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IMPACTS OF POLICY MEASURES ON THE DEVELOPMENT AND DIFFUSION OF MICRO CHP TECHNOLOGY IN GERMANY

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13.1 Introduction

The utilisation of combined heat and power (CHP) generation is an important component of Germany's CO_2 emission reduction strategy. Since 2002 the CHP law (*Kraft-Wärme-Kopplungsgesetz KWKG*) has set the target for CHP to attain a share of 25 % in German electricity generation capacity by 2020. This target is part of the EU's 2020 targets to reduce greenhouse gas emissions by 20 %, increase the share of renewable energy in final energy consumption to 20 % and realise 20 % of energy efficiency improvements (European Commission 2010).

CHP technology has been applied for decades in large-scale commercial power plants as well as in medium and small scale decentralised installations. However, micro CHP (capacity of less than 5 kWel) technology is still emerging because crucial components have only been developed recently or are still at the stage of technological development and demonstration.

Since the KWKG came into force in 2002, a number of policy measures have been taken to promote the use of micro CHP technology. While this has led to an increase in sales numbers for mini CHP plants with capacities between 5 and 50 kWel, smaller units have not benefitted in the same way. Therefore, the aim of this work is to examine the impact of policy measures on the development and diffusion of micro CHP technology in Germany.

There has been considerably more political activity in the energy sector than in other sectors. Numerous technical decisions have therefore been triggered by policy measures. Due to the prominent role of policy measures in the development and deployment of low-carbon technologies, it is appropriate to analyse the impact of these measures. Micro CHP as a potential technology for future electricity and heat supply for households is an interesting field for this analysis.

Before analysing their impact, policy measures affecting micro CHP technology development and diffusion have to be identified and categorised and further framework conditions affecting CHP like administrative requirements and energy market conditions are defined. At the company level, a number of relevant factors for innovation decisions regarding micro CHP can be found. These factors are then discussed and based on a framework for development and diffusion activity, key questions for the methodological approach of the study are derived.

Since the character of this study is exploratory, qualitative expert interviews were chosen as a method. Most of the innovation activity in the micro CHP sector is accomplished by corporate actors, therefore company representatives were chosen as interview partners. The results presented here are based on expert interviews with representatives of five different firms.

The contribution is structured as follows: the next section will give an introductory overview of the state of micro CHP technology and market development. Section 13.3 provides the theoretical background, consisting of the underlying understanding of innovation, the categorisation of the political framework and the structure of the interview process. In Section 13.4, the results of the expert interviews are presented and in Section 13.5, recommendations for a more efficient policy design are derived. Section 13.6 contains a discussion of results and final conclusions.

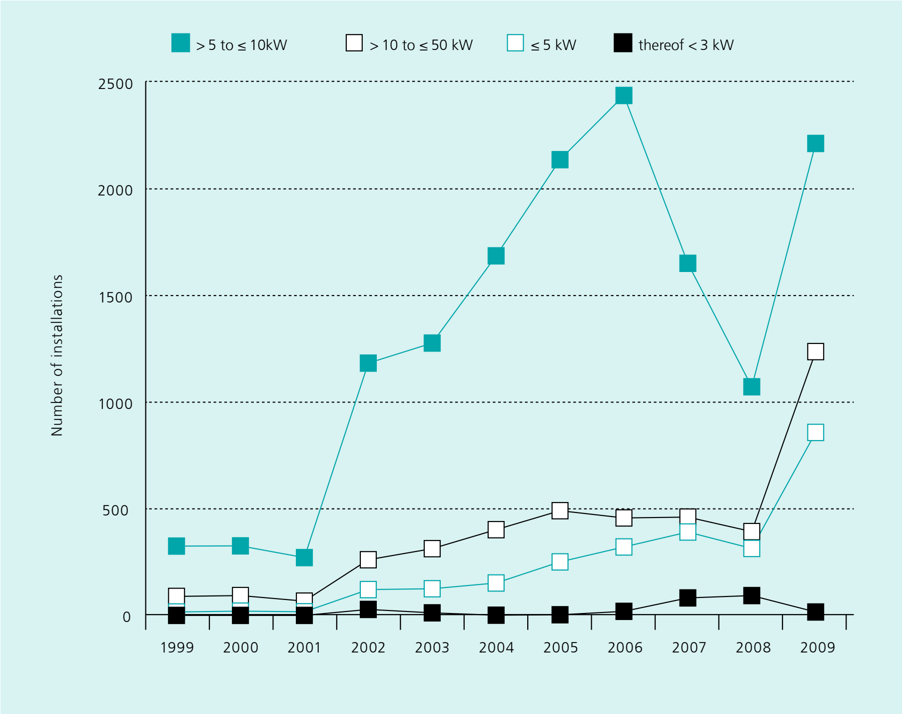
13.2 State of micro CHP technology and market development

Currently, there are three main technology groups competing in the micro CHP market. Most available units are equipped with internal combustion engines (ICE), while considerable development activity can be seen in the area of stirling engines (SE) and fuel cell systems. Out of 30 products monitored by a micro CHP information service[1], as of November 2011, twelve are commercially available. Eight units rely on ICEs, three are equipped with SEs and one unit used a free-piston engine, but is no longer available because the manufacturer declared bankruptcy.

