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Energiewende
Switch to the Future

Electricity 2030: Long-term trends – Tasks for the coming years

Summary report on Trend 7: "Modern CHP plants produce residual power and contribute to the heating transition"

Imprint

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Preliminary remark: The findings described in this report are not necessarily and not in every case identical to the stance taken by the Federal Ministry for Economic Affairs and Energy or by individual participants of Working Group 1 of the Electricity Market Platform.

Summary

The input paper "Electricity 2030" outlines 12 trends in the electricity sector based on current studies. One of these trends looks at the long-term role of combined heat and power generation in the energy transition (Trend 7).

Working Group 1 of the Electricity Market Platform engaged in an extensive discussion on development of CHP. The Fraunhofer Institute for Systems and Innovation Research, the Fraunhofer Institute for Wind Energy and Energy System Technology, Prognos AG, the Danish Technical University and the Institute for Applied Ecology presented scientific findings on the topic. The participants of the working group discussed these findings on 27 October and 15 November 2016, and on 10 January 2017.

The findings illustrate the following situation:

- **Heat networks are of strategic importance as a viable infrastructure for the future.** Heat networks have various advantages: for one thing, they provide central heating to many buildings. Also, they can employ various technologies. This allows heat network operators to react flexibly to unexpected developments (a "change enabler"). The question as to whether heat networks or decentralised providers should supply heat is dependent on the specific situation and location. The general trend is however clear: in densely populated areas, heat networks should provide the major part of heat supply. In doing so, these networks take on a different role. In addition to simply distributing heat over a large area, in the future they will collect heat from various sources and distribute it to heat consumers – often with lower temperatures than today.

- **Fuel-powered CHP plants can continue to play an important role in the energy system for many years yet, if they are modernised.** This applies to CHP plants operating with fossil fuels, as well as those operating with renewable fuels. This is because by 2030 CHP plants will largely replace non-co-generating fossil fuel power generation and will provide substantial capacity for residual load, thereby serving to reduce emissions. The significance of fuel-operated CHP plans will then however continually decline. By 2050, renewable energy and demand efficiency will extensively push aside fossil fuels in the electricity and heating sectors. This means that if CHP plants are to basically remain greenhouse gas-neutral, they will only be viable in the future if they use renewable fuels. However, even renewable fuels will have only a limited range of uses, because in the long term even they will only be available to a limited extent or will be expensive. In the long term, they will be used wherever there is little alternative – for example in air and shipping traffic. Support for CHP technology must therefore keep in mind the competition for their use beyond the traditional sector boundaries.

- **CHP plants in industry and public utilities are faced with varying challenges.** Supplying residential buildings with space heating is possible in many cases using heat at lower temperature ranges than currently used. In contrast, many industrial processes require heat at very high temperatures. It is therefore evident that in these areas different technologies will prevail in the future: in industry, power-to-heat systems will play an important role alongside CHP plants in the mid- to long-term. On the other hand, public utilities can use solar-thermal and geothermal power plants and waste heat to cover major portions of heating needs.

In order to help CHP technology develop in the desired direction, the general framework surrounding such technology must be redefined. For example, it must be possible to make decisions regarding important infrastructure such as heat networks at an early stage. In addition, local potential capacity for renewable energy sources that could be fed into heat networks should be identified now. Municipal heating strategies should become standard in order to provide the parties involved in shaping municipal strategy more information for decision making. At the same time, the industrial sector should remove barriers to flexibility that prevent electricity price signals from reaching providers. In addition, these companies should be in a position to integrate flexibility options such as power-to-heat. Furthermore, the role of CHP in private households and small facility networks should be examined as part of an effective overall strategy for the heating sector.

Introduction

Which course must we set in the years to come in order to make the energy transition affordable? This is the starting point of the discussion paper that the Federal Ministry for Economic Affairs and Energy used to initiate the discussion process titled “Electricity 2030” in September 2016. The goal is to optimise the overall system and ensure that power generation from renewable sources of energy as well as conventional power generation, co-generation, networks and load management are able to fulfil their new functions in the overall system.

The “Electricity 2030” discussion paper describes twelve long-term trends in the electricity sector based on current studies. These trends define how wind and solar energy are increasingly influencing the energy system and are gradually becoming the most important energy sources, while the energy supply will remain secure and cost effective. These trends will be the starting point for future energy policy.

This report summarizes the findings of the Electricity Market Platform on Trend 7 (“Modern CHP plants produce residual power and contribute to the heating transition”). Working Group 1 of the Electricity Market Platform at the Federal Ministry for Economic Affairs and Energy (BMWi) met on 27 October 2016, 15 November 2016 and 10 January 2017, to discuss the topic of CHP generation as part of the overall discussion “Electricity 2030”. The issue discussed was what challenges CHP will be facing due to the energy transition.

The following scientists presented their findings (in chronological order):

- Norman Gerhardt, Fraunhofer Institute for Wind Energy and Energy System Technology (Fraunhofer IWES)
- Dr. Frank Sensfuß, Fraunhofer Institute for Systems and Innovation Research (Fraunhofer ISI)
- Dr. Marie Münster, Danish Technical University
- Marco Wünsch, Prognos AG
- Sabine Gores, Institute for Applied Ecology
- Gerda Deac, Fraunhofer ISI

In addition, Mr. Stefan Lochmüller provided insights into day-to-day operations at the energy utility N-ERGIE. Summaries of the meetings prepared by BMWi as well as the presentations can be found on the BMWi website under the page Electricity Market Platform[1].

This report is structured as follows:

- **Chapter I** describes the approach BMWi is using to evaluate the Electricity 2030 process.
- **Chapter II** describes the main points of the scientific presentations and the work group discussions.
- **Chapter III** lists tasks and specific steps to be taken in order to achieve the desired long-term development of CHP technology.

The working paper has shortened the discussions and presentations in many places for ease of reading. The working paper therefore expressly does not necessarily and not in every case reflect the position of the individual participants.

1 In German only: http://www.bmwi.de/DE/Themen/Energie/Strommarkt-der-Zukunft/plattform-strommarkt,did=646624.html

I. The approach

The goals of the Energy Concept, the blueprint for energy policy, provide the guardrails for developing the energy system. The aim is to reduce greenhouse gas emissions by 80% to 95% by 2050, and in line with the energy policy triad of goals, to also guarantee a secure, sustainable and low-cost supply of energy, in Germany as well as in Europe. The "Electricity 2030" process has initiated discussions on this development in various areas of the energy system. These areas also include co-generation of heat and electricity.

