, CHP systems with 1 kW of output capacity apiece are installed in some 5 million homes. There would then be 5 gigawatts of electricity available. This equals the output of roughly five large conventional power plants. Such dimensions are significant and are a reason for thinking "out of the box".

[7] See also Hofmann, J. (2002). My home is my power plant. Can hydrogen lead the way to decentralised energy supply? Deutsche Bank Research. Current Issues. Frankfurt am Main. December 19, 2002.

Utilities will become managers of virtual power plants

Established utilities could conceivably become managers of virtual power plants by interconnecting the many new and decentralised CHP units in private homes and commercial buildings. Since the construction of new power plants in Germany has increasingly encountered resistance over the past few years, this idea has a certain appeal. It is necessary, though, to overcome a conflict of interests typical of the mindset linked to the days of the energy monopolies. The conflict is between the established electricity generators, which up to now have also operated the electricity networks, and the many new, independent generators feeding in power from the household and small business segments.

Initial virtual power-plant projects off to encouraging start

In Germany, several projects have been launched and implemented under the “virtual power plant” banner in this decade.[1] One of the first virtual power plants to be tested is in Unna; it was commissioned at the end of 2004. The entities participating in the project are Stadtwerke Unna, EUS GmbH and ABB New Ventures. It links 5 CHP units, 1 hydropower plant, 1 photovoltaic plant and 2 wind farms, generating 26 GWh per annum. Unna was soon considered a “successful example of rational energy use and distribution”.[2]

1 For an overview of the individual projects see Arndt, Ulli; von Roon, Serafin; Wagner, Ulrich (2006). Virtual power plants: Theory or reality? In BWK, Yr. 58, No. 6, pp. 52-57.

2 Janzing, Bernward (2005). Kraftwerke im Keller. In Petermann, Jürgen (ed.). Sichere Energie im 21. Jahrhundert. pp. 289-293, here p. 293.

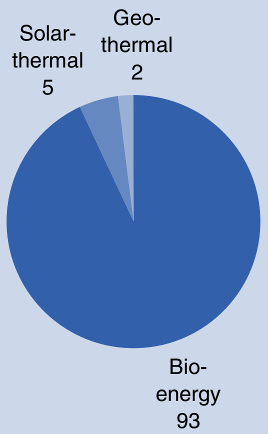
The main feature of virtual power plants is that the utility suppliers and/or network operators obtain direct access to the facilities of the small generators. From their control centres the utilities balance the supply and demand for electricity. To do so they require modern communications technology and full interconnectivity with the micro-CHP units at the decentralised locations. The network managers have to be able to switch on or switch off the private systems in people’s cellars or under their roofs to be able to optimise the system as a whole as required. A storage facility for the excess heat generated guarantees the private households that they will always have enough available for heating purposes or hot water.

The interests of an optimised energy supply system would be served if the network operators were to cease regarding the growing number of private operators feeding electricity into the system as competitors, but rather as promising future partners for cooperation. Naturally, such a radical transformation of the supply structures will still take several decades to happen. The growing number of micro-CHP units nevertheless already offers business opportunities for small and medium-sized enterprises, the skilled trades and the agricultural sector.

