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Exploring transition pathways to sustainable, low carbon societies

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Country Report 4: Regime analysis of the German heat system

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Executive Summary

For this analysis the German heat domain was sub-divided into two regimes, heat generation and heat demand, that were examined regarding the central regime elements relevant to space heating: Heating technologies and building stock. For each regime-element different incumbent sub-systems were identified. Heat generation in Germany is mainly based on gas and mineral oil and to a minor share on district heat. As a consequence, these subsystems were analysed. For the building stock, we focused on residential buildings. Each of the incumbent subsystems offers different potential onsets and restrictions for a low carbon transition. While e.g. heat generation suggests pathways primarily through environmentally friendly technologies and energy sources, heat demand and the building stock respectively, offer a huge potential for energy efficiency and energy savings through refurbishment.

Before the regimes themselves were examined, an analysis of landscape development revealed support for a transition of the German heat domain from outward sources. Even though not perceived as the major problem by the general public, environmental issues are an essential part of the political and societal debate in German society. This leads to a generally positive perception of environmental friendly technologies and an accordingly high acceptance in society and to support from the political side. German commitment to global and EU-targets and policies for climate protection and reduction of GHG-emissions contributes to a favourable landscape as well. Moreover, a concern for the security of resource supply manifested itself over the last years caused by volatile markets and political instability of some supplying countries leading to more intensive debates on measures for a transition.

For the heat domain itself the development over the past decade reveals decreasing energy consumption and CO_2-emissions. This development occurred despite of an increase of average living space per capita, a trend towards less inhabitants per unit and main heating technologies that are still relying on fossil energy sources (gas has a current market-share of 49 % and mineral oil has 29%, district heating ranges at about 12% (cf. BDEW 2013)).

The German government has set clear targets for emission reduction and energy efficiency that deeply affect the heat domain (“Energiekonzept”). Several measures have been introduced to reach those goals. They mostly aim to stimulate the markets and increase the adoption of green technologies in society. We hence see significant cracks and tensions in the German heat demand regime due to the political will and effort for change.

Since investment cycles are extremely long, retrofitting and replacement will play much more important roles than new construction. Next to legislative effort, the government promotes a transition by setting up funding schemes and monetary incentives to trigger refurbishment in the building stock. Another factor playing towards a transition in this regard is the age structure of the building stock. Almost 70 % of which was built before 1978, has not been refurbished yet and thus offers large potential for an increase of overall building energy efficiency through retrofit measures. Still, to reach an almost climate neutral building stock in 2050, the retrofitting rate would need to be raised from 1 % to 2 % of the building stock per year, and thus would effectively need to be increased by 100%. However, the assessment of many other actors in this field shows strong stabilising forces. Their main objections are

related to the economic reasonability of investments (amortisation time) and the split incentive dilemma, which leads to non-investment on the side of homeowners who cannot raise rents in accordance with the sums invested. Since a large amount of German housing is based on renting this leads to considerable disincentives for retrofitting. Also, many of these actors judge current policy design as not appropriate. The refurbishment rates needed for a fast transition are hence not reached.

We suggest that a more intensive refurbishment rate would yield knock-on effects to the technological subsystems in heat supply which has been identified as rather stable and locked-in. However, even though the external landscape promotes a shift away from fossil fuel to renewable energy solutions, here too, the present constellation favours regime stability. The present infrastructure is well established and an industry with strong associations as well as other interest groups stabilise the incumbent systems. Related to this, there are clear signs of asset specificity[1] leading to re-investment into known and already installed gas- or oil-installations and infrastructures, coupled with rather long re-investment cycles. Constant improvements of the related technologies with regard to efficiency are very favourable in this respect, too. Consumers perceive e.g. gas heating systems as an environmentally friendly heating solution due to its efficiency and cleanliness. A possible application with organic gas and the potential to couple both gas- and oil-heating with other renewable installations like solar-thermal also work towards a continuation of existing technologies.

Due to this lock-in situation, and especially caused by the dominance of gas heating systems, we do not expect a full regime shift in the heat supply regime. However, the assessment hints to (relatively) positive developments for a future transition towards a low-carbon society dependent on the refurbishment rate and the progress of technologies. Due to constant incremental changes in technologies concerning, for example, energy efficiency or compatibility with renewable energy sources (e.g. organic gas), an overall improvement in environmental regime performance could be expected.

All in all, we see the German heat domain on a critical point in its development towards a transition. If the amendment of incentives for retrofitting measures in the heat demand regime is convincing and knock-on effects to the heat supply subsystem follow, a regime shift may become much more possible. The resulting transition pathway could then be classified as a stronger Pathway A, with incumbent actors being lead actors, radically changing the (e.g. insulation) technology but leaving the other system elements as they are. The social dimension, e.g. the trend of increasing living spaces and other consumer related behaviour would not foreseeably be changed by this transition.

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[1] Asset specificity is embedded in the transaction cost theory (Williamson, 1975) describing the economic reusability and use of a capital good to a narrow purpose. "The asset specificity of a transaction refers to the degree to which the transaction needs to be supported by transaction-specific assets. An asset is transaction-specific if it cannot be redeployed to an alternative use without a significant reduction in the value of the asset. Asset specificity may refer to physical or to human assets" (S.Douma, H. Schreuder: Economic Approaches to Organizations, 2002).

1 Introduction: Background and Objectives

The purpose of this paper is the analysis of the German heat domain regarding space heating in residential buildings. The objective is to assess the degree of lock-in and path dependence of the existing regimes and possible cracks and tensions.
The approach is based socio-technical regime analysis (cf. Geels 2007). In an earlier task (2.1*"Niche innovations in the heat domain – case study of Germany"* (cf. Berg et al. 2014) the main objective was to investigate the extent to which niche innovations may contribute to a low carbon transition of the German heat domain. As a complement, this report (as result of Task 2.2) analyses the incumbent socio-technical regimes of the German heat domain with regard to established tangible system elements like infrastructure and technologies as well as intangible elements like institutional rules, routines and actors. In Figure 1, we provide an overview of the structure of the German heat domain, its established regime-elements and dominating sub-systems.

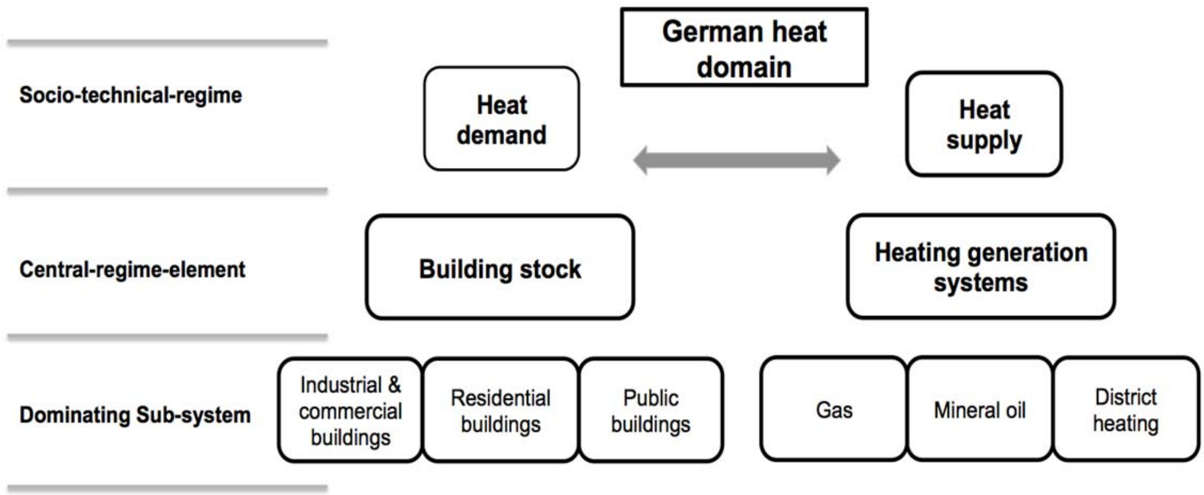

Figure 1: Sketch of the socio-technical regime of the German heat domain

The heat domain (of space heating) in Germany can be divided into two interdependent but distinct socio-technical regimes: heat demand and heat supply. Heat demand arises from the existing building stock, which changes over time due to the construction of new buildings, replacement and refurbishment of old buildings and changes in consumer behaviour. Thus, the central-regime element we focus on is the building stock of residential buildings as the dominating sub-system of interest. Heat generation on the other hand depends on the heating technologies in place and the energy resources required. For Germany, gas and mineral oil are mainly applied and are thus indicated as dominating sub-systems chosen for in-depth analysis. District heating is currently not a dominant heating technology in Germany, but due to its importance in other countries analysed in PATHWAYS, it is taken up to allow cross-country comparisons.
Even though related, the regimes have clearly differing characteristics: For example, heating appliances within a building can be replaced more easily than buildings themselves and thus have typically lower life-times, making them subject to shorter modernization cycles. Additionally, the principle of (water-based) central heating systems makes them an easy

leverage point for technological change: The heating technology can be changed (e.g. oil for wood pellets), while the water tubes etc. stay in place. The heat generation side may therefore undergo transitions at a higher pace than the building stock and follows its own transition pathway.

Another aspect is the potential particular contribution of each regime to a low carbon transition of the German heat domain. Heat generation has the potential for low carbon environmentally friendly technologies and energy sources, the building stock side on the other hand has a huge potential for energy efficiency gains through refurbishment and insulation as well as potential for energy savings through changes in consumption patterns.

This paper is structured as follows: First, the heat domain is described in terms of overall environmental performances, the regimes as well as central-regime-elements and sub-systems, and the domain’s longitudinal development (Chapter 2). Chapter 3 focuses on the main external landscape developments that influence the system. Chapter 4 and Chapter 5 describe the established socio-technical regimes heat generation and heat demand in more detail regarding tangible and intangible elements that are shaping, stabilizing or destabilizing these regimes. Chapter 6 will draw conclusions on the findings with regard to lock-in, path dependence, cracks and tensions within the German heat domain.

2 The German heat domain – introductory overview

Before starting with the socio-technical analysis of the heat domain, we present the overall status of the heat domain and describe the longitudinal developments of sub-systems in the heat supply (Chapter 2.1) and heat demand regime (11). In the last section of this chapter, we present the overall environmental performance of the regime with regard to CO_2-emissions, to give a reason for the need of a transition in the German heat domain.

2.1 Final energy consumption and energy for heating in private households

In 2013, almost 40 % (3 524 PJ) of the final energy consumption in Germany of about 9 269 PJ is related to the building sector (cf. BMWi 2014: 17). A major share of this is caused by space heating with 2 710 PJ. The building sector is sub-divided into residential buildings, commercial / industrial and public buildings. According to the PATHWAYS' research agenda, the following analysis will focus on residential buildings.

In 2013 the residential building sector had the largest final energy consumption by far with 2 603 PJ. 68 % of this amount is used for space heating, the remaining 32 % for water heating and other energy applications such as lighting, cooking etc. (about 16 % each) (cf. AGEB 2013, see also Figure 2). The German residential heat domain is thus responsible for a significant share of the country's total energy consumption.

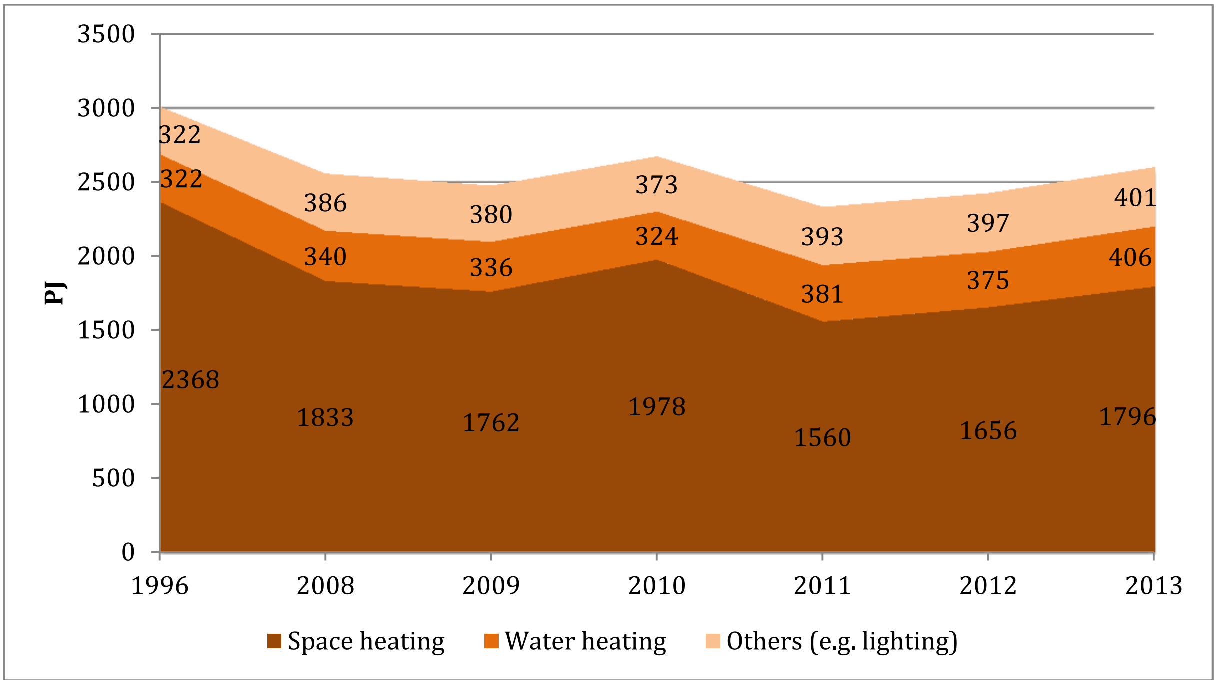

Figure 2: Final energy consumption in German private households
Source: Data AGEB 2013

In 2012 the heating structure of the residential building stock was primarily based on gas (49 %) and mineral oil (29 %), followed by district heating (12.8 %) and electricity (5.4 %) (cf. BDEW 2013: 13). Solid fuels like coal, wood (2.9 %) and heat pumps (0.7 %) played a minor role (see Figure 3). A shift from coal and mineral oil towards more environmentally friendly energy carriers such as gas has occurred since 1995 (see Figure 3). For the analysis of the incumbent regime in heating technologies, this paper hence focuses on the subsystems gas, mineral oil as the most important sources of heat at present and touches upon district heating.

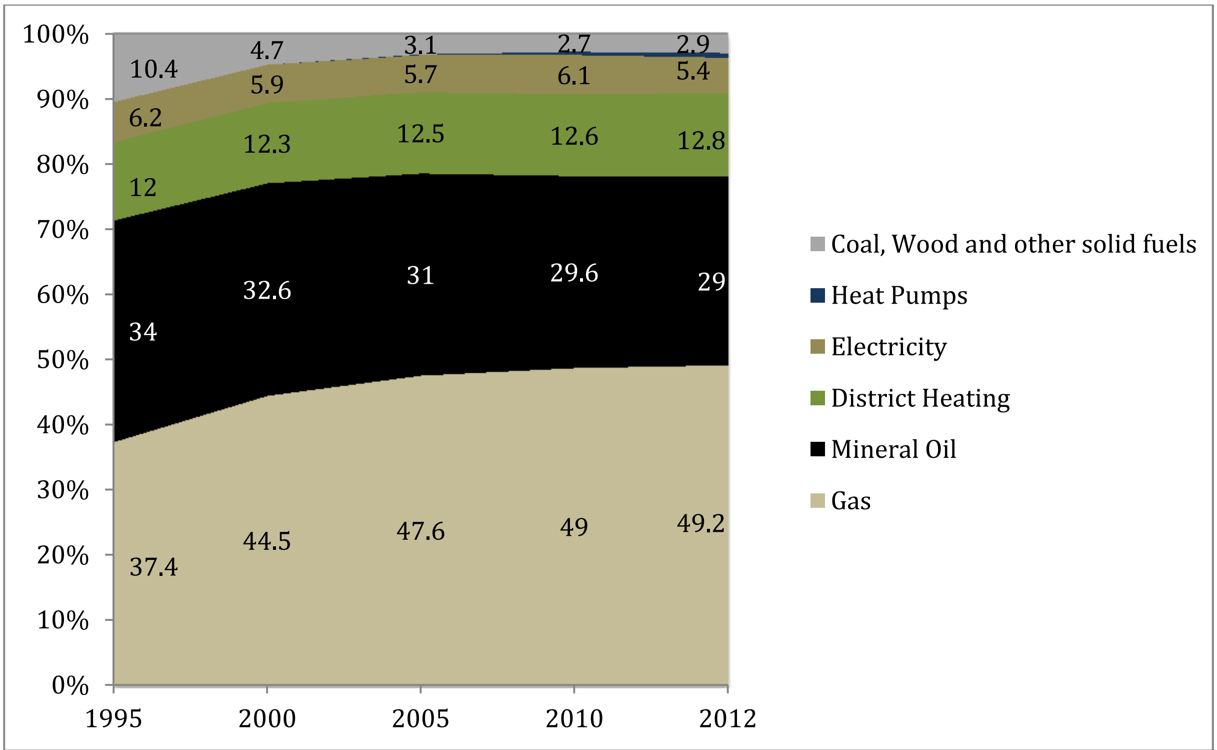

Figure 3: Heating technology appliances in the German residential building stock from 1995-2012 in %
Source: Data BDEW 2013

The development of the heating technologies and energy sources indicates that a sustainable transition of the German heat generation regime towards low-carbon energy sources is not imminent and will be a long-term goal. Over the past 10 years gas and mineral oil heating systems with a share of almost 80 % were the dominant technologies and energy sources. Nevertheless, the development of the absolute numbers reveals a constant increase of energy efficiency for the heat generation regime: Figure 4 shows a decreasing demand for fossil fuels, particularly mineral oil, gas and coal, over the last decades. While the relative share of gas-heating systems in the building sector increased from 37 % (1996) to 49 % (2012) the absolute gas consumption declined over the last decades from 1 152 Petajoule 1996 to 903 Petajoule 2012 (cf. BMWi 2014a: 8). Mineral oil heating systems also show a significant increase in energy efficiency. The relative share in the heating structure decreased by 5 percentage points from 34 % to 29 % (cf. BMWi 2014a: 8). However, the absolute consumption almost halved between 1996 (950 Pj.) and 2012 (502 Pj.) (cf. BMWi 2014a: 8, see also Figure 4). Beside technological innovations in the field of heat appliances the reasons for the incremental energy savings also come from increasing insulation and refurbishment measurements in the residential building stock (cf. BMWi 2014a, Dena 2012).

In contrast to the data of the heating structure from the BDEW (Figure 3) data provided by the BMWi (Figure 4) exhibits a significant share of renewable energies for space and water heating. However, this share is mainly based on firewood (biomass) that is used in small furnaces/stoves. These furnaces are often employed as a secondary heating system in private households and therefore do not appear to this extent in data of the BDEW (2013), which only comprises the primary central heating systems in German households. Therefore it is important to note that the increasing amount of renewable energies (in Figure 4) over the last decade cannot be identified or assessed as an indicator for a transforming heating system towards environmentally friendly energy sources.