CHP generation in Germany mainly takes place in large plants. In 2001, only 6.7 % of CHP electricity production came from small-scale CHP installations (Bauer 2009), since then the market structure has not changed significantly. After the KWKG came into force in 2002, there has been an increase in the number of smaller installations, but installed capacities have not yet reached levels comparable to large scale commercial power plant CHP production. The development of installation numbers for mini and micro CHP plants in Germany from 1999 to 2009 is illustrated in Figure 13–1. The figure clearly illustrates that the share of micro CHP installations below 3 kWel is still insignificant.

1 See http://www.stromerzeugende-heizung.de.

Figure 13–1: Mini and micro CHP installations in Germany from 1999 to 2009



Source: own illustration, Federal Office of Economics and export control data

In 2010, electricity production in CHP plants reached 15.8 % of total generation. Almost 60 % of CHP electricity production comes from natural gas fired installations, 22 % from coal fired installations and a growing share of currently almost 13 % is produced using renewable energy sources, i.e. biomass (UBA 2012).

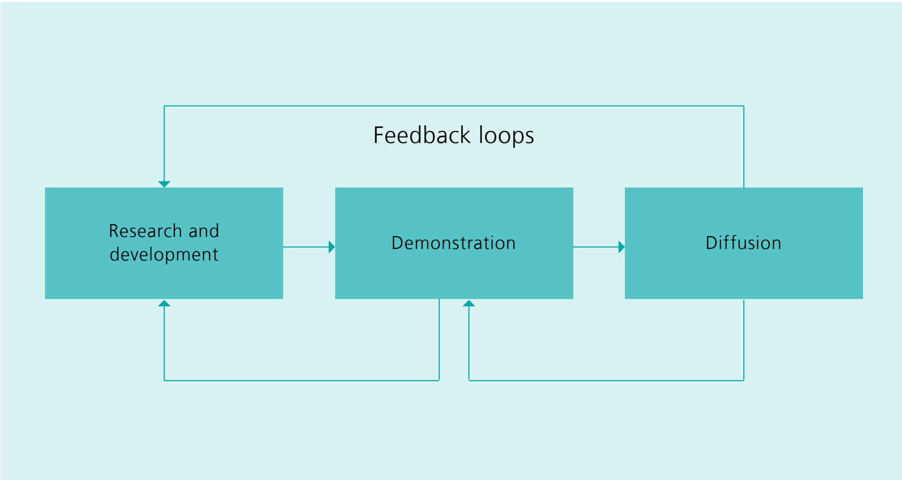
13.3 Theoretical background

In a market economy, politics cannot directly participate in economic decision-making. Instead, influence on corporate decisions and innovation activities can be exerted by a number of different policy mechanisms and institutions. The political support for CHP installations in Germany is based on the technology's positive effect on CO_2 emissions and primary energy consumption described in the first section. In the following section, underlying concepts will be described, policy mechanisms will be systemised, and the existing policy framework for micro CHP in Germany will be described.

13.3.1 The innovation process

To start with, the innovation concept underlying this study has to be clarified. Innovation processes consist of three overlapping and interacting phases which are not intended to be understood as a linear process. It is however possible to determine a sequence of phases. First, knowledge has to be generated (research and development). In a next step, this knowledge has to be translated into products (demonstration), and finally these products have to be distributed and adapted to consumer requirements (diffusion) (Pavitt 2005). There are various feedback loops between these phases, making the process non-linear. (Edquist 2005). This understanding of the innovation process is illustrated in Figure 13–2.

Figure 13–2: Phases of the innovation process



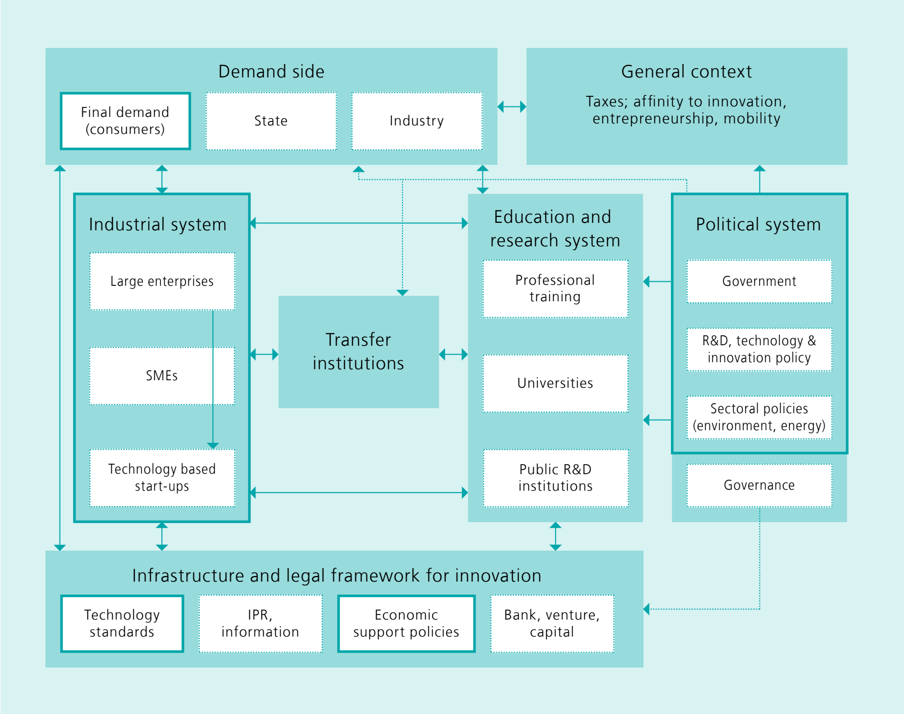
Source: based on Pavitt (2005)