Macroeconomic efficiency of virtual power plants

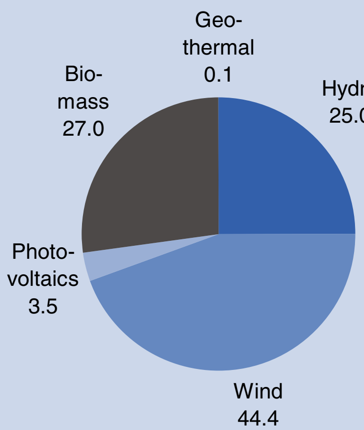
The many diverse projects suggest that virtual power plants are a fundamentally suitable means of saving primary energy. However, the actual savings depend on the conception, configuration and composition of the respective systems. Thanks to the high efficiency of CHP plants the energy savings will rise with the increasing integration of the facilities. On the macroeconomic level, another advantage is a policy of peak-shaving. This means reducing the level of consumption peaks. One particularly interesting aspect is the generation of peak load current at times of high overall loads and thus relatively high prices on the electricity exchange. To this end, the CHP units run up their output during times of high overall power loads (often during midday or the early hours of evening), while cutting back at times of low loads. Moreover, the macroeconomic effects are positive if a virtual power plant can provide balancing energy by means of its decentralised generating plants (a so-called virtual load-balancing power station). All in all, virtual power plants will thus pave the way for the CHP unit owners to generate additional value-added. However, the concept is still in the test phase. While progress can be seen, some challenges will remain for a while such as the further integration of the plants into the overall energy supply, the development of low-cost thermal storage facilities and of high-performance information and communication systems. Once the problems have been solved, the

Bioenergy dominant in sourcing heat from renewables
% of renewables-based thermal generation in Germany, 2007



Sources: BEE, BBE 8

Bioenergy ranks 2nd on generation from renewables
% of renewables-based electricity generation in Germany, 2007



Sources: BEE, BBE 9

result will be an interesting option for a futureproof set of power plants and for a modern energy supply.

CHP trend opens up opportunities for farmers and forestry engineers

CHP technologies are in principle well suited for the integration of renewable energies into the thermal and electrical power supply chain. The main role in this event will be played by biomass. In Germany, bioenergies[8] contribute over 90% of the heat generated from renewable sources of energy. Wind energy is the leading renewable power source. Biomass overtook hydropower in 2007. Wind and water are still scarcely feasible for CHP purposes, though. By contrast, biomass (incl. biogenic waste) has high CHP potential.

One fundamental problem is that not every CHP technology is suitable for every biofuel. This is because biofuels differ depending on the state of the aggregate (solid, liquid or gas), calorific value, combustion properties (e.g. burnout, ignition pattern) and combustion and/or other residues (ash, tar). Typically for biofuels, moreover, the quality fluctuates and – at least in the development phase – there is an absence of long-term supply structures which enable demand-oriented provision. For most CHP technologies (e.g. diesel, petrol, gas-driven engines or gas turbines) the biomass has to be converted into liquid or gaseous fuels. Only external thermal methods such as the Stirling or steam engine allow direct deployment of solid fuels (e.g. energy crops such as rapeseed and sunflowers, wood, organic waste or residual biomass such as straw, manure or residual forestry products) for CHP generation.[9]

Important changes to institutional rules

EEG favours biomass in CHP generation

The amendment to the Renewable Energy Sources Act (EEG) is based on a broad definition of biomass. The EEG promotes the use of biomass sourced from agricultural and forestry operations, industrial waste and municipalities. One major target in 2004 was to increase the share of renewables in power generation in Germany to 12.5% by 2010. Thanks to the high incentives offered, this target was already overshot in 2007, coming to 14%. The draft dating from December 5, 2007 for the upcoming amendment to the EEG, which is to take effect in 2009, sets a new target for renewables in the electricity suppy of 25-30% by 2020. It attaches an important role to biomass – not least as part of the special promotion of electricity from CHP plants.

Bioenergies have been supported to a much greater degree than they were before the EEG was amended in 2004. The size of the incentives varies according to the capacity range of the plants, input and technology. In particular, a new type of bonus system has assumed a steering function for energy policy. Since then, the sector has differentiated between three types of bonus: first, a fuel bonus for renewable resources (referred to as the renewables bonus); second, a bonus for power generation using CHP technology

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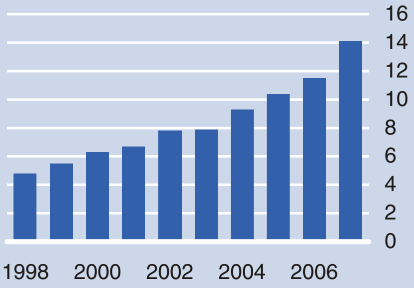
8 For more on bioenergies see also Auer, Josef (2005). Bioenergies after the petroleum age. Deutsche Bank Research. Current Issues. Frankfurt am Main. August 15, 2005.