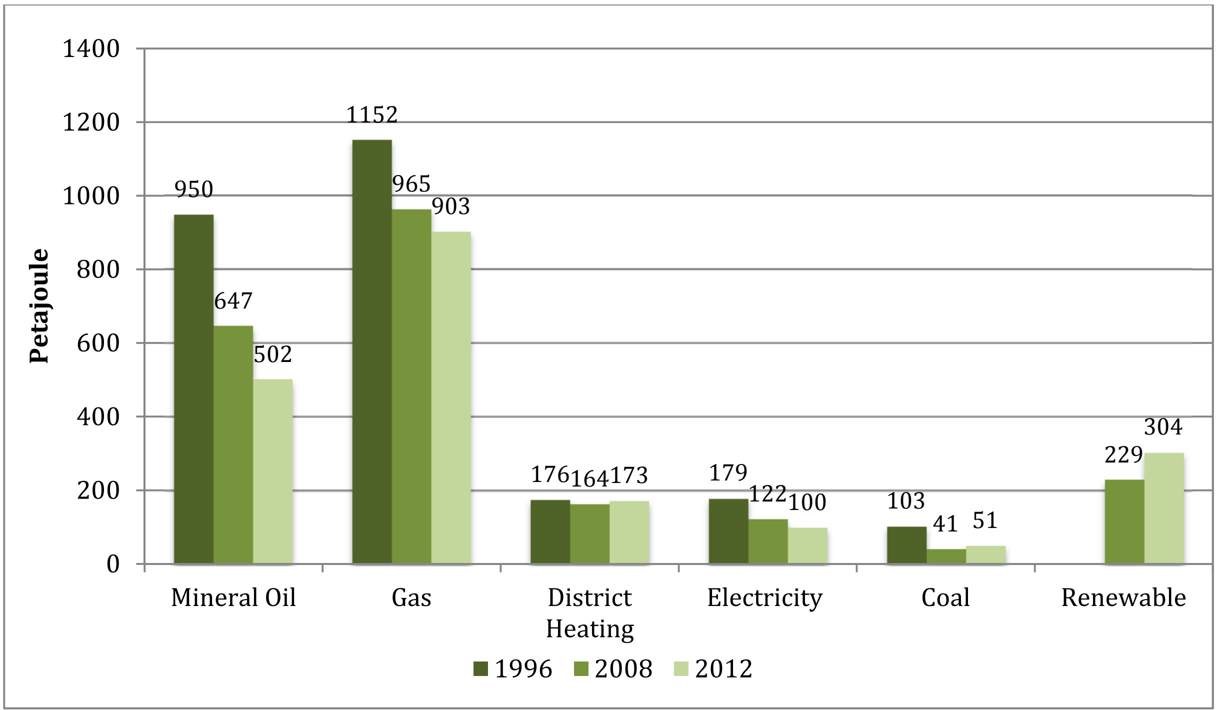

Figure 4: Allocation of energy source on space heating and water heating in German households Source: Data BMWI 2014a

Overall, the development of energy consumption is remarkable in the face of a contrasting development towards an increase in living space. From 2006 to 2012 heated living space increased by 3.6 % from 3.45 billion m^2 to 3.57 billion m^2 (cf. Destatis 2014).

2.2 Development and status of the Building sector

The heat demand of a building strongly depends on its energy efficiency characteristics (especially insulation). Legal efficiency standards in Germany have been tightened since the 1980s and reached low-energy standards since the enactment of the EnEV 2009 (cf. BMWI 2014a, see also chapter 3). Figure 5 shows total residential building area by year of construction. About 64 % of the building area has been constructed before the first building regulation (WSVO) in 1977, and about 95 % before the enactment of the already relatively strict EnEV 2002. Of this old building stock a large share has not been refurbished yet, which indicates a high amount of energetically inefficient building stock and implies a large potential for increasing the overall energy efficiency for German residential buildings (cf. BMWi 2014a).

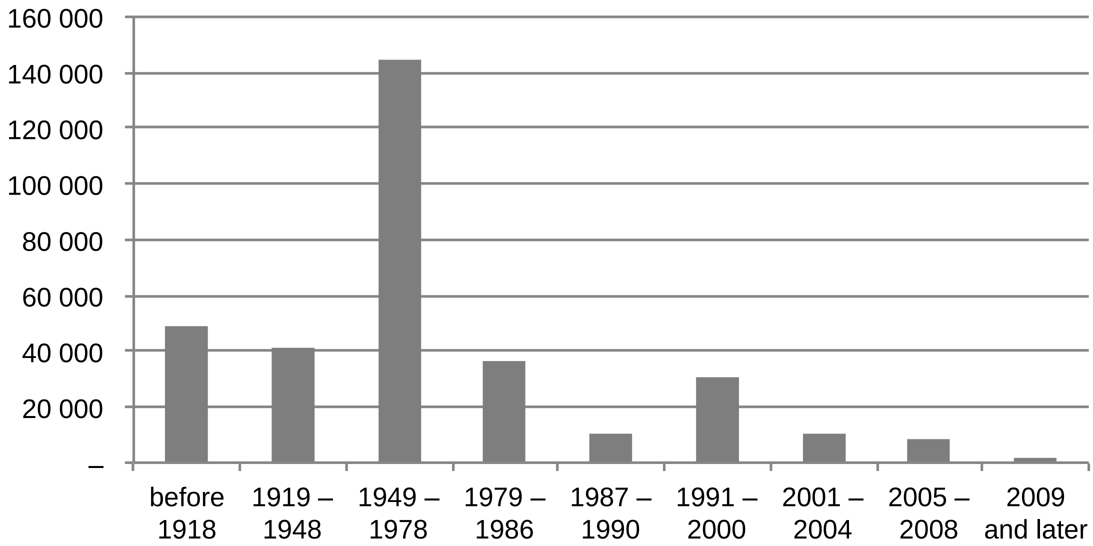

Figure 5: Residential building area by year of construction[2] (10,000 m^2)
Source: Data from Destatis (2010)

In addition, over half of German buildings are rented, representing 72 % of all households (cf. BMWI 2014a). This leads to a deceleration effect in refurbishment known as "split incentive dilemma": While the owner has to invest, it is the occupants who mostly profit from efficiency gains[3] since – due to legal regulation – only a limited part of the investment may be realized through a raise of rents. Figure 6 provides an overview of the occupation structure of the residential building stock after year of construction.

[2] The time-series by year of construction based on political developments: for example „post-war period“ as well as „striking ordinances“ and is therefore given by Destatis and can not be modified.
[3] In Germany, tenants usually pay for heat and electricity based on individual metering of housing units.

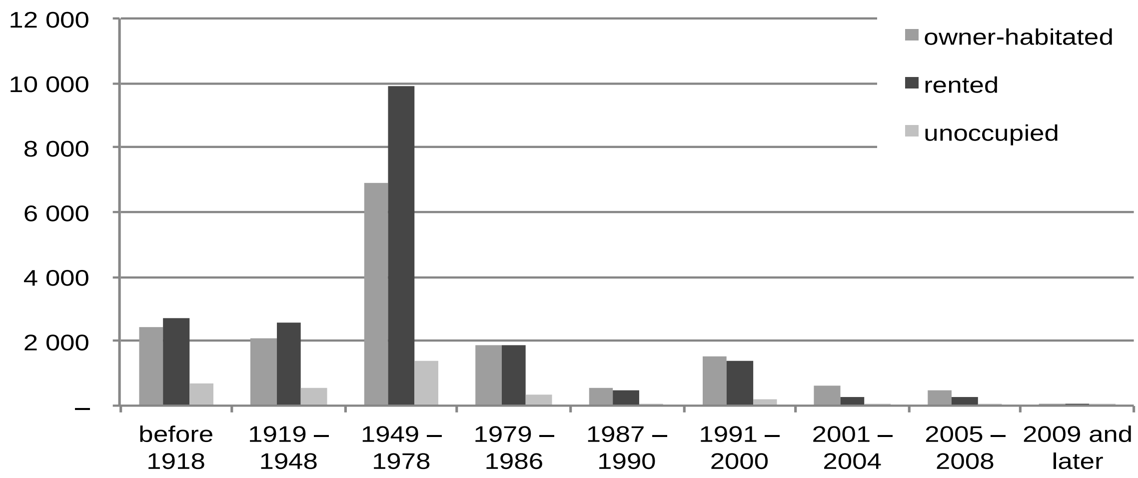

Figure 6: Number of residential buildings by occupation type and year of construction[4]
Source: Data from Destatis (2010)

2.3 CO_2-emissions of private households in the heat domain

In 2012, the overall CO_2-emissions[5] amounted to 894.6 million tons in Germany (c.f. Destatis 2014a). With a total share of 18 % space heating (135 million tons[6]) and water heating (26 million tons[4]) in private households caused almost one fifth of the overall CO_2-emissions (see Figure 7) (Destatis 2014 & 2014a). In the last decade the CO_2-emissions of private households have been reduced by 13 %. This development is mainly based on three factors: 1) replacement of old heating technologies (e.g. boilers), 2) increased expansion of gas heating systems instead of mineral oil or coal and 3) progressing refurbishment of the existing building stock (insulation) (cf. BMWi 2014, AGEB 2013).

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[4] The time-series by year of construction based on political developments: for example „post-war period“ as well as „striking ordinances“ and is therefore given by Destatis and can not be modified.

[5] The overall CO_2-emissions are based on CO_2-equivalent calculations and comprise direct and indirect climate-relevant greenhouse gases in all sectors of Germany (not temperature corrected).

[6] The calculated values (CO_2-equivalent) for space heating and water heating respectively comprises direct and indirect greenhouse gases as well and are temperature corrected for the stated period. Therefore the total share of 18 % comprises small inaccuracies and differs minimally from the realities.

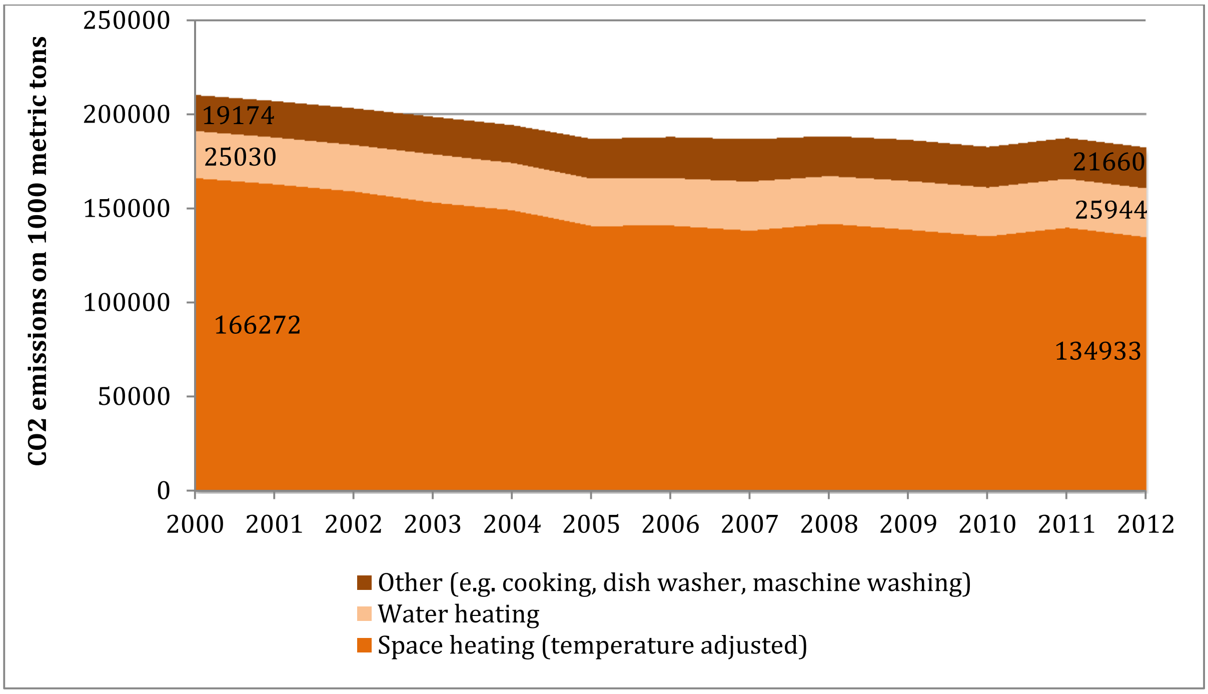

Figure 7: CO_2 emissions (direct & indirect[7]) for private households in Germany in 1 000 metric tons Source: Data Destatis (2014a)

[7] CO_2 emissions within the preparation/supply for the energy source

3 Landscape development: Political and social developments, and economic influences through resource supply and markets in the German heat domain

The landscape relevant for the German heat domain is influenced by factors and developments on a global, European and German level. In this chapter we firstly present the general evolution of the environmental discourse in German society and politics with a focus on developments relevant for the heat domain. We introduce the political debate on climate change and relevant targets set on international, European and German level and how Germany translated those targets into its energy strategy, the "Energiekonzept", also influences from the global resource markets are shortly discussed. In a second step we look more closely into relevant legal developments such as new regulations or funding programs directly addressing the heat demand and heat generation regimes.

3.1 Influences from the environmental discourse in Germany

Triggered by negative environmental impacts from economy and promoted through favourable conditions in civil society and the political environment, a new policy field emerged in the late 1960s : environmental policy (cf. Aden 2012). First steps in this young policy field were the institutionalization and definition of responsibilities, which initially were waste, emissions and water. The institutionalization on an international level was promoted by the oil crises and the Club of Rome´s publication of "Limits of growth" in the early 1970s (cf. Aden 2012). Both influenced and dominated the public discourse in Germany and led to a gap between public perception and politics: Due to the global recession at that time, the political actors' main focus was on economic policies promoting Germany´s economy instead of environmental issues, while the public became more and more interested in the environmental debate. The gap was further widened by a growing debate on the use of nuclear power. This issue polarised society and was, beside other environmental issues, taken up by an establishing social movement advocating ecological responsibility and environmental aspects (cf. Brand 1993). In the 1980s, a new "Green" party emerged drawing part of its members from these environmental movements. This party would later continually improve its political influence (cf. Aden 2012). In the second half of the 1980s, the mobilization of citizens first faded until it was reactivated by the Chernobyl catastrophe in 1986. This event also brought a further wave of institutionalization of environmental policy, leading to the establishment of the Federal ministry for the environment, nature conservation, building and nuclear safety (BMUB) (cf. Aden 2012). Today, this ministry is responsible for e.g. Environment, Building and Urban Development Policy, Climate Policy, Environmental Health, Emission Control, Water Management, Resource Conservation and Safety of Nuclear Installations. While Energy policy has also been dealt with in the BMUB, it has been shifted to the Federal Ministry for Economic Affairs and Energy (BMWi) in 2013 in the context of the "Energiekonzept" of the Federal Government of Germany.

Present surveys indicate that the German society does not perceive environmental issues as the most prominent problem for Germany. A representative survey by the BMUB (2015) revealed that while only 19 % named environmental protection, 37 % voted for social security as the dominant political issue on the national level. According to this survey, environmental policy is rather seen as a global problem, since 63 % of interviewees think that sufficient environmental and climate protection are fundamental to solve global challenges such as globalisation.

The political discourse regarding climate protection takes place on the global, European and national level. One important part of global climate protection policy has been the Kyoto Protocol that was signed in 1997 by 85 countries (including Germany), who committed themselves to reducing their greenhouse gas emissions (cf. UN 1998). In 2010 Germany also joint the Cancun agreements to consent that future global warming should be limited to below 2.0°C compared to the pre-industrial level (cf. UN 2011, UNFCCC 2014).
On the EU-level, in accordance with the 2°C-goal, the European Union set own energy and climate change targets with the Europe 2020 strategy which Germany is subject to. Main goals until 2020 are (cf. EC 2010):

- Reduction of greenhouse gas (GHG) emissions by 20 %
- Increase energy production from renewables by 20 %
- Increase of energy efficiency by 20%

Those targets were then translated into national targets by the Federal Government within the aforementioned “Energiekonzept”. The following goals were set for 2020 (cf. EC 2010, BMWi 2014b, Bundesregierung 2010):

- Reduction of GHG emissions by 40% compared to 1990 levels until 2020 (and by 95% until 2050)
- The share of renewable energy of gross final energy consumption should be increased to 18 % in 2020 (and to 80% in 2050)
- Reduction of primary energy consumption by 20 % compared to 2008 levels until 2020 (and by 80 % until 2050).
- Increase of the total refurbishment rate of buildings from above 1% to 2% annually to redevelop the building stock to achieve climate neutrality[8]
- Reduction of final energy consumption in transport by 10 % until 2020 (and by 40% until 2050)

The Energiekonzept also describes the way for the so called “Energiewende” – the transition of the existing energy supply system based on fossil fuels into an energy supply system based on renewable energies. To achieve those aims an extensive range of laws and regulations were introduced with the “Energiepaket” (German energy package) (cf. BMWi 2012), which also affects the German heat domain (cf. Chapter 3.2)
Beside climate challenges, the Energiekonzept of the German Federal Government also addresses energy security aspects. To cover its demand for natural gas and mineral oil, Germany currently depends to 87% and 98%, respectively, on resource imports. The largest share of German fossil energy imports are sourced from politically unstable regions.

[8] Energy efficiency and renewable energy targets were reasserted by the parliamentary decision in 2011 to phase out nuclear energy by 2022, which was made in the aftermath of the Fukushima accident (cf. UBA 2014).

Furthermore, the globally rising demand for fossil fuels and decreasing availability of fossil energy sources (peak-oil discussion) threaten the security of energy supply and stability of energy prices. The development of crude oil prices are shown in Figure 8. The increasing and volatile energy prices in the last decade were another reason for intensified efforts to reduce energy consumption and for support for energy efficiency gains (cf. BMWi 2012, BMWi 2014b for more information about energy price impacts on the heat domain see chapter 4 P.19).

Figure 8: Development of crude oil prices, period 2000 - 2015 (Brent in US Dollar)
Source: Scholtens 2015, Data: EIA 2015

3.2 Legal framework for the German heat domain

After presenting the societal and political discourse relevant for the heat domain, we now introduce the concrete and present legal framework that was formed and influenced through this debate.

The **Energieeinsparungsgesetz** (**EnEG** – Act on Energy Saving), initially implemented in the wake of the first oil crisis in 1976, was adjusted in 2005 and 2013, respectively, with the aim to reduce energy consumption in the building sector as one step to reach the GHG emission reduction target. The EnEG enables the federal government to regulate the following aspects with respect to the heat domain (§1-§2a):

- Energy efficient thermal insulation in new buildings to reduce loss of energy (§1 (1))
- New installations of energy-saving systems in buildings (concerning new installations of heating, room air technology, cooling and water supply systems, etc. specifically in the course of retrofitting) (§2 (1))

- Building standards: Buildings with heating or cooling systems that are constructed after 31st December of 2020 have to meet criteria as lowest energy buildings (“Niedrigstenergiehaus”) (§2a (1))

More regulations and standards set by the Federal Government are formulated in the **Energieeinsparverordnung**[9] (**EnEV –** Energy Saving Ordinance). It states that buildings must comply with several minimum energy and heating performance standards that have gradually been raised since 1979. The latest update of the EnEV was made in 2014 (cf. BMWi 2014a). Besides energy performance standards, the regulation also addresses technical aspects for example the replacement of oil and gas boilers, thermal insulation of ceilings and top floors or the application of energy performance certificates.

Another law relevant for the domain is the **Erneuerbare-Energien-Wärmegesetz** (**EEWärmeG** – renewable energy heating act), which was passed in 2009 to increase the share of renewable energies for heating and cooling in the building sector to 14 % until 2020. The act introduces the obligation for proportional use of renewable energy in new buildings if this is economically possible (EEWärmeG §1, §3). It defines the share of specific renewable energies for new buildings and refurbished public buildings (§5) and regulates exceptions for buildings where the installation of renewables are technically impossible or public obligations are contradictional (§9).