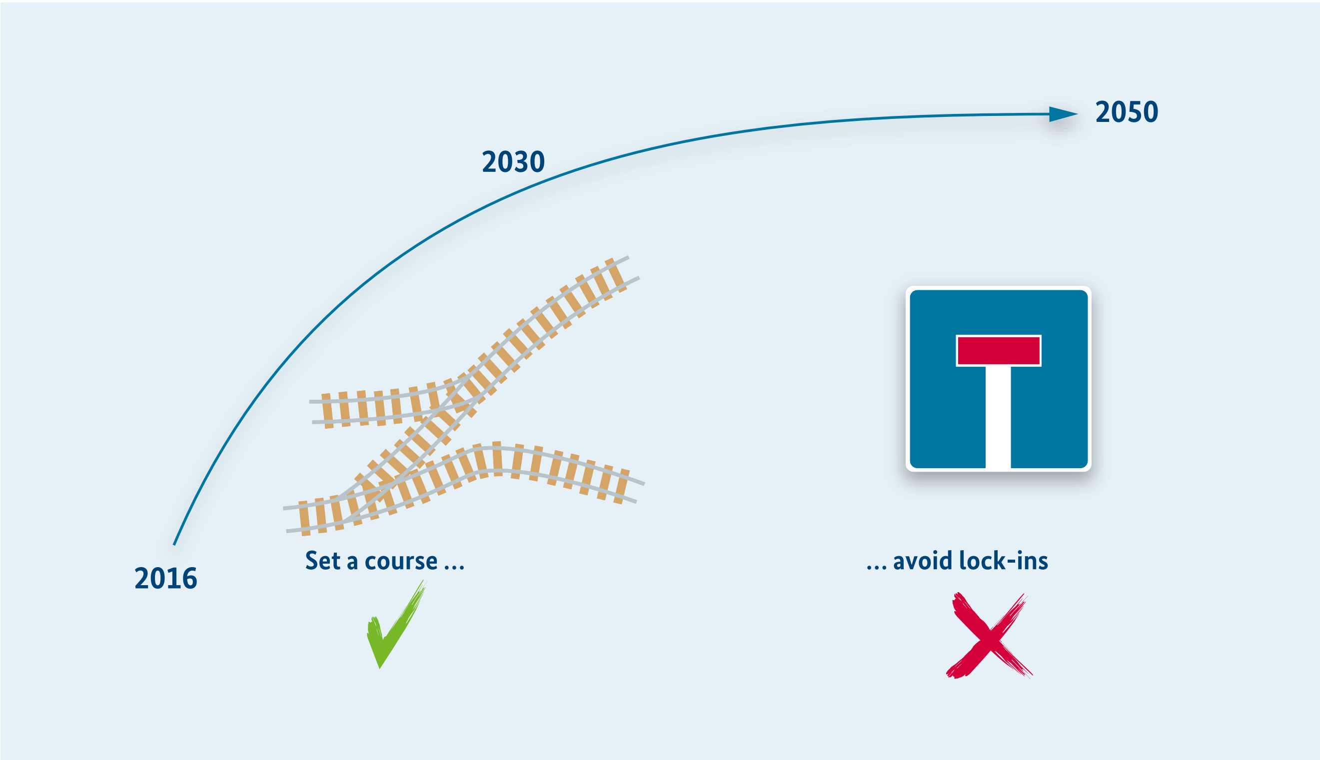
How the electric and heating sectors develop over the long term is decisive for the future of CHP. Co-generation is at the interface of the electricity and heating markets. Both sectors will grow closer together in the coming decades. For example, houses will increasingly be heated with heat pumps operated with electricity. The transition in the electricity and heating sectors will also change the role of CHP.

The goal of this report is to define the course to be followed over the next few years so that CHP can efficiently fulfil its new role in the energy transition and contribute to a cost-effective transition. The time is ripe, because heat networks are often used for a very long time, sometimes longer than power plants and industrial plants that often have operating lives of over 40 years.

Chapter II discusses the question as to how co-generation should evolve in order to remain a robust, cost-effective component of the energy transition. The main question is: what are the conclusions to be drawn from the long-term scenarios reaching to 2050, regarding the function and development of CHP? Scientific studies help us in answering these questions. A selection of relevant studies can be found in the annex to this report.

Chapter III deduces from these findings how support for CHP technology should be adapted so that this goal is actually achieved.

Figure 1: Approach



Source: Authors

II. The trend – future developments in CHP technology

The discussions taking place in the Electricity Market Platform have provided a clear picture of the future development of CHP. The following chapter describes this development, based on the presentations and discussion of the three meetings of Working Group 1 of the platform. For the sake of brevity, the discussions and presentations have been reduced to the major issues.

The presentations and discussions have focused on three key questions regarding the future development of CHP. The key questions evaluate the development of the energy system and CHP from the perspective of the goal to be achieved.

The answers to key questions 1 and 2 describe what the energy system could look like in 2050 if it achieved the Energy Concept goals. The first key question focusses especially on the role of CHP, and the second question on the role of the accompanying infrastructure.

The answers to key question 3 derive the consequences for 2030 from this long-term trend. The subchapter describes the challenges for CHP plants and infrastructures in public utility operation and in industry.

? Key question 1: What will the long-term trend for CHP look like if emissions are reduced by 80% to 90%?

There is a big difference between an energy system with 80% to 90% less greenhouse gas emissions and today's energy supply.

- The electricity, heating and transportation sectors will be largely greenhouse gas-neutral.
- The electricity and heating sectors will be much more interconnected than today.

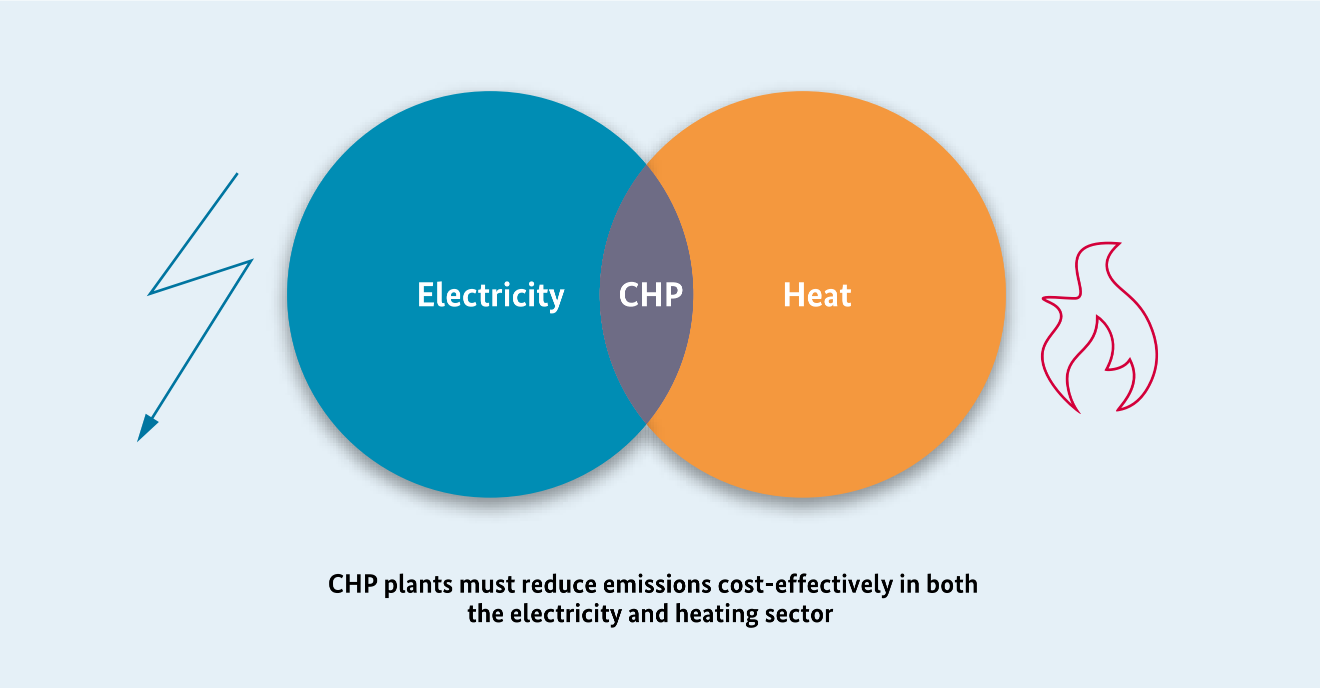
By 2050, fossil fuels will be largely replaced in the electricity and heating sectors by a greatly enhanced efficiency in demand and renewable sources of energy. The federal Government aims to reduce greenhouse gas emissions by 80% to 95% compared with the levels in 1990 by the year 2050. The lower and upper bounds of these climate targets for 2050 have various effects on the energy system. In a system that will be basically neutral regarding greenhouse gas emissions, mainly the agricultural sector and some industry processes will continue to produce emissions.