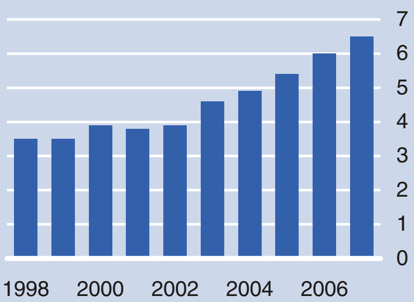
9 For an overview of the different CHP technologies used to fire biomass see Bard, Jochen (2001). pp. 73-81. For challenges and problems related to the use of biomass for CHP purposes see Krautkremer, Bernd; Böhnisch, Helmut; Lokurlu, Ahmet (2005). Kraft-Wärme-Kopplung zur effizienten energetischen Nutzung von Biomasse. In FVS. Wärme und Kälte. pp. 61-65.

Renewables-based power generation surging
% of gross electricity consumption in Germany



Source: German Federal Environment Ministry **10**

Renewables-based thermal generation growing in importance
% of heating supply in Germany



Source: German Federal Environment Ministry **11**

(CHP/efficiency bonus); and third, an innovation/technology bonus. The latter is only granted in connection with the CHP bonus; the prerequisite is that a particularly new and innovative CHP technology is deployed. The bonuses are not subject to a time-related degression formula (which is 1.5% per year for newly commissioned plants from 2004) and can be added together.

For small-scale plants (up to 150 kW) which use renewable resources in a particularly innovative CHP unit, the initial subsidy was 21.5 ct/kWh. This is much more than is granted for hydropower, wind energy or geothermal power, but still much less than the amount granted for photovoltaics. Since the level of compensation is guaranteed for 20 years, it has not failed to fulfil its intended purpose. In the bioenergy sector, the EEG will especially help to encourage the building of new biogas plants and the use of vegetable-based renewable resources, since this unites the advantages of small plant scale and high basic compensation. Almost all biogas (95%) is used to generate electricity and heat in CHP units; only about 5% of the plants generate only electricity.

EEG 2009 will fire further expansion of bio-CHP

The number of agricultural biogas plants that cogenerate power and heat is likely to continue climbing also in future. This forecast is backed by the fact that the “success story of the EEG”– as the *Bundesverband BioEnergie* (BBE) puts it – is being continued with the present draft amendment to the EEG, since it upholds the basic structure and the main pillars of the EEG in the area of bioenergy.[10] It is important that the EEG was retuned not least to benefit smaller-scale plants and CHP technology. The following individual aspects of the compensation and bonus system to be in place from 2009 are particularly revealing:

— The basic compensation for electricity from biomass totals 11.67 ct/kWh for units with a capacity of up to 150 kW of electrical output and then declines gradually to 7.79 ct/kWh for units up to and including those with output of 20 MW. This means a higher level of basic compensation for small plants rather than large plants.

— The degression for bio-fired plants that go online from 2009 will fall to 1% per year (currently 1.5%).

— At the maximum, the renewables bonus for plants with output of up to 150 kW will be 10 ct/kWh, provided that only renewable resources and at least 30% liquid manure are used. The so-called liquid manure bonus alone comes to 2 ct/kWh.

— The CHP bonus for plants up to and including 20 MW will total 3 ct/kWh in future (currently 2 ct/kWh). The increase will provide an even stronger incentive to use CHP and thus tap efficiency potentials.

— In future, too, an additional technology/innovation bonus of 2 ct/kWh is possible alongside the CHP bonus if a particularly new and innovative CHP technology is used.