A further political framework for the heat and building domain is the efficiency strategy named **Nationaler Aktionsplan Energieeffizienz** (**NAPE –** national energy efficiency action plan) that has been published by the BMWi for the current 18th legislative period (cf. BMWi 2014c). NAPE addresses the final energy consumption and thus the demand side with e.g. households, transport, and industry. It promotes the reduction of energy consumption and an increase in energy efficiency. It uses several instruments and measures: consulting and communication on rewarding efficiency measures, funding and standard setting. Concrete measures concerning heat technologies and buildings are an expansion of funding for refurbishments and the introduction of tax incentives for efficiency measures on the national and federal state level. Within the framework of NAPE, the “Energieeffizienzstrategie Gebäude” (energy efficiency strategy for buildings) is to be designed in 2015. Following the targets of the Energiekonzept to create a climate neutral building sector until 2050, the Energieeffizienzstrategie Gebäude will be set out to achieve those ambitious goals (cf. BMWi 2014c, BMWi 2015). Therefore, several means that have proven to promote and establish energy efficiency so far e.g. through refurbishments and the use of renewable energy will be further established and extended. The “Sanierungsfahrplan” (plan/measurements for refurbishments) will be the first part of the “Energieeffizienzstrategie Gebäude” (cf. BMWi 2014c, BMWi 2015). It will highlight the need for refurbishments and set fundamental directions in energy policy.
As indicated, monetary incentives are an important means of the Federal Government to promote energy efficiency in the heat and building domain. One source of funding is the **Kreditanstalt für Wiederaufbau (KfW)**, Germany’s federal state bank for funding issues

[9] The Wärmeschutzverordnung (WSchV - thermal insulation ordinance) and Heizungsanlagenverordnung (HeizAnIV – Heating System Ordinance) were replaced by the EnEV in 2002.

and subsidies, which provides soft loans and grants to building owners for whole-house retrofitting and single measures as well as for the construction or purchase of energy-efficient homes or passive houses. This marks the current state of a development: While the KfW's CO_2 Reduction Programme introduced in 1996 focussed on single refurbishment measures, KfW has gradually altered its funding scheme in favour of whole house refurbishment and also funds the construction and purchase of energy efficient or passive houses (cf. BMWi 2014a, BMWi 2015).

The **Marktanreizprogramm** (**MAP –** market incentive program) for renewable energies in the heating sector is another central funding instrument for increasing investments in renewable energies for heating or cooling systems in the existing residential building stock and industrial or commercial processes. The program was launched in 1993. In 2009 it was anchored within the EEWärmeG and was amended in 2012 (cf. BMWi 2015a). The aim of the MAP is to make investments into energy efficiency more attractive by lowering barriers for the investors.

3.3 Overall assessment of landscape influences

All in all, the developments of the landscape are in favour of a transition of the German heat domain. Even though not perceived as a major problem, environmental issues are part of the political and societal debate in German society. This leads to a general positive perception of environmental friendly technologies and accordingly acceptance in society and support on political level. The discussion on peak-oil and security of supply for fossil fuels also bring about favourable conditions for a transition.

The assessment of landscape influences points to political support being an important driver in the sustainability transition. Besides global commitments, the German government set clear reduction and efficiency targets on European and national level, that deeply affect the heat domain ("Energiekonzept"). To reach those goals, several political measures have been introduced that are to stimulate the market and increase the adaption of green technologies in society.

4 Developments in the heat generation regime

The German heat generation system and regime is characterized by three dominant sub-systems: Gas-heating, oil-heating and district-heating. The developments within and between these sub-systems have been very different in the past decades, following specific trends in the respective industries and infrastructures, the behaviour of consumers, public debates, civil society and the measures implemented by policy actors. This chapter provides insights into these developments and the status quo, focussing on the tangible and intangible elements characteristic for each of these sub-systems (see Figure 9). Tangible elements are defined as measurable aspects such as infrastructure and technology while intangible elements address rules, beliefs, strategies, social relations and governance style defined by actors in concrete contexts (cf. Geels 2007a).

The analysis of these elements concludes with the evaluation of the importance of the sub-systems for the overall German heating domain. The identification of possible lock-in mechanisms as well as cracks and tensions within the subsystems, which may lead to transition are of main interest.

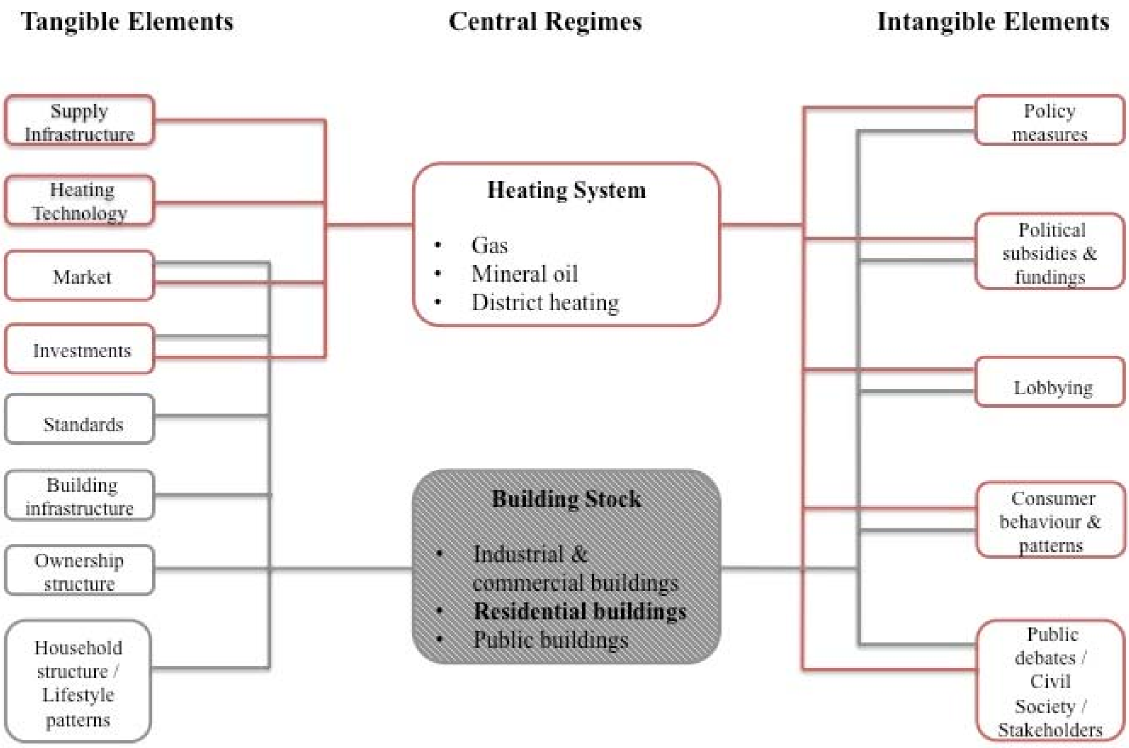

Figure 9: Tangible and Intangible Elements Source: Wuppertal Institute

4.1 Gas-heating system

Starting with the first and the second oil crisis in the 1970s, gas-heating systems have experienced a tremendous and continuous increase in sales quantities. In 1995, gas-heating systems replaced oil as the most applied heating system in German residential buildings (see Figure 11). Gas heating is especially influenced by its technical development in recent years, increasing energy efficiency, a huge supply industry and strong political promotion.
The following chapter elaborates in detail the factors that are shaping the gas-heating sub-system. Firstly, the tangible elements will be assessed. In a second step the intangible elements, as described in Figure 9, will be presented.

Infrastructure and technical development (Tangible Elements)

In 2011, households in Germany consumed 26 % of the overall 837 billion kWh gas sales (cf. Statista 2014). A good gas infrastructure, including of pipelines, reliable imports, and storage systems are very important to maintain the attractiveness of gas as a heating source. Moreover, the consumers' trust into gas-heating systems highly depends on the supply security and system stability. This chapter will analyse the status of these factors. The gas pipeline system in Germany has an overall length of 510 000 km and has been continually expanded (cf. BMWi 2015b). The gas grid is covering the main metropolitan areas in Germany. Rural areas, however, are often not yet connected (cf. Presseportal 2013). Between 1992 and 2014, on average 2.3 billion Euro were invested by the gas industry for the maintenance and expansion of the German gas network (cf. BDEW 2012). To cover supply shortages 48 underground gas reservoirs exist in Germany. This represents the forth-biggest gas storage capacity worldwide with up to 20 431 million m^3 of stored gas (cf. BDEW 2012). The stored amount of gas is sufficient to cover a quarter of the annual consumption. In 2012, there was an average time of supply breakdown of 2 minutes.
The price of gas is comparatively low to that of oil although the prices have been couples. The average heating-gas price in 2014 was 6,45€ per kWh. While 71 % of that price related to import/production, transport, storage and distribution, 19 % referred to value added tax and another 9 % covered gas tax (cf. BDEW 2012).
Regarding natural gas supply, Germany is import-dependent. In 2012, 11 % of the gas volume in Germany was extracted domestically, 89 % was imported. Russia has the main share on German gas imports with 31 %; Norway has the second largest share second with 28% (cf. BDEW 2012)
Gas heating appliances have become the most demanded heating technology by far. In 2013, 530. 000 gas-heating systems were sold in Germany, which represents a 75 % share on the sales market for heating systems. The average life expectancy of a modern system is around 15 years. The state of the art of gas-heating systems is the condensing boiler technology, in which gas burns under air supply. The heat generated is then transmitted through water into a heat storage system for utilisation. Remarkable is the additional usage of the condensing heat, through which the condensing boiler systems can produce 11 % additional heat. Condensing boilers can be operated with organic-gas without technological restrictions or together with solar thermic installations (cf. BDEW 2015). They are among the most economical heating systems on the market costing on average between 6 000 and 8 000 euro, including installation. A replacement of a 25 years old gas low-temperature boiler in a single family

household with an annual gas consumption of 46 000 kWh by a modern gas condensing boiler can save up to 20 % of fuel annually (cf. BDEW 2015). This investment amortises after a few years, as the heating costs can be reduced by about 550 Euro annually. With additional installations of modern high-efficiency pumps, balancing valves and modern thermostatic valves further energy saving can be achieved with little additional investments. 8.9 million gas boilers and 4.2 million condensing boilers that run with gas existed in German households in 2014 (see Figure 10). Over 40 % of the existing gas-heating systems were installed between 1991 and 1997 and 75 % of the currently installed heating systems are thus estimated to be out-dated (BDEW 2015). Still, refurbishment rates of heating systems show a downward trend: While in 2002 800 000 heating systems have been installed, only 686 500 occurred in 2013, representing a 3 % share of the overall existing heating systems in Germany (cf. BDEW 2015).

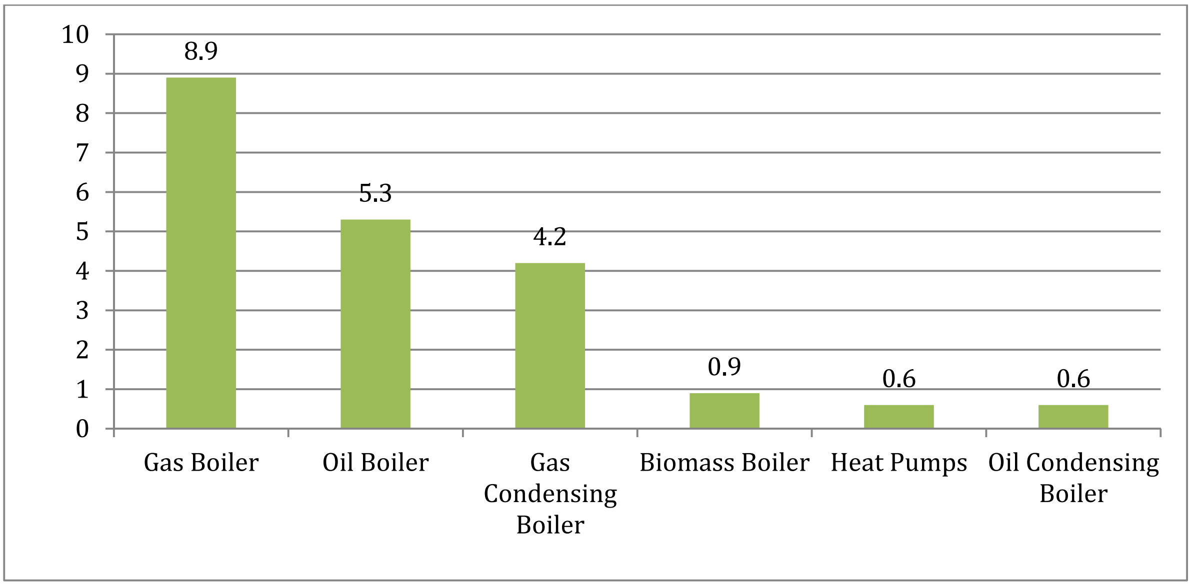

Figure 10: Stock of Existing Heat Generators by Category in Germany in 2013 (in Million) Source: Data Statista 2015

The EnEV of 2014 (see 16) is targeting this issue. In light of the target of the Federal Government to have a climate neutral building stock until 2050, building owners are not allowed to operate heating boilers that are older than 30 years from 2015 onwards. They are required to replace their oil- and gas-heating systems by more energy efficient systems. Partly exempted from this regulation are gas condensing boiler and gas low-temperature boiler that already have a high efficiency level (cf. EnEV 2014). During the elaboration of this agreements it was consensus that in general the energy transition in the building sector should be achieved through market-based incentives given by the government rather then through legal enforcement (see 38). The replacement of old heating boilers represents in this context an exception.

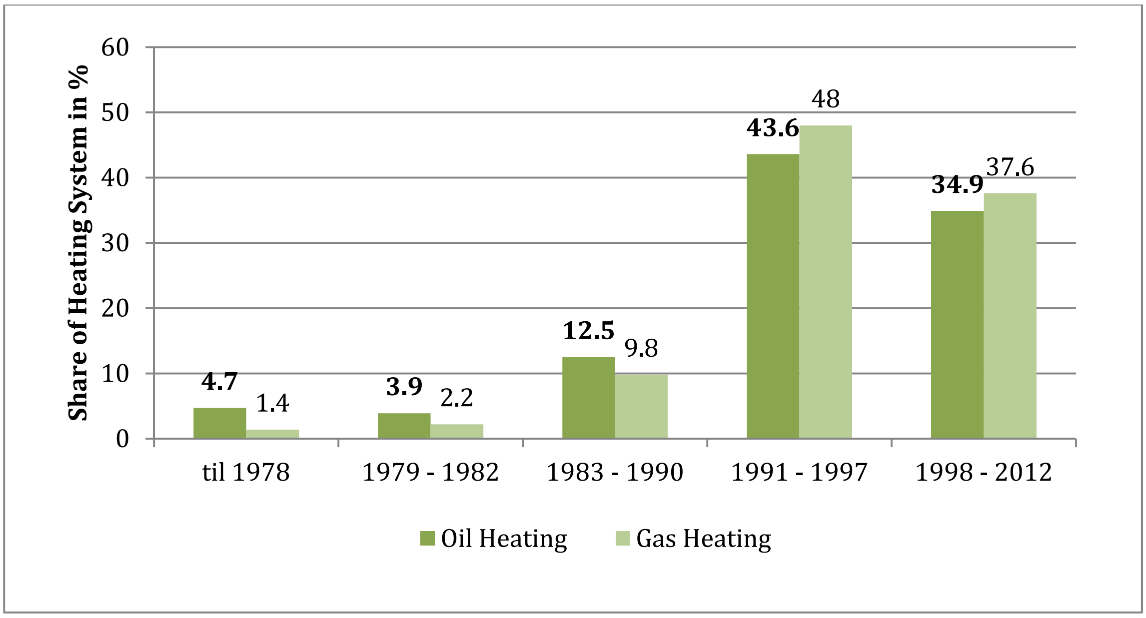

Figure 11: Time of Installation of Existing Oil and Gas-heating Systems in Germany
Source: Data Statista 2015

Intangible elements

In this section, we assess the mainly intangible elements with respect to consumers and households, politics, civil society, and public and industry debates that influence and shape the gas-heating sub-system. Please note that within the issues discussed tangibility and intangibility are somewhat interdependent. While intangibility is clearly in the focus in the following paragraphs it is not exclusively dealt with.

Consumers, households

This section explores the question which factors and aspects influence consumers when they decide for a specific heating system and how popular gas-heating systems are in general. The following elaboration mainly relies on statistical data published by the German Association of Energy and Water Industries (BDEW – Bundesverband der Energie- und Wasserwirtschaft).
In 2013, 41 million dwellings existed in Germany. 19.3 million of them used gas as main heating source. In over 50 % of newly constructed buildings, gas-heating systems are being installed (cf. BDEW 2013a). A survey of the BDEW conducted in 2013 shows that 45.2 % and therewith the majority of households would prefer gas over any other heating system, if they had to decide for a new technology. These findings can be explained by the consumer perception of gas-heating systems. Gas-heating systems receive the best ratings of satisfaction by consumer households with respect to economic feasibility, energy efficiency, supply security and independency – factors that are of main interest for consumers (cf. BDEW 2013a). Further perceived advantages are good environmental compatibility, technical reliability and comfort in use. One important aspect for consumers´ appreciation of gas is related to grid-based supply to their buildings so that there is no need for space intensive storage appliances. Consumers see gas and gas-heating systems as an environmentally friendly energy source that can be used as a door opener for renewable energy, as this technology can easily be utilized with a combination of conventional and renewable energy

sources (cf. BDEW 2013a) such as organic gas or solar thermal. 46 % of the responding house owners perceive organic-gas as an attractive product and substitution for conventional gas, especially because of its potential to achieve the CO_2-reduction targets in a cost-effective manner with regard to infrastructure and building technology. In 2013, 520 million standard cubic meters organic-gas has been produced and stored the German gas network.
Overall, gas-heating systems have experienced a continuous increase in acceptance over the past decades. The gas-heating technology has established itself as the leading heating system on the heating market in Germany (see Figure 11 & Figure 12).

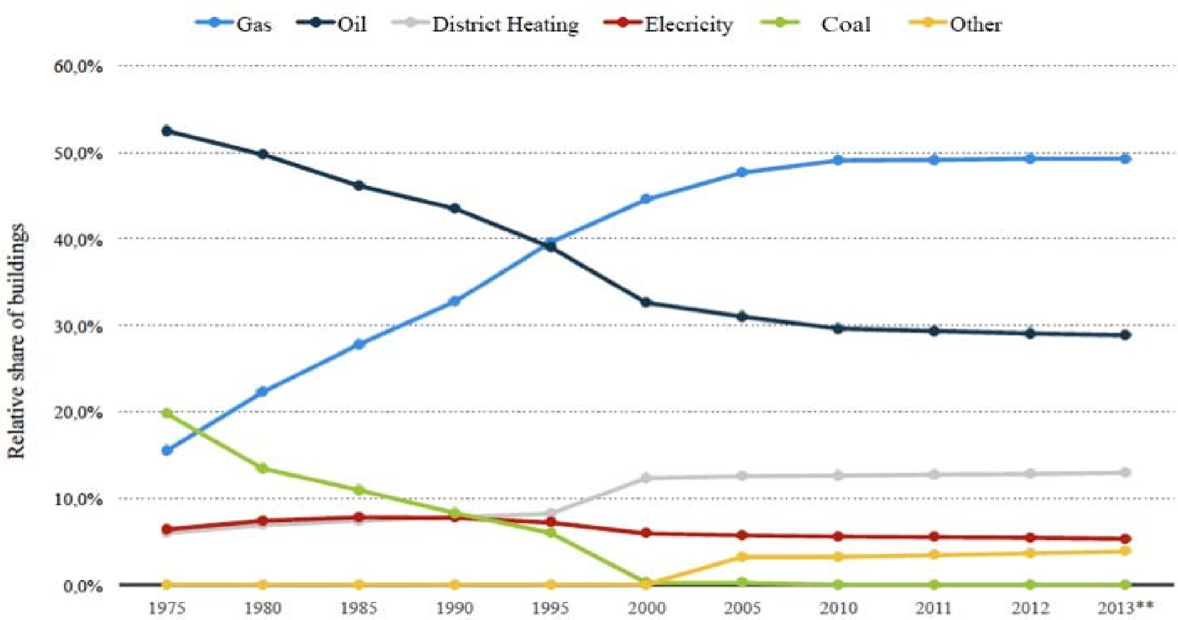

Figure 12: Heating Structure of Residential Buildings in Germany from 1975 – 2013
Source: Statista 2015

Policy Makers

The Federal Ministry for Economy and Energy (BMWi) is responsible for the implementation and formulation of energy related policy targets. Within the framework of the energy transition, restructuring the heating market plays a major role in the policy strategies, with energy efficiency and the utilization of renewable energy sources as the main focus (see 16). Nevertheless, political actors are aware that in the next decades gas will still largely contribute to the energy supply and security in Germany and on the heating market. Strategically, gas and its established infrastructure forms a bridge technology for power generation and storage (e.g. "power to gas"), especially in context of the energy transition (Schwürer et al. 2010). Therefore, the "network development plan" for gas of 2015, elaborated by the Federal Network Agency (BNetzA – Bundesnetz Agentur) in light of the energy transition and the withdrawal from nuclear energy, provides 51 measures including the new construction of 748 km of gas pipes until 2024 (cf. BMWi 2015b).
Recently, negotiations for additional funds for refurbishment measures, including replacement of gas-heating systems, of an annual volume of 1 billion euro from 2015-2019 within the

EnEV failed (cf. Zeit 2015). The main reason for the unsuccessful adaption was the disagreement between the political coalition partners of the Federal Government with regard to content and extent of the subsidies. The Christian Social Union voted against the additional fund within EnEV as in consequence current subsidies especially for craftspeople in the technical sector would have been reduced. Since 2003 work performed by craftsmen is tax-deductible up to an amount of 1.200 Euro (cf. Zeit 2015). Nevertheless, even though these additional funds are not available, under certain conditions there are governmental subsidies for refurbishments of (gas-)heating systems (cf. 16 and 27 Policymakers).