Figure 2: Key questions regarding the CHP trend

Key question 1:	What would the **long-term development trajectory for CHP** look like, if emissions are reduced by 80% to 90% by 2050?
Key question 2:	What would a **viable infrastructure** look like in this case at the interface between the electricity sector and the heating sector?
Key question 3:	What **consequences will arise from the long-term development trajectory by 2030** – both those for CHP in public utility operation and for CHP in industrial use?

Source: Authors

Figure 3: Prerequisite for an important role for CHP plants



Source: Fraunhofer ISI/Presentation by Dr. Sensfuß on 27 October 2016

For CHP this means: in a system that will be chiefly greenhouse gas-neutral, fuel-operated combined heat-power plants will only be viable in the future if they use renewable fuels. Whether fuel-operated CHP plants can even play a role at all in a largely greenhouse gas-neutral energy system cannot be answered for once and for all. It is however clear that CHP plants will no longer be operated with fossil fuels, rather – if at all – with renewable fuels. Renewable fuels include biomass and synthetically generated gases produced with renewable electricity.

There is only limited availability of renewable fuels or they are expensive. Local availability of biomass is limited. Synthetic gases can only be generated using a lot of energy. This makes renewable fuels relatively expensive. Studies such as the long-term scenario published by BMWi[2] therefore assume that expansion of renewables and the electrical grid in a largely greenhouse gas-neutral energy system is cheaper than the (wide-spread) use of renewable fuels in CHP plants.

Many factors influence the role that fuel-operated CHP plants should play on the path to a largely greenhouse gas-neutral system. Fuel-operated CHP plants would play an increasingly important role for instance if demand for electricity increased due to new consumers, also in hours when less energy from renewables is generated, and the electrical sector requires more output to ensure supply. CHP plants would play a lesser role for example if efficiency measures take hold and reduce heating demand.

It is essential that fuel-operated CHP plants reduce emissions at low cost in both the electrical and heating sectors. How much a fuel-operated CHP plant can actually reduce its emissions depends both on the operating location and on the time the plant is operating. For example, it is important whether a local alternative low-CO_2 emission heating utility is available (operating location). An equally important factor is whether the CHP plant reacts to price signals and goes off grid if wind and solar are feeding particularly large amounts of power into the grid (operating time).

2 Available in German only: Fraunhofer ISI, et al. (2016): Long-term Scenarios for the Transformation of the Energy System in Germany; Fraunhofer IWES et al. (2015): Interaction Between Renewable Energy Electricity, Heat and Transport

As long as the electricity and heating sectors still create emissions, fuel-operated CHP plants can play an important role as backup. This applies to combined heat and power plants operating with renewable fuels, but also to those still operating with fossil fuels. The largest advantage of CHP plants is that they can utilize fuels very efficiently. The aforementioned studies published by Fraunhofer-Institute for Systems and Innovation Research et al. (2016) and Fraunhofer Institute for Wind Energy and Energy System Technology et al. (2015) therefore describe scenarios that still include CHP plants, even with a greenhouse gas emission reduction of 80%.

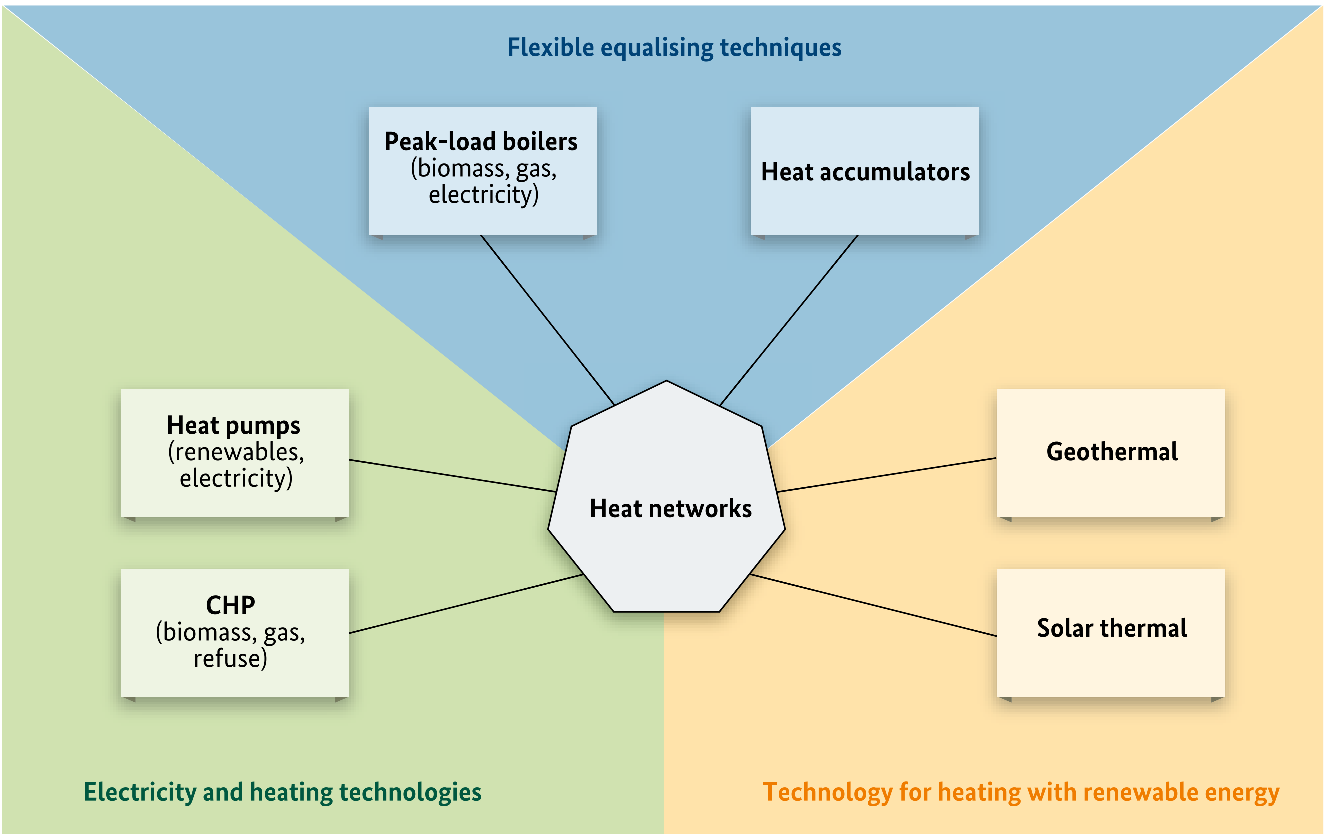
In the electricity sector these fuel-operated CHP plants can provide the major portion of residual load. The residual load is the energy consumption not covered by wind and solar power. In the long term scenarios, however, the residual load will be much lower than today. In addition, the CHP plants still being operated then will be much more flexible. That means that they can not only ramp up and down very quickly, but can also remain inactive for weeks.