As at present, the bonuses will not be subject to degression and can be added together. The maximum subsidisation possible according to the EEG 2009 climbs to 26.67 ct/kWh (currently 21.5 ct/kWh), and applies to small-scale plants up to 150 kW using renewable

[10] See the BBE’s statement in: Stellungnahme des BBE zum Entwurf eines Gesetzes zur Neuregelung des Rechts der Erneuerbaren Energien im Strombereich. Bonn, November 12, 2007. p. 3.

Maximum support for bio-electricity under EEG 2009

	ct/kWh
Basic compensation	11.67
Maximum renewables bonus	10.00
CHP bonus	3.00
Technology bonus	2.00
Maximum subsidy	**26.67**

Source: Draft of EEG 2009 12

resources in particularly innovative CHP units. The calculations can be seen in the box in the margin. Only 2-3% of the plants will receive the maximum support subsidy.[11]

The bottom line is that CHP will be given considerable underpinning by the EEG 2009 framework. Hence, the amendment visibly reflects the objective of the German government to boost energy efficiency even more strongly in future.

EEG compensation for biomass under development

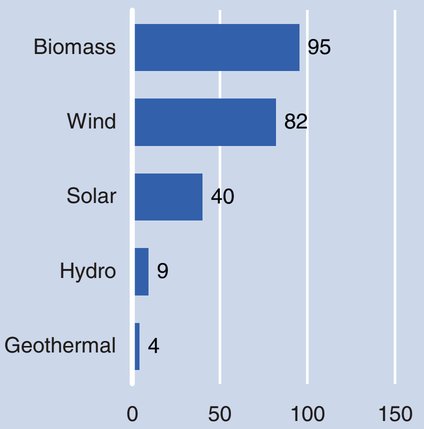
In special market situations the rigid compensation rates of the EEG harbour risks, though. This holds especially for bioenergy. For unlike with windpower, hydropower or photovoltaics, the factors relevant to biomass use are not only the investment costs but also the fuel costs. The increases over the past few years in the prices of iron and steel, building materials and non-ferrous metals such as copper impact the investment calculations for nearly all renewables in a similar way. However, the situation is completely different for fuel costs. Only bioenergies are subject to the phenomenon of fluctuating – and, in recent years, sharply rising – procurement prices. Therefore, with a view to a reliable promotion of biomass for power production it would seem appropriate to anchor the indexation of biomass compensation rates in the EEG. Otherwise, surges in the price of agricultural commodities might undermine the profitability of biofuel plants or even mean their ruin.

Technological advances in bio-CHP on the horizon

When evaluating the prospects of bio-CHP one ought to bear in mind that substantial technological advances are to be expected going forward. Some estimates say that the cost of generating power in biogas plants for the 1 MW range will decline to between 7.5 and 12 ct/kWh by 2030.[12] With solid biomass, the power-generating costs for large 20 MW plants with combined thermal production may lie between 6 and 9 ct/kWh, depending on the type of fuel and price. Thanks to feasible economies of scale these large-scale plants will probably come to replace the still widespread units of the “less than 5 MW” category over the long term.

Biomass segment offers the most jobs

Jobs (‘000), Germany, 2006



Source: German Federal Environment Ministry 13

Since biomass has the potential to supply energy in line with demand, it looks set to have a key buffer function. Power from solar energy sources, e.g. photovoltaics, and wind energy generally fluctuates, since they deliver little energy if the sun is not shining or the wind is not blowing. Fundamentally, bioenergy is well suited to plugging the resultant gaps in supply. Moreover, bioenergy can be used to reduce demand peaks. Furthermore, bio-CHP offers the additional advantage that the waste heat produced can be used to upgrade the fuel inputs. For example, when alcohols are used, the heat produced can be used for distillation purposes (internal use). Or with biogas-fired CHP, the waste heat produced may be used to dry wood pellets (external use).[13]