In the light of import dependency for natural gas and recent political unrest in eastern Europe as well as tense relationship with Russia, import security and hence supply security are other major issues in the public and political debate. The Federal Government has therefore adopted a new fracking law on the first of April 2015. It includes stricter penalties for environmental damages that might occur from fracking but no general prohibition of fracking in Germany. Test drilling is allowed (cf. tagesschau 2015). Fracking is therefore not banned but under critical surveillance, however this is to be seen as opening Germany for fracking in general and as a support to the gas system, as the public and political opinion is very sceptic towards this production technology. Further steps in this development may depend on the geopolitical development in the near future.

Civil Society and Public Debates

The civil society and public debates mirror the political agenda on gas. The public debate that can be related to the gas-heating sub-system is mainly driven by associations, internet platforms and the media. Especially gas supply is in the focus of these debates.

Specifically fracking has been a highly discussed topic in recent years. For example, the NGO BUND- Bund für Umwelt und Naturschutz Deutschland (Association for Environment and Nature Conversation) as one of the major players in German environmental protection, demands a general legal prohibition of fracking. They are against the extension of gas extraction and demand a stronger focus on renewable energies (cf. BUND 2015). Like the BUND, also smaller organizations mainly express doubts about fracking. They refer to the immature technologies and the risk of environmental contamination (cf. SHIP 2014).

Another topic in the media is the discussion about funding mechanisms for refurbishment measures of out-dated gas-heating systems. They stress that the consumers are generally confused by the complexity and the contradiction of these programs (cf. Der Tagesspiegel 2014). Furthermore, they also report about the gas import dependency of Germany that is critically discussed in public debates, especially due to the dependency on Russian gas imports (cf. Handelsblatt 2014).

Many people perceive organic-gas as a useful resource and substitution for conventional gas. A study by Greenpeace and the Wuppertal Institute for Climate, Environment and Energy (conducted on behalf of the NGO “Greenpeace”) comes to the conclusion that gas and its application could therefore form a suitable bridge technology in Germany towards renewable energies. The flexible usability in terms of heat and power generation and the improved environmental performance compared to coal, nuclear energy and oil are the crucial arguments. In combination with the existing high potentials for energy savings in the heat domain (heat generation & building sector), it could lower dependencies in terms of imports and geopolitical questions (Schüwer et al. 2010).

Nevertheless, some negative aspects are discussed in media and in public debates as well: As the production of organic-gas yields higher revenue than the production of vegetables and grains for animal food or the conventional sales, farmers drastically shifted their production to organic-gas crops. As a result, maize monocultures, overpriced leasing cost for scarce cultivation areas and toxic fermentation residues in soil and water resources are named as problems in the current debate on the agricultural landscape in Germany (cf. BR 2012). Therefore, especially organic farming lobbies stand up for a restriction of tax advantages and funding programs for organic gas to make food production compatible again in context of leased land (cf. BÖLW 2013).

Industry and incumbent firms

A diverse field of players and actors characterizes the gas industry in Germany. In April 2014, there were 890 gas suppliers, 730 gas network operators, 70 gas trader, 27 gas-storage unions and 6 gas producing companies (cf. Statista 2015). The biggest gas network operators in Germany are EWE Netz GmbH with 55 000 km, RWE with 44 000 km and E.ON with 22 000 km of the gas network. The German gas industry employs 38 800 people. Annual investments add up to 1.4 billion Euro, while the annual revenue adds up to 35.7 billion Euro (cf. BDEW 2012).

It is German companies that sell around 80 % of the gas-heating systems in Germany. Bosch Thermotechnik (Buderus and Junkers) with 3.12 billion, Vaillant with 2.38 billion and Viessmann with 2.1 billion Euro of total revenue are the biggest companies with respect to sales of heating systems in Germany (cf. Statista 2015). The gas and the gas heating technology industries are hence of some importance the German economy. Both industries have established well functioning and politically active trade unions that aim to stabilize the gas system.

The German gas industry is organized in three big associations: The Association of Energy and Water Industries (BDEW - Bundesverband der Energie- und Wasserwirtschaft) is one of the main unions that represent the German gas industry on a political level. It was founded in 2007 and represents 1 800 companies. In light of the energy transition, the BDEW strives for a stronger focus on gas as the central instrument to achieve the energy- and climate goals. They refer to the lower emissions caused by gas heating compared to oil, high level of efficiency and flexible application with respect to organic-gas mixtures (cf. BDEW 2015).

The Association for Crude Oil and Gas Extraction (WEG – Wirtschaftsverband Erdöl- und Erdgasgewinnung e.V.) acts on behalf of the German mineral oil and gas producers, the operators of underground storage systems and of the service providers in this sector. It was founded in 1945 and has 92 institutional members. It strives for a stronger concentration on domestic exploration of gas and promotes fracking as the main technology for the future. Its line of arguments focuses job creation and ecological advantages of gas utilisation in comparison to oil (cf. WEG 2015). WEG expects a gas exploration potential in Germany of 50-150 billion m^3. It admits that the exploitation of this gas is very risky, but nevertheless strives for the extraction to stabilise the domestic gas reserves and reduce import dependency.

The Federation of the German Heating Industry (BDH – Bundesverband der Deutschen Heizungsindustrie) represents the members of technology production. It was founded in 2003 and represents 103 actors. In general, they support the market-based incentives for heat-generation systems implemented by the German Federal Government and therefore lobby for a diversified spectrum of heating technologies (renewable and fossil energy sources) (BDH 2014). In this context they lobby for more incentives for consumers to refurbish their old heating systems. The concrete claims are consumer orientated subsidies and tax incentives (BDH 2014). They refer to the low refurbishment rate and argue that the energy transition cannot be conducted without an efficient modernisation of the heat domain in Germany (cf. BDH 2015). The actions of the gas and heating industry therefore serve to support the status quo and to stabilize the gas heating systems.

Overall assessment of the gas-heating System

The gas-heating technology is the predominant system in Germany. Since the mid-90s, gas-heating systems have been the favoured heating system and the latest evaluations have shown that the majority of building owners are preferring gas over any other heating source. There is currently no evidence, neither in civil society, politics or economy, for a shift of that observation. The German gas-heating sub-system has experienced a continuous growth in the past decades and is nowadays the most applied heating technology in German households. A strong industry of gas suppliers and heating system manufacture, which are represented by influential unions and associations on a political and societal level, promote gas as a reliable heating source, which can be used as a door opener for the energy transition. A big advantage for the manufacturers is the flexibility of their technology. As modern gas-heating systems can run with organic-gas, they fit in the energy transition strategy of the policy makers.

The political strategy on the one hand includes governmental funds that can be obtained for an energy efficient refurbishment of heating systems as part of a strategy to promote the energy transition (see also 16). On the other hand the EnEV decrees the replacement of heating systems older than 30 years. However, the overall political approach triggers the energy transition by market-based incentives rather than legal enforcement. It is critically discussed in German civil society, which demands more enforcement mechanisms to restructure the German heating market. Consumers benefit from the good gas infrastructure in Germany, the marked based competition of heating systems suppliers and the legal framework in Germany. This framework is influenced by consumer preferences and also supported by the industry lobby.

Taking the terminology of Geels and Schots (2007b), the gas-heating system is currently undergoing a transformation rather than a reconfiguration. New gas-heating technologies are adopted that aim to reserve and to expand the importance of this system. All in all, both tangible and intangible elements tend to stabilize the system instead of enforcing cracks and tensions. For an overview of the key lock-in mechanisms and cracks and tensions observed in the description of the gas-heating sub-system are presented in Table 4.

4.2 Oil-heating system

Heating with oil has a long history in Germany. As the price for crude oil, and therefore for heating oil had been very cheap in the middle of the past century, oil-heating systems especially oil heating-stoves were very popular at that time. Starting with the first and the second oil crisis in the 1970s, this popularity began to decline (see Figure 11). However, oil-heating systems still have the second largest share of applied heating systems in residential buildings in Germany. How the oil-heating regime in Germany has developed in the past decades and how it is influenced by recent developments in politics, industry and civil society, will be elaborated in the following section (see Figure 9).

Infrastructure, technical developments (Tangible Elements)
Heating-oil is a product of crude oil and has a very high-energy conversion: 1 litre of heating oil has a heat value of 10 kWh. Germany and the US have the biggest markets for heating oil. Around 60% of the available heating oil in Germany is used for heating purposes in residential buildings (cf. ECT 2013). In 2013, 19.8 million tons have been sold in Germany, accounting for 16% of the overall oil consumption in Germany. However, while average annual consumption was about 35 million tons in the 1990s, it has halved until today (cf. ECT 2013). The reasons for this trend are the consumer perception (see intangible elements) of oil-heating systems, improved technology of the systems and milder winters. The association of German chimneysweepers have published data in 2013 whereupon 5.9 million oil-heating systems currently exist in Germany. 1,3 millions are older than 20 years and therewith have exceeded their regular life span of 15 years. 0.3 million oil-heating systems are older than 32 years and 2.45 million systems older than 12 years (cf. ECT 2013), leaving only 1.8 million oil-heating systems younger than 12 years. As a consequence, the main share of the existing oil-heating systems is not corresponding to the latest state in terms of technology and efficiency (cf. ECT 2013).
Technologically, the oil condensing boiler system represents the state of the art. Whereas low-temperature boilers loose a lot of the heat during the transformation process, the condensing technology is able to use the contained energy of the fuel almost completely for the heating purpose (see Figure 13). Oil-condensing boilers cost around 5.500 Euro, the necessary adjustment of the chimney additional 3.000 Euro and the oil-tank another 2.000 Euro. The advantages of the oil-condensing boiler are especially a higher degree of utilization (up to 100%) and lower CO_2-emissions than older oil-heating systems. The whole system of the oil-condensing boiler is called a “Unit”, whereby a Unit consists of the boiler, torch and control system (cf. Heizsparer 2015). It is possible to combine the condensing heat boiler with solar thermic technology. Oil-heating systems have a high level of reliability and independency. An external connection to a grid, like in the case of gas-heating systems, is not necessary. The heating oil can be bought on a low price level and can be stocked.

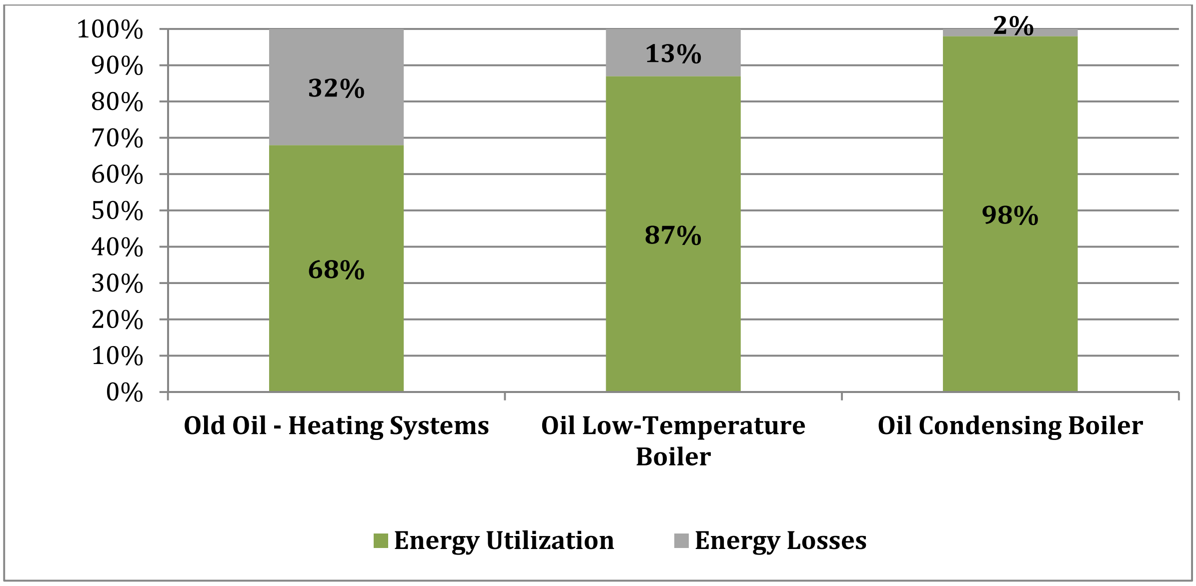

Figure 13: Performances of Oil-Heating Systems
Source: Data IWO 2013

The short-term price developments of heating-oil are difficult to predict and are becoming rather volatile, but for the longer run the price has drastically risen since the 1960s (see Figure 14). 68,3% of the price for oil in relates directly to the product, 19% for value-added tax, 8,9% for mineral-oil tax and 3,9% for contribution margins (cf. heizoelpreise24 2015). Besides the price for heating-oil, the consumer has to consider additional aspects if he decides for an oil-heating system. The oil-heating system, costs of reparations, maintenance and the chimneysweeper (cf. Heizsparer 2015). The tangible elements do not provide a clear picture for the sub-system. While the technology has improved in general, the system is clearly declining, specifically there seems to be a lack of investment into new systems, here.

Intangible Aspects

Consumers, Households

Oil lost its leading position to gas in 1995, which can be mainly attributed to environmental considerations on the consumer side and the rising price of heating-oil. While in 1970 one litre of heating oil cost 8.2 cent, it cost 21.9 cent in 1995 and 88.1 cent in 2012 (see Figure 14). However, oil-heating systems are the second most applied heating technology in Germany after gas-heating systems. In 2014, 10.8 million households in Germany used oil as their primary heating source. That accounts for 26.8% of the housing stock in Germany but it had been 32.6% in 2000 (cf. DHZ 2014).
In the first six month of 2014, oil-heating systems have had a share of 0.7% of applied heating systems in new constructed buildings (see Figure 15) and 46.000 of the overall 686.500 sold heating generators in 2013, were oil-heating systems (cf. Statista 2015). Oil heating systems have still a high importance in rural areas for energy supply because of missing alternatives (e.g. no gas grid).

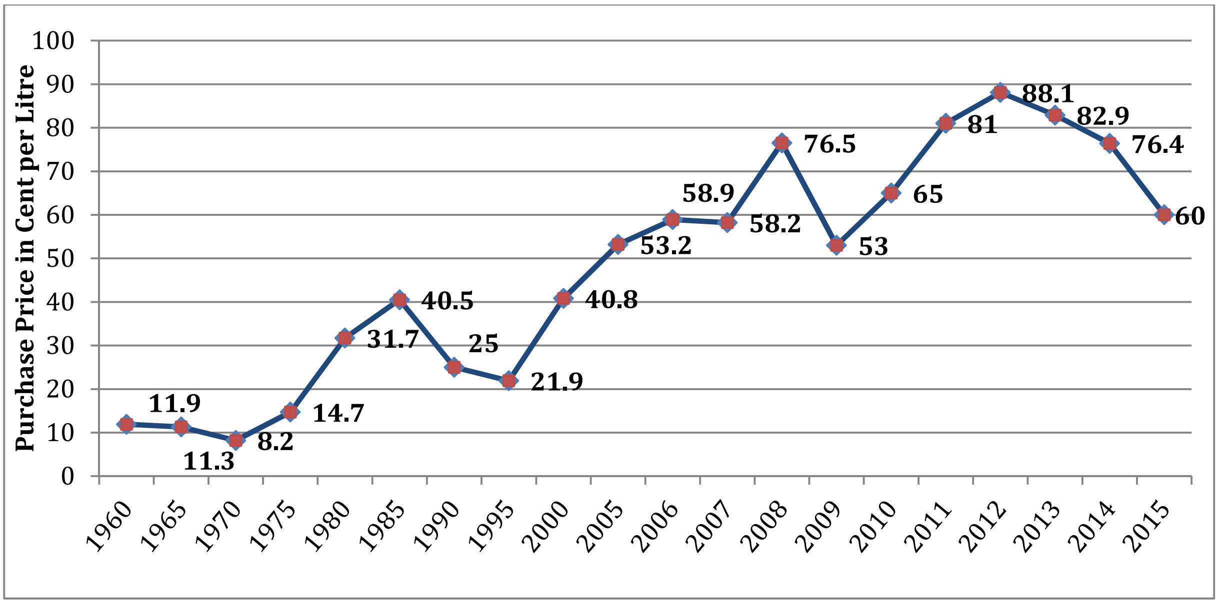

Figure 14: Average Purchase Price for Light Heating Oil in Germany 1960 – 2015 (in Cent per Litre[10]) Source: Data Statista 2015

Oil-heating systems have experienced a continuous decrease in acceptance over the past decades. With respect to the consumer perception the share of oil-heating systems on the German heating market will thus most likely continue to decline. Although new oil condensing boilers do not have a much worse CO_2-performance[11] than gas-heating appliances their image is perceived as a dirty and out-dated technology by the majority of the consumer households (cf. Statista 2014a). In the view of the customer, oil-heating systems receive the worst ratings with respect to economic feasibility and efficiency, supply security and independency, compared with gas-heating systems, wooden pellets and heat pumps. The same holds true for comfort in use, environmental compatibility, technical security and potential of innovation (cf. BDEW 2013a).

On the other hand, even though the share of oil-heating systems in new buildings is low, the overall share of this technology has only declined little. This is due to the fact, that many households tend to refurbish or modernize their old oil-heating system with a modern oil-heating technology rather than with an alternative technology. They do so, because oil-heating systems are very reliable and appreciated by consumers that already have this technology installed in the past (cf. IWO 2015a). Moreover aspects of asset specificity will play a role here, since the change of system is more cost intensive than exchanging one oil heating appliance for another.