When analysing technological innovation systems (cf. Carlsson 1995), technology development and, accordingly, framework conditions are the focus of attention. Suurs (2009) describes the approach as related to the micro-level of innovation processes, so it is an approach suitable to investigate firms' reactions to the political framework, which is the aim of this work.

Legal framework conditions are an important part of the technological innovation system. Besides technology development and diffusion, a number of other components in the innovation system interact with the political system, but the scope of this work has to be limited to selected parts. Based on the innovation system heuristic commonly used in studies by Fraunhofer ISI (cf. Chapter 1 of this volume), Figure 13–3 clarifies which areas of the (technological) innovation system were selected for the analysis. It also depicts where policy measures for CHP have effects and which actors play important roles in technology development and diffusion.

On the demand side, the focus of this study is on final demand, since private consumers constitute the largest share of home owners in the area of detached one- and two-family houses. On the supply side, no limitations regarding firm size or other

Figure 13–3: Relevant technological innovation system components and their interaction



Source: own translation of Edler (2007, p. 42)

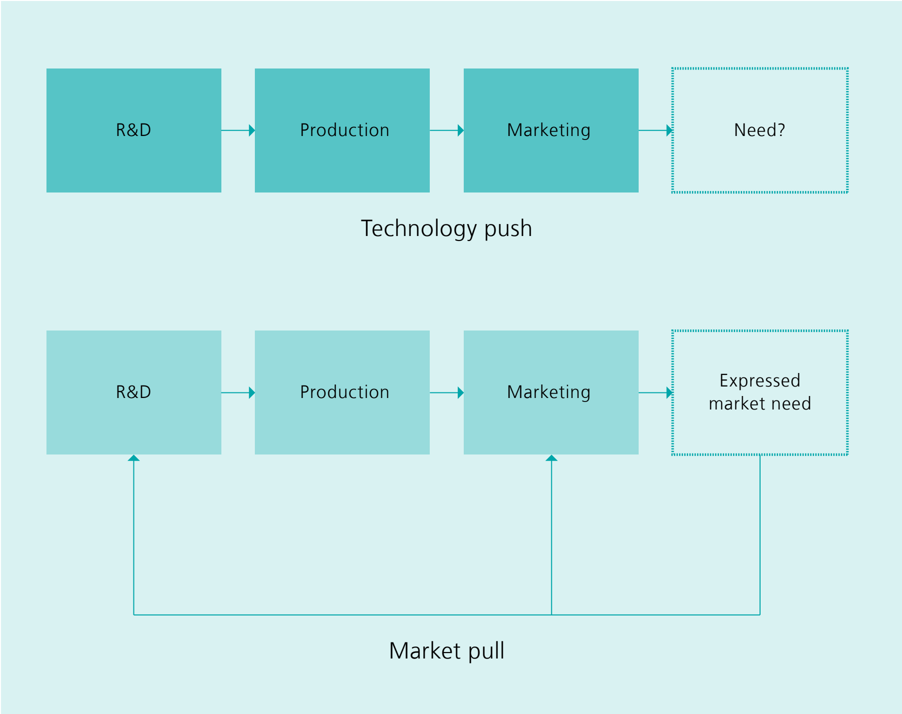
specifics were taken because the number of firms active in the area of micro CHP is quite small. Infrastructure and legal framework conditions investigated included technology standards and economic support policies. Financing and intellectual property right (IPR) information was included wherever possible, but due to the sensitivity of this data, this was not the centre of attention. With regards to the political system, pre-interview analysis was limited to the investigation of existing policy measures. Governance style and non-legally binding measures were not included to keep the scope concise.

Public education and research and transfer institutions were excluded from the study because most micro CHP development activities take place in private companies and cooperation with public research institutions only occurs to a very limited extent.

13.3.2 Categorisation of policy measures

As noted in the previous subsection, policy measures to promote CHP technology impact different elements of the technological innovation system. In this section, a classification of policy measures is undertaken. This classification is useful because

Figure 13–4: Technology push and market pull



Source: Martin (1994, p. 44)

innovation processes exhibit a number of different mechanisms. On the one hand, innovation processes can be triggered by research and development activities and inventions that give the respective company a competitive advantage which can be taken to market. In this case, final demand for the product is uncertain. The technology driven introduction of new products is called "technology push" (cf. Figure 13–4). This development contrasts with the so-called "market pull" mechanism, where an innovation process is initiated by an expressed or perceived demand for a certain product or service (Martin 1994). To correspond to these mechanisms, policy measures can be classified as being either demand-side or supply-side oriented.