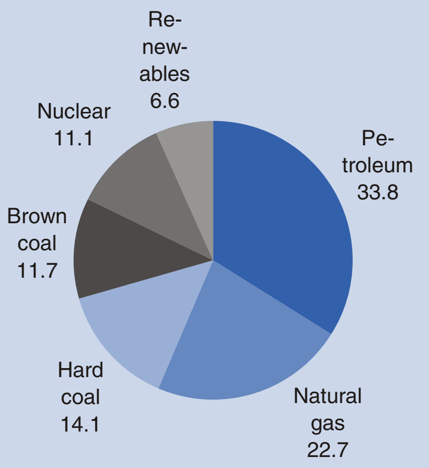
[11] From 2004 to 2007 the average compensation disbursed was 14 to 16 ct/kWh. Today, the capacity of the average plant runs from 300 to 400 kW.

[12] See EWI/Prognos (2005). Die Entwicklung der Energiemärkte bis 2030. Schlussbericht. pp 108-109. Today, the costs of power generation for 1 MW plants are around 13-14 ct/kWh if renewables are used. If organic waste is used, there are no costs for the biomass and the costs of electricity production only range around 9 ct/kWh. About one-tenth of the bio-electricity is based on organic waste.

[13] See Krautkremer (2005), p. 63.

Germany's energy mix

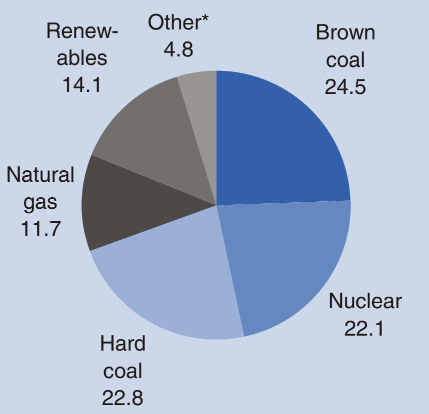
% of primary energy consumption, 2007



Source: AG Energiebilanzen **14**

14% of Germany's electricity generated from renewables

% of gross power generation in Germany, 2007



*Incl. petroleum

Sources: AG Energiebilanzen, German Federal Statistical Office. DB Research **15**

CHP Act – second pillar of the technology approach

Unlike the EEG, which regulates the development of CHP with renewable sources of fuel, the CHP Act (KWKG) organises the incentives used to promote plants using fossil-based inputs. The KWKG took effect on April 1, 2002 and replaced the law for the protection of electricity generation from CHP (*KWK-Vorschaltgesetz*) of May 18, 2000.

The KWKG is based on an agreement between the German government and German industry from 2001 (called the CHP agreement). This provides for a reduction of CO_2 emissions and promotion of CHP. The objective of the agreement – and later also of the KWKG (Section 1) – was to help contribute towards a reduction of the annual CO_2 emissions in Germany by 10 million tonnes versus the base year 1998 by the year 2005 and by 23 million tonnes by 2010, or by 20 million tonnes at the very least.

In essence, the result was a type of division of labour: the focus of the government contribution was to shore up the existing stock and modernise old plants on the one hand, while also promoting small new CHP units up to a capacity of 2 MW. By contrast, industry was expected to shoulder the expansion of CHP facilities exceeding the 2 MW threshold.[14]

An interim review by the BMWi/BMU (German Federal Ministry of Economics and Technology and Federal Ministry of the Environment) in 2006 showed that up to end-2005 there was a total of 11,416 CHP plants being promoted under the KWKG framework.[15] A detailed breakdown shows there were 402 old plants and 3,827 new plants, 68 modernised ones and 7,049 small CHP plants. Moreover, 70 fuel cell plants were receiving government support. The installed capacity of these CHP plants totals 38 GW and the maximum thermal capacity is 66 GW. Thus, the KWKG covered 87% of the installed CHP capacities in Germany. Existing plants accounted for 80% of subsidised power generation.