In the heating sector, fuel-operated CHP plants can in particular provide heating at high temperatures. Specifically, they produce process heat for industry and space heating for poorly insulated buildings. Room heating and hot water with low temperatures will be provided in the mid- and long-term primarily by renewables and heat pumps. Fuel-operated CHP plants serve as a backup for electrical and heat needs.

Key question 2: In this case, what will a viable infrastructure look like at the interface between the electricity and heating sectors?

Hybrid systems will take over provision of energy at the interface between the electricity and heating sectors. This is because the electricity and heating sectors must interact extremely efficiently if more and more renewable energy is to be converted to heat and used immediately or stored as heat. These hybrid systems combine various flexible, low

Figure 4: Heat network-based system at the interface between the electricity and heating sectors
(schematic illustration)



Source: Authors

CO_2 emission technologies at the interface between the electricity and heating market – frequently in heating networks and using heat accumulators. This is illustrated in Figure 4.

Heat networks are of strategic importance as a viable infrastructure for the future. Heat networks have various advantages. For one thing, they provide central heating to many buildings. Also, they can employ various technologies. This allows heat network operators to react flexibly to unexpected developments (a "change enabler"). Heat network operators can for example connect a heat accumulator to the heat network with relatively little ease whenever the need for flexibility increases.

The question as to whether heat networks or decentralised providers will supply heat is dependent on the specific situation and location. Decisive factors are the costs and potential benefits of decentralized, renewable energy sources and other low-carbon providers – for example industrial waste – as well as local heating demand.

The general trend is however clear: in densely populated areas, heat networks should provide the major part of heat supply. In the heat networks the portion of renewables will increase in the course of the next few years – either directly through utilization of locally available renewable energy sources or by using electricity. In the same manner, heat pumps and renewables will tend to take over heat supply in less populous areas. In such areas space is frequently available for decentralized renewable energies and the regional heating demand is lower. In all cases, however, the specifics of the location will decide whether heating will be provided centrally or decentrally. For example, sometimes small regional heat networks are appropriate for municipal planning.

Heat networks will change their role. In addition to distributing heat over wide areas, heat networks collect heat from various sources and distribute it to the heating customers. They, too, must be made viable for the future. Viability in the future means in particular that the heat networks must be able to run at lower temperatures in order to integrate new technologies efficiently. Which temperature level is right is determined by local circumstances, in particular the heating demand structure.

? Key question 3: What consequences will arise from the long-term development trajectory for CHP technology by 2030 – both those for CHP in public utility operation and for CHP in industrial use?

In the medium-term, fossil-fuel operated CHP plants can also replace non-cogenerating fossil producers in the electricity and heating sectors and thereby contribute to reducing emissions. By 2030 or thereabouts, even fossil fuel-, natural gas-operated CHP plants can still assume a key role. After this point in time, the significance of fossil-fuel operated CHP plants will continually decline. However, the expansion of fossil-fuel operated CHP plants may not create any lock-in-effects. For this reason, decisions on expansion of such CHP plants or decisions regarding infrastructure for such plants such be made keeping in mind the life span of the plants.

Fossil-fuel CHP plants can only take on this role if they are modernized. Fuel-operated CHP plants can take on an important role if they reduce emissions in the electricity and heating sectors (see key question 1). This applies both to renewables and to fossil fuels. Fuel-operated CHP systems must therefore adapt to the expansion of renewable sources of energy and to growing energy efficiency in both the electricity and the heating sectors.

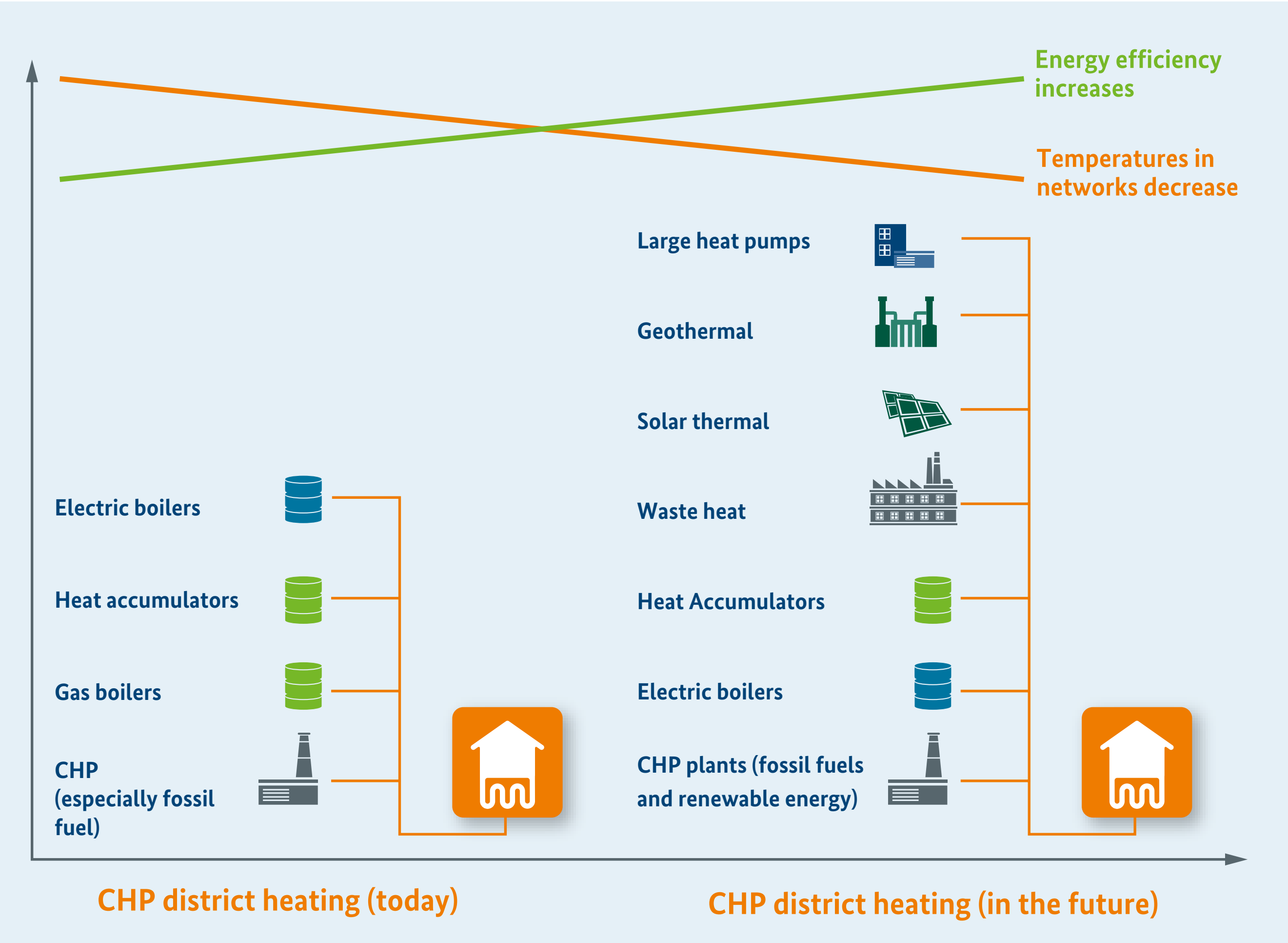
Flexibility is a major component of this modernization process. Flexibility refers to both the electricity and the heating sectors. This means that fuel-operated CHP plants must be operated in such a way that, using price signals, they can react to renewable electricity or renewable heat production. To do this, transparent market incentives for flexibility in the heating market should be created.