A further useful distinction of policy measures is offered by Edler (2007). He describes direct, indirect and regulatory measures. Following this categorisation, policy measures relevant to micro CHP technology can be classified as shown in Table 13–1. In the next sections, German policy measures for the CHP sector will be identified according to this scheme.

Table 13–1: Supply and demand side policy measures relevant for micro CHP development and diffusion

	Supply side	Demand side
Direct support	(Financial) R&D support	Subsidies, bonuses and tax rebates
Indirect support	Educational and regional economic policy	Raising of awareness, information
Regulation	Product requirements	Technology standards (best available technology, building efficiency requirements), mandatory use of technology

Source: own compilation

Supply side policy measures

Supply side policy measures do not play a prominent role in German CHP policy. The only exception is strong R&D support for fuel cell research (OECD 2011), which is potentially a technology that can be applied to micro CHP installations. The National Hydrogen and Fuel Cell Technology Innovation Programme (NIP) has a volume of 1.4 billion euros, spanning from 2008 to 2016. It benefits the sectors transport, stationary energy supply in industry and households, and special markets.

The Callux project is a large-scale field test programme for fuel cell heating appliances, co-funded by industry and the NIP with up to 86 million euros. As of March 2012, 211 fuel cell heating units have been installed under this programme.

Further supply side measures mainly address energy and resource efficiency issues with merely indirect results for the micro CHP sector. There is no public R&D supply for combustion engine driven CHP units listed in current funding databases of both the Federal Environment Ministry and the Federal Ministry of Education and Research. Also, only very limited activity by universities or other public research bodies can be monitored.[2] The only topic apparently receiving some academic attention is the application of micro CHP units in virtual power plants, i.e. the coupling of decentralised generators to level out fluctuation in renewable energy electricity generation (Houwing et al. 2009). A recent study investigating the technological innovation system for micro and mini CHP in Germany concludes that the micro CHP sector in Germany has mainly developed due to corporate activities, and not because of public R&D support (Praetorius et al. 2010).

Demand side policy measures

On the demand side, the political framework for micro CHP technology is more

2 Exceptions are micro CHP field trials conducted by the chair for energy economy and application technology at Technische Universität München and a number of CHP related research projects coordinated by the Fraunhofer Information-Centre for Regional Planning and Building Construction.

comprehensive. Besides direct support mechanisms, a number of regulatory measures influence technology diffusion.

The first direct demand side support mechanism is a feed-in tariff for electricity generated in CHP installations. The KWKG guarantees a premium of 5.11 euro cent/kWh over a period of 10 years for operators of CHP installations with a capacity of less than 50 kWel. Furthermore, the KWKG guarantees prioritised grid access for electricity from CHP installations, which may only be denied if grid stability is endangered. However, the installation and grid connection of new CHP plants is complicated by a number of technical and legal restrictions and connecting conditions imposed by grid operators. A successful diffusion of micro CHP technology would require the removal of a number of technological and economic barriers (Watson et al. 2008).

Operators of micro CHP installations can benefit from further financial incentives. They may be exempted from energy taxes paid for fuel that is consumed and for electricity produced and consumed in close proximity to the installation. If the CHP plant is operated with biomass, instead of receiving the KWKG feed-in tariff, operators can also apply for funding through the Renewable Energy Act (*Erneuerbare-Energien-Gesetz EEG*), which offers a higher fixed remuneration over a period of 20 years.

Rather than aiming at reducing the operating costs of CHP installation, a second set of direct support mechanisms helps to reduce the initial investment. The "Impulsprogramm", a support programme for micro and mini CHP installations, granted an investment subsidy of 1550 euros/kWel for installations with a capacity of up to 4 kWel from 2008–2009. Due to the unexpected success of the programme, from August 2009 onwards, no more funding notifications were issued, and in March 2010 the end of the programme was backdated to August 2009. In January 2012 however, a new subsidy programme was announced, supporting new installations with 1500 euros/kWel for a capacity of up to 1 kWel and 300 euros/kWel for capacities of 1–4 kWel. When the programme was announced, no volume or funding time limitations were published, and changes to support rates can be made at any time. Furthermore, the state owned KfW bank issues loans with reduced interest rates for energy efficient building renovations.

In terms of regulatory measures, the Renewable heat act (*Erneuerbare-Energien-Wärmegesetz EEWärmeG*) obliges home owners to include renewable energy sources in the heat supply of new buildings. They can be exempted from this obligation if a micro CHP unit is installed.

Hawkes and Leach (2008) point out that energy efficiency measures like the Energy Saving Ordinance for new buildings (*Energieeinsparverordnung EnEV*) combined with support for micro CHP installations may be problematic. The resulting CO_2 emission reductions can be small or non-existent if the building's heat demand is too low to allow for efficient operation of the CHP plant. The authors demand that support for CHP installations is coupled with the requirement to prove that there is sufficient heat demand and that the installation is dimensioned accordingly.

Public procurement can also support the diffusion of innovative technology (Edler 2007). In this context, the public building refurbishment programme can be seen as potentially relevant for CHP diffusion because one focus of this programme is on energy efficiency of buildings.