Two investigations have shown that at the very least the CO_2 reduction target for 2010 will not be reached. A study conducted by the *Institut für Energiewirtschaft und Rationelle Energieanwendung* (IER) [16] reached the conclusion that the KWKG would enable a CO_2 reduction of 8.5 to 10 million tonnes per year up to 2005 (target achieved) and a maximum of 14 million tonnes by 2010 (target missed). According to a study by the *DIW/Ökoinstitut*[17] even the 2005 target of reducing CO_2 by 3.5 to 5 million tonnes per year fell wide of the mark.[18]

Amendment of the KWKG is overdue

Even back then it was clear that the KWKG 2002 would not go far enough to fulfil the long-term CO_2 reduction targets. On top of this, the cabinet meeting that took place in Meseberg in 2007 produced new, even much more ambitious climate targets. Combined, they render an amendment of the still valid KWKG 2002 overdue. After the announcement of the CO_2 targets on the international stage,

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[14] See Lamfried, Daniel (2007). Die aktuellen Vorschläge zur Novellierung des Kraft-Wärme-Kopplungsgesetzes. In ZNER. Vol. 3. pp. 280-284, here p. 281.
[15] BMWi/BMU (2006). Zwischenprüfung des Kraft-Wärme-Kopplungsgesetzes.
[16] IER (2005). Untersuchung der Wirksamkeit des Kraft-Wärme-Kopplungsgesetzes.
[17] DIW/Ökoinstitut (2006). Ermittlung der Potenziale für die Anwendung der Kraft-Wärme-Kopplung und der erzielbaren Minderung der CO_2-Emissionen einschließlich Bewertung der Kosten.
[18] For more on the study's findings, see BMWi/BMU (2006). pp. 5-10.

Key elements for KWKG amendment

— Continuation and capping of CHP apportionment rate at the current level (approx. EUR 750 m per year).

— Retention of the KWKG incentive system, i.e. supplementary payments from the network operator for the CHP electricity fed in from the approved CHP plants and refinancing by passing on costs to the electricity grid customers.

— Planned expiry of incentivisation of existing plants (under current law).

— Promotion of new building and modernisation of CHP facilities if commissioned between 2007 and 2014.

— The expansion of the local and district heating networks (up to 20% investment subsidy) is entered in the apportionment procedure of the KWKG without exceeding the above top financial level (up to EUR 150 m).

— Promotion of only highly efficient CHP generation.

— Introduction of sourcing documentation for CHP electricity.

— Limitation of the incentive period in terms of both time (years) and quantities (peak use hours) (Incentivisation to be stopped after one of the two criteria is reached).

Source: The integrated energy and climate programme of the German government.

sticking to the status quo would risk damaging Germany's reputation on climate issues.

The German government summarised the most important measures linked with CHP as the "Key elements of its integrated energy and climate programme" (see box on the left). A few points are particularly noteworthy:

KWKG amendment heads in the right direction

One surprising feature of the integrated energy and climate programme is the placing of CHP at the top of the agenda (Key element No. 1). This signifies the special role accorded to CHP in the context of the German government's energy and climate strategy up to 2020. The Ministry of Economics and Technology, which is responsible for shaping the amendment to the KWKG, has apparently come to a fundamental reassessment of the technology in light of urgent energy and climate policy issues. This is a welcome development.

The target of doubling the use of CHP by 2020 hinged from the outset on the cooperation of industry. Expanding (only) the district heating side in order to achieve the target would have been too complex and too expensive. Therefore, it is practical that the amendment will now, partly by means of CHP, also provide support to electricity generated by industry. From a climate-policy standpoint, though, it is most dubious why the incentive rates for public CHP plants should be higher than those for industrial electricity – after all, the climate benefits are equal. This is a case of discrimination. In principle, the CO_2 target and thus efficiency should be the yardstick, and not the owner of the plant (neutrality of target group).