CHP plants in industry and public utilities are faced with varying challenges arising from modernization. This is because supplying residential buildings with space heating is now possible in many cases using heat at low temperature ranges. In contrast, many industrial processes require heat at very high temperatures. Ultimately, various technologies will provide heating with lower carbon dioxide emissions.

In industry, in the mid- to long-term electric boilers and heat pumps will play an important role alongside CHP plants. In order to reduce emissions in the long term at low cost, fuel-operated CHP plants will convert their production to heat at high temperatures. In addition, CHP systems will integrate electric boilers and/or heat pumps in order to convert renewable electricity into heat at low prices. At the present, integrating heat pumps is already economical to a certain extent, in particular wherever they can simultaneously provide heating and cooling to buildings. The waste heat produced by industrial processes can for example provide heating to buildings. Wherever it makes sense, renewables can take over heating supply – for example in industry processes requiring only low temperature levels for their heating.

In addition, public utilities can also use solar-thermal and geothermal power plants and waste heat to cover major portions of heating needs. In addition to fuel-operated CHP plants, renewable energy sources increasingly generate heat either directly (solar, geothermal energy) or indirectly (electric boiler, heat pump) to provide buildings with space heating, warm water, process heat and cooling. Furthermore, low-carbon heat sources such as industrial waste heat can provide low-cost heat in addition to fuel-operated CHP plants. Heat accumulators and heat networks offer flexibility. In the final analysis, district heating will increasingly source more heat from various technologies. This is already the case in Denmark (see Figure 5).

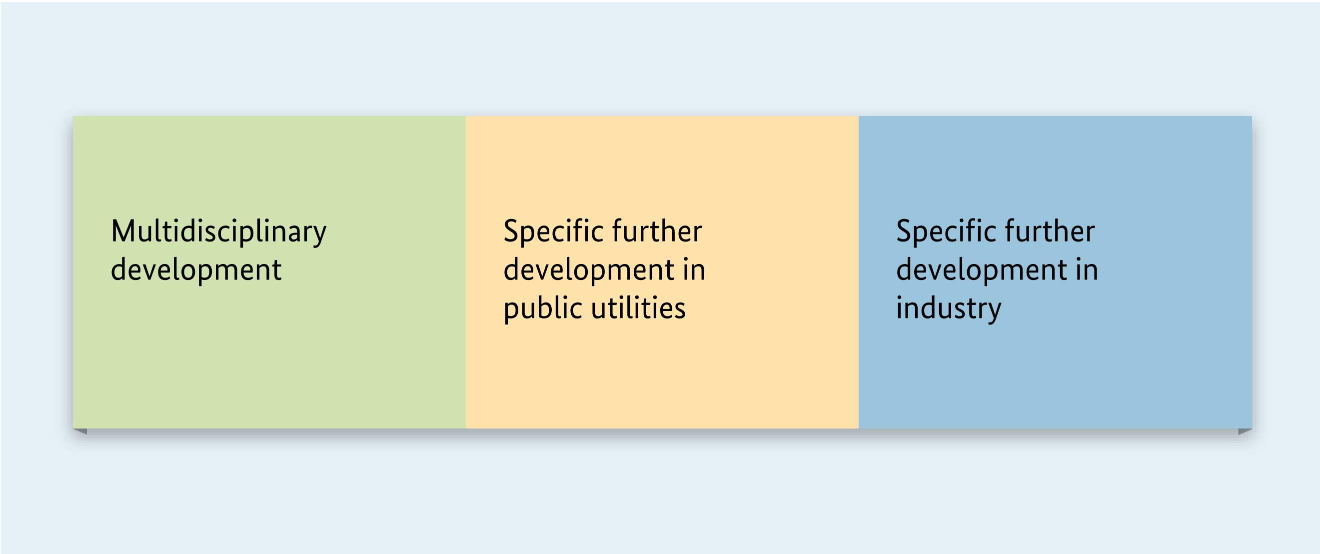
Figure 5: Modernizing district heating (simplified)



Source: Dr. Marie Münster, Working Group 1 meeting on 27 October 2016, cited from Lund et al. (2014) in Energy 68, 1–11, 4th Generation District Heating (4GDH): Integrating smart thermal grids into future sustainable energy systems

III. The task – a need for adjusting the framework for CHP technology

Figure 6: Action areas of further development of CHP technology

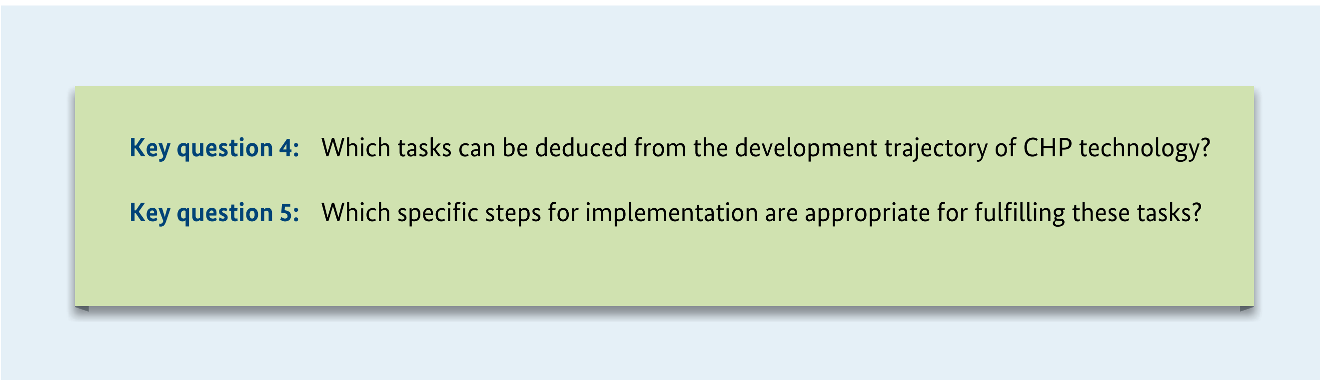


Source: Authors

There are three central areas for action for the further development of CHP technology: multidisciplinary tasks, specific tasks for public utilities and specific tasks in the area of industry. The areas needing action reflect that there are both similar and varying challenges for industry and public utilities using CHP technology.

For each action area there are specific tasks and implementation steps. The key questions on the task “A need for adjustment in the framework for CHP technology” take a two-tier approach. Key question 4 determines which tasks can be generally deduced from the CHP development trajectory described in Chapter II. Key question 5 aims to formulate specific recommendations for implementing the abstract tasks.