[10] Prices are not inflation adjusted

[11] For a comprehensive comparison (with a view to CO_2-emissions) of common and innovative heating systems for the heat supply of residential buildings in Germany see Bettgenhäuser & Boermanns (2011: VIII - IX)
Executive Summary is in English, copy Link below:
https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/4070.pdf

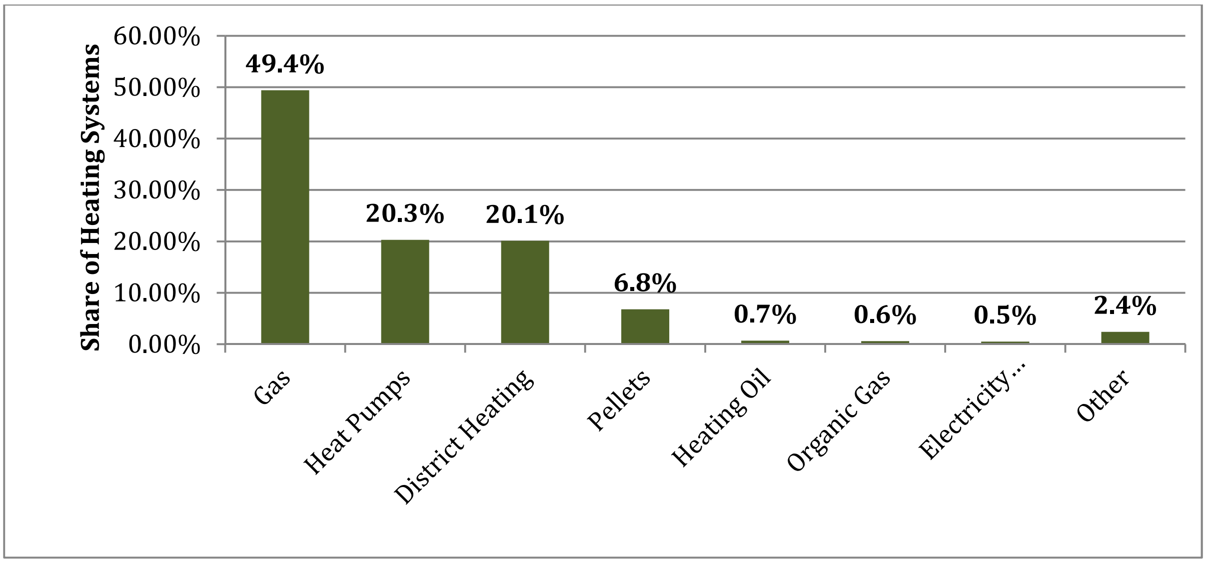

Figure 15: Distribution of Heating Systems in New Buildings in Germany in the First Six Month of 2014 Source: Data Statista 2015

Policy Makers

As already mentioned in chapter 4.1, several measures have been adopted for the heating market in Germany, which can be interpreted ambiguously. In general, the political discourse about oil-heating systems is diverse. The current government of Christian Democratic Union, Christian Social Union and Social Democrats is not striving for a general ban of oil-heating systems but is rather implementing measures that provide incentives for refurbishment and modernization. The Federal government pursues therefore a liberalized market strategy to ensure security of supply based on a diversified energy source mix. The oppositional, and environmentally oriented party Bündnis 90' die Grünen on the other hand, has formulated a general ban of oil-heating systems in its program. In detail they state that from 2015 onwards it should be prohibited to install new oil-heating systems in residential buildings (cf. Klimaschutz 2013). They take Denmark as an example, where it is already legally prohibited to install new oil-heating systems from 2015 onwards and to refurbish with oil-heating systems from 2016 onwards.

Under certain conditions, especially considering aspects like increasing energy efficiency and including renewable energy into the refurbishment measures, the Federal Office for Economic Affairs and Export Control still subsidises the refurbishment of oil-heating technology. The KfW is offering two funds for subsidising refurbishment measures of oil-heating systems: a credit up to 50.000 Euro on favourable conditions or a financial contribution of up to 5.000 Euro for direct self-financed refurbishment measures. However, the terms and conditions foresee the application of modern oil-heating systems that increase efficiency and the combination with renewable energy (cf. Heizsparer 2015). As discussed in chapter 4.2 the negotiation of additional funds within the EnEV failed in 2014.

Civil Society and Public Debates

Since the debate about climate change started and the Federal Government of Germany adopted measures to increase energy efficiency and renewable energy sources, oil as an energy source has experienced a continuous decrease in acceptance in the public debate which was further spurned by concerns from a broad range of social actors about price volatility and supply security. As it has been stated before, the consumer perception of heating with oil is very negative nowadays.

Different actors lead this public debate over advantages and disadvantages of the oil-heating sub-systems. On the one side are the representatives of the oil-industry. They are especially trying to influence the public opinion about oil-heating sub-systems by trying to counter the arguments put forth by oil sceptics calling them “myths” and promoting the potential of modern oil-heating systems. Arguments addressed by the opponents are that oil-heating systems have a much worse CO_2-performance than other systems, that the technology is out-dated and that oil-heating is more cost-intensive than heating with other systems (cf. Themendienst Heizöl 2015).

However, e.g. the BUND - Bund für Umwelt und Naturschutz Deutschland (Association for Environment and Nature Conversation) as one of the leading NGOs lobbying for environmental protection in Germany also promotes refurbishment and modernization measures for heating systems rather than demanding complete substitution at this point. They do not strive for a general ban of oil-heating systems, like the Green Party, but are stating, that the switch to other heating systems than those that run with fossil fuels, is always the better choice for environment (cf. BUND 2008), thus leaving them in a more ambiguous position. The media and the majority of public debates evaluate the proposal to legally prohibit oil heating, as not useful and as contradictory for the energy transition (cf. Themendienst Heizöl 2014). Another topic within the discussion about the oil-heating sub-system is the import dependency of Germany with regards to oil and uncertainties in price security (cf. Zeit 2014). This topics are also discussed in the light of “peak oil” (cf. Rost 2014). Therefore import dependency and the problem to predict the price developments (fluctuations) of oil in a secure manner are the major topics of the public debates.

Summarizing these observations it becomes clear that the public debate, while critical on oil, especially when compared to gas in only moderately weakening the system and stabilizing forces exist as well.

Industry

In order to meet the targets of the energy transition as implemented by the Federal Government of Germany, it is necessary to use mineral oil products more efficiently. Developments in the heating industry meet these expectations as they involve innovative technologies for more effective energy utilization and possibilities for the combination of oil-heating systems with renewable energy sources.

Similar to the gas-heating case the majority of oil heating systems is constructed and sold by German companies like Bosch Thermotechnik (Buderus and Junkers), Vaillant and Viessmann. These companies have established well functioning and politically active trade unions that aim to stabilize the oil-regime.

In general, numerous smaller companies characterize the distribution industry of the oil-heating regime. Those traders, service providers, chimneysweeper and installers have faced a shrinking market development in the past decades. Nevertheless, they profit from demand for refurbishments of oil-heating systems, which accounts for the main sales of this technology in recent years. The industry offers modern technology and the possibility of combination of oil-heating systems with renewable energy sources and is thereby integrating the consumer preferences into its strategic orientation.

The BDEW, BDH and the Institute for Heat and Oil-technology (IWO – Institut für Wärme und Öltechnik) are representing the main actors that are active in the oil-heating sub-system. They promote the advanced technology of oil-heating systems and refer to the possible combination of oil and renewable energy as heating sources. The IWO, that is closely connected to the producers of heating systems, currently conducts a campaign, “Deutschland macht Plus!” (Germany is doing Plus!) to promote the oil condensing-boiler technology. Many producers of heat generators participate, offering the consumer a grant of about 1.200 Euro, when they decide for the installation of an oil-heating system (cf. IWO 2015b).

The BDH states, that the oil-heating technology does still play an important role within the heating market, as many households in the rural areas of Germany do not have a gas grid connection. The association criticises the unsuccessful adoption of further subsidies and tax incentives for refurbishment measures by the Federal Government of Germany. It is consensus within the industry that these incentives are of main importance to push the refurbishment and modernization rates of oil-heating systems forward. Therefore the industry (gas & oil industry) pull and lobby together for a liberalized market supported by subsidies and incentive programs addressing refurbishment and modernisation (cf. BDH 2015a). With the technological developments in the past decade (condensing boiler and combination with renewable energies) the whole industries stabilizes the oil-heating system.

Overall assessment of the Oil-Heating Regime

The development of the oil-heating regime has been significant in the past decades: While the majority of households have used oil heating until the 1970s, a transfer of importance in favour of gas proceeded ever since. Nowadays, the majority of consumer households perceive the oil-heating technology as out-dated and with no viable future. Nevertheless, those who already use oil for heating are more likely to refurbish with a modern oil-heating system rather than with a different technology. Today 29% of all households are still using oil-heating systems for space heating. The industry is trying to promote the technical improvements of this technology in recent years with respect to efficiency and the combination with renewable energy sources. They are trying to exploit the refurbishment and modernization potential of oil-heating systems as many systems that are installed in residential buildings have expired their regular life span. The measures, which are implemented by the policy makers are pointing the way to achieve a change in the heating domain through market-oriented incentives rather than through legal enforcement, as they are not implementing a general ban of oil-heating systems and promote refurbishment. An ambiguous public debate adds to this picture. The oil-heating system is therefore undergoing a slow transformation that has to be defined according to Pathway A but might give evidence for Pathway B in some sectors: The market and the industry provide technical changes within the existing system. The established actors in the industry and the consumers are influencing the political measures by their preferences. Multi-dimensional change is given as the consumer perception of oil heating has radically changed influencing user practices, as well as

social and cultural preferences. However, incremental steps and not revolutionary changes define the transformation of the oil-heating sub-system as a whole.
However, the German oil-heating sub-system does still play a role within the country's heating domain especially in rural areas, even though many aspects indicate its declining importance over the past decades. It is to be expected that the system will live on for the next decades but on a smaller basis than it used to. Specifically the issue of few opportunities for efficient substitution for dwellings without connection to the gas grid will play a role here. For an overview of the key lock-in mechanisms and cracks and tensions observed in the description of the oil-heating sub-system are presented in **Table 5**.

4.3 District Heating

District Heating (DH) played a constant role in the heat supply over the last 17 years. In D2.1 (Berg et al. 2014) the technology has already been presented as part of the niche innovations analysis. There, emphasis was put on renewable energy potentials in DH and the technology of combined heat and power generation: heat and power plants (CHP)[12]. CHP represent the majority of all facilities in Germany with 82 % in 2012 (AGFW 2013). Even though DH is very important in other countries analysed in PATHWAYS (e.g. Sweden), in Germany, it is of minor importance due to low market shares and the dominance of gas and oil subsystems. The decision to still include DH into this report is to offer a link for cross-country comparisons. However, we refer to D2.1 for a more intensive analysis.

Tangible Elements: Infrastructure and Technology
In a cross-European comparison, Germany holds a top position in DH and CHP generation capacity and production in absolute terms. With the first installations in the 1950s the grid of DH has continuously expanded to a total length of approx. 20.000 km in 2013 and hence is among the longest grids in Europe. However, the overall market shares are rather low: approx. 12%[13] in the heating sector in 2013[14] (BDEW 2013). Over the last decade this share has been almost constant, which assigns DH only a minor role compared to the subsystems gas and oil. In 2012 the energy supply (private households & industry summarized) for DH and CHP regarding power and heat generation comprised approx. 445 PJ (AGEB 2014).
In Germany, the dominant energy source for DH has always been fossil fuels. Figure 16 shows the shares of energy sources used in 2013: Fossil fuels like gas (38 %), hard coal (37

[12] CHP is mostly equalled with district heating. CHP installations are thermal power plants utilizing both thermal and electric energy from the combustion process. CHP mostly generate steam used for the operation of steam turbines generating electricity. At the same time, surplus heat is used for district heating which increases total efficiency of the plants, typically to about 50-90%. The highest efficiencies of 85-95% are reached by gas-fired CHP (UBA 2014).
[13] The BDEW evaluates the primary central heating systems in German households, second heating systems like furnaces are not determined
[14] Please note however, that numbers vary here. E.g. http://de.statista.com/themen/2034/kraft-waerme-kopplung/ refers to 17% in 2012, but it is not clear in how far this relates to the share of heat as the source talks about electric power generation.

%) and lignite (11 %) provide the largest segment in this subsystem with an overall share of 86 % (AGFW 2013). Biomass (4 %) and waste heat (10 %) represent a minor share of 14 %.

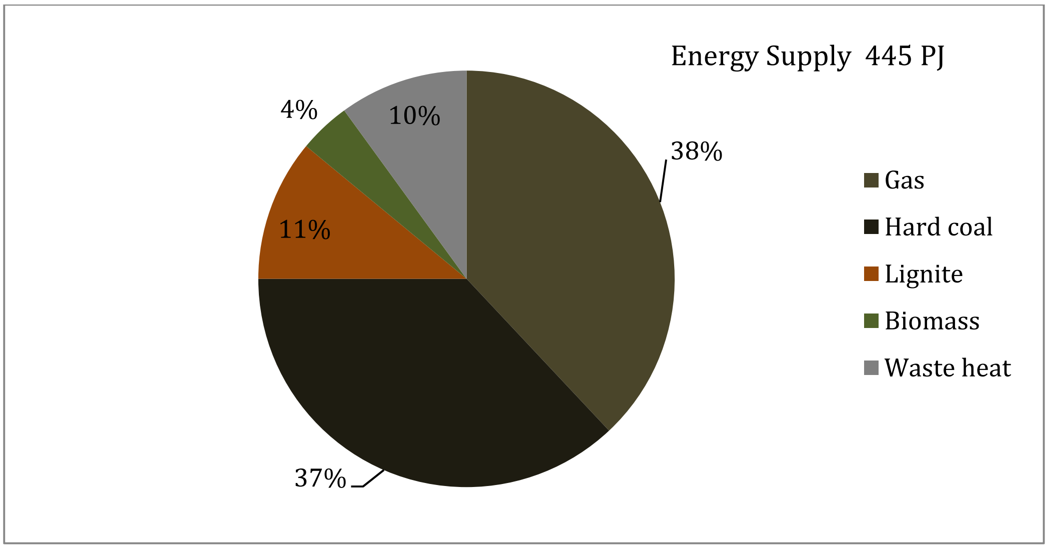

Figure 16: Energy Sources for DH and CHP (heating and power generation in 2013
Source: Data AGFW 2014

DH energy prices are coupled with the prices of its energy source. Accordingly, the dominance of gas and coal as main energy sources is reflected in the end-user prices (see Figure 17). The price develops almost parallel to gas prices. This is generally seen as one factor contributing to the stagnating market share of DH.

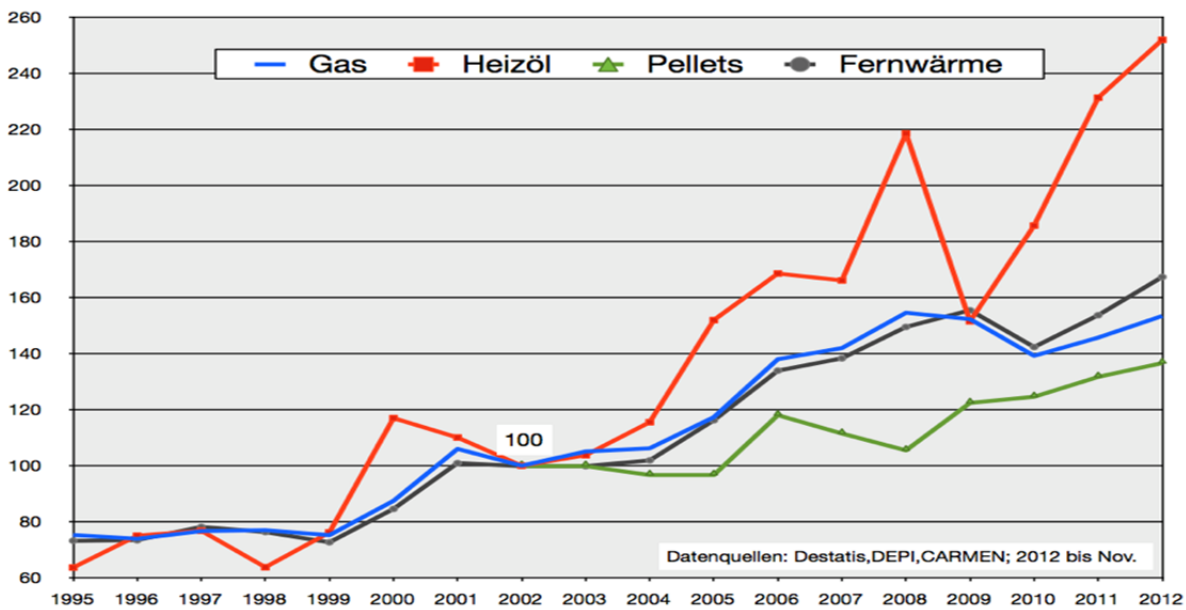

Figure 17: Comparison of end-use price developments (2002 = 100)

Source: Energy Comment (2013). Note: oil = Heizöl, district heating = Fernwärme

Intangible Elements: Stakeholders, Strategies

In the DH sector, the main actors are the large incumbent energy providers, grid operators and technology plant manufactures. In the DH and CHP technology field, it is hence mainly a few large plant-manufacturing companies (such as Siemens) who are driving innovations. In general, most DH plant and grid operators are partially publicly owned and partially private companies. This leads to (local) interdependencies that may be of non-economic and rather institutionally problematic effects. E.g. due to the physical grid infrastructure, the demand side (consumers, in many cases housing enterprises forwarding costs to end-users) faces a local monopoly, which led the German federal cartel authority to check on the DH market in 2012. The authority found out that in some cases, DH providers used their monopoly power to raise un-proportionally high fares and will possibly start investigations, if the respective companies cannot give appropriate explanations (Bundeskartellamt 2012). Based on the involvement of major industrial and public-private partners, there are considerable interest groups involved which affect the state of the regime. The umbrella association for DH and CHP providers is the AGFW (Energieeffizienzverband für Wärme, Kälte und KWK e.V.) that lobbies for better DH framework conditions, norms, and providing information on DH. The association of the German energy and water companies (BDEW) is the main actor lobbying for better legal framework conditions for CHP.

NGO actors such as the Association for environment and nature conservation (BUND) are as well lobbying for a general extended use of CHP (in combination with DH) in Germany (BUND 2013). However, environmental NGOs are very critical on carbon-fuelled plants, which represent about 42% of district heating plants (cf. AGFW 2013). Another point they raise is a reversal of the privatisations (re-communalization) of the 1990s. So that support from this side for large-scale installations is limited at best.

This makes a common position of the various stakeholders difficult, given that large private companies currently own a significant share of plants and grids. The actual development is further complicated by its direct link to the Energiewende with high uncertainties for investors and a history of failed investments especially in gas power plants over the last years and a non-existent bust cost-intensive infrastructure.

Institutions/governance

There is no consistent strategy to fully switch to a DH heating system even in regions where this is technically and economically sound such as in densely populated urban areas. This is a clear difference compared to the past developments in e.g. Sweden, where such a transition has taken place. Still, there is support from the German government: The overall target within the German energy transition (“Energiewende”) framework is to generate 25% of the electricity from CHP (in combination with DH) by 2020 (the share in 2012 amount 16%) and studies expect that this target may be met (Prognos 2013). This development would simultaneously lead to an increase in DH application in the heat domain.

Overall assessment

In Germany, almost 90 % of district heat is generated from fossil fuels (to about equal shares from gas and coal, see above). This constitutes a major distinction to e.g. the Swedish case, where a full fuel switch from fossil to renewable fuels has already taken place. There may be some potential to a similar fuel switch in Germany, but as a) the absolute heat amounts are much larger and b) renewable fuel supply is much more limited, a full "green" transition cannot be expected in the mid-term view. It remains an issue for the political agenda that has not been initiated in Germany and is not in sight[15]. Although AGFW (2013) sees a grid extension potential of about 100% in Germany, it may be doubted that these figures are realistic given the stagnation over the last decade. Overall, district heating does not seem to account for regime change but mostly has a constant (side) role in the present regime. Gas-based DH is sometimes seen as a bridging technology towards a renewable systems and for a phase-out of nuclear power because it can compensate for some of the present short-comings of renewables but large-scale application is not in sight (Fischedick et al. 2006).

Table 1: Subsystem - District-Heating

	Lock-in, stabilising forces	Cracks, tensions, problems
External landscape pressures	MODERATE • Long History since 1950s and well expanded grid of 20.000 km • The whole subsystem is dominated by fossil fuels as energy source. • Biomass production as energy source is limited in Germany. • Long history of sunk cost and failed investment.	LOW • Dependence on fossil fuels and therefore price uncertainties and fluctuations. • CHP mainly based on gas is seen as bridge technology (for heat and power generation) towards transition processes. • Biomass as energy source has lower market prices
Industry	MODERATE • In some cases: existence of monopoly positions leading to high fares. • Only few companies driving innovations. • High uncertainties for investors • Cost intensive infrastructure	MODERATE • Lobbying for better framework conditions, norms, and providing information on DH for an expansion of the market share. In context of CHP and Gas there is an emerging windows of opportunity for energy efficient technologies (bridge technology)
Consumers	STRONG • Constant market share • The access is geographically bounded. • High uncertainties for investors (for public grids) • Cost intensive infrastructure (for public grids)	
Policy-makers	MODERATE • No consistent strategy to fully switch to DH even in regions where this is technically and economically sound. • Uncertainties about further ordinances and incentives in context of the Energiewende.	MODERATE • Political target is to generate 25% of electricity from CHP by 2020 (16% / 2012). This could as well increase DH share in heat generation.
Pressure from social movements, NGOs, scientists	MODERATE • No uniform position • Lobbying for an extended use of CHP (which supports mainly big private companies and investors)	MODERATE • Lobbying for more public ownership (plants & grids) • Promoting CHP & DH as a more environment friendly technology.