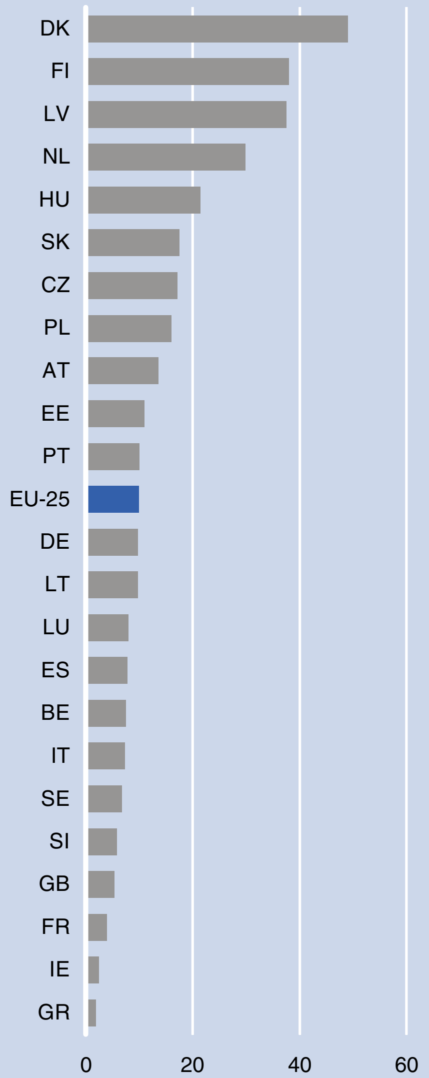
As a rule, a large amount of time passes between the planning stage and the time when a CHP plant is commissioned and thus eligible for subsidisation. Therefore, it is to be welcomed that the promotion period was extended by one year (versus the initial draft) to 2014. The annual reduction of the applicable incentive by 0.2 ct/kWh of course runs counter to the objective of a rapid expansion of CHP in trade and industry. Currently, there is a tight market for plant systems and components. Therefore, plant modernisation can take up to 2 years or more. For this reason, it would be good if the incentivisation period were extended to an even later date. A "first-past-the-post" procedure applies to the incentive programme, with only the first movers standing to benefit. The German CHP association, *Bundesverband Kraft-Wärme-Kopplung* (BKWK), makes a case for a changeover from "calendar-year subsidisation" to "subsidisation from the day of commissioning". This seems like a practical proposal.

There has also been criticism of the so-called 50% criterion for modernisation under the KWKG. This stipulates that CHP modernisation programmes will not be subsidised unless the costs of the efficiency measures total at least 50% of the overall revamp costs. Germany's Association of Industrial Energy Users and Self-Generators, the *Verband der Industriellen Energie- und Kraftwirtschaft* (VIK), says that this contradicts the CHP target of the policy. More flexibility would make sense here, for the specific characteristics of some of the plants make them miss on this criterion.

As with every form of subsidisation, the CHP incentive volume of EUR 750 million per year, of which EUR 150 million is earmarked for the development of local and district heating networks, is the subject of criticism. The BKWK's demand that the annual cap on incentives be replaced by a multi-year mean was not met by the policymakers. The association argued that the peak of incentivisation would not arrive until 2012 or 2013 at the earliest. For technical and administrative reasons, there was only little new construction in the first few years so the incentive volume was not fully exhausted during this time. Germany's second chamber of government, the Bundesrat, recommended on February 15, 2008 that the funding be increased to EUR 950 million, since otherwise the objective of doubling the volume of CHP electricity would not be attainable.[19]

CHP-based electricity generation in EU member states

%



Sources: Eurostat 2006, BKWK 16

Doubling of CHP generation thanks to variety of instruments

The proposal to double CHP by 2020 outlined here is a typically German approach to the matter. It is marked by a plethora of instruments, plant types and size categories. Much argues for taking a critical view of this proposal. Since the measures are ultimately meant to serve the goal of raising efficiency to raise climate protection, one cannot help wondering whether one instrument shouldn't be used for all purposes. Logically, first place should go to efficient CO_2 emissions trading. Distortions and inefficiencies due to overlapping, competitive relations or differing competencies in connection with the KWKG, EEG, emissions trading, eco-tax etc. could be eliminated.