Figure 7: Key questions regarding the tasks in the areas of CHP and heat networks



Source: Authors

Key question 4: Which tasks can be deduced from the development trajectory of CHP technology?

The areas for action are divided up into tasks. The tasks are derived from discussion on the development trajectory. Figure 8 provides an overview. BMWi prepared a list of tasks after discussions with the participants.

Figure 8: Task list

Action area 1: Multidisciplinary development of co-generation of heat and electricity

1. Build only system-conforming and flexible fuel-operated CHP plants
2. Retain existing low-emission fuel-operated CHP plants
3. Regularly verify carbon savings achieved by fuel-operated CHP plants using up-to-date reference systems
4. Take into consideration conflicting uses and availability of renewable fuels
5. Create a market environment supportive of expansion and the desired development of CHP technology

Action area 2: Specific further development of CHP technology for public utilities

6. Expand future-viable heat networks according to demand
7. Involve more producers with low CO_2 emission in the heat networks
8. Gradually transform existing heat networks
9. Make fuel-operated CHP plants more flexible

Action area 3: Specific further development of CHP technology for industry

10. Differentiate high-temperature process heat from low temperature process heat
11. Incorporate more flexibility into production sequences
12. Utilize more power-to-heat technologies for process heat
13. Move fuel-operated CHP plants to high-temperature heating production

Source: Authors

Key question 5: Which specific steps for implementation are appropriate for fulfilling these tasks?

The discussion participants drew up the following list of priorities (see Figure 9) setting out which measures should be taken first.

These recommendations for specific implementation steps were based on recommendations of the scientists named in the foregoing. The participants evaluated these recommendations in their discussions and added their own recommendations.

Figure 9: Priority list

Action area 1: Multidisciplinary development of CHP technology

- **Increase CO_2** prices
- Emphasize systemic **flexibility**
- Create the conditions for **important infrastructure decisions** at an early stage

Action area 2: Specific further development of CHP technology for public utilities

- Identify **local potential for renewable energy sources**, because these are the necessary prerequisites for long-term greenhouse gas-neutral heat networks
- Make municipal heating plans mandatory for general regional strategies and incorporate **power-to-heat/waste heat/renewable energies into heat networks**
- Grant municipals authority to act with regard to **municipal heating planning** (e. g. provide access to existing buildings within the municipality) – if necessary using regulatory law or other measures at the federal level

Action area 3: Specific further development of CHP technology for industry

- Remove **barriers to flexibility** for electricity price signals (e. g. Capacity prices for grid charges)
- Integrate flexibility options such as **power-to-heat** into CHP plants via company decisions
- Incorporate **low-temperature heating** in the form of industrial waste heat into heat networks

Source: Authors

Action area 1: Multidisciplinary development of CHP technology

Task 1: Build only system-conforming and flexible fuel-operated CHP

Recommendations for implementation (scientific proposals):

- Operate CHP systems only with **low-emission fuels** (Fraunhofer IWES, Institute for Applied Ecology)
- Exploit low-emission fuels with **high operating efficiency** – even if the plants are operated flexibly (Institute for Applied Ecology)
- Increasingly only create fossil energy generation where there are **no better alternatives** (Institute for Applied Ecology)
- **Consider future CHP electricity capacity and life span** when approving new plants – and in turn forecast future CHP electricity capacity of existing plants and new plants and compare this with the actual current and future demand for new, fuel-operated CHP electricity capacity (Institute for Applied Ecology)
- Set out **distinct flexibility requirements** for new CHP plants – e.g. new plants in the low-temperature are, or in the mid-term in the high temperature area, should only receive support if they can react flexibly to electricity and heat from wind and solar sources (Institute for Applied Ecology)
- Utilize heat sinks, in order to enhance CHP potential where they are attractive from the viewpoint of the overall system (Fraunhofer-Institute for Systems and Innovation Research, Fraunhofer Institute for Wind Energy and Energy System Technology, Prognos AG)

Additional recommendations from the participants:

- Examine more closely the role of CHP technology in private households and in small facility networks as part of an efficient overall strategy for heating buildings (including carbon dioxide effects of micro-CHP technology)

Task 2: Retain existing low-emission fuel-operated CHP plants

Recommendations for implementation (scientific proposals):

- Ensure that low-emission fuel-operated CHP plants will continue operation by adjusting the amount of support, in order to retain the heat networks required in the long term (Institute for Applied Ecology)

Additional recommendations from the participants:

- **Make existing fuel-operated CHP plants more flexible**

Task 3: Regularly verify the efficiency of CHP plants using up-to-date reference systems

Recommendations for implementation (scientific proposals):

- Collect data on actual operation of CHP plants – assess especially which efficiency losses occur when the plants are operated flexibly (Institute for Applied Ecology)

Task 4: Take into consideration conflicting uses and availability of renewable fuels

Recommendations for implementation (scientific proposals):

- Wherever it is reasonable, use renewable fuels such as **biogas and refuse** in CHP plants (Institute for Applied Ecology)
- **Keep an eye on competing uses and availability of biomass** (Fraunhofer ISI, Fraunhofer IWES, Institute for Applied Ecology, Prognos AG) e.g. provide municipal players with decision support to better assess expected cost increases for fuel (Fraunhofer IWES), or if possible compare CO_2 prices and fuel prices across sectors, and if the need arises, reduce support for renewable fuels in the electricity sector (Fraunhofer ISI)
- **Future (economical) supply** of biomethane and synthetic gases produced with renewable electricity should **not be overestimated** (Institute for Applied Ecology)
- **Increasingly move fuel-operated CHP plants to areas where there are fewer low-CO_2 emission providers that could alternatively provide electricity and heating** → e.g. switching to process heat with high temperatures in industry, see below (Fraunhofer-Institute for Systems and Innovation Research, Fraunhofer IWES, Institute for Applied Ecology, Prognos AG)
- **Review and plan (if appropriate)** long-term possibilities for using hydrogen in CHP plants (Prognos AG, Institute for Applied Ecology)

Task 5: Create a market environment supportive of expansion and the desired development of CHP technology

Recommendations for implementation (scientific proposals):

- **Raise prices for CO_2 or taxes for fossil fuels** (Fraunhofer IWES, Institute for Applied Ecology, Prognos AG)
- **Introduce specific emission standards** for generation of electricity and heating for all producers (Fraunhofer IWES, Institute for Applied Ecology, Prognos AG)
- **Implement infrastructure measures early on** – for example evaluating the potential for geothermal power and solar heat plants as well as identifying possible routes for heat networks in order to transport such heat to consumers (Fraunhofer IWES, Institute for Applied Ecology, Prognos AG)
- **Consider expanding heat networks when making road improvements** – e.g., also lay heat networks when internet cable is being lain (Institute for Applied Ecology)

Action area 2: Specific further development of CHP technology for public utilities

Task 6: Involve more producers with low CO_2 emission in the heat networks

Recommendations for implementation (scientific proposals):

- **Identify and use regional potential** for renewable energy sources and industrial waste heat (Fraunhofer-ISI, Fraunhofer IWES, Institute for Applied Ecology, Prognos AG)
- **Make fuel-operated CHP plants in heat networks "renewable-energy-ready"**: For example, CHP plants should be able to utilize fuel efficiently even at partial load and also experience only slight wear and tear from frequent starts (Institute for Applied Ecology)
- Determine a **regional order of operation** for providers in the heat networks (Institute for Applied Ecology)