[15] No information on such district heating fuel switch process in Germany has been found

The potential of district heating to initiate a regime shift of the German heat supply regime is rather unlikely. With 12 % market share, its influence compared to the other subsystems is low and stable. On the other hand, both chance and a condition sine qua non for a “green niche district heating” as analysed in D2.1 is set in renewable energy sources. Therefore, a shift from fossil fuels to green energy sources would be needed. However, this would imply major investments into dedicated plants. Currently, there are no signs to achieve either prerequisite. The assessment of lock-in and stabilising forces as well as of cracks and tensions in Table 1 points to a Pathways 0, that preserves the existing system as it is.

5 Developments in the residential building stock regime

Pathways to a low carbon transition of the building stock mainly rely on the buildings' energy efficiency and energetic performance. In the last decades the energy efficiency of residential buildings improved continuously through technological improvements, legislation and governmental ordinances. Due to the long life- and investment-cycles of buildings, the central challenge for accelerating a sustainability transition would be initiating a rapid refurbishment for the majority of old residential buildings according to current energy standards and state of the art in the near future. Moreover, the demographic development and changing life-styles and behaviour also influence heat consumption in private households.

The regime developments are again presented by describing tangible and intangible elements (for definition c.f. chapter 4). The elements relevant for a successful refurbishment of the current residential building sector in Germany are summarized in Figure 18.

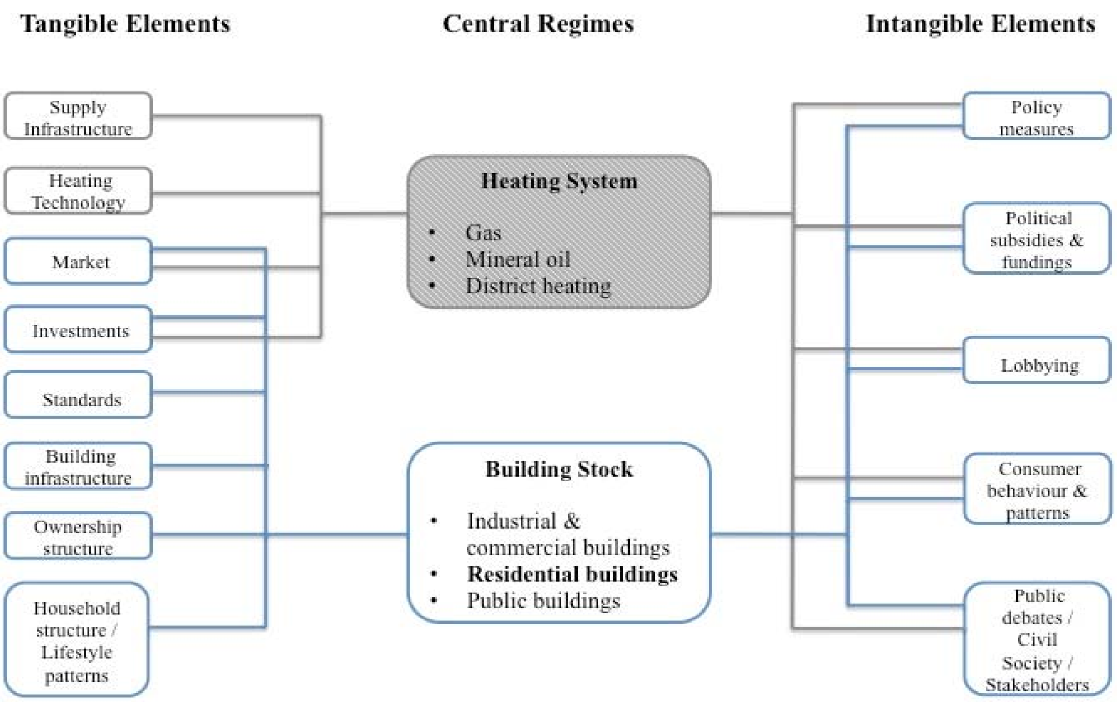

Figure 18: Tangible and Intangible Elements Source: Wuppertal Institute

Tangible Elements: Infrastructure and technological development

The German residential building stock is very heterogeneous and consists of various types of buildings and building age classes with different architectural, constructional and energetic characteristics. The current building stock for private households comprises approx. 19 million residential buildings with almost 41 million dwellings (cf. BMWi 2014a). The majority of around 7 million buildings (and 17.6 million dwellings) have been built after the Second World War and in course of the economic recovery during the 1960s and 1970s (see Figure 19). In this period, the priority was set on a rapid expansion to cover the high demand for living space. Issues such as energy and physical performance of buildings were not on the political agenda.

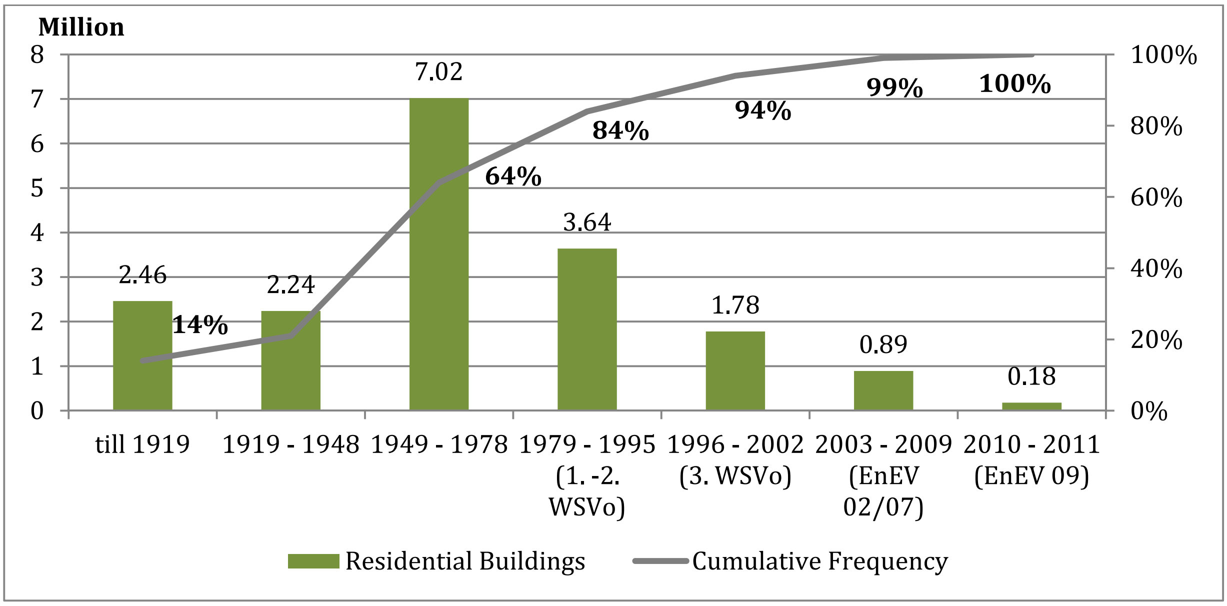

Figure 19: Distribution of the residential building stock classified by year of construction Source: Data BMWi 2014a

The residential building sector can be subdivided into detached houses, semi-detached houses, terraced housing and multi-flat houses. The major share of dwellings belongs to multi-flat houses with 19.6 million apartments. Multi-flat houses provide around 40 % of the living space in Germany (cf. BMWi 2014a, BMWi 2014d). The second largest share of apartments is related to detached houses with 12.4 million dwellings. Semidetached and terraced housing have a minor share with 8 million dwellings (see Figure 20).

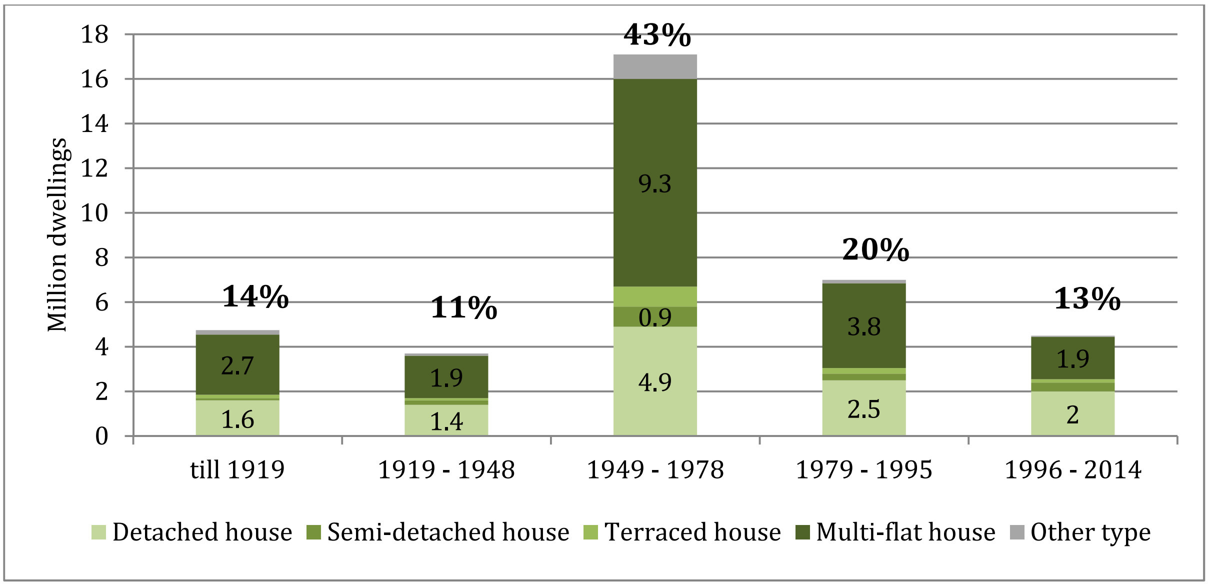

Figure 20: Apartment structure classified by year of construction and building type Source BMWI 2014a

The annual building permission rate since the mid 1990s reveals a decreasing trend in new constructions from 208.000 in 1995 to 95.000 thousand in 2010. This development indicates a market-saturation after strong growth rates in course of the German reunification. Since 2011 the permission rate has become stabilized with approx. 110.000 annually (cf. Figure 21). An interesting fact illustrated in Figure 21 is the continuing high demand and growing share of detached houses over the past decades, which reveal a shift in consumer behaviour. Additionally, in recent years the importance of multi-flat houses has also grown again. This is reflected, among an increasing rate since 2010, in comparison with semi detached houses over the past decades (see Figure 21).

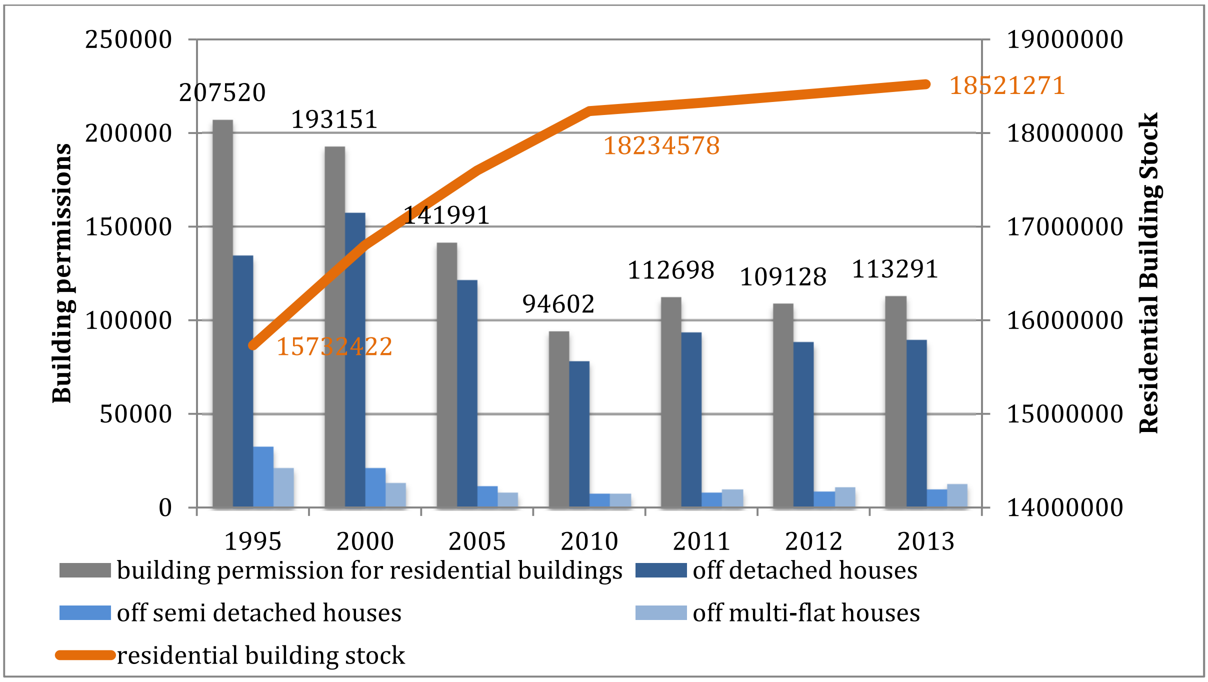

Figure 21: Permission rate for residential buildings and building type 1995 – 2013
Source: Destatis 2013 & 2013a

The German government estimates that 50% of the current building stock requires a fundamental refurbishment and retrofitting within the next 20 years (cf. BMWi 2014a). Estimations indicate that building envelopes in Germany have refurbishment cycles (investment cycles) of 30 to 40 years (cf. BMWi 2014a). Therefore, buildings from the 1970's and 1980's with a relatively low energy efficiency level are in the focus right now.

A survey of the IWU (Institut Wohnen und Umwelt) documented an annual modernization rate for the years 2000-2009 of external wall insulation of about 1 % for residential buildings constructed before 1978. In the same period the annual modernization rate for thermal insulation of roofs or upper floors varies between 1 % and 2 %. In the case of basement ceiling insulation it is below 1 %. In the last decade, it can therefore be assumed that the annual overall refurbishment/retrofitting rate in Germany lies between 0.9 – 1.3 % (cf. BMWI 2014d).

The German Energy Agency (Dena[16]) estimated that on average the general heat energy consumption will be reduced by 25 % per performed refurbishment/retrofitting (cf. Dena 2012a). Another survey of the "Dena" (2012) estimated that only 12 % of the installed heating systems have the latest state of the art. In addition, 80 % of the building stock have no proper wall insulation and 30 million windows are still based on single glazing. These findings exhibit a significant potential for energy and economic savings in the residential building stock (cf. Dena 2012) and a rather inert system in terms of a sustainability transition.

The KfW (Kreditanstalt für Wiederaufbau) assumes a need of residential real investments of 838 billion euro by 2050 to achieve the political energy transition targets. In the same period energy costs of only 370 billion euro could be saved through the investments. This calculation reveals that it is not possible from today's perspective to refinance residential real investment for energy efficiency only by reducing energy costs in private households (cf. KfW 2013). Still, the KfW emphasizes that this calculation does not comprise enhancement in value of residential buildings and improvements of living comfort, which were not subject of the investigation. These findings are contrary to the early statement of Dena (2012) and the federal government, which identify positive saving effects within amortization cycles for the majority of the cases of energetic refurbishment measures.

Policy towards energy efficiency in buildings chiefly started with the first Thermal Insulation Ordinance (WSVo)[17], an energy performance standard for buildings that was enacted in 1977 as a reaction to rising energy prices and uncertainties in security of supply. Since then, the policy regulations for low-energy standards in the building sector were constantly adapted (WSVo 1982, WSVo 1996) (see 16). From 2002 on the German federal government implemented a new political ordinance, the "Energy Conversation Ordinance" (Energieeinsparverordnung - EnEV), which combines the Thermal Insulation Ordinance (WSVo) with the "Heating Systems Ordinance" (Heizungsanlagen Verordnung - HeizAnlV). The objective of this new enactment was, beside the enforcement of low-energy standards in line with GHG emissions targets, to provide a more accurate detection of the primary energy demand and better comparison of energy consumption (state of the art in technology and level of insulation) for private households. With respect to the analysis on the heating system (chapter 4) it becomes clear, that this ordinance is a major factor in linking the development of the building stock and the heating system in Germany towards more sustainable standards.

The continuous improvement over the past decades illustrates a dynamic transition forced by technological innovation and political influence. The comparison of the area related-energy consumption by year of construction illustrates how energy performance of new buildings has steadily improved over the past 40 years in wake of policy regulations (see Figure 22). While buildings constructed in the period 1949 to 1978 have an average energy consumption of 208 kWh/m^2a, building energy efficiency has more than quadrupled under the ordinance of WSVo (1978-1996) and EnEV (2002-2009) for today´s low-energy houses with <50 kWh/m^2a (cf. BMWi 2014a). Nevertheless, 64 % of the current building stock were built before the first Thermal Insulation Ordinance (1.WSVo) and the majority have not been refurbished in terms of EnEV 2002 or later, leaving a huge potential for energy efficiency improvements (cf. Dena

[16] Deutsche Energie Agentur „Dena“

[17] Exact wording is: *Verordnung über energiesparenden Wärmschutz bei Gebäuden* commonly known as *Wärmeschutzverordnung* (WSVo).

2012). Against this background, there is a broad public debate on the economic feasibility of these potentials and their suitability for all building types (cf. Galvin 2013, Dena 2013 see also Social & Public Debate below).

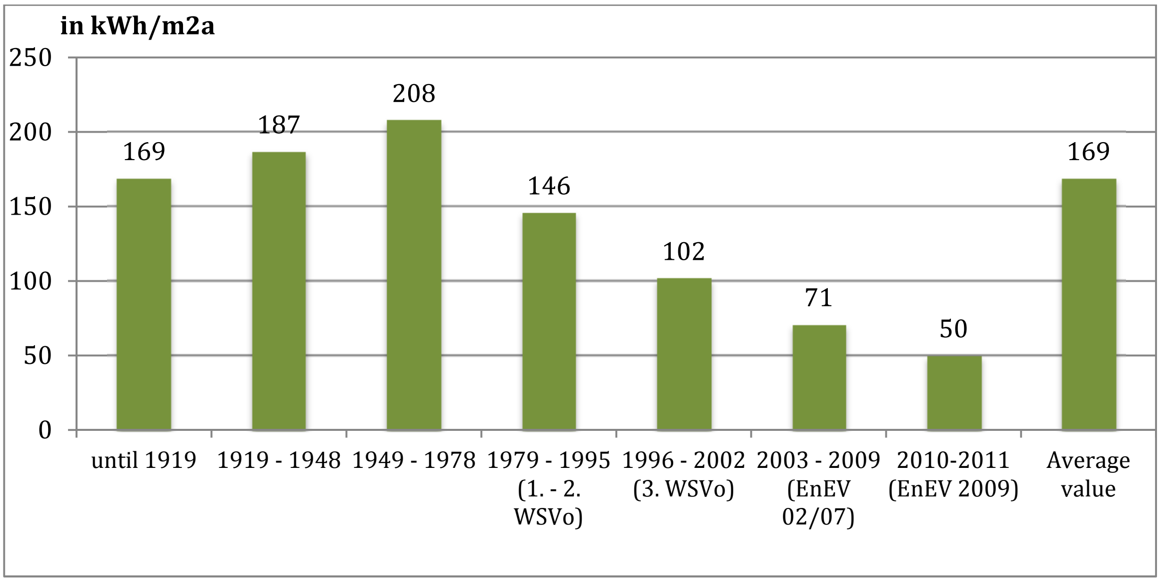

Figure 22: Allocation of the area-related energy consumption of existing buildings by year of construction Source: Data BMWi 2014a

From today´s perspective the residential building sector is growing slowly (see Figure 21) implying a strong importance for retrofitting, since substitution by new dwellings does not take place in relevant amounts – old buildings regarding long-life cycles are being used and reused instead of erecting new constructions. This underscores the necessity of raising the retrofitting rate within the next years. With the current retrofitting rate differ (0,9% – 1,3% in the last decade) it would take almost 100 years for a complete refurbishment of the residential building sector.