The previous sections have shown that there are a considerable number of policy measures influencing the market for micro CHP in Germany. The overall context of these measures is the commitment to reduce CO_2 emissions and reach international climate policy targets. The main focus of micro CHP-related policy measures is on the demand side, consisting of direct support as well as regulatory mechanisms. On the supply side, only one instrument could be identified. Furthermore, a lack of indirect support instruments is noticeable; possibly resulting in reducing the effectiveness of direct measures (cf. Table 13–2).

Table 13–2: Summary of policy measures for CHP technology in Germany

	Supply side	Demand side
Direct support	NIP	KWKG, EEG, Impulsprogramm, tax exemptions
Regulation		EEWärmeG, EnEV

Source: own compilation

Besides policy measures, further framework conditions influence CHP technology development and diffusion.

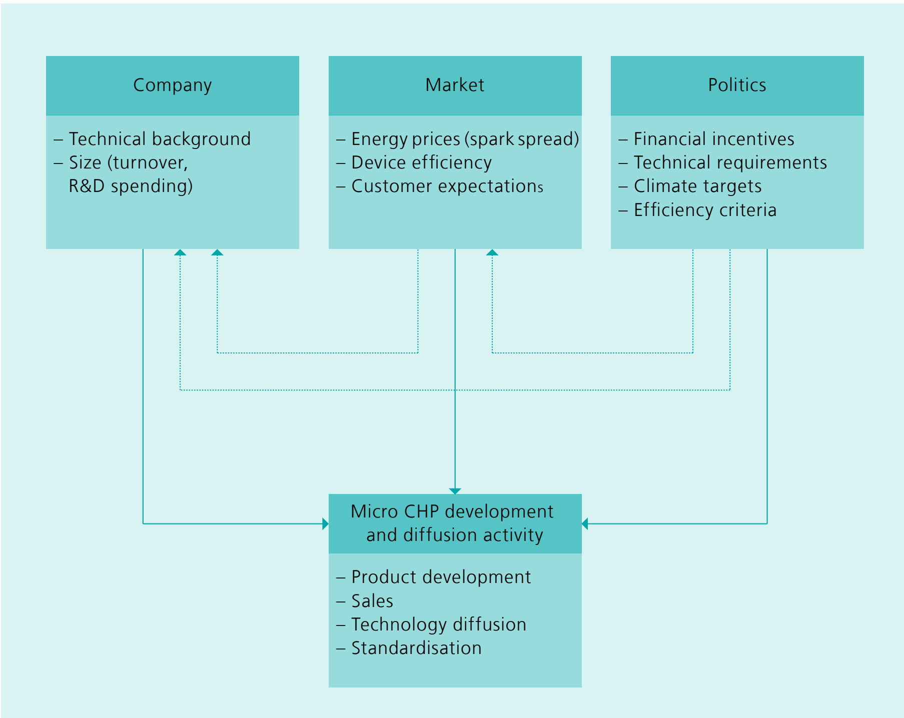
- legal aspects: grid connection conditions, purchase obligation for grid operators
- market development: competing technologies, (fossil) fuel and electricity prices
- administrative procedures (as follows)

To receive full financial support for micro CHP installations, it is necessary to go through numerous procedures. The comprehensive demand side support results in an increase in administrative requirements when operating micro CHP plants. Potential users have to contact at least three different additional authorities compared to one when installing a condensing boiler if they want to benefit from all the preferential treatments available. These authorities are the Federal Office of Economics and Export Control (for investment subsidies and feed-in remuneration), the customs office (for tax exemptions) and the local area electricity grid operator (for grid connection). The additional effort is compensated with revenues from several support mechanisms which reach around 8 % of heat generation costs for a typical micro CHP installation. Even with these subsidies in place, micro CHP installations are still not cost competitive in most cases.

13.3.3 Structure of the interview process

The aim of the interview process was to gain insights on how actors in the German micro CHP market perceive the influence of policy measures on their development and diffusion activities. Since these activities are influenced by a number of factors, these will first be discussed briefly. Then, the three main questions that form the underlying structure of the interview process are presented. In total, there are three main groups of influences on micro CHP development and diffusion activity which are summarised in Figure 13–5. First, prevailing expertise and origin of business (path dependency, cf. Dosi 1982) of the company predetermine the scope and direction of their activities. Second, market factors have a strong influence on development and diffusion activity. Third, and centrally for this investigation, politics influence development and diffusion activity as well as the other two groups of factors. Because of numerous additional interdependencies between the three groups, it is difficult to isolate one of them. Instead, this study attempts to gain an overview and then weight the influence of different factors. Accordingly, the main questions that served as the guideline for the interview process relate to the influencing factors identified.

Figure 13–5: Influences on micro CHP development and diffusion activity



Source: own illustration

The first main question tries to answer what degree of development and diffusion activity is shown by the interview participants. It aims to capture their motivation to enter the micro CHP market (cf. Beckenbach 2007), and who they see as their main competitors.

The second main question is how the interviewees perceive the importance of individual policy measures for their development and diffusion activities. One of the interviews' aims also was to determine what degree of independence from policy measures micro CHP manufacturers want to achieve and to what degree they could accept a dependence on policy measures.