Task 7: Make fuel-operated CHP plants more flexible

Recommendations for implementation (scientific proposals):

- Build more heat accumulators (Fraunhofer IWES, Institute for Applied Ecology, Prognos AG)
- **Make power-to-heat standard for gas-based CHP plants**, so that 1) CHP plants can be geared to partial load, in accordance with the criteria of high efficiency and sometimes using power-to-heat (as with exclusively partial use of fuel-operated gas-fired boilers), thereby enabling them to react flexibly to market prices during autoproduction; and 2) also so that the CHP plants can take on additional surplus electricity (EInsMan, even when prices become negative in the future), and thereby have twice as much impact as a gas-fired boiler (Fraunhofer IWES)
- **Do not allow any privileges** for fuel-powered CHP plants, or **reduce privileges**, so that they react more flexibly to electricity price signals – privileges include the exemption from electricity tax for small CHP plants or CHP plants avoiding grid charges when they are connected at low voltage levels (Fraunhofer IWES)
- Network operators should give fuel-operated **CHP plants preference over renewable energy sources for evening out network congestion problems** (Feed-in management) (Fraunhofer ISI, Fraunhofer IWES, Institute for Applied Ecology, Prognos AG)
- Only use power-to-heat for verifiable **surpluses of renewable energy**, in order to prevent conversion of electricity produced by coal-fired power stations into heat, instead of ramping down coal-fired power stations (Institute for Applied Ecology, Prognos AG)

Task 8: Expand future-viable heat networks according to demand

Recommendations for implementation (scientific proposals):

- **Establish municipal heating strategies** in order to embed the expansion of CHP and district heating in a reasonable, regional strategy (Fraunhofer ISI, Fraunhofer IWES, Institute for Applied Ecology, Prognos AG)
- **Expand and consolidate heat networks** (Institute for Applied Ecology, Prognos AG)
- **Where possible, avoid dual infrastructures** (gas network vs. district heating network vs. pure electricity grid) – to this end, make municipal heating strategies obligatory and allow municipalities to set out specific requirements, such as primary energy requirements for buildings (Fraunhofer IWES)

- Create or convert **secondary networks** with individual, decentralized solutions (additional renewables, temperature reductions, connecting primary networks) (Fraunhofer IWES)

- **Take into full consideration the possibility of expanding heat networks when underground street improvements take place** → e.g., also lay heat networks when internet cable is being lain (Institute for Applied Ecology)

Additional recommendations from the participants:

- **Create uniform expansion support schemes at the State level**

Task 9: Maintain existing heat networks and transform them gradually

Recommendations for implementation (scientific proposals):)

- **Establish municipal heating strategies** in order to embed the modernization of CHP and district heating in a reasonable, regional strategy (Fraunhofer ISI, Fraunhofer IWES, Institute for Applied Ecology, Prognos AG)

- **Maintain existing heat networks** (Fraunhofer ISI, Institute for Applied Ecology, Prognos AG)

- Connect up more buildings to district heating (**Increasing the rate of connections or densification**) (Fraunhofer ISI, Fraunhofer IWES, Institute for Applied Ecology, Prognos AG)

- **Dismantle steam networks and modernize hot water networks**, in order to reduce network loss (Fraunhofer IWES, Institute for Applied Ecology, Prognos AG)

- **Reduce temperatures in heat networks** and at the same time **gradually integrate renewable energy sources** such as solar-thermal power and geothermal energy (Fraunhofer IWES, Institute for Applied Ecology, Prognos AG)

- Convert heat networks from **distribution to collection networks by conceiving and planning decentralized heat networks and planning for many** actors (Institute for Applied Ecology)

- Continually reduce **primary energy factors** in heat networks and at the same time increase efficiency requirements for existing buildings, in order to even out competitive disadvantages for heat networks (Fraunhofer Institute for Wind Energy and Energy System Technology)

Additional recommendations from the participants:

- **Support renewable energies in the existing heating sector** (as long as CO_2 prices are not high enough)

- Set up **competition in municipalities** e.g. to equip schools with energy efficient systems as examples for projects

Action area 3: Specific further development of CHP technology for industry

Task 10: Differentiate high-temperature process heat from low temperature process heat

Recommendations for implementation (scientific proposals):

- **Integrate low temperature heat into heat networks** (Institute for Applied Ecology)
- **Use waste heat wherever feasible for low-temperature applications** and – if necessary – integrate large heat pumps to provide higher temperatures (Fraunhofer IWES)

Task 11: Move fuel-operated CHP plants to high-temperature heating production

Recommendations for implementation (scientific proposals):

- Shift the production of fuel-operated **CHP plants to high-temperature heat in the range of 130/140° up to 500/600°**, in order to decarbonise combined heat and power generation in industry (Fraunhofer IWES)

Task 12: Utilize more power-to-heat technologies for process heat

Recommendations for implementation (scientific proposals):

- **Incorporate power-to-heat as a standard in fuel-operated CHP plants** – not only for short- or medium-term flexibility (see Task 6: “Make power-to-heat standard for gas-based CHP plants”), but also for the long-term demand for power that is greenhouse gas-neutral, due to lack of alternatives in the high temperature area (Fraunhofer IWES)

Task 13: Allow more flexibility in production processes

Recommendations for implementation (scientific proposals):

- **Ensure flexible alignment of CHP plants to electricity prices and remove inflexible minimum generation requirements** – to this end, remove barriers to flexibility in grid charges, for example (capacity prices/special grid charges) (Fraunhofer IWES)
- **Increasingly** adapt operation of CHP plants on industrial property to **local network** circumstances and adapt supply to fluctuating renewable sources of energy (Institute for Applied Ecology)
- **Adapt taxes, fees and grid charges in the medium-term**, so that wholesale electricity prices can have a more direct influence on the operation of CHP plants in autoproduction (Fraunhofer ISI, Institute for Applied Ecology, Prognos AG)
- **Align regional grid charges**, in order to create equal competition for construction of CHP plants

  <u>The problem at present:</u> varying regional grid charges lead to differing prices for companies. Autoproduction is worthwhile if electricity procurement prices are high. Therefore, the incentives for CHP plants for autoproduction are especially high whenever grid charges are particularly high – in essence more in the North and East of Germany, unfortunately, where frequent network congestion problems already occur (Fraunhofer Institute for Wind Energy and Energy System Technology, Institute for Applied Ecology, Prognos AG)
- **Install heat accumulators** or set up **demand-side-management** (Institute for Applied Ecology)
- **Take into consideration the effects on the overall system** when setting out flexibility requirements: as long as coal-fired power generation represents a large portion of energy, more flexible CHP plant operation can lead to higher CO_2 emission, because coal-fired power stations must then be operated with less flexibility (Prognos AG)

Annex 1: Selection of current studies

Fraunhofer ISE et al. (2013): Integrated Heating and Cooling Strategy for Germany (Phase 2) – Target systems for the building sector in 2015; Fraunhofer Institute for Solar Energy Systems, Fraunhofer-Institute for Systems and Innovation Research, Fraunhofer-Institute for Production Engineering and Applied Materials research, Institute for Applied Ecology, Technical University of Vienna, commissioned by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Fraunhofer ISI et al. (2016): Long-term Scenarios for the Transformation of the Energy System in Germany; Fraunhofer ISI, Consentec GmbH, Institut für Energie- und Umweltforschung Heidelberg GmbH, commissioned by the German Federal Ministry for Economic Affairs and Energy (to be published late 2016)