Intangible Elements

Policymakers

In the past decade whole house retrofitting has seen political support in-spite of change in government. The extent and depth of the refurbishment to the existing building stock will be essential to reach targets for GHG-emission reduction and final energy consumption of households (see 16). To increase the retrofitting rate (up to 2%), the German government pursues different approaches (cf. BMWI 2014, Galvin 2013, DDIV 2014):

- *provisions* in terms of specified energy standards like EnEV (see Chapter 3.3),
- *incentives* in terms of soft loans and grants for energy efficient refurbishment and whole house retrofitting (WHR). The legislative agenda is called "CO_2-Gebäudesanierungsprogramm" and was established in 2006. It addresses building insulation, windows and heating exchange and the use of renewable energies as well

as optimized measurement and control technology. Since 2006 about 12.5 billion euro and around 3 million dwellings have been successfully retrofitted or newly built up in terms of energy-efficiency measurements. In 2013 the program has been renewed for further 8 years with an annual amount of 300 million euro.

- *demonstration projects* by means of exemplary refurbishment measures performed and published by the German Energy Agency (Dena),
- *Information campaigns* about the different incentive programs and the economic efficiency of successful retrofitting.

These approaches mainly rely on and aim to improve voluntary engagement and put the economic profitability for owners and investors into the middle of political argumentation. The political strategy in the heat domain therefore pursues a cascade model: In a first step the reduction of heat demand through private investments supported by the so called “CO2-Gebäudesanierungsprogramm” in supplement with the expansion of renewable energies on the supply side through the so called “Marktanreizprogramm” (MAP) (see 16). Despite the different subsidy and incentive programs, it has not yet been possible to raise the refurbishment rate over the last decade (for barriers cf. Social and Public debate). The federal government currently works on a new refurbishment roadmap, the so called “Sanierungsfahrplan für Bestandsgebäude” for owners, with the aim to more accurately demonstrate the viability and benefits of energetic refurbishment. To follow this guideline is voluntary as well and therefore meant as a landmark to improve future investment-cycles in terms of depth and outreach of energy-efficiency measures (cf. BMWi 2014a, DDIV 2014). Previous barriers such as restrictions on the conservation of old building facades have been already reduced in a first step of the reissue of EnEV 2014 (cf. IVH 2015). Moreover, with the reissue of EnEV 2014 all residential buildings that will be constructed or energetically retrofitted have to get a needs-focused “Energy Performance Certification” (Energieausweis für Gebäude) as an orientation for tenants and investors (cf. Dena 2014, **Error! Not a valid bookmark self-reference.**). In addition, the German federal government founded a new exchange platform, the so called „Energiewende Plattform Gebäude“ in 2014 gathering important actors under one umbrella: owners, real estate industry, building industry, unions, consumer associations, and the public domain (cf. BMWi 2014d). The motivation for the exchange platform is to establish a more direct exchange of expertise, meeting the specific needs of particular stakeholders. The past public and political debates have shown significant gaps between the political programs,

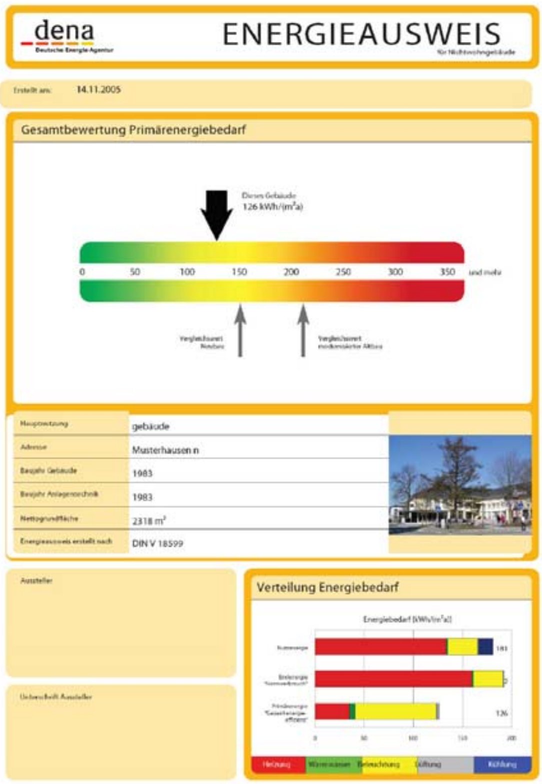

Figure 23: Energy Performance Certification Source: Dena 2014

ordinances and subsidies with regard to the realities of investors, homeowners and other stakeholders (for concrete barriers and problems see Social & Public debate), the platform is aiming to close these gaps. The measures and strategies shown above indicate that governmental action itself relies on less tangible effects like incentives and voluntary engagement.

Consumer households

Since the 1990s the living space per capita in Germany has grown steadily from 39 m^2 (1998) to 45 m^2 in 2013 (cf. BiB 2013). This development had manifold reasons and does not apply to all regions equally. Especially in growing cities multi-person households like families face challenging difficulties through rising prices and housing shortages, which result in smaller living space per capita to this population group. In general, the social development shows a significant trend to one and two person households. In Germany 40 % of all households are single-households (in urban areas the share increases up to 50%). Together with two person households they have an overall share of 75 %. Households with three or more persons (for example families with children) only accounted for 25 %, in the largest cities even much less (cf. Kaltenbrunner et al. 2014). In addition living space per capita rises steadily: The improving economic situation due to rising age leads to a greater claim of living space with increasing age of the inhabitants. While underage persons have around 30 m^2 of living space, 65-year-old persons have approximately 55 m^2 (cf. BiB 2013). The future development of living space utilization and distribution depends on many factors: population, demographic and migration development, change of lifestyles and budgets (cf. Kaltenbrunner et al. 2014). In the midterm view the claim for living space will rise especially for rental apartments in prospering core areas due to the flexible and prospering life-style of the younger generation. In the long-term view until 2060, the demand for residential buildings will decline. A key factor for a successful increase of the refurbishment rate will depend on whether the existing residential building stock, the market and the political conditions can meet these changing requirements or not.

Today, around 23.7 million (58 %) of the approximately 41 million dwellings are rented and mostly located in multi-flat houses. In European comparison Germany has a minor ownership rate in the residential building sector of 43 % (European average is around 60 %) (cf. Kaltenbrunner et al. 2014). The major share in terms of ownership rate belongs to detached houses with 88 %, followed by semidetached houses with 59 % (cf. BMWi 2014a). Conversely, 87 % of the multi-flat houses are rented.

In Germany young people and especially women recently focus more on their own career and self-fulfilment, which results in a more “flexible and prospering” life style. Therefore, issues like founding a family and house/dwelling purchase is postponed to middle age (Kaltenbrunner et al. 2014) leaving more room for renting. In general, it can be assumed that topics like energetic refurbishment and energy performance is mainly related to acquiring ownership and therefore younger people are less aware of these questions. A survey of the VUMA (Verbrauchs- und Medienanalyse 2014) on “the consumer interest in being informed about possible information addressing refurbishment and building aspects” reveals that only 3.88 million people are “very interested”, 14.03 million are “interested”, 18.97 million are “little interested” while the majority with 33.71 million are “not interested” (cf. Statista 2015a). Keeping in mind the high share of tenants and the relative low owner rate, these findings should not be overrated. In contrast, the awareness in terms of consciousness for energetic performance constantly rose in the last decades. This is mainly induced by NGO´s, the media, political campaigns and scientific studies, which push the topic motivated by climate change and economic savings (cf. UBA 2013, Galvin 2013). Also companies discovered the topic of energy-saving behaviour through new developments in the field of “smart home systems”, which support and assist new lifestyle patterns of improved energy performance (cf. Handelsblatt 2014a).

A survey from the GfK (Gesellschaft für Konsumforschung 2013) examined “the main reasons for performed refurbishments in residential buildings”: 75 % of respondents stated “reduction of energy cost” as the most relevant aspect followed by “improvement of living environment” with 12 %, “mandatory regulations” (9 %) and “environmental protection” (3 %) (cf. Statista 2015b). These results indicate that investments are rather driven by economic expectations and incentives than by idealistic motives towards sustainability. A survey from the GEEA (Gebäude Energieeffizienz Allianz 2013) especially addressing homeowners and their general attitude to refurbishment measures reveals that 74 % are generally open for energetic refurbishments, while 14 % are completely uninterested and 12 % are undecided homeowners who do not care about energy savings (cf. Dena 2013). Comparing the different studies, a great gap in awareness between homeowners and tenants with regard to energetic refurbishment is visible. Nevertheless a change towards conscious energy-saving behaviour can be observed on the consumer household level (cf. Handelsblatt 2014, UBA 2013, Galvin 2013).

With a view to the demographic development in context of the ownership rate, today around 50 % of all owners are 60-years-old or even older (cf. BMWi 2014a). Therefore a considerable change of ownership will occur in the near future which leaves different windows of opportunity in terms of energetic refurbishment and investment measures (cf. BMWi 2014a). However, this does not apply to all regions equally. While urban agglomerations benefit from a surplus in migration due to suburbanization and gentrification, rural and peripheral areas register increasing building vacancies through the same migration effects at the same time, especially in the eastern parts of Germany (cf. Kaltenbrunner et al. 2014). Another important variable will be the future development of population in Germany. Studies reveal a decreasing trend from approx. 82 million 2013 to 69 or 74 million in 2050 (see Figure 24). The variation and extent depends mostly on the future immigration rate (cf. BiB 2013, Destatis 2007, Destatis 2013b). The consumer side does not point towards a strong movement towards transition. While there is a certain awareness for energy efficiency measures the retrofitting rate does not support the conclusion that his has lead to major efforts on the side of owners and tenants in terms of a social movement.

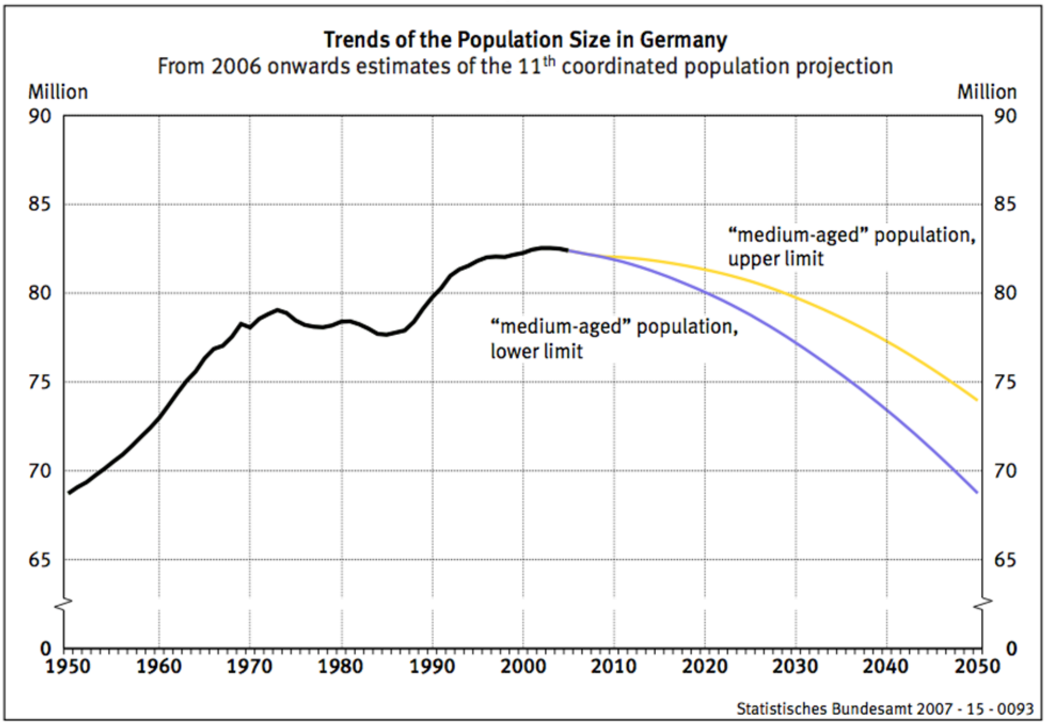

Figure 24: Population in Germany for the period 1950 – 2050
Source: Destatis 2007

Industry (stakeholders)

Due to a slow refurbishment rate the commercial interests that link to the existing stock are of highest interest here. The building sector has a wide range of stakeholders and lobby groups. As commercial actors, they are specifically subject to their monetary obligations and interests. The central actors are builders, owners, tenants, investors, and their respective unions. Today around 23.7 million (58 %) of the approximately 41 million dwellings are rented. 14.5 million are rented by private lessors and around 9 million have commercial suppliers (cf. BMWi 2014a). About 80 % of the rented units are dwellings in multi-flat houses. The suppliers are primarily represented through commercial suppliers (39 %), private occupants (17 %) cooperatives (9 %) and communal lessors (9 %) (cf. BMWi 2014a).

The main association of private building owners is called "Haus und Grund" with 22 regional associations and over 900 unions (HuG 2015). In context of refurbishment measures "Haus und Grund" has a decelerating effect: They argue that refurbishments are only cost-effective, if the building was in a bad energetic condition, all measures are taken simultaneously, are (partly) funded by KfW and costs could be shifted adequately to tenants. As this is seldom the case, they lobby for an adjustment of the current ordinances and incentive programs towards support of graduate measurements instead of Whole House Retrofitting (cf. HuG 2014).

The GdW (Federal Association of German Housing and Real Estate Companies) is the biggest lobby group for investors, commercial suppliers and cooperatives. It comprises 15 unions and has over 3 000 members. They state that between 1998 and 2013 36 % of the buildings of *GdW*-Members have been completely energetically restored while 28 % have been restored partially. Through these measurements the CO_2-emissions of the *GdW*-Members buildings has been successful reduced by 50 % since 1990 (GdW 2015). In this context the *GdW* claims that the current Federal Government does not adequately regard improvements undertaken during the 1990s (with a view to investment- and lifecycles) because recent political climate targets and the reissue of EnEV 2014 refer to the year 2008 for comparison (cf. GdW 2015). Therefore the GdW expresses concern on the current political orientation in terms of investment cycles, cost shifting and for the "Energy Performance Certification" as an orientation for tenants and investors (cf. GdW 2015).

The biggest lobby for tenants is represented through the so-called "Deutscher Mieterbund", an umbrella organization of 15 regional associations and more than 300 local tenant unions. The association lobbied successfully for a so-called "rent-brake" that limits rent increases. As the federal government now plans to allow more cost-shifting of energy efficiency measures to tenants, the association has a critical position fearing rising rents, and formulates doubts on the cost-effectiveness of refurbishments (cf. Deutscher Mieterbund 2014). As 58 % of German households rent their apartments – representing 72% of the population (cf. Destatis 2013b), the importance of the critical position of this associations becomes clear: at present due to legal arrangements, investments have to be taken by owners, but mostly tenants gain the benefits – this results in the "split incentives dilemma" (cf. Kumbaroglu & Madlener 2012). A change in this would put more monetary burden on the tenants which is not in the interest of the Mieterbund. Low-energy investments are thus more likely for owner-inhabited buildings and easier for newly constructed buildings avoiding split incentives.

Subsuming the industry stakeholders, two central barriers for refurbishment measures can be observed: first of all the reservations to current political goals, ordinances and incentive programs regarding Whole House Retrofitting (WHR) which put financial burdens on these groups. In this context their unions lobby for a more graduate development, which would allow for stepwise refurbishment measures (see also Social & Public Debate). A second issue is the split incentive dilemma between tenants and homeowners and investors. While the first barrier offers opportunities for adjustment and therefore windows of opportunity for raising the retrofitting rate, split incentive seems to be a lock-in factor, especially with the view to the relative low owner rate in Germany (see Consumer / Households).

Civil Society & Public debate

The public debate to refurbishment measures is very heterogeneous and divergent, represented by a wide range of stakeholders and media. It reflects the situation of consumers and industry as pointed out above. Despite political information campaigns and incentive programs, the general public interest in refurbishment and building measures seems to be rather low, except for building owners (see Consumers / Households).

The media is an important actor here. Whole house retrofitting (WHR) has been discussed highly controversial. It was claimed to be uneconomic or to hardly offer any cost savings (cf. FIW 2013)[18]. While the media can make a positive contribution in informing building owners to pay special attention to certain aspects of building retrofits, the FIW[19] (Research Institute for Thermal Insulation 2013) criticises, that several reports focus mainly on few case studies with limited scientific objectivity providing their recipients with rather unsubstantiated

[18] For example, media articles speak of "Dämmwahn" ("insulation madness"; Zeit Online 2012).

[19] Forschungsinstitut für Wärmeschutz e.V

information.[20] In general, positive and critical reporting is in balance and depends on the point of view of the individual reporter (for example tenants vs. homeowners or WHR vs. graduate measurements).

Since 2012 a change can be observed in the public and political debate in terms of economic and feasibility questions. Studies on the so-called “prebound effect”[21] and the “practical implementation of refurbishments measures” reveal that political ordinances, guidelines and subsidies in terms of EnEV may be losing track of homeowners and investor realities (cf. Galvin 2013). The authors state that current political measures focus especially on the “all or nothing principle” regarding WHR and exclude gradual refurbishment measures meeting the specific need of certain building-types and ages. Especially for old building-structures (before 1980) the ordinances of EnEV 2009 and later are not applicable. Against these backgrounds, the authors claim the need for a rethinking in current political guidelines, ordinances and subsidies addressing the specific needs of homeowners and investors (cf. Galvin 2013).

Initiated through the critical debates, a survey by the Dena (2013) on behalf of the German federal government examined central market barriers for current refurbishment measures: In addition to lack of “market transparency”, “concrete information” and “trust into actors”, the “high complexity of refurbishment measures” combined with “uncertainties about the quality and reliability” and “concrete funding problems” seem to be the main reasons and barriers (cf. Dena 2013). In conformity with these findings an open discourse emerged on the re-adjustment of the EnEV and other funding instruments (cf. Galvin 2013, Dena 2013). Central aspects are:

- flexible alignments of the current ordinances addressing gradual developments and specific needs,
- an increase of subsidies in terms of the “CO_2-Gebäudesanierungsprogramm” and the “Marktanreizprogramm MAP” (see 16),
- the adoption of a financial and tax aid scheme addressing energy efficiency measurements,
- strengthening of energy consultancy,
- transparency through a qualified list of experts,
- widespread refurbishment guidelines and campaigns (cf. Galvin 2013, Dena 2013).

It remains to be seen to what extend the claims will be realized. With the re-adjustment of the EnEV 2014 regarding flexible alignments, the forthcoming “refurbishment guideline” for homeowners and the “needs-focused Energy Performance Certification”, some of the claims

[20] The negative image conveyed might be one reason for the decreasing numbers of insulated exterior building components from 42.5 million m^2 to 40.1 million m^2 between 2011 and 2012 (cf. FIW 2013, p. 212).

[21] The “prebound effect” designates the gap between “theoretical energetic savings” based on fixed kwh/m^2 to reach a calculated temperature and the “real energetic savings” which are linked to the actual consumption and behaviour of people. Sunikka-Blank and Galvin (2012) demonstrated that in Germany the average measured consumption is around 30% lower than the calculated need (cf. Sunnika-Blank & Galvin 2012). These findigs have a huge social and politcal impact regarding investment cicles and amortisation caclulations.

are already implemented (see Policymakers). In terms of subsidies and re-adjustment of the current incentive program no particular decision has yet been taken in this field (cf. BMWI 2014). With the implementation of the new exchange platform „Energiewende Plattform Gebäude“ the cornerstone for a better exchange of specific needs of the stakeholder is applied. This could lead to a harmonisation of the different political actors and lobby groups. However, right now the public debate rather works as a stabilizer to the existing system than pointing towards regime change.