The third main question is related to the participants' future expectations regarding market and framework conditions development. This includes asking which factors would benefit future technology development and what future framework conditions should look like to enable successful technology diffusion. This question also served as the basis for policy recommendations derived from the interview process.

13.4 Expert interview results

To gain insights from an actors' perspective on the impact of the German policy framework for micro CHP support, five expert interviews with company representatives were conducted. The interviews were structured around three main questions described in the previous section. In this section, the results are briefly summarised, according to the structure of these questions.

The expert interviews have yielded a number of interesting results. Albeit there are a considerable number of policy measures to support CHP technology, the positive effect of these measures is perceived to be fairly limited. The rate of diffusion of micro CHP is still very low. On the one hand, there still are not many devices that are commercially available. On the other hand, technology diffusion is also slowed down by a number of administrative barriers that are faced by prospective technology adopters.

13.4.1 Corporate innovation activity

The motivation for corporate activity in the micro CHP sector is mainly driven by path dependencies. Most actors have previous experiences in the condensing boiler market. Development activity is strongly motivated by politically imposed efficiency criteria and emission reduction targets, but financed by corporate funds. Other than in the area of fuel cell development, cooperation between manufacturers only plays a minor role, resulting in mainly independent technology development and diffusion activities of large producers of heating systems.

The participants expressed that they did not want to enter the micro CHP market as fast as possible, but rather aim to develop a technically sound product. Due to the long lifespan of heating systems, reliability is a very important product feature and malfunctioning systems would endanger the manufacturer's reputation.

In total, while there are no direct political requirements for micro CHP development and corporate activity is mainly motivated by firm-internal competencies, indirectly overarching efficiency and climate policy have an influence on these activities. However, the degree of these activities shows that political signals are too weak to override firm internal structures or development paths.

13.4.2 Influence of policy measures

The focus of the interviews was not on fuel cell development, therefore results regarding the relevance of policy measures for technology development and diffusion are related to engine driven micro CHP plants. The results are divided into impacts of direct support and regulatory policy measures.

For the relevance of direct support mechanisms, the participants' perception is congruent. The KWKG is described as a suitable and stable support mechanism, but its overall influence on technology development and diffusion is seen as low – possibly due to the fact that is has been in force for a relatively long time span. Most participants only took up activities in the micro CHP sector several years after the KWKG's enactment.

The Impulsprogramm is seen as a good support mechanism for an early stage of technology diffusion. However, the insecurity that was created by backdating changes to the programme is seen as an important barrier, neutralising the programme's positive impact. Several participants voiced the opinion that they would rather pass on investment subsidies in return for clearly set political and technical framework conditions. In sum, the positive impact of direct support mechanisms is not seen as strong enough to justify development activity, which is rather driven by firm internal factors, as described in the previous subsection.

The role of regulatory policy measures is seen as more differentiated. Efficiency requirements imposed by EEWärmeG and EnEV are generally perceived as beneficial for micro CHP because they increase customer awareness and final demand. Thus, these regulatory measures make markets accessible for the technology. If micro CHP competes against heat pumps or solar thermal heating support, its operation becomes financially more attractive than it would be in a situation where condensing boilers set benchmark prices. In this respect, the obligation to use renewable energy or micro CHP in heat supply for new buildings imposed by the EEWärmeG supports the technology. However, strict insulation requirements for new buildings limit the scope of application of the technology, making the impact of the EnEV ambivalent. Also, the degree of technical complexity makes it difficult for final customers to fully understand all exemptions and requirements, even leading some CHP producers to take over approval and accounting processes for their customers and, hence, inducing the development of service innovations.

In addition to complex administrative requirements, the role of local electricity grid operators is criticised. Technical requirements for grid connection are unclear, and, according to the interviewees, response time and collaboration with some grid operators are not satisfactory.

A positive indirect effect is seen to come from climate policy, which raises awareness of energy efficiency issues and thus helps to promote CHP technology. But all participants emphasise that positive political signals are outweighed by the previously named barriers. In total, the influence of the political framework is seen as rather a hindrance and, above all, inconsistent. The results for individual policy instruments are summarised in Table 13–3.

Table 13–3: Summary of interview participants' opinions on policy impacts on micro CHP development and diffusion

Direct support	**KWKG**	**Few explicit statements; weak positive signal for development activity**
	Investment subsidy (Impulsprogramm)	Positive signal for diffusion, negative impact due to lack of predictability
Regulatory measures	EEWärmeG	Stimulation of demand (micro CHP as replacement measure); raising of awareness and opening markets for diffusion
	EnEV	Negative impact on diffusion by reducing heat demand in new buildings; positive impact by favourable primary energy factor for CHP
	CO_2 reduction target	Positive impact on development and diffusion by raising of awareness, CHP perceived as efficient technology

Source: own compilation

13.4.3 Future developments

Participants expect that the diffusion of micro CHP technology can take place quite rapidly if an accordant political framework is set. Currently, a lack of predictability in micro CHP related policies as well as in energy policy in general is seen as an important impediment. Due to the current ambivalent design of policy measures, other areas of influence are perceived to have a relatively small impact on technology diffusion. If technical restrictions and administrative requirements are simplified and clear political signals for technology support are given, the manufacturers are confident that they can provide an efficient technology that may help to reduce primary energy consumption and CO_2 emissions. Given the right conditions, participants are also convinced that they can quickly become independent of direct financial support mechanisms.