Actually, though, a very cautious approach appears to be what is required. For the laws and regulations often do anything but serve one goal alone. One example is the EEG, which besides helping the climate target to be met is also meant to help conserve fossil fuels which are gradually becoming more scarce. Moreover, the law looks to promote innovative (and often still not competitive) technologies, nature conservation and environmental protection. One further aspect is the stabilisation of living conditions in rural areas. In this respect, prematurely streamlining the complex mix of instruments might easily prove to have undesirable effects. Above all, the infant technologies starting to sprout up thanks to the nurturing forces of the EEG should not find their growth hindered before they have taken root. Only in this way will it be possible for the new renewables to develop the potency required to offer us a noticeably better energy supply in several decades than they do now.

One positive note at present is that the politicians have taken a clear stand on the problems which may arise from the coexistence of differing incentive instruments. One good example is the current competition between feeds of EEG and KWKG electricity. As part of the KWKG amendment, both will be treated equally. Otherwise, especially in view of the sometimes surging feeds from windpower plants – particularly during strong winds and/or because of rising volumes of offshore supply – the result would have been scarcely predictable technological and economic problems for industrial companies. Operational disruptions might have hit industrial CHP plants in particular. Thanks to the new arrangement the diverse interests can be accommodated better.

In the longer run, the impact of EU emissions trading will no doubt also have an impact on Germany's promotion laws. Germany was still allowed exceptional treatment just a few weeks ago. However, Germany's politicians would be well advised to keep tabs on the developments at the European level and to enrich the debate with proposals of their own. For if the EU continues in future to grab

[19] See Bundesrat-Drucksache 12/08, 15.2.2008, pp. 10-11.

further competencies in connection with energy and climate policy, this could also impact modern legislation such as the EEG and the KWKG.

Instruments are advancing CHP – with room for greater vigour

Legislation will give CHP even stronger backing

The promotion of CHP in the EEG and KWKG frameworks appears fundamentally suitable to bring Germany closer to its CHP target. Occasionally, CHP supporters demand an even higher target – e.g. 30% by 2020. In our opinion, the target already set is very ambitious. If it should turn out in several years' time that the problems surrounding the security of energy supply and climate protection were underestimated or that the amendments did not create the desired stimuli, politicians should not hesitate to take an even bolder approach to readjustment. With CHP as an important pillar of the energy and climate programme, Germany can hold its head high on the international stage. Nevertheless, the fact that other countries already have higher CHP shares today shows that even more is possible going forward.

Conclusion: Greater efficiency reduces worries

Looks like there can only be winners

The global increases in energy and environmental problems urgently require a reorientation of energy and environmental policies. There is no question that it is rational to use energy as efficiently as possible. If the way to the future is paved today, it looks like there can only be winners in the game. The latest signals from the political arena are very encouraging. CHP generation is not the only instrument towards a better energy future, but it is certainly a very important one that can be upgraded further. The better climate surrounding CHP is to be welcomed.

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Energy and climate change

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The growing scarcity of fossil fuels must be addressed with intelligent, future-proof strategies. In the longer run, securing energy supplies will be possible only with a broad range of measures. Every available option has to be exhausted – the diversification of energy carriers and technologies and the mobilisation of all conservation, reactivation and efficiency-boosting strategies. One issue closely linked with the energy sector is the global challenge posed by climate change. Over the coming years a variety of measures will be taken to slow the pace of climate change and mitigate its negative consequences. All this will have a tangible impact on many aspects of business and society.

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