Overall assessment

The crucial point for a sustainable transition of the building regime is the successful increase of the current retrofitting rate from 1 % to 2% to reach an almost climate neutral building stock (energy consumption of buildings <50 kWh/m^2a) in 2050. The theoretical potential is tremendous: the majority of buildings (64 %) have been constructed before the first enactment of Thermal Insulation Ordinances in 1978 and therefore have poorly energetic performances and large parts have not been refurbished yet. Estimations reveal that in the next 20 years 50 % of the current building stock needs fundamental refurbishment measures. Despite these potentials, previous political measurements on Whole House Retrofitting (WHR) did not succeed, but failed due to inter alia the complexity of the heterogeneous building structure in terms of building types, age and energetic characteristics (all or nothing principal). In addition, the public and scientific debate as well as the situation and the position of consumers and the industry reveal the claim that existing subsidies, incentives and ordinances may be losing track of investors, homeowners and tenants realities.

Previous political approaches mainly relied on voluntary engagement of society and put the economic profitability for owners and investors into the middle of the argument. The central problem therefore lies in an actual gap between energy savings and economic profitability of energetic measures. Only for a small share of the total building stock, WHR seem to be a win-win situation. In most of the cases, economic profitability may not be achieved despite long investment cycles. Actually, the central barriers for refurbishment measures are perceived uncertainties due to the high complexity of refurbishment measures, concrete funding problems e.g. for of gradual measures, lack of market transparency and trustworthy information (e.g. on environmental and economic benefits, leading to lack of trust in actors). From today´s perspective (retrofitting rate of 1 %) it would take 100 years for a complete refurbishment of the German residential sector. Most of the stakeholders, lobby groups, homeowners, investors, scientist and expert as well as the media support the approaches of the federal government in general but call for a re-adjustment of specific measures e.g. the incentive programs and guidelines. Central claims are flexible alignments of the current ordinances, addressing gradual developments, increasing subsidies, the adoption of financial and tax aid scheme, strengthening of energy consultancy, transparency through a qualified list of experts and widespread refurbishment guidelines and campaigns. As for now, all this works rather towards a perpetuation of the status quo. Moreover a slow reconstruction rate and the development of lifestyles do not support the idea of an altered regime where efficiency and GHG-emissions are lowered through technological, architectural or social innovation. Nevertheless, a suitable amendment of subsidy schemes could lead to a transition following Pathway A.

6 Conclusion

In this final chapter, we assess the two regimes of the heat domain with regard to lock-in and stabilising forces and concerning the cracks, tensions and problems that they face. From this we evaluate the possibility of a regime shift and transition. Although both central regime elements – **supply** through heat generation systems and **demand** represented by the residential building stock – are interdependent and connected, they are considerably different in many regards, specifically investment cycles, useful life and hence asset specificity. Acknowledging this observation we will therefore discuss them in two distinct sections.

6.1 Assessment of degree of stability and tensions of heat supply regime

The analysis of the heat generation sub-systems gas-, oil- and district heating revealed a clear lock-in situation towards existing technologies, which is slowly amended (especially in the case of oil) but not replaced by renewable technologies. However, there is a within-regime development from oil towards gas and an unclear picture for district heating. Even though the external landscape promotes a shift away from fossil fuel to renewable energy solutions the well-established infrastructure and an industry with strong associations and interest groups stabilises the incumbent system.

Constant technological developments with regard to efficiency were very favourable in this respect. Consumers perceive e.g. gas heating systems as an environmentally friendly heating solution also because of the possibility to use them with organic gas. Oil heating systems on the other hand fell behind in recent years, which might indicate a further downward trend for this respective sub-system in agglomeration areas. For decentralized and rural areas oil-heating systems have still importance in security of supply.

Policymakers have set goals for CO_2-reduction that affect the regime, but they mainly rely on market-based incentives and set monetary incentives for refurbishments of heating systems e.g. when applying a combination of gas with renewable energy sources. Currently there is only one mandatory and binding regulation set by the government: oil- and gas-heatings older then 30 years have to be replaced, but this replacement can be done within the same resource based technology, yielding no stronger effects for regime change. In combination with the current framework and actual consumer preferences, this regulation further stabilises the regime, since consumers connected to the gas grid tend to stick with their current heating system, the same holds true for oil-consumers. In Table 2 we summarise the most important statements from the regime analysis in chapter 4, related to lock-in factors as well as cracks and tensions. We focus this on oil and gas since DH is less important and was mostly analysed for subsequent use in cross-country comparison.

Table 2: Heat Supply Regime - lock-in, stabilizing forces cracks, tensions & problems

	Lock-in, stabilising forces	**Cracks, tensions, problems**
External landscape pressures	For gas: MODERATE • Gas maintains a constant and growing role for German heat energy supply • Discourse about climate change is stabilising gas, as it is perceived to be a more reasonable resource than oil (bridge technology) For oil: MODERATE • In more peripheral areas oil plays an important role for energy supply when there is no connection to the gas grid. This will likely remain for at least the mid-term	For gas & oil: MODERATE/STRONG • Strong discourse about climate change and CO_2-emissions and fossil fuels as finite resources • Political unrest in eastern Europe reveals import dependency as a weakness. For gas: MODERATE • Criticism on fracking For oil: STRONG • Oil crises in the 1970s, and • Recent volatility of prices
Industry	For gas & oil: STRONG • Well organized in associations and interest groups • Strong German enterprises: producers, suppliers etc. • Extensive investments in recent and upcoming years into (already well developed) gas infrastructure. • Development of new technologies follow consumer preferences: more efficient and combinable with renewable energy sources but no essentially new technologies.	For gas & oil: MODERATE/WEAK • Low domestic potential of gas and oil exploration shows evidence of import dependency leading to public concern. For gas: MODERATE • Development of technical alternatives for gas heating (organic gas). But these function as hedging strategy not as full reorientation strategy. For oil: STRONG/MODERATE • Low share of oil-heating systems on the sales market • Innovation potential of the oil heating technology is assumed to be exhausted caused by a lack of investments in the sub-system.
Consumers	For gas: STRONG • Gas is most appreciated heating technology by the consumers. • Majority would choose gas-heating system in the future (75% of the overall new installed heating generators are gas-heating systems, consumers formally using oil heating tend to stick to this technology). For oil: MODERATE • Oil is best available conventional resource in rural areas without access to the gas or DH grid. Effects of asset specificity. • Still appreciated by consumers that already own a oil-heating system	For gas: WEAK • No objections of customers against gas-heating systems. For oil: MODERATE • Since the oil-crisis in the 1970s and the rising prices for heating oil: declining acceptance of the oil-heating sub-system • Perceived as dirty and out-dated by the majority of consumers and thus very low share in new constructed buildings
Policy-makers	For gas & oil: MODERATE/STRONG • On a political level, fossil fuel-based heating is integrated into the funds and subsidies schemes that provide incentives for refurbishments For gas: MODERATE • Fracking law: no legal prohibition of fracking improves resource supply outlook.	For gas & oil: MODERATE/WEAK • CO_2-reduction and climate protection policy provides steps towards less fossil fuel-based technologies but has strong ties to prevailing regime. • Funds are only available for refurbishments applying a combination of gas & oil with renewable energy sources. • Legal enforcement to replace oil- and gas-heatings older then 30 years

		For gas: MODERATE • Fracking law: harsh penalties for fracking related environmental contaminations somewhat reduces the supply prospect. For oil: MODERATE: • A central overall strategy to promote the industry like it exists in the case of gas is missing.
Public debate and opinion	For gas & oil: STRONG • No general ban of either technology but incentives for refurbishment with the same (but more efficient) technology. • Especially for gas: strong support as bridge technology both in single-house and DH due to flexibility of use with organic gas and good image of environmental performance.	For gas: WEAK • Concerns about fracking, especially due to possible ecological damages • Dependency on gas-imports is critically discussed • Biofuel production leads to critical debate on competing land use and mono-cultures. For Oil: MODERATE • In light of the discourse about climate change, oil is generally perceived as an energy source with no future prospects in the long term.
Pressure from social movements, NGOs, scientists	For gas and oil: MODERATE • Present importance of gas as a heating medium is generally acknowledged. • Focus on implementing changes WITHIN the heating sub-system, like modernization of existing gas- /oil-heating systems instead of replacing the system	For gas & oil: WEAK • Critical on implemented political measures (funds, subsidies for refurbishments) as ineffective, contradictory and non-transparent.

6.2 Assessment of degree of stability and tensions of heat demand regime

To evaluate stability or possible tensions for the heat demand regime, it is important to define what we understand as change of the residential building stock which is the sub-system under investigation here. Since the rate of new constructions is negligible compared to the existing building stock, and a complete demolition and new construction is neither economically nor ecologically feasible, a sustainable transition concerns the reduction of total energy consumption per capita and thus an increase in energy efficiency instead of replacement. Since a lot of the existing housing stock is expected to need such retrofitting, a movement to a new shape of the subsystem is implied, which relates to a Pathway A design.

It is the political will to change from which we identify significant cracks and tensions in the German heat demand regime. The government promotes this transition by legislation, as well as by the provision of funding schemes and other monetary incentives to trigger refurbishment. Nevertheless, also because of current policy design, which many significant actors judge as not appropriate, the refurbishment rates needed for a fast transition are not reached yet.

Consequently, the assessment of many other actors shows strong stabilising forces. The main objective is related to the economic reasonability of investments (amortisation time) and the split incentive dilemma between owners and tenants (see chapter 5 of the country report). The uncertainty on the side of investors is even more increased by contradictory information. While on the one hand, refurbishment is promoted by the government and affiliated

organizations, a study published by KfW reveals that the total investments needed until 2050 will not be covered through the energy saving potential.
Overall, the situation of the heat demand regime appears to be undecided. The condition of the building stock in place and the political programs towards retrofitting hint towards a Pathway A movement. The given potential of improvement in the shape of reduction of resource consumption through efficiency measures, point this way, too. However, reluctance on the side of many key actors – real estate owners as well as tenants – to commit to investments imply very slow change. Also the present change in lifestyles for larger flats and single occupancy do not work in favour of a more sustainable regime. Nevertheless, one should remember that investment cycles in this sub-system are rather long, so that no fast processes are to be expected unless significant unexpected occurrences like a breakdown of supplies occur.
Table 3 gives an overview on the main stabilising and destabilising influences as a result of the analysis in chapter 5.

Table 3: Heat Demand Regime –lock-in, stabilising forces, cracks tensions &problems

	Lock-in, stabilising forces	**Cracks, tensions, problems**
External landscape pressures	MODERATE • General inertia of society visible in low retrofitting rate (0,9 – 1,3% p.a.) • Environmental problems caused by housing not perceived as major national problem in society	MODERATE • Global-, EU- and Federal conventions towards lowering GHG-emissions/improving climate friendliness • Insecurity of supply and uncertainties in energy prices as a general motivator
Industry	STRONG • Low rate of new construction provides little opportunity for basic innovations • A study of the KfW indicates that needed investments for a complete refurbishment of the residential building stock cannot be covered by energy saving potential. • Homeowners and investors lobbying for market-based measures for refurbishment (incentives). They fear the political ordinances due to uncertainties of economic profitability. • Tenants lobbied successful for a “rent brake” strengthening the “split incentive dilemma”, reducing owners’ motivation for investment.	WEAK • Need for refurbishment of 50% of the current building stock within the next 20 years; but owners and tenants are reluctant. • Some lobbying for flexible alignments and gradual development opportunities in terms of energetic refurbishment measures (instead of whole house retrofit) and an increase of subsidies. • Support for the new exchange platform (“Energiewende Platform Gebäude”) implemented by the Federal German Government • Some open-mindedness for debates and re-adjustment of EnEV and more specific incentive programs
Consumers	STRONG • Growing living space per capita and age. • Changing lifestyles towards self-fulfilment and single households lead to a flexible way of life and therefore to a low ownership rate. • Low ownership rate (43%) resulting in a disproportionate “split-incentive dilemma” especially in multi-flat houses. • Long-time investment cycles.	MODERATE • Rising awareness for energetic saving behaviour • 50% of all owners are 60 years and older. Therefore a change of ownership will occur in the near future creating windows of opportunity for energetic investment measures • Urban-rural gap leads to residential shortages in urban spaces and to vacancies in peripheral areas → changing requirements to the residential

		building sector.
Policy-makers	MODERATE • Ordinances and subsidies in the past decades support especially Whole House Retrofitting (WHR) building up barriers for gradual development. • Lack in flexibility of subsidies, lack of transparency regarding support and orientation	MODERATE/STRONG • Legislation enforces change: Enactment of first Thermal Insulation Ordinance (WSVo 1978) and the enhancement to the Energy Conversation Ordinance (EnEV 2002 and later). • Since 2014 stepwise re-adjustment of subsidies, ordinances and guidelines to meet the specific needs of homeowners and investors • Measures to improve market transparency are being taken
Civil Society & Public debate and opinion	STRONG • Interest in energetic refurbishment rather low with a view to the entire population • Lack of appropriate and objective information on refurbishment in the media (WHR is discussed controversially which results in uncertainties.) • Disagreement on the economic feasibility for private homeowners (investment vs. amortisation cycles) though energetic performance and reduction of energy costs are the most relevant factors for homeowners to conduct refurbishments	MODERATE • The basic attitude towards energetic performance of house owners is positive • Change in the public, scientific and political debate towards a re-adjustment of current ordinances, subsidies and guidelines resulting in build-up of pressure on policy makers • Rising awareness for energy saving behaviour through media and debates
Pressure from social movements, NGOs, scientists	MODERATE/STRONG • Most active are groups that represent tenants or owners working mostly towards regime stability or mild modernization. • No specific pressure groups towards drastic regime transformation	MODERATE/STRONG • Scientific studies and public awareness pushed the critical debate addressing current barriers for energetic refurbishment • Pressure for adoption of financial and tax aid schemes addressing energy efficiency, strengthening of energy consultancy, widespread refurbishment guidelines and campaigns and also flexible alignments of the current ordinances • NGOs rather work toward refurbishments than for drastic measures • Government seeks to initiate an alliance with important players through a common exchange platform.

6.3 Overall conclusion on transition pathways in the heat domain

The two regimes analysed show different potential for transitions. All in all, we see the German heat domain on a potential verge towards a Pathway A transition. This is especially due to the heat demand regime where imminent but slow change can be expected.

Due to political targets set by the German government, there is significant political support for an energy-efficiency transition in the building stock. However, change will be subject to a relatively long period of time. First-steps towards a transition of the building stock already took place (first ordinances from the 1970s) and the regime actors had time to develop strategies and respective technologies to adjust. Therefore incumbent actors, many of them German companies, are part of the transition, which might make changes less detectable than e.g. in the energy regime. Promoting energy and resource efficient heating systems is a win-win situation for the German government: Offering incentives for refurbishment and whole-house retrofits directly leads to investments into the local economy as many appliances are bought from the German companies in the heat-supply regime and are installed by local craftsmen. Supporting retrofitting thus also causes knock-on effects for the heat-supply system. The analysis of barriers for refurbishments, and thus lock-in factors in favour of the current regime, revealed that most arguments relate to a lack of financial attractiveness and information. Potential transition pathways for this regime point towards Pathway A according to the PATHWAYS project terminology, with incumbent actors playing important roles, significantly changing the (e.g. insulation) technology but leaving the other system elements more or less as they are. The social dimension, e.g. the trend of increasing living spaces and other consumer related behaviour would not be changed by this transition.

For the second regime, the heat generation regime, we do not see a radical regime shift in the near future unless related to changes in building stock. The niches of relevant technologies (analysed in D 2.1 c.f. Berg et al. 2014) did not reveal significant momentum and the existing technologies, especially gas heating systems, dominate the current market. Even without a major change in the regime, but a pursuit of pathways 0 or a mild Pathway A, the assessment hints to (relatively) positive development for a future transition towards a low-carbon society of the heat domain with regard to heat supply. However, due to constant incremental changes in technologies concerning, for example, energy efficiency or compatibility with renewable energy sources (e.g. organic gas), an overall improvement in environmental regime performance will be visible.

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Appendix

Table 4: Gas Heating System – lock-in, stabilising forces, cracks, tensions & problems

	Lock-in, stabilising forces	Cracks, tensions, problems
External landscape pressures	MODERATE • Oil crisis in the 1970s. • Discourse about climate change and CO2-emissions promote gas as compared to oil. • Policy generally works in favour of gas.	MODERATE/STRONG • Gas is a finite resource • Supply problems, criticism on fracking. • Political unrest in eastern Europe reveals import dependency as a weakness.
Industry	STRONG • Extensive investments in recent and upcoming years • Well developed supply infrastructure • Development following consumer preferences: offering increased organic-gas mixtures and efficient technologies • Gas as a main pillar within the heating domain • Well organized in associations and interest groups • Strong German enterprises: producers, suppliers etc.	WEAK • Low domestic potential of gas exploration • Development of technical alternatives (organic gas), but as hedging strategy not as full reorientation strategy
Consumers	STRONG • Most appreciated heating technology by the consumers • Majority would choose gas-heating system in the future • 75% of the overall new installed heating generators are gas-heating systems • Flexibility for consumers: See advantages of organic-gas mixtures and utilization • Appreciate infrastructure that is still developing /external connection to gas grid	WEAK • No objections of customers against gas-heating systems
Policy-makers	MODERATE/STRONG • On a political level, the importance of gas is recognised and integrated into policy measures. • Funds and subsidies that provide incentives for refurbishments • Fracking law: no legal prohibition of fracking.	MODERATE/WEAK • Funds are only available for refurbishments in a combination of gas with renewable energy sources. • Legal enforcement to replace gas-heating systems older then 30 years • Fracking law: harsh penalties for fracking related environmental contaminations.
Public debate and opinion	STRONG • In general strong support through flexible combination opportunities and good image in question of environmental performance • Supported as bridge technology	WEAK • Concerns about fracking, especially due to possible ecological damages • Dependency on gas-imports is critically discussed

Pressure from social movements, NGOs, scientists	MODERATE • See general importance of gas as a heating medium • Focus to implement changes WITHIN the gas-heating sub-system, like modernization of existing gas-heating systems instead of replacing the system	WEAK • Criticise implemented political measures (funds, subsidies for refurbishments) as ineffective, contradictory and non-transparent

Table 5: Oil Heating System – lock-in, stabilising forces, cracks, tensions & problems

	Lock-in, stabilising forces	**Cracks, tensions, problems**
External landscape pressures	• In a diversified energy market oil is playing a constant role for a secure energy supply • In peripheral areas oil plays an important factor for energy supply	• Oil crises in the 1970s • Uncertainty of oil supply • Volatility of prices • Discourse about climate change
Industry	STRONG • Many different actors, therefore high level of risk diversification • Loyal consumers: high modernization potential in mid term prospects • Intense advertising of oil-heating by the industry • Offers new technologies: more efficient / combination with renewable energy sources	Moderate • Low share of oil-heating systems on the sales market • Innovation potential of the technology is assumed to be exhausted
Consumers	STRONG • Still highly appreciated by consumers that already own a oil-heating system • Effects of factor specificity • Best available conventional resource in rural areas without access to the gas or DH grid.	MODERATE • Since the oil-crisis in the 1970s and the rising prices for heating oil: declining acceptance of oil-heating sub-system • Perceived as dirty and out-dated by the majority of consumer • Very low share in new constructed buildings • Many different expenditures: storage tank, boiler, chimney etc., additional costs through maintenance
Policy-makers	MODERATE • Funds for refurbishments with oil-heating technology are available • No general ban of oil-heating generators	MODERATE/WEAK • Old oil condensing boiler have to be replaced • An central overall strategy to promote the industry of the oil-heating sub-system is missing, like it exists in the case of gas

Public debate and opinion	STRONG • A general ban of oil-heating systems is not considered to be beneficial, rather more incentives for refurbishments within the oil-heating system	MODERATE/WEAK • In light of the discourse about climate change, oil is generally perceived as an energy source with no future prospects in the long term
Pressure from social movements, NGOs, scientists	MODERATE • Rather strive for incentives for refurbishment measures with modern oil-heating technology than general ban	