In conclusion, it can be observed that one important point of criticism is the lack of coherence of policy measures. Interview participants appreciate the direct support for CHP technology through the KWKG and the Impulsprogramm. At the same time, these support mechanisms are slowed down by administrative complexity and technical difficulties which could be removed quite easily, increasing the effectiveness of existing support mechanisms.

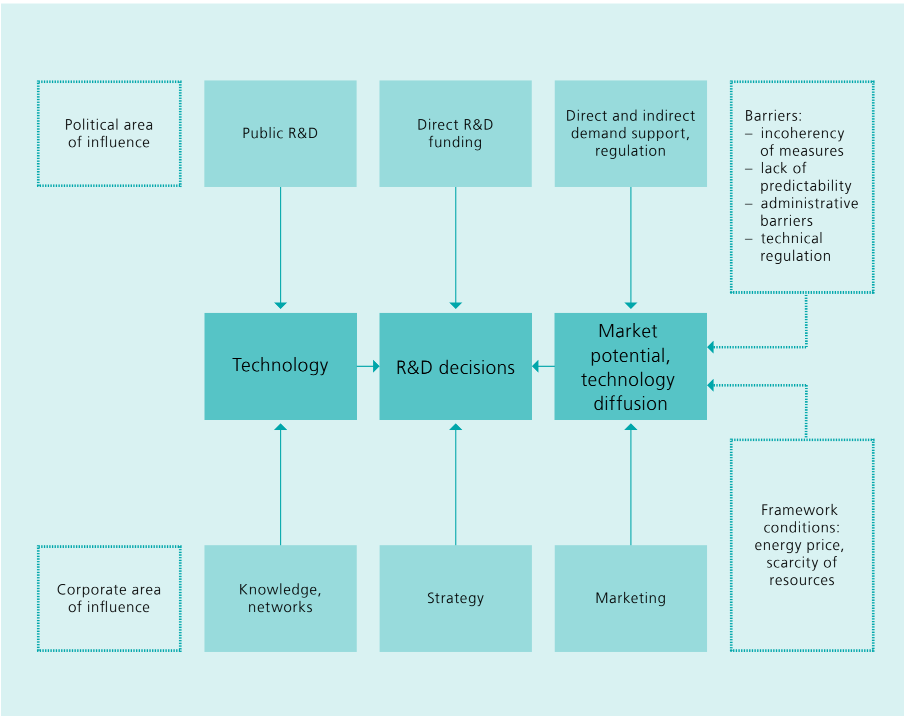
Another important result is that all participants claim that they want to become independent from direct support mechanisms. Even investment subsidies like the Impulsprogramm are only considered useful if they are combined with consistent framework conditions and reliable information on volume and time span of such support mechanisms. If these conditions are given, direct investment subsidies can considerably accelerate the diffusion of micro CHP technology. But currently, consumer uncertainty is fuelled by a lack of predictability of energy related political decisions.

Future expectations of interview participants can be summarised as pretty optimistic. They believe that micro CHP is a promising technology which offers considerable scope for application. Should producers be able to gain significant market shares, they are confident to be able to offer a competitive product and become independent of financial support mechanisms. However, until now, the influence of policy measures on technology development and diffusion is seen as rather small. A positive evaluation of existing policy measures to support micro CHP development and diffusion based on the results of the expert interviews can therefore not be given.

13.5 Policy recommendations

Based on the results presented in the previous section, a number of policy recommendations can be derived. The aim of these recommendations is to serve as guidelines for a more efficient policy framework design that can support technology development and diffusion without unjustifiable preferential treatment of micro CHP compared to competing technologies. However, it has to be kept in mind that the interviewees' opinions may be biased, and neutrality of results cannot be guaranteed.

Figure 13–6: Summary of determinants of corporate innovation activity



Source: own illustration

The results have shown that the direct influence of policy measures on corporate innovation activity in the area of micro CHP can be seen as relatively low. However, policy influence, technical regulation and perceived uncertainty on the demand side have a conflicting impact on technology diffusion and thus on the perception of market attractiveness by technology providers. Corporate innovation activity is determined by a number of firm internal and external factors, offering a number of starting points for policy measures. These are summarised in Figure 13–6.

Since most policy measures aim at direct demand support and also most barriers are identified in this area, recommendations derived from the interview results focus on the demand side politics:

– Removal of administrative barriers: Currently, mini and micro CHP installations have to pass the same approval procedures. Since micro CHP installations are mainly dedicated to non-commercial purposes, standardised processes could help reduce the administrative burden for potential customers.
– Modified calculation of avoided electricity network charges: If micro CHP installations are not used by their owner, but by tenants, the current incentive structure is not very attractive. Tenants will benefit from reduced heating costs, while the owner only receives the feed-in bonus for produced electricity and remuneration for avoided network charges. Interview participants find it questionable whether current calculation methods correctly capture these charges. They call for a modification, which could make micro CHP more attractive for operators who do not intend electricity and heat production for their own consumption.
– Improved design of investment subsidies: Both the previous and the current investment subsidy programme lack clear signals regarding volume and duration of the programme. The positive diffusion effect of such subsidies could be increased considerably if their predictability was improved. The current on and off-policy leads to extremely unstable markets.
– Adapted training of heating installers: Otto et al. (2009) suggest that heating installers are also trained in electrical engineering. Against the background of increased popularity of heat pumps and photovoltaic systems, this proposal is particularly relevant. A combined training would enable heating installers to promote the use of innovative heating technology such as micro CHP.