Fraunhofer IWES et al. (2015): Interaction between Renewable Energy Electricity, Heat and Transport; Fraunhofer IWES; Fraunhofer Institute for Building Physics; Institute for Energy and Environmental Research Heidelberg GmbH; Foundation for Environmental Law, commissioned by the German Federal Ministry for Economic Affairs and Energy

Ifeu Heidelberg et al. (2013): Transformation strategies from fossil-fuelled central district heating supply to grids with a higher percentage of renewable energy; Institute for Energy and Environmental Research Heidelberg; GEF Ingenieur AG; AGFW, commissioned by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Institute for Energy and Environmental Research (2015): Method paper on Evaluation of CHP Plants in the Medium-term until 2030; Institute for Energy and Environmental Research, commissioned by the Federal Ministry for Economic Affairs and Energy

Prognos et al. (2014): Potential and Cost-benefit Evaluation of Uses of Combined Heat and Power (transposition of the EU Energy Efficiency Directive) as well as Evaluation of the Combined Heat and Power Act in 2014; Fraunhofer-Institute for Production Engineering and Applied Materials research; Institute for Resource Efficiency and Energy Strategies; BHKW-Consult; Prognos AG, commissioned by the Federal Ministry for Economic Affairs and Energy

Annex 2: List of participants in the meetings of WG 1 of the Electricity Market Platform

on 27 October 2016 and/or 15 November 2016 and/or 10 January 2017

(Based on the registration list)

1 **Alena Baasch**, Senate Department for Economics, Technology and Research, Land Berlin
2 **Lara Bender**, Ministry for Commerce, Energy, Industry, Small and Medium Business and Trades of North Rhine-Westphalia
3 **Marian Bons**, Ecofys
4 **Magnus Buhlert**, Ministry for Environment, Energy and Environmental Protection in Lower Saxony
5 **Till Bullmann**, Association of German Chambers of Commerce and Industry
6 **Gerda Deac**, Fraunhofer Institute Systems and Innovation Research (ISI)
7 **Matthias Deutsch**, Agora Energiewende
8 **Kai Dittmann**, Member of the SPD parliamentary group in the Bundestag
9 **Matthias Dümpelmann**, 8KU GmbH
10 **Guido Ehrhardt**, Professional Association for Biogas e.V.
11 **Sebastian Franke**, German Chemical Industry Association e.V.
12 **Christiane Fuckerer**, German Federal Office for Economic Affairs and Export Control (Bafa)
13 **Markus Gebhardt**, Federation of Industrial Energy Consumers and Self-Producers e.V. (VIK)
14 **Norman Gerhardt**, Fraunhofer Institute for Wind Energy and Energy System Technology (IWES)
15 **Martina Gikadi**, Federal Chancellery
16 **Sabine Gores,** Institute for Applied Ecology
17 **Achim Haid**, Ministry for the Environment, Climate Protection and the Energy Sector in Baden-Württemberg
18 **Ingrid Hanhoff,** Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BUMB)
19 **Klaus-Peter Heinrich**, Ministry for Commerce and Energy, Land Brandenburg
20 **Jutta Hufnagel**, Ministry for the Environment, Energy and Nature Conservation in Thüringen
21 **Franz Wilhelm Iven**, Ministry for Commerce, Energy, Industry, Small and Medium Business and Trades of North Rhine-Westphalia
22 **Eva Klotz,** Prognos AG
23 **Gerd Krieger**, VDMA Power Systems
24 **Alexander Kronimus,** German Chemical Industry Association e.V.
25 **Stefan Laibach**, Ministry for Environment, Energy, Nutrition and Forestry in Rheinland-Pfalz
26 **Björn Liebau**, Ministry for Environment, Energy and Environmental Protection in Lower Saxony
27 **Martin Lienert,** r2b energy consulting GmbH
28 **Steffen Lindemann**, Ministry for Energy, Infrastructure and Digitalization in Mecklenburg-Western Pomerania
29 **Stefan Lochmüller**, N-ERGIE Aktiengesellschaft
30 **Tina Löffelsend**, Friends of the Earth, Germany e.V. (BUND)
31 **Werner Lutsch**, Association for Energy Efficiency in Heating, Cooling and CHP e.V. (AGFW)
32 **Johannes Meya**, Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (Bundesnetzagentur)
33 **John Miller**, Association for Energy Efficiency in Heating, Cooling and CHP e.V. (AGFW)
34 **Claudia Mitsch-Werthwein**, Ministry of the Environment, Climate Protection and the Energy Sector in Baden-Württemberg
35 **Karsten Mitzinger**, Association for Heating Supply e.V.
36 **Marie Münster**, Technical University of Denmark
37 **Bastian Olzem,** German Association of Energy and Water Industries e.V. (BDEW)
38 **Markus Peek**, r2b energy consulting GmbH
39 **Maren Petersen**, German Association of Energy and Water Industries e.V. (BDEW)

40 **Carsten Pfeiffer,** German Renewable Energy Federation (BEE)
41 **Dennis Rendschmidt**, Federation of German Industries (BDI)
42 **Michael Richts**, Senator for Building, Environment and Transportation in Bremen
43 **Anna Rohwer**, Ministry for the Energy Transition, Agriculture, Environment and Rural Spaces in Schleswig-Holstein
44 **Florian Schaefer**, State Ministry for Commerce, Labor and Transport in Saxony
45 **Sabine Schmedding**, German Wind Energy Association e.V.
46 **Thorsten Schmiege**, Bavarian State Ministry for Commerce and Media, Energy and Technology
47 **Fabian Schmitz-Grethlein**, Association of Local Utilities e.V. (VKU)
48 **Milena Schulz-Gärtner**, Ministry for the Energy Transition, Agriculture, Environment and Rural Spaces in Schleswig-Holstein
49 **Oliver Seel**, Federal Environment Agency (UBA)
50 **Stephan Seiler**, Agency for Environment and Energy in Hamburg
51 **Frank Sensfuß**, Fraunhofer Institute Systems and Innovation Research (ISI)
52 **Christoph Sievering**, Federation of Industrial Energy Consumers and Self-Producers e.V. (VIK)
53 **Jana Spieß,** Senate Department for Environment, Transport and Environment, Land Berlin
54 **Uwe Steffen,** Ministry for Commerce and Energy, Land Brandenburg
55 **Peter Stratmann**, Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (BnetzA)
56 **Monique Strübig**, Ministry for Agriculture, Environment and Energy of Saxony-Anhalt
57 **Silvana Tiedemann**, Ecofys
58 **Nils Thamling**, Prognos AG
59 **Volkmar Voigt**, State Ministry for Commerce, Labor and Transport in Saxony
60 **Stephan von Hundelshausen**, German Association of Electrical and Electronics Manufacturers e.V.
61 **Gabriele Werner**, Member of the SPD parliamentary group in the Bundestag
62 **Günter Wignanek,** Ministry for Commerce and Energy, Land Brandenburg
63 **Philipp Wolfshohl**, Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (BnetzA)
64 **Marco Wünsch**, Prognos AG

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