Compared to direct financial support, a probably less costly policy measure would be an information campaign to advertise micro CHP's efficiency advantages. Such a campaign could also be combined with advice on the correct dimensioning of installations and it could contribute to increasing the perceived attractiveness of the technology. To ensure its success, technical and administrative barriers would have to be removed beforehand. Concluding, Table 13–4 summarises the policy recommendations proposed in this chapter.

Table 13–4: Summary of policy recommendations

	Supply side	Demand side
Direct support	No need for action – support of fuel cell research sufficient, funding of micro CHP development by manufacturers	Positive evaluation of policy instruments, but predictability must be improved significantly
Indirect support	–	Information campaign could be a cost-effective way to promote micro CHP
Regulatory measures	–	Largest need for improvement: grid connection and administrative requirements pose important barriers for successful technology diffusion

Source: own compilation

13.6 Discussion and conclusions

As mentioned in the introduction to the previous section, the results from this study must be seen with caution because of the participants' bias. There are a number of other limitations to qualitative research which shall briefly be discussed in this section, before a conclusion will be drawn.

13.6.1 Discussion of results

The study did not aim to yield statistically significant results, but to conduct a first exploratory evaluation of the German micro CHP sector. Since this is still a relatively small market, even with a low number of participants, it was possible to gain broad insights into actors' perspectives. This does not make further research redundant; for example, surveys on customer acceptance and economic feasibility of micro CHP devices can offer important insights as soon as the number of available devices has increased.

When investigating corporate innovation activity, one general problem is that interviewees are asked for extremely sensitive data. While all interview results were made anonymous, still not all questions could be answered in all interviews, making some of the results incomplete. At the same time, results yielded have to be seen with caution, since all participants had the opportunity to prepare for the interview situation. Therefore, it cannot be ruled out that in some points the participation was seen as an opportunity to express political or marketing opinions. Thus, the assessment of political framework conditions undertaken in this study is not objective, but may be influenced by corporate interests. One important step for future research would be to triangulate results with opinions of different actor groups such as grid operators, politicians or final customers. In this study, this was prevented by a limited time frame.

One policy measure that was probably not assessed properly is the KWKG. Only one of the five participants was already employed in his current position when the

KWKG came into force, making it difficult for the other participants to fully acknowledge its impact on strategic decisions and innovation activity. This may result in an underestimation of the KWKG's positive effect on technology development.

A positive aspect that should be emphasised is that all participants were very interested in the topic of the study. The interviews took place in a very constructive atmosphere, and the interview results are broadly consistent with hardly any contradictions between different interview partners. Thus, the overall quality of the obtained results can be judged as fairly reliable.

13.6.2 Conclusion

In this study, a qualitative assessment of the impacts of policy measures on development and diffusion of micro CHP technology has been conducted. A partial analysis of the technological innovation system was undertaken by interviewing company representatives and gathers their views on the political framework and other influencing factors. The results allow insights into decision making processes and technology development activities.

The existing incoherent political framework has an ambivalent influence on the development and diffusion of micro CHP technology. While regulatory measures like EnEV and EEWärmeG favour high efficiency technology, requirements for grid connection and extensive administrative procedures when installing and accounting for micro CHP plants neutralise positive effects to a large extent. The direct support mechanisms KWKG, Impulsprogramm and tax exemptions had a positive impact on technology diffusion until backdated changes in subsidy legislation negatively impacted confidence in the political framework conditions. Interview participants claim that since these changes were made, demand for micro CHP plants has been very hesitant.

There were three main questions underlying the interview process. First, corporate innovation activity is mainly driven by internal factors and – with the exception of fuel cell development – not supported by public research funding. Second, the relevance of policy measures for technology development and diffusion is seen as ambivalent. Direct support mechanisms were seen as suitable instruments in an early technology diffusion phase, but participants call for a coherent policy framework rather than extensive financial support measures. The third and final question is related to future expectations and framework condition requirements for successful technology diffusion. Participants expect that, given suitable administrative and regulatory conditions, micro CHP can successfully compete in the heating market. It is now a matter of reaching significant sales numbers to build up political pressure in order to improve these conditions.

This leads to the final conclusion for an efficient policy design to facilitate micro CHP technology diffusion. A consistent, predictable policy framework is required for this, especially regarding direct support mechanisms. Reducing technical and administrative barriers to an acceptable level would result in a considerable improvement of micro CHP's competitiveness and accelerate technology diffusion. For the new investment subsidy programme, it is advisable to give clear indications with regard to duration and volume of the financial support to reduce consumer uncertainty. In general, the interview participants see a very promising market potential which can be fostered by a positive political framework.

13.7 